EXHIBIT 25

POTENTIAL ENHANCED GREENHOUSE EFFECTS

STATUS AND OUTLOOK

DUANE G. LEVINE

PRESENTATION
TO
THE BOARD OF DIRECTORS
OF
EXXON CORPORATION

FEBRUARY 22, 1989

THE GREENHOUSE EFFECT IS REAL...HAS EXISTED THROUGHOUT MAN'S HISTORY...AND IN FACT...WITHOUT IT, CURRENT LIFE COULD NOT EXIST. TODAY'S CONCERNS ARE ABOUT AN EN-HANCEMENT OF THIS EFFECT DUE TO HUMAN ACTIV-ITIES. SO, I'LL REFER TO THESE CONCERNS COLLECTIVELY AS "POTENTIAL ENHANCED GREEN-HOUSE" OR PEG. IT HAS BEEN UNDER INTENSIVE SCIENTIFIC STUDY FOR OVER A DECADE BEFORE IT RECENTLY LEAPED TO THE FRONT PAGE.

IN SPITE OF THE RUSH BY SOME PARTICIPANTS IN THE GREENHOUSE DEBATE TO DECLARE THAT THE SCIENCE HAS DEMONSTRATED THE EXISTENCE OF PEG TODAY...I DO NOT BELIEVE SUCH IS THE CASE. ENHANCED GREENHOUSE IS STILL DEEPLY IMBEDDED IN SCIENTIFIC UNCERTAINTY, AND WE WILL REQUIRE SUBSTANTIAL ADDITIONAL INVESTI-GATION TO DETERMINE THE DEGREE TO WHICH ITS EFFECTS MIGHT BE EXPERIENCED IN THE FUTURE.

POTENTIAL ENHANCED GREENHOUSE (PEG)

What's Known/Not Known About the SCIENCE

- Chemistry/Physics
- Climate Models
- Data
- Projections

Who Are the Principal PLAYERS

- Programs
- Plans
- Perceptions

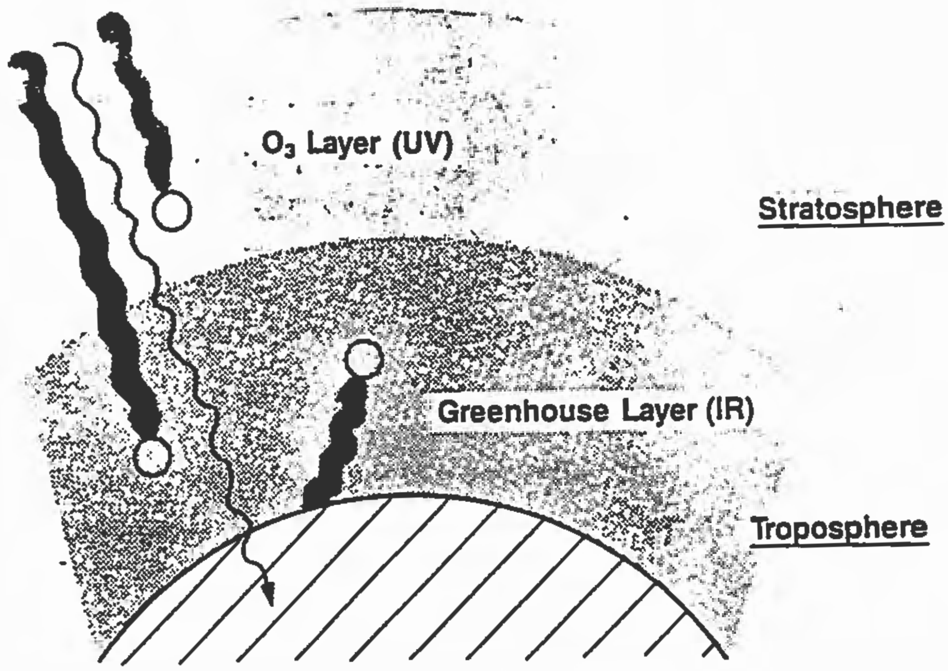
What's NEXT

SO THIS REVIEW WILL BEGIN WITH WHAT IS KNOWN AND NOT KNOWN ABOUT THE SCIENCE...FIRST THE ESSENTIAL CHEMISTRY AND PHYSICS...AND THEN PROCEED WITH A DESCRIPTION OF CLIMATE MODELS WHICH ARE USED TO PREDICT FUTURE POTENTIAL

EFFECTS. I'LL COVER THE HARD DATA AND THEN SUMMARIZE PROJECTED EFFECTS...BASED ON COMPLEX CLIMATE MODELS...WHICH...INCIDENTLY...HAVE YET TO BE VERIFIED.

HOWEVER, POLICY INITIATIVES ARE BEING ADVANCED NOW AND THEY COULD WELL OUT-PACE SCIENTIFIC PROGRESS. I'LL COVER THE CURRENT ROSTER OF PRINCIPAL PLAYERS IN THIS DEBATE, OUTLINE THEIR PROGRAM AND PLANS, AND SUMMARIZE SOME OF THEIR MOST VISIBLE PERCEPTIONS. FINALLY, I'LL TRY A GLIMPSE AT WHAT'S NEXT.

GLOBAL ATMOSPHERIC CONCERNS



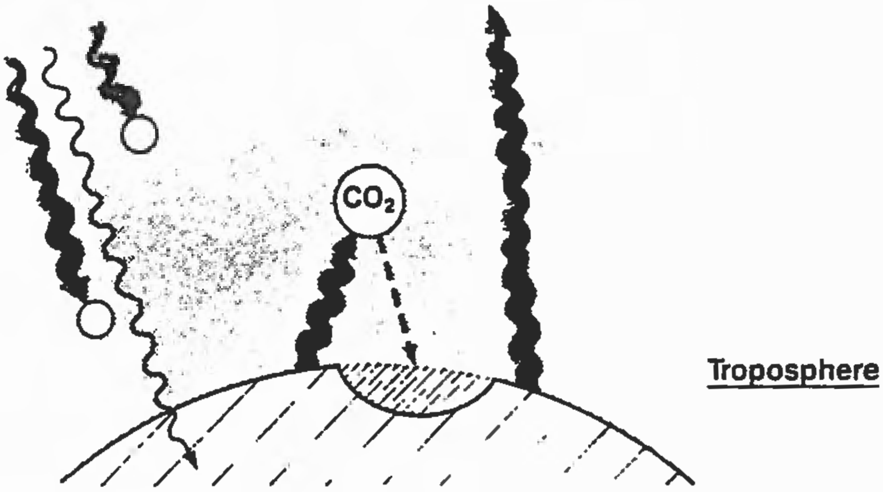
TO PUT PEG IN PERSPECTIVE, LET'S START WITH A GENERAL MODEL OF THE EARTH'S ATMOSPHERE AND 2 OF THE CURRENT MAJOR GLOBAL ATMOSPHERIC CONCERNS. ON THE LEFT, SOLAR RADIANT ENERGY IS REPRESENTED BY A BEAM RANGING FROM INFRARED (IR IN RED) TO ULTRAVIOLET (UV IN BLUE)...WITH THE BULK OF THE ENERGY IN THE VISIBLE RANGE SHOWN IN YELLOW. MOST OF THE

UV IS PICKED UP IN THE O_3 LAYER IN THE STRATOSPHERE OR UPPER ATMOSPHERE (WHICH EXTENDS APPROXIMATELY 15-50 KM ABOVE THE EARTH'S SURFACE). THIS, OF COURSE, REVEALS THE CONCERN OVER DETERIORATION OF THIS LAYER BY MAN-MADE CHLOROFLUOROCARBONS (CFCS) WHICH CAN ATTACK O_3 AND REDUCE ITS CONCENTRATION IN THE STRATOSPHERE. SUCH DETERIORATION WOULD ALLOW MORE UV TO PENETRATE THE ATMOSPHERE AND IMPACT LIFE ON THE EARTH'S SURFACE. PROTECTION OF THIS O_3 LAYER BY REDUCING CFCS IS THE GOAL OF THE RECENT MONTREAL PROTOCOLS.

MOST OF THE IR PENETRATES THE STRATOSPHERE AND IS ABSORBED BY GREENHOUSE GASES IN THE LOWER ATMOSPHERE OR TROPOSPHERE. THIS, OF COURSE, HELPS WARM THE EARTH. THE BULK OF THE RADIANT ENERGY REACHING THE EARTH IS ABSORBED IN THE VISIBLE RANGE (SHOWN IN YELLOW)...<u>DIRECTLY</u> WARMING THE EARTH. THE RE-EMITTED ENERGY...AND THIS IS MOST IMPORTANT...IS CONCENTRATED IN THE IR RANGE AND THAT ADDS TO THE AMOUNT OF IR IN THE TROPOSPHERE.

OVERALL, THEN, THE UPPER ATMOSPHERE IS DOMINATED BY UV...AND O_3 LAYER PROTECTION IS THE ISSUE...WHILE THE LOWER ATMOSPHERE IS DOMINATED BY IR AND GREENHOUSE-TYPE PROCESSES... WITH CLIMATE CHANGE AS THE ISSUE.

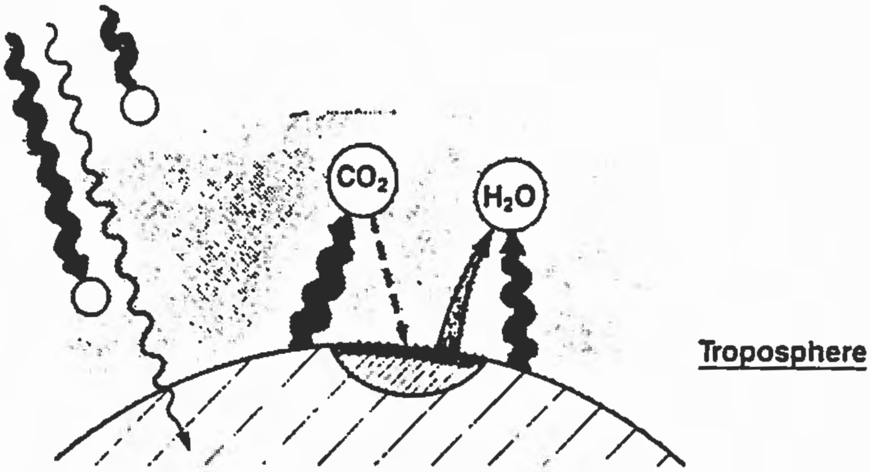
ATMOSPHERIC GREENHOUSE EFFECT



Troposphere
- Earth Concentrates IR

WE CAN GO A LITTLE DEEPER ON GREENHOUSE TO HIGHLIGHT 2 KEY ASPECTS WHICH DETERMINE ITS OVERALL EFFECTIVENESS. AGAIN...THE BAND OF SOLAR RADIATION IS DEPICTED ON THE LEFT. AS MENTIONED, MOST OF THE INCIDENT VISIBLE SOLAR RADIATION (IN YELLOW) IS ABSORBED BY THE EARTH'S SURFACE AND RE-EMITTED ALMOST EXCLUSIVELY AS IR (IN RED). IF THIS RE-EMITTED IR ENCOUNTERS GREENHOUSE GAS-ES...LIKE CO2...WHOSE PROPERTIES FAVOR IR ABSORPTION...THEY ABSORB IT...LEVERAGING THE IR WARMING...INDICATED BY THE DASHED LINE. WHEN NO GREENHOUSE GASES ARE ENCOUNTERED, THE RE-EMITTED IR ESCAPES TO SPACE. THUS, THE EARTH SERVES TO CONCENTRATE IR IN THE TROPOSPHERE AND GREENHOUSE GASES CONVERT IT

ATMOSPHERIC GREENHOUSE EFFECT



Troposphere
- Earth Concentrates IR
- Water Vapor Increases IR Trapping Effect

TO HEAT. NOW...THIS ADDITIONAL HEATING PROMOTES MORE WATER VAPORIZATION AND WATER VAPOR ITSELF IS A VERY EFFECTIVE GREENHOUSE GAS. IN FACT, IT IS ABOUT 3 TIMES MORE EFFECTIVE THAN CO_2. IT'S REALLY THE WATER VAPOR THAT DOES MOST OF THE JOB. THIS LATTER POINT IS SIGNIFICANT BECAUSE ANY GREENHOUSE GAS...INCLUDING TRACE GREENHOUSE GASES LIKE CFCS, CH_4, HALOGENS, N_2O, AND O_3 IN THE TROPOSPHERE...CAN TRIGGER THE ADDITIONAL WATER VAPOR LEVERAGING EFFECT.

THIS INSIGHT ALSO EXPOSES THE ENORMOUS DIFFERENCES BETWEEN O_3 LAYER PROTECTION AND ENHANCED GREENHOUSE...

- THEY OCCUR IN DIFFERENT PARTS OF THE ATMOSPHERE.
- THEY INVOLVE DIFFERENT PHYSICS AND CHEMISTRY.
- THEY HAVE DIFFERENT EFFECTS ON LIFE.

AND

- WHEREAS O_3 LAYER DETERIORATION IS CURRENTLY TRACED TO A SINGLE FAMILY OF MAN-MADE CHEMICALS...GREENHOUSE INCLUDES THE LIFE CYCLE GASES CO_2 AND H_2O WITH MANY NATURAL SOURCES AND SINKS.

FINALLY, I SHOULD ACKNOWLEDGE THAT THERE ARE SOME INTERACTIONS BETWEEN O_3 LAYER PROTECTION AND GREENHOUSE IN THAT O_3 AND CFCS ARE BOTH GREENHOUSE GASES AND O_3 CAN REACT WITH CERTAIN OTHER GREENHOUSE TROPOSPHERIC GASES.

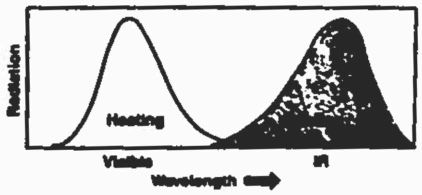
EXACTLY HOW THE GREENHOUSE GASES DETERMINE GLOBAL HEAT OR ENERGY BALANCE...AND HOW THE FLOW OF ENERGY IN AND OUT OF THE EARTH'S ATMOSPHERE DRIVES OUR CLIMATE IS DESCRIBED IN THE NEXT 2 FIGURES...FIRST, THE GLOBAL ENERGY BALANCE...

GREENHOUSE GASES & GLOBAL HEAT BALANCE

- Radiation Balance Regulates Global Temperature

Cooling Depends On:

Temperature
Atmospheric Composition

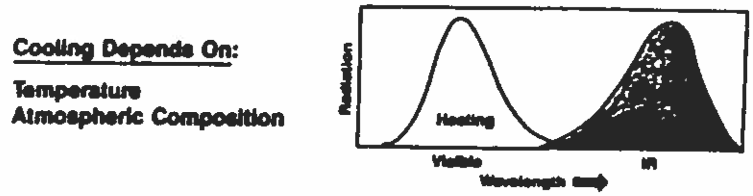


VIEWED FROM SPACE, THE EARTH MUST BE IN ENERGY EQUILIBRIUM. THAT MEANS...HEAT FLOWING IN FROM SOLAR RADIATION (SHOWN IN YELLOW) MUST EQUAL HEAT RE-EMITTED BY THE EARTH (SHOWN IN RED). THIS PLOT SHOWS THE RADIANT ENERGY IN AND OUT AS A FUNCTION OF WAVE LENGTH...YELLOW SOLAR HEATING IN THE VISIBLE RANGE AND RED EARTH COOLING IN THE IR RANGE...ALTHOUGH THE SHAPES OF THE CURVES ARE DIFFERENT AND THE RADIATION IS AT QUITE DIFFERENT WAVELENGTHS, THE FACT IS THAT THE AREAS UNDER THE CURVES ARE EQUAL. THIS EQUALITY INDICATES THE BALANCE BETWEEN TOTAL RADIATIVE HEATING AND COOLING.

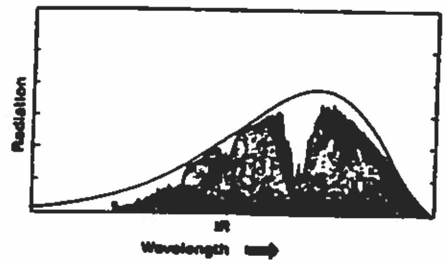
NOW, INCOMING SOLAR RADIATION...IS ESSEN-TIALLY A CONSTANT OVER TIME. HOWEVER, RADIANT COOLING DEPENDS ON THE EARTH'S TEMPERATURE AND ATMOSPHERIC COMPOSITION. THE COOLING CURVE IS SHOWN IN MORE DETAIL IN THE FIGURE. COMPARED WITH THE SOMEWHAT

GREENHOUSE GASES & GLOBAL HEAT BALANCE

- Radiation Balance Regulates Global Temperature



- Greenhouse Gases Selectively Trap IR Radiation



- Existing Greenhouse Produces 60°F Surface Warming
  — Without IR Greenhouse Earth Would Be Largely Frozen

IDEALIZED, SMOOTH COOLING CURVE SHOWN ABOVE...HERE, IN FINER DETAIL, WE SEE THE EFFECT OF GREENHOUSE GASES. THE CLEAR AREA BENEATH THE CURVE SHOWS THE ABSORPTION OF IR RADIANT ENERGY RE-EMITTED BY THE EARTH AT PARTICULAR WAVELENGTHS. QUITE OBVIOUS ARE THE STRONG ABSORPTION FEATURES PRODUCED BY CO_2 AND O_3. WATER VAPOR, THE MOST POWERFUL GREENHOUSE GAS, ABSORBS AT ALL WAVE LENGTHS. THE TOTAL GREENHOUSE EFFECT DEPENDS ON THE NATURE (MOLECULAR STRUCTURE) AND NUMBER (ATMOSPHERIC CONCENTRATION) OF ALL GREENHOUSE MOLECULES.

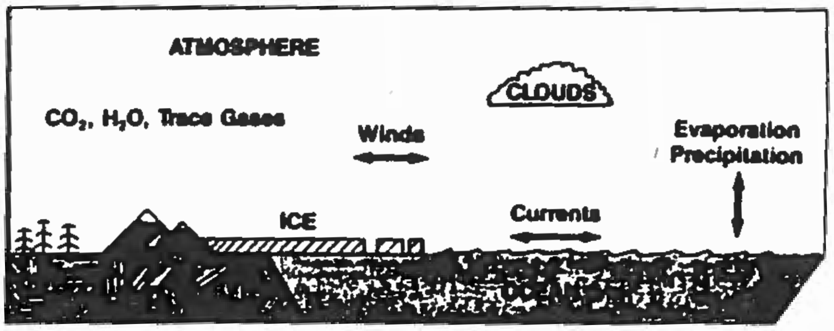
SINCE THE SOLAR HEATING INPUT REMAINS CONSTANT...WHILE THE GREENHOUSE GASES HAVE ABSORBED SOME OF THE IR COOLING, THE EARTH MUST INCREASE ITS TEMPERATURE TO MAINTAIN EQUILIBRIUM RADIANT HEAT OUTPUT. IN MODERN

CLIMATE, THE EXISTING GREENHOUSE PRODUCES A 60°F SURFACE WARMING. WITHOUT THIS EFFECT ...THE EARTH WOULD BE LARGELY FROZEN AND LIFE AS WE KNOW IT COULD NOT EXIST.

NOW FOR THE SECOND FIGURE...DESCRIBING HOW THE FLOW OF ENERGY IN THE ATMOSPHERE DRIVES CLIMATE.

ELEMENTS OF CLIMATE

- Climate Response is Governed By Complex Interactions

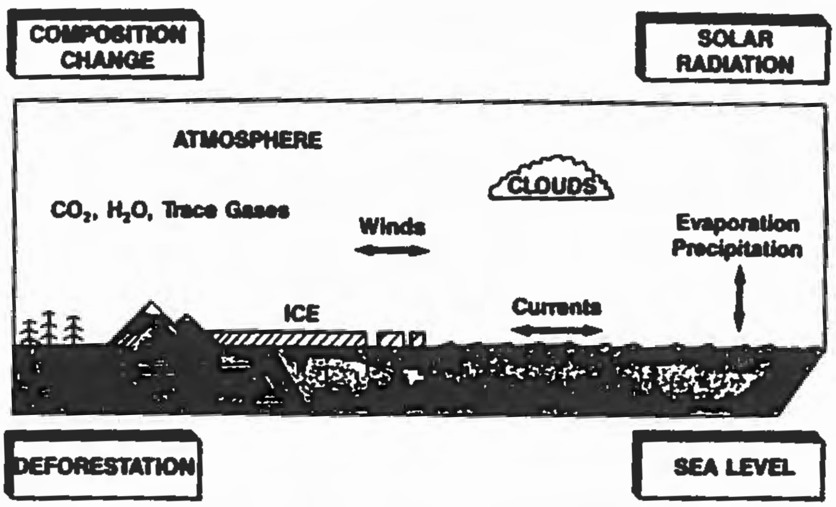


ALTHOUGH OUR TOTAL ATMOSPHERE VIEWED FROM OUTSIDE SPACE MUST BE IN EQUILIBRIUM WITH RESPECT TO SOLAR HEATING AND EARTH COOLING, WIDE VARIATIONS IN HEATING CAN EXIST INSIDE OUR ENVIRONMENT. ONCE HEAT IS ABSORBED, IT SETS IN MOTION ALL THE COMPLEX PROCESSES WHICH SHAPE OUR CLIMATE. THE PURPOSE OF CLIMATE MODELS IS TO ATTEMPT TO SORT-OUT THESE EFFECTS. CLIMATE REFERS TO THE AVERAGE TREND OF WEATHER, INCLUDING VARIABILITY. DYNAMIC EFFECTS OF WINDS AND CURRENTS CONTROL GLOBAL CLIMATE BY TRANSPORTING HEAT OVER LARGE DISTANCES. IMPORTANT FEATURES OF AVERAGE CLIMATE INCLUDE EVAPORATION/ PRECIPITATION AND CLOUD FORMATION...ALL OF WHICH DISPLAY ENORMOUS VARIABILITY.

THE DIFFICULTY IN PREDICTING CLIMATE CHANGE...THEN...IS NOT ASSOCIATED WITH GREENHOUSE GAS IR RADIATIVE PROPERTIES...BUT RATHER WITH CAPABILITIES TO UNDERSTAND AND MODEL THE RESPONSE OF CLIMATE. FOR EXAMPLE, LET'S BRIEFLY OUTLINE THE EFFECTS OF A COMPOSITIONAL CHANGE...INCREASING CO_2...ON CLIMATE.

ELEMENTS OF CLIMATE

- Climate Response is Governed By Complex Interactions



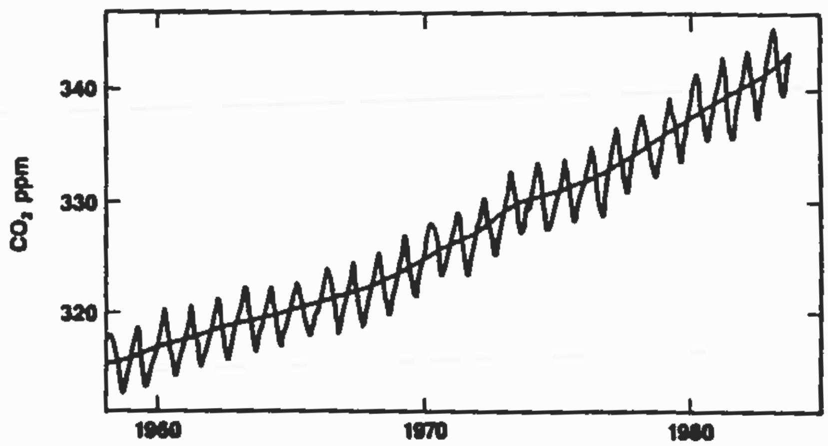
THE ADDED CO_2 TRAPS SOME ADDITIONAL HEAT...WARMING THE ATMOSPHERE BY A SMALL AMOUNT. THIS TRIGGERS OTHER CHANGES. MODELS SHOW THAT A WARMER ATMOSPHERE BECOMES MORE MOIST...WITH MORE WATER VAPOR (A MORE POWERFUL GREENHOUSE GAS) CAUSING EVEN MORE WARMING. BUT DEPENDING ON CLIMATE RESPONSE...AN INCREASE IN MOISTURE MAY INCREASE CLOUD FORMATION...SHIELDING PARTS OF THE EARTH'S SURFACE FROM DIRECT SOLAR RADIATION, AND...PERHAPS...COMPENSATING FOR THE ADDITIONAL GREENHOUSE WARMING. OTHER EFFECTS NOT WELL UNDERSTOOD...LIKE OCEAN

CURRENTS...CAN ALSO AMPLIFY OR REDUCE WARMING.

IN ADDITION TO ATMOSPHERIC COMPOSITION CHANGES, WE ARE ALSO CONCERNED TODAY WITH CLIMATE CHANGES FORCED BY MASSIVE DEFORESTATION. THIS DESTRUCTION ADDS TO THE CO_2 LOADING TO THE ATMOSPHERE AND REMOVES SOME CO_2 SINK CAPACITY THROUGH PHOTOSYNTHESIS.

FINALLY, OVER VERY LONG GEOLOGICAL TIME SCALES...CONTINENTAL DRIFT, SHIFTS IN THE EARTH'S ORBIT, AND OTHER SOLAR VARIATIONS...MAY CAUSE CHANGES IN SEA LEVEL AND SOLAR RADIATION WHICH CAN HAVE ENORMOUS EFFECTS ON CLIMATE. BUT THESE ARE USUALLY NOT PART OF CURRENT PEG PREDICTIONS.

HISTORICAL RECORD OF ATMOSPHERIC CO_2 VARIATION



- Measurements Confirmed in Detail
- Increase 3 GTON Carbon Per Year
- Pre-Industrial CO_2 Level 270 ppm (28% Growth)

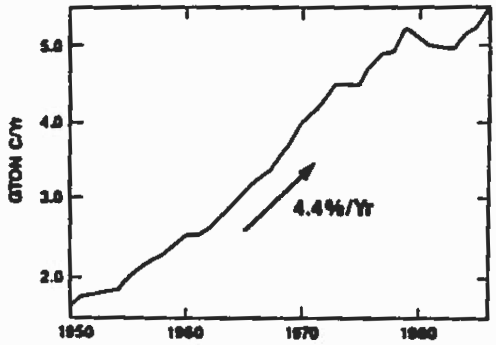
NOW I'LL COVER THE HARD DATA WE HAVE ON PEG. FIRST, THE FAMOUS MAUNA LOA (HAWAII) RECORDINGS SHOWING THE INCREASING CONCENTRATION OF ATMOSPHERIC CO_2. OBSERVATIONS AT THE SCRIPPS INSTITUTE BEGAN IN 1958 AS PART OF THE INTERNATIONAL GEOPHYSICAL YEAR. THE DATA SHOW A STEADY INCREASE IN CO_2 WITH AN OBVIOUS ANNUAL OSCILLATION. THE PERIODIC VARIATION OCCURS BECAUSE CO_2 IS DRAWN DOWN DURING THE GROWING SEASON AND RELEASED IN THE FALL AND WINTER. SINCE 1958, CO_2 HAS RISEN FROM 315 PPM TO ABOUT 345 PPM, TODAY.

THESE MEASUREMENTS HAVE BEEN CONFIRMED (± 1 PPM) IN GREAT DETAIL AT SITES FROM THE NORTH POLE TO ANTARCTICA. CO_2 MIXES RAPIDLY IN THE ATMOSPHERE, SO RESULTS ON THE AVERAGE GROWTH OF CO_2 ARE SIMILAR ACROSS THE GLOBE.

THE NET ACCUMULATION RATE OF CARBON IN THE ATMOSPHERE IS ABOUT 3 GIGATONS (BILLIONS OF METRIC TONS) PER YEAR CORRESPONDING TO THIS GROWTH.

FROM MEASUREMENTS OF AIR BUBBLES TRAPPED IN GLACIAL ICE CORES, IT IS ESTABLISHED THAT THE RECENT BUILDUP OF CO_2 BEGAN WITH THE INDUSTRIAL ERA. IN THE MID 1800s THE CO_2 LEVEL WAS ABOUT 270 PPM (± 10 PPM). CO_2 GROWTH IS ABOUT 28% SINCE THEN.

HISTORICAL RECORD OF FOSSIL FUEL CO_2 EMISSION



- Growth Resumed Following Reversal in Mid 70s
  — Growth Rate Again at Historical Levels 4%/Yr
- If Growth Persists, CO_2 Doubling Occurs Sooner
  — By Several Decades

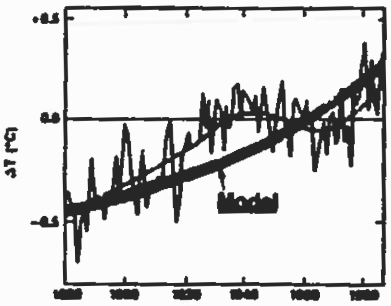
THE NEXT DATA SHOW CO2 EMISSION FROM FOSSIL FUELS BETWEEN 1950 AND TODAY. THE UNITS ARE BILLIONS OF TONS (GTON) OF CARBON PER YEAR. THERE ARE TWO IMPORTANT POINTS FROM THIS FIGURE:

FIRST NOTE THAT MODERN EMISSION RATES ARE MUCH LARGER THAN THE RATE OF ACCUMULATION OF CO2 IN THE ATMOSPHERE. RECALL THAT ATMOSPHERIC CO2 IS GROWING BY ABOUT 3 GTON/YR. FOSSIL FUEL EMISSIONS TODAY ARE ABOUT 5 GTON, AND DEFORESTATION IS THOUGHT TO ADD ABOUT 1 GTON. EXACT VALUES FOR DEFORESTATION ARE CONTROVERSIAL. ESTIMATES RANGE FROM LESS THAN 1 TO OVER 2 GTON PER YEAR. NONETHELESS, ONLY ABOUT HALF THE EMITTED CO2 STAYS IN THE ATMOSPHERE. THE OTHER HALF IS THOUGHT TO BE ABSORBED INTO THE OCEANS. IT IS ALSO TRUE THAT PLANTS GROW BETTER IN AN ATMOSPHERE ENRICHED IN CO2. THAT HAS LED

SOME SCIENTISTS TO SUGGEST THAT CO_2 IS BEING TAKEN UP AND CONVERTED TO BIOMASS. BUT THAT IS VERY DIFFICULT TO CONFIRM IN STUDIES OF NATURAL ECOLOGICAL SYSTEMS SO FAR.

THE SECOND POINT FROM THE FIGURE CONCERNS THE GROWTH IN CO_2 EMISSION. PRIOR TO THE ARAB OIL EMBARGO, EMISSIONS GREW STEADILY AT ABOUT 4.4% PER YEAR. WHEN THE GREENHOUSE ISSUE WAS FIRST IDENTIFIED IN THE MID-1970S, THAT RATE WAS EXTRAPOLATED TO PROJECT ATMOSPHERIC CO_2 LEVELS WOULD DOUBLE EARLY IN THE NEXT CENTURY, SAY 2025. HOWEVER, THE REDUCED USE OF FOSSIL FUELS SINCE THEN, CAUSED FORECASTS OF DOUBLING TO MOVE OUT BY SEVERAL DECADES, SAY TILL 2075-2100. THE FIGURE SHOWS THAT THE GROWTH RATE HAS ONCE AGAIN RECOVERED TO PAST HISTORICAL LEVELS. IF THE HIGHER GROWTH PERSISTS, THE DOUBLING TIME WILL AGAIN MOVE CLOSER BY SEVERAL DECADES.

HISTORICAL RECORD OF GLOBAL TEMPERATURE CHANGE



Noteworthy Differences With Greenhouse Predictions

- Recent Warming Reverses Cooling From 1940-1970s
  - 1980s Warmest Decade on Record
  - Persistent Trend Could Signal Greenhouse Warming
- US 1988 Summer Heat and Drought, A Critical Media Event
  - Not a Predicted Consequence of Greenhouse Warming
  - Due to a Natural Weather Fluctuation
  - Cited as an Example of Future Trends

THE FINAL DATA SET COVERS PAST VARIATION IN GLOBAL AVERAGE TEMPERATURE. OF COURSE, GLOBAL AVERAGE TEMPERATURE IS A STATISTICAL CONCEPT. IT CANNOT BE DIRECTLY MEASURED. THERE ARE SERIOUS ISSUES CONCERNING COMPLETENESS, ACCURACY, AND INTERPRETATION OF THIS HISTORICAL DATA. HOWEVER, THE PROBLEM IS RECEIVING A GREAT DEAL OF ATTENTION, AND MOST STUDIES SHOW RESULTS SIMILAR TO THESE.

THE DATA SHOW A RELATIVELY LARGE SCATTER OF A FEW TENTHS OF A DEGREE FROM YEAR TO YEAR. THIS "NOISE" OCCURS FROM NATURAL FLUCTUATIONS THAT ARE NOT COMPLETELY UNDERSTOOD. IT IS KNOWN THAT EVENTS LIKE VOLCANIC ERUPTIONS AND CHANGES IN OCEANIC UPWELLING (SUCH AS EL NINO), CAUSE PART OF THE VARIABILITY. THE DASHED TREND LINE ILLUSTRATES THE GENERAL BEHAVIOR. THE RECORD SHOWS AN APPARENT RISE OF ABOUT 1/2° C OVER THE PAST 100 YEARS.

HOWEVER, THE WARMING DOES NOT AGREE WITH MODELS BASED ON CO_2 VARIATIONS. IN PARTICULAR, ENHANCED GREENHOUSE MODELS PREDICT A SMOOTHLY <u>ACCELERATING</u> INCREASE OF TEMPERATURE WITH TIME (SHOWN IN RED). THE DATA ARE QUITE DIFFERENT. MOST NOTICEABLE IS A COOLING TREND BETWEEN THE 1930S AND LATE 1970S WHEN THE MODEL PREDICTS WARMING.

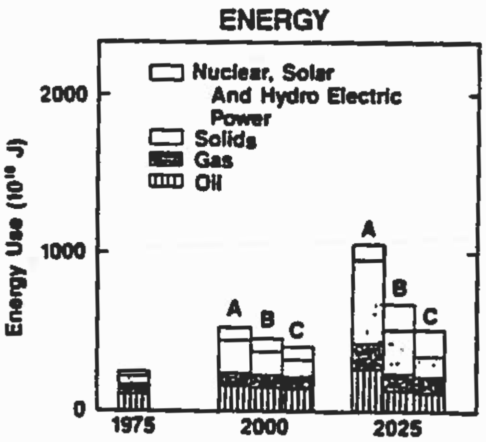
DATA ON TEMPERATURE VARIATION IN THE 1980S ARE NOW BECOMING AVAILABLE. THEY SHOW A REVERSAL OF THE RECENT COOLING TREND. IN FACT, THE 3 WARMEST YEARS ON RECORD OCCURRED IN THE 1980S. IF THIS TREND PERSISTS IT

COULD SIGNAL THAT ENHANCED GREENHOUSE WARMING IS FINALLY BECOMING DETECTABLE.

THERE IS NO DOUBT THAT THE 1988 HEAT AND DROUGHT WERE A CRITICAL EVENT IN THE GREENHOUSE ISSUE, BECAUSE THEY STIRRED PUBLIC ATTENTION, AND BROUGHT HOME <u>POTENTIAL</u> CONSEQUENCES OF CLIMATE WARMING. HOWEVER, 1988 WAS NOT A PREDICTED CONSEQUENCE OF ENHANCED GREENHOUSE MODELS. MOST METEOROLOGISTS INTERPRET THE SUMMER AS AN INFREQUENT, BUT NOT UNEXPECTED FLUCTUATION IN WEATHER. GREENHOUSE SCIENTISTS BY AND LARGE HAVE NOT CLAIMED THE US HEAT AND DROUGHT WERE CAUSED BY ENHANCED GREENHOUSE, BUT THEY HAVE CITED IT AS AN EXAMPLE OF WHAT PEG MIGHT BRING.

SO FAR WE HAVE DISCUSSED THE HISTORICAL RECORD, AND SHOWN THE IMPORTANT DATA. HOWEVER, PEG IMPACTS OCCUR IN THE FUTURE. SO NOW WE TURN TO PROJECTIONS.

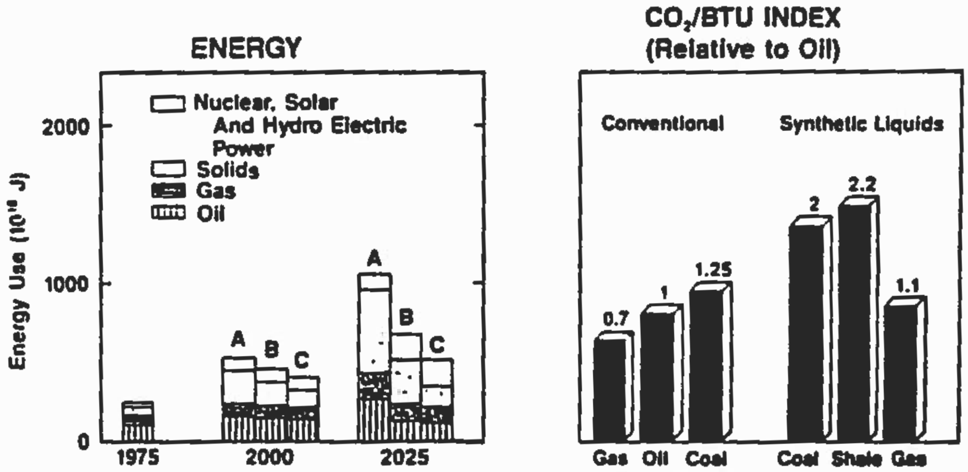
PROJECTED SOURCES OF ENERGY AND CO_2 EMISSION



- Future Emission Sensitive to Forecasts of Energy Demand, Source
  — Projections Differ Significantly Beyond Near Term

FORECASTS OF FUTURE LEVELS OF ATMOSPHERIC CO_2 BEGIN BY PROJECTING ENERGY NEEDS AND SOURCES WELL INTO THE NEXT CENTURY. THE FIGURE SHOWS THREE FORECASTS OF ENERGY DEMAND TAKEN FROM A DOE STUDY, LABELED CASE A, B, AND C. THE UNIT OF ENERGY IS 10^{18} JOULES, WHICH IS ABOUT THE SAME AS QUADS, OR QUADRILLIONS OF BTUs. CASE B IS CLOSE TO RECENT EXXON PROJECTIONS.

PROJECTED SOURCES OF ENERGY AND CO_2 EMISSION



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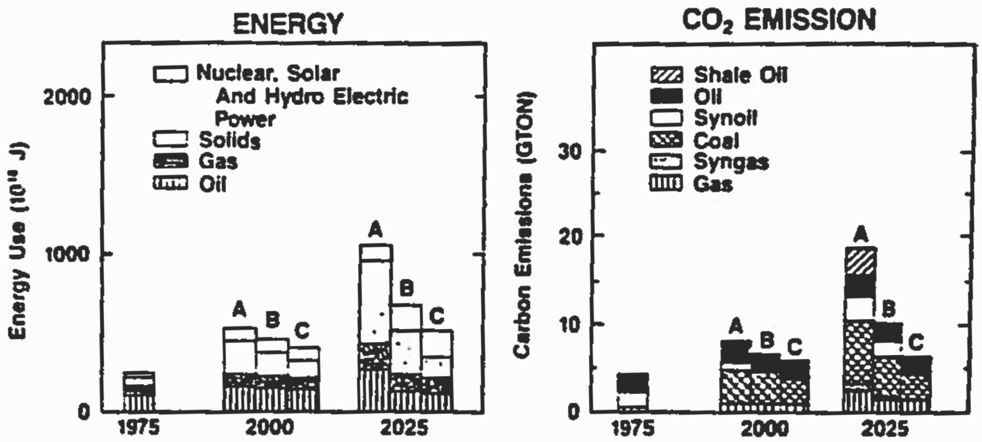
IT IS WELL KNOWN THAT FOSSIL FUELS EMPLOYED TO SATISFY THE DEMANDS, DIFFER IN THE AMOUNT OF CO_2 RELEASED TO PRODUCE A BTU OF ENERGY. THIS PART OF THE FIGURE COMPARES FOSSIL FUELS ON A RELATIVE SCALE WHERE EMISSIONS PER BTU FROM CONVENTIONAL OIL ARE TAKEN AS ONE. THEN, GAS IS 0.7 AND COAL IS 1.25. WE ALSO SHOW THE INDEX VALUES FOR SYNTHETIC LIQUIDS. SYNTHETIC LIQUIDS FROM COAL AND SHALE RESULT IN GREATER CO_2 EMISSIONS. THE EXTRA CO_2 IS GENERATED IN THE MANUFACTURING PROCESS. ESPECIALLY FOR SYNTHETICS FROM

COAL AND SHALE THE CO_2 FACTOR IS SENSITIVE TO THE RAW MATERIAL AND PROCESS ROUTE. LIQUIDS DERIVED DIRECTLY FROM GAS HAVE SIGNIFICANTLY LOWER CO_2 INDICES.

PROJECTED SOURCES OF
ENERGY AND CO_2 EMISSION



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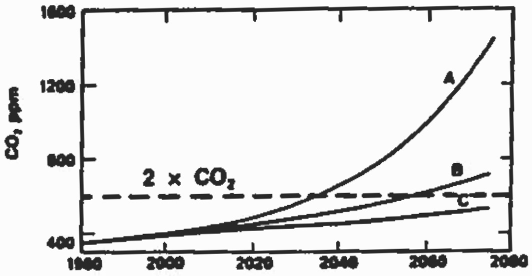
FOR EACH ENERGY DEMAND CASE...(A, B, & C)... THIS CO_2 GENERATION INDEX CAN BE USED TO COMPUTE CO_2 EMISSIONS AS SHOWN IN THE FINAL FIGURE. CASE A WITH THE GREATEST ENERGY DEMAND ALSO PRODUCES MUCH HIGHER CO_2 EMISSIONS, SINCE IT RELIES ON HIGH CO_2 PRODUCING FUELS FROM SYNTHETICS. OVERALL FORECASTS DIFFER WIDELY BEYOND THE NEAR TERM. EXTENDED OUT TO 2100 THEY VARY BY FACTORS OF 20 IN CO_2 EMISSION LEVELS.

PROJECTED GROWTH OF ATMOSPHERIC CO_2

- Combine Forecasts: Economic Growth, Energy Use, CO_2 Growth



- Atmospheric CO_2 Doubles (600 ppm)
  - — Case A: 2030
  - — Case B: 2060
  - — Case C: 2100

BY COMBINING THESE THREE TYPES OF PROJECTIONS FOR THE FUTURE...

- TOTAL ENERGY CONSUMPTION
- CO2 EMISSION FACTORS FOR VARIOUS FOSSIL FUELS

AND

- DISTRIBUTION OF FOSSIL FUEL ENERGY CONSUMPTION BY RESOURCE...

IT IS POSSIBLE TO FORECAST FUTURE LEVELS OF ATMOSPHERIC CO2. THE PROJECTIONS SHOW DOE FORECASTS FOR THE 3 CASES THROUGH THE YEAR 2080.

IN THESE FORECASTS THE CO2 DOUBLING TIME IS A CONVENIENT BENCHMARK TO MEASURE CO2 BUILD-UP. (IT IS THE LEVEL CONSIDERED IN MOST CLIMATE SIMULATIONS OF THE GREENHOUSE EFFECT.) HOWEVER, THERE IS NOTHING MAGICAL ABOUT DOUBLING ITSELF. TAKING THE DOUBLING LEVEL TO BE 600-700 PPM, THE VARIOUS CASES LEAD TO A DOUBLING BETWEEN 2030 AND 2100 AS INDICATED.

POTENTIAL CLIMATE IMPACT FROM CO_2: NEXT 100 YEARS

"CHANGING CLIMATE", NATIONAL RESEARCH COUNCIL 1983

- Temperature
  - — Global Mean Temperature Increase ... 1.5 – 4.5°C
  - — Greater Warming in Polar Regions (2–3×)
- Sea Level/Sea Ice
  - — Coverage and Thickness of Sea Ice/Glaciation Will Decrease
  - — Sea Level Rise (Meltwater + Thermal Expansion) ... 70 cm
- Natural Ecosystems and Agriculture
  - — Regional Climate Change: Temperature, Hydrology
  - — Enhanced Productivity From Increased CO_2
  - — Global Net Effect Uncertain

THESE CO2 PROJECTIONS ARE USED IN CURRENT CLIMATE MODELS TO PREDICT IMPORTANT CHANGES OVER THE NEXT 100 YEARS. THIS SET OF RESULTS IS TAKEN FROM THE NATIONAL RESEARCH COUNCIL (NRC) REPORT "CHANGING CLIMATE".

CONSENSUS PREDICTIONS CALL FOR WARMING BETWEEN 1.5-4.5 OC FOR DOUBLED CO2 WITH GREATER WARMING AT THE POLES. NOTE THAT THESE NUMBERS REFLECT THE RANGE PRODUCED BY AVAILABLE MODELS. NO ONE KNOWS HOW TO EVALUATE THE ABSOLUTE UNCERTAINTY IN THE NUMBERS.

THE EXTENT AND THICKNESS OF GLACIERS ARE PREDICTED TO DECREASE, LEADING TO SEA LEVEL RISE. THE NRC REPORT CHOSE A MOST LIKELY VALUE OF 70 CM SEA LEVEL RISE. OTHER PREDICTIONS SUGGEST A BROADER RANGE FROM 30-200 CM. THE RISE OCCURS BOTH FROM A LARGER AMOUNT OF WATER IN THE OCEANS, AND FROM THERMAL EXPANSION.

FINALLY, CLIMATE CHANGE AND HIGHER LEVELS OF ATMOSPHERIC CO_2 AFFECT AGRICULTURE AND ECOSYSTEMS. THERE ARE TWO ASPECTS. FIRST, THE DIRECT EFFECT OF CLIMATE CHANGE ALTERS THE LENGTH OF THE GROWING SEASON AND THE AVAILABILITY OF WATER. SECOND, NEARLY ALL PLANTS GROW MORE RAPIDLY, AND USE LESS WATER, IN A HIGH CO_2 ENVIRONMENT. THE SECOND EFFECT CAN BE QUITE POSITIVE FOR MANAGED AGRICULTURE.

MODELS CANNOT YET PREDICT REGIONAL CLIMATE CHANGE WITH MUCH ACCURACY. I AM SURE YOU HAVE ALL HEARD THAT THE US MID-WEST MAY BECOME A DUST BOWL FROM ENHANCED GREENHOUSE, WHILE RUSSIA MAY BECOME MORE FRUITFUL. THAT IS A PROJECTION OF SOME MODELS, BUT OTHERS SHOW THE OPPOSITE.

THE CLIMATE MODEL IMPACTS OF PEG ARE NOT ALL NEGATIVE. THEY AFFECT DIFFERENT PARTS OF THE GLOBE UNEQUALLY. THE MODELS PREDICT VARIOUS WINNERS AND LOSERS.

THIS COMPLETES THE GREENHOUSE SCIENCE DISCUSSION.

SUMMARIZING:

DATA CONFIRM THAT

- GREENHOUSE GASES ARE INCREASING IN THE ATMOSPHERE.
- FOSSIL FUELS CONTRIBUTE MOST OF THE CO_2...BUT DEFORESTATION IS ALSO SIGNIFICANT.

AND

- HISTORICAL TEMPERATURES SHOW ONLY SLIGHT WARMING...NOT ENOUGH TO CONFIRM ENHANCED GREENHOUSE.

THAT'S ALL THE DATA.

PROJECTIONS SUGGEST

- SIGNIFICANT CLIMATE CHANGE WITH A VARIETY OF REGIONAL IMPACTS.

AND

- SEA LEVEL RISE WITH GENERALLY NEGATIVE CONSEQUENCES.

FINALLY, THE SIZE AND TIMING OF IMPACTS ARE UNCERTAIN.

POTENTIAL ENHANCED GREENHOUSE

PLAYERS...

- US
  - CONGRESS/PRESIDENT
  - EPA/DOE/STATE
  - NOAA/NASA/NSF
  - AND THE
  - MEDIA
- UN
  - GENERAL ASSEMBLY - "WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT"
  - UNEP/WMO
- CANADA
  - PRIME MINISTER
  - FEDERAL ENVIRONMENTAL MINISTRY
- INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS
- EEC
- OECD
- ENVIRONMENTAL GROUPS

THE KEY PLAYERS ON PEG ARE IN THE US AND UN. IN THE US, CONGRESS IS VERY INTERESTED. SENATORS LIKE WIRTH, MITCHELL, BAUCUS, AND GORE HAVE VERY HIGH PROFILES. PRESIDENT BUSH HAS COMMITTED TO CONVENE A GLOBAL GREENHOUSE CONFERENCE. WITHIN THE ADMINISTRATION, THE PLAYERS ARE EPA (WHICH HAS A PARTICULARLY CRITICAL ROLE THROUGH ITS INTERNATIONAL ACTIVITIES), DOE (WHICH SPONSORED AN EXTENSIVE REVIEW OF THE SUBJECT COMPLETED IN 1985), AND THE STATE DEPARTMENT (WHOSE INTERESTS ARE DIRECTED TOWARDS INTERNATIONAL TREATIES AND CONVENTIONS). IN ADDITION, TECHNICAL AGENCIES INCLUDING NOAA, NASA, AND NSF HAVE SIGNIFICANT ROLES...AND, OF COURSE, THE MEDIA IS VERY ACTIVE.

ALL OF THESE EFFORTS ARE ESTABLISHING LINKS WITH OTHER NATIONAL AND INTERNATIONAL INTERESTS...ESPECIALLY IN THE UN WHICH HAS DEVOTED A GREAT DEAL OF EFFORT TO PEG. THE GENERAL ASSEMBLY ESTABLISHED A WORLD-WIDE COMMISSION HEADED BY MME. GRO BRUNDTLAND (PRIME MINISTER OF NORWAY) TO EVALUATE PROBLEMS OF ENVIRONMENTAL PROTECTION AND ECONOMIC DEVELOPMENT. THE COMMISSION'S REPORT..."OUR COMMON FUTURE"...CONTAINS A HEAVY DOSE OF GREENHOUSE CONCERNS...ON CLIMATE, AGRICULTURE, ENERGY...AND LISTS IT AS THE #1 ENVIRONMENTAL PROBLEM WE FACE. THE GENERAL ASSEMBLY HAS DIRECTED ALL OF ITS AGENCIES TO DEVELOP SPECIFIC PLANS TO DEAL WITH PEG.

THE UNITED NATIONS ENVIRONMENTAL PROGRAM (UNEP) IS ONE OF THESE AGENCIES AND IT HAS

MADE PEG ITS #1 PRIORITY. UNEP...LIKE EPA HAS A CRITICAL ROLE...HAVING BEEN DIRECTED TO DEVELOP DETAILED PLANS WITH THE WORLD METEOROLOGICAL ORGANIZATION (WMO) FOR ACTION PROGRAMS AND POLICY PROPOSALS TO BE RECOMMENDED TO THE GENERAL ASSEMBLY.

THERE ARE NUMEROUS OTHER PLAYERS. THE CANADIANS, INCLUDING THEIR PRIME MINISTER AND FEDERAL ENVIRONMENTAL MINISTRY, HAVE BEEN...PERHAPS...THE MOST OUTSPOKEN GOVERNMENT IN RESPONDING TO THE NEED FOR GREENHOUSE LIMITATIONS. THEY SPONSORED A WORLD CONFERENCE ON PEG DURING THIS PAST JUNE...WHICH CALLED FOR 20% REDUCTION IN CO_2 EMISSIONS BY 2010 WITH AN OVERALL GOAL OF 50% REDUCTION...AND A TAX ON FOSSIL FUELS TO FUND ALTERNATE ENERGY DEVELOPMENT.

THE INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS (ICSU) IS PROVIDING A FORUM FOR WORLD-WIDE SCIENTIFIC EFFORTS UNDER THE BANNER OF THE "INTERNATIONAL BIOPHYSICAL YEAR". THE EUROPEAN ECONOMIC COMMUNITY (EEC) IS PURSUING ITS POSITION AND DEVELOPED COUNTRIES IN THE OECD HAVE ESTABLISHED ACTIVITIES TO PARTICIPATE IN THE EXPECTED DEBATE.

OF COURSE, NUMEROUS ENVIRONMENTAL GROUPS...INCLUDING HIGH PROFILE ORGANIZATIONS LIKE THE GREENS, WORLD RESOURCES INSTITUTE, AND NATIONAL RESOURCES DEFENSE COUNCIL...HAVE NOW INVESTED A LOT OF TIME AND EFFORT IN EXPERTISE RELATED TO ENERGY AND GREENHOUSE. HAVING INVESTED SIGNIFICANT

EFFORT, THEY NEED...AND INTEND...TO HAVE SIGNIFICANT IMPACT.

SCHEDULED ACTIVITIES - PEG

US

- INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (WITH WMO/ICSU) — 1988
- EPA REPORTS ON — 1988
  - POTENTIAL CONSEQUENCES FOR US/WORLD
  - MITIGATION/STABILIZATION APPROACHES
- DOE — 1989
  - ASSESSMENT OF R&D ON ALTERNATE ENERGY
  - INVENTORY OF GREENHOUSE GASES
  - ANALYSIS OF PRIVATE SECTOR OPTIONS
  - POLICY OPTIONS TO LIMIT EMISSIONS
- US/INTERNATIONAL SCIENCE ASSESSMENT — 1990

UN

- COORDINATE WORLDWIDE SCIENTIFIC ASSESSMENT WMO/ICSU — 1990
- REGIONAL IMPACT ASSESSMENTS — 1990
- POLICY OPTIONS TO LIMIT CLIMATE CHANGE — 1990
- INTERNATIONAL CONVENTION TO LIMIT CLIMATE CHANGES — MID '90'S

THE INTENSITY OF THESE EFFORTS IS REFLECTED IN THE SLATE OF ACTIVITIES CURRENTLY SCHEDULED. FOR EXAMPLE, IN '88 THE US, THROUGH NOAA AND NASA, SET UP AN INTERGOVERNMENTAL CLIMATE PANEL WITH WMO AND ICSU TO PROMOTE LIAISON BETWEEN GOVERNMENTS...AND EPA WAS TO REPORT TO CONGRESS ON BOTH POTENTIAL CONSEQUENCES OF PEG FOR THE US/WORLD AND... MITIGATION/STABILIZATION APPROACHES TO LIMIT CLIMATE CHANGE. THIS REPORT IS NOW DUE IN 1989. DOE WILL BE VERY BUSY. IN 1989, IT

IS DUE TO DEVELOP REPORTS ON VARIOUS ASPECTS OF PEG INCLUDING:

- ASSESSING ALTERNATE ENERGY R&D
- CATALOGUING GREENHOUSE GASES
- ANALYZING ENERGY OPTIONS FOR THE PRIVATE SECTOR

AND

- EVALUATING POLICY OPTIONS FOR LIMITING CO_2 EMISSIONS

FINALLY, NSF IS PLANNING A US/INTERNATIONAL SCIENCE ASSESSMENT BY 1990.

THE UN HAS RECENTLY COMMISSIONED A WORLDWIDE SCIENTIFIC ASSESSMENT DESIGNATING WMO TO WORK CLOSELY WITH ICSU. BY THE WAY, NSF WILL ALSO COORDINATE CLOSELY WITH THIS EFFORT IN DEVELOPING ITS VIEWS. REGIONAL IMPACT STUDIES ARE BEING SET UP USING CLIMATE MODELS TO PROJECT THE VARIOUS WINNERS AND LOSERS AS RAINFALL, WIND, STORMS, AND SEA LEVEL PATTERNS CHANGE. THIS COULD BE ESPECIALLY CONTENTIOUS BECAUSE OF THE WIDE ROOM FOR INTERPRETATION IN APPLYING THE MODELS AND THE ENORMOUS POTENTIAL POLITICAL CONSEQUENCES. CONCURRENTLY, UNEP WILL DEVELOP ITS VIEW OF POLICY OPTIONS TO LIMIT CLIMATE CHANGE. ALL OF THESE ACTIVITIES ARE PLANNED FOR COMPLETION IN 1990. UNEP HAS BEEN URGED TO AIM FOR AN INTERNATIONAL CONVENTION ON PEG BY ABOUT 1995. HOWEVER, THIS TARGET DATE SEEMS TO BE ADVANCING TOWARDS 1992.

GIVEN, THE...

- COMPLEXITY OF THE SCIENCE
- ENORMOUS POTENTIAL GLOBAL IMPACTS
- DIVERSITY OF THE PLAYERS

AND

- INTENSITY OF THEIR ACTIVITIES...

WHERE IS ALL THIS HEADED? I BELIEVE THERE IS A PATTERN...AND IT'S ROOTED IN THE EVOLUTION OF THE JUST-COMPLETED MONTREAL PROTOCOLS TO PROTECT THE STRATOSPHERIC 03 LAYER BY LIMITING MAN-MADE CFCS.

STRATOSPHERIC OZONE/PEG ANALOGY

	OZONE LAYER		ENHANCED GREENHOUSE	
'74	✓	ATMOSPHERIC CHEM/PHYS	✓	'76
	✓	GROWTH IN (CFC'S) / (CO2) & (TRACE GASES)	✓	
	✓	INDUSTRIAL SOURCES	✓	
	✓	MODELS: END EFFECT PROJECTIONS	✓	
	✓	CONCEPT OF "DELAY"	✓	
	✓	ENVIRONMENTAL CAUSE	✓	
	✓	INTERNATIONAL OWNERSHIP	✓	
	✓	US/UN AXIS	✓	
	✓	CRITICAL EVENT	✓	
	✓	CALL FOR ACTION	?	
	VIENNA CONVENTION		?	
'87	MONTREAL PROTOCOLS		?	

ABOUT 20 YEARS AGO, THE ATMOSPHERIC CHEMISTRY AND PHYSICS BEGAN WITH CONCERNS OVER THE EFFECT OF SUPERSONIC TRANSPORTS ON THE 03 LAYER. AS THESE FEARS ABATED...IN 1974... SOME SCIENTISTS' LABORATORY TESTS INDICATED THAT THE VERY STABLE CLASS OF MAN-MADE CHEMICALS (CFCS) BREAK DOWN UNDER THE KIND

OF INTENSE UV RADIATION THAT IS PRESENT IN THE STRATOSPHERE...WITH THE RESULTING CL AND BR ATOMS ATTACKING AND DESTROYING O_3.

SUBSEQUENTLY, IT WAS ESTABLISHED THAT THE CFC CONCENTRATIONS WERE INCREASING IN THE STRATOSPHERE. THESE CFCS, OF COURSE, WERE EASILY TRACED TO MAN-MADE SOURCES AND INDUSTRIAL APPLICATIONS.

EXTENSIVE MODELING EXERCISES PREDICTED...

- THE LONG TERM RATE OF O_3 LAYER DETERIORATION

- THE RESULTING INCREASED UV PENETRATION OF THE EARTH'S ATMOSPHERE

AND

- THE SERIOUS POTENTIAL REPERCUSSIONS LIKE INCREASED HUMAN CANCER RATES AND PLANT DAMAGE

NOW THESE PREDICTED EFFECTS WERE WELL INTO THE FUTURE. SO A CRUCIAL STEP WAS THE INTRODUCTION OF "A DELAY CONCEPT" BASED ON THE UNUSUAL CHEMICAL STABILITY OF CFCS IN THE LOWER ATMOSPHERE AND THE VERY LONG TRANSPORT TIMES FOR CFCS TO REACH THE UPPER STRATOSPHERE. THE REASONING WAS...THERE WAS AN <u>ALREADY</u> COMMITTED O_3 LAYER DETERIORATION BASED ON CFCS <u>ALREADY</u> "IN THE PIPELINE". THIS GAVE RISE TO AN ENVIRONMENTAL CAUSE WHICH WAS QUICKLY ADOPTED AS AN INTERNATIONAL ISSUE. THE PLAYERS WERE BASICALLY SIMILAR TO THOSE ORGANIZING AROUND THE CURRENT

GREENHOUSE ISSUE...PRIMARILY IN THE US AND UN. WHEN THE US BECAME ACTIVELY INVOLVED...INITIATING COOPERATION WITH THE UN TO LIMIT WORLDWIDE CFC PRODUCTION AND SALES...ALL OF THE ELEMENTS WERE IN PLACE.

BUT WITH ALL OF THIS, PROGRESS BEGAN TO LANGUISH AND THE EFFORT MIGHT WELL HAVE FOUNDERED, EXCEPT FOR THE DISCOVERY OF THE SO-CALLED "O_3 LAYER HOLE" OVER ANTARCTICA. THIS WAS A MOST CRITICAL EVENT - ALTHOUGH ITS EXACT RELEVANCE TO CFC RELATED O_3 LAYER DETERIORATION REMAINS UNEXPLAINED. IT RE-ENERGIZED THE EFFORT AND DIRECTLY LED TO A "CALL FOR ACTION" AND THE VIENNA CONVENTION. SHORTLY THEREAFTER...IN 1987...THE MONTREAL PROTOCOLS TO LIMIT CFCS WITH A PHASED 50% REDUCTION BY THE TURN OF THE CENTURY WERE APPROVED AND ARE EXPECTED TO BE ADOPTED. I SHOULD ADD THAT IN 1988...JUST WITHIN THE PAST 6 MONTHS OR SO...THERE IS FOR THE FIRST TIME CONVINCING SCIENTIFIC EVIDENCE THAT O_3 LAYER DETERIORATION HAS BEEN DETECTED. SO THAT <u>AFTER THE FACT</u>...SOME ACTION SEEMS JUSTIFIED.

NOW, I HOPE FROM THE MATERIAL COVERED ON GREENHOUSE SO FAR...IT IS CLEAR THAT WE HAVE ADVANCED THROUGH SIMILAR STAGES. A CRITICAL EVENT OCCURRED WITH THE "LONG HOT SUMMER OF '88". ALTHOUGH MOST RESPONSIBLE SCIENTISTS BELIEVE THIS WAS DUE TO NATURAL FLUCTUATIONS IN WEATHER PATTERNS...IT HAS DRAWN MUCH ATTENTION TO THE POTENTIAL PROBLEMS AND WE'RE STARTING TO HEAR THE INEVITABLE CALL FOR ACTION. EXACTLY WHAT HAPPENS NOW IS NOT

CLEAR...BUT THIS CRITICAL EVENT HAS ENERGIZED THE GREENHOUSE EFFORT AND RAISED PUBLIC CONCERN OVER PEG.

SOME KEY PERCEPTIONS/MISCONCEPTIONS...

- "PEG" IS PART OF/CLOSELY LINKED TO "O_3 LAYER PROTECTION"
- ENOUGH RESEARCH HAS BEEN DONE
  - EXISTENCE OF PEG IS NOW ESTABLISHED
  - ADVANCING THE SCIENCE WILL TAKE TOO LONG
- '88 SUMMER WAS DUE TO PEG
- CAN'T TOLERATE DELAY
- NEED POLICY DEVELOPMENT NOW
- PROJECTED SHIFTS IN WEATHER WILL FEATURE BIG WINNERS AND LOSERS WITH MAJOR POLITICAL IMPLICATIONS
- DEVELOPED COUNTRIES WILL SHIFT RESOURCES TO DEVELOPING COUNTRIES
- NUCLEAR AND/OR RENEWABLE ENERGY RESOURCES CAN SOLVE THE PROBLEM

OVERALL...

- RISK FROM PEG CLIMATE CHANGES IS NOT ACCEPTABLE...
  MUST DEVELOP (IMPLEMENT) CONTROL POLICIES NOW

IN FACING THIS REALITY, THERE ARE SOME KEY PERCEPTIONS AND MISCONCEPTIONS WE'LL HAVE TO DEAL WITH. THE FIRST MISCONCEPTION IS THAT PEG AND O_3 LAYER ARE SOMEHOW THE SAME PROBLEM...OR AT LEAST CLOSELY LINKED. THIS IS PARTICULARLY DANGEROUS BECAUSE THE TWO PROBLEMS ARE, IN FACT, VERY DIFFERENT AND EFFECTIVE SOLUTIONS ARE BOUND TO BE VERY DIFFERENT...BANNING A SINGLE CLASS OF MAN-MADE CFC CHEMICALS IS VERY DIFFICULT...BUT PALES BY COMPARISON TO THE DIFFICULTIES OF APPLYING SIMILAR APPROACHES TO LIFE CYCLE GASES LIKE CO_2 AND WATER.

THE SECOND MISCONCEPTION IS THAT ENOUGH RESEARCH ON THE BASIC PROBLEM HAS BEEN DONE. FAILURE TO UNDERSTAND THE NEED FOR SUBSTANTIAL ADVANCES IN THE SCIENCE TO REDUCE THE UNCERTAINTY AND EXTREME VARIABILITY IN THE PROJECTIONS CAN LEAD TO PREMATURE LIMITATIONS ON FOSSIL FUELS.

USING THE '88 SUMMER WEATHER PATTERNS AS PART OF THIS ARGUMENT...THE THIRD MISCONCEPTION...IS SIMPLY INCORRECT.

ARGUMENTS THAT WE CAN'T TOLERATE DELAY AND MUST ACT NOW CAN LEAD TO IRREVERSIBLE AND COSTLY DRACONIAN STEPS.

PROJECTING PEG INDUCED CLIMATIC REGIONAL WINNERS AND LOSERS...AND COMPETITION BETWEEN DEVELOPED AND DEVELOPING COUNTRIES IN RATIONING ENERGY TO LIMIT PEG...COULD EASILY DOMINATE ANY DEBATE AND MAKE RATIONAL CO-OPERATION LESS LIKELY.

THERE HAVE BEEN DRAMATIC SHIFTS IN ATTITUDES TOWARDS NUCLEAR ENERGY BY ENVIRONMENTAL GROUPS BECAUSE OF THEIR CONCERNS OVER PEG. FURTHERMORE, RENEWABLE ENERGY ADVOCATES HAVE TRADITIONALLY OVERSTATED CAPABILITIES. THESE BOTH TEND TO ENCOURAGE A PRECIPITOUS SHIFT TO ALTERNATE ENERGY AND UNDERSTATE THE CONSIDERABLE DIFFICULTIES WHICH MUST BE OVERCOME.

WHAT'S NEXT

Expect:

- Continued Pressure to...
  OVERSTATE SCIENTIFIC UNDERSTANDING
- Prominent Media Role to...
  INCREASE PUBLIC CONCERNS
- More Initiatives to...
  INCREASE PACE OF INTERNATIONAL NEGOTIATIONS

→ 'Crisis Mentality'

Rational Responses Require:

- Efforts to...
  EXTEND THE SCIENCE
- Emphasis on...
  COSTS/POLITICAL REALITIES

→ 'Adaptation'

AS FOR "WHAT'S NEXT"...WE CAN EXPECT CONTINUED PRESSURE TO OVERSTATE CURRENT SCIENTIFIC UNDERSTANDING. THE MEDIA ROLE...ALREADY PROMINENT...IS LIKELY TO INCREASE PUBLIC AWARENESS AND CONCERN, AND THERE WILL BE CONTINUING INITIATIVES TO EXTEND INTERNATIONAL NEGOTIATIONS. AS THE DEGREE OF THESE EFFORTS EXCEED UNDERSTANDING (OR ABILITY TO RESPOND CONSTRUCTIVELY)...THERE IS A TENDENCY TOWARDS A "CRISIS MENTALITY." MEANWHILE, MORE RATIONAL RESPONSES WILL REQUIRE EFFORTS TO EXTEND THE SCIENCE AND INCREASE EMPHASIS ON COSTS AND POLITICAL REALITIES TO FRAME "ADAPTIVE" MEASURES WHICH ARE DOABLE AND MOVE TOWARDS CONSTRUCTIVE OPTIONS.

EXXON'S POSITION

- IMPROVE UNDERSTANDING
  Extend the Science
  Include the Costs/Economics
  Face the Socio-Political Realities
- STRESS ENVIRONMENTALLY SOUND ADAPTIVE EFFORTS
  Support Conservation
  Restrict CFCs
  Improve Global Re/De Forestation

TO BE A RESPONSIBLE PARTICIPANT AND PART OF THE SOLUTION TO PEG, EXXON'S POSITION SHOULD RECOGNIZE AND SUPPORT 2 BASIC SOCIETAL NEEDS. FIRST...TO IMPROVE UNDERSTANDING OF THE PROBLEM...NOT JUST THE SCIENCE...BUT THE COSTS AND ECONOMICS TEMPERED BY THE SOCIO-POLITICAL REALITIES. THAT'S GOING TO TAKE YEARS (PROBABLY DECADES). BUT THERE ARE MEASURES ALREADY UNDERWAY THAT WILL IMPROVE OUR ENVIRONMENT IN VARIOUS WAYS...AND IN ADDITION REDUCE THE GROWTH IN GREENHOUSE GASES. THAT'S THE SECOND NEED INCLUDING THINGS LIKE ENERGY CONSERVATION, RESTRICTION OF CFC EMISSIONS, AND EFFORTS TO INCREASE THE GLOBAL RATIO OF RE/DE FORESTATION. OF COURSE, WE'LL NEED TO DEVELOP OTHER RESPONSE OPTIONS...IMPLEMENTING MEASURES WHEN THEY ARE COST EFFECTIVE IN THE NEAR TERM AND PURSUING NEW TECHNOLOGIES FOR THE FUTURE.

EXHIBIT 26

CONNECTIONS

For creating opportunity and advantage

Corporate Research
Exxon Research and Engineering Company
CR.3B-H.89 Fall 1989
PROPRIETARY INFORMATION FOR COMPANY USE ONLY

Directions

TECHNOLOGY'S PLACE IN THE MARKETING MIX

Gord Thomson, Vice President
Marketing Department
Exxon Company, U.S.A.

As we look at all five "P's" of the marketing mix--products, place, price, promotion, and people--new technology continues to play a strong role in our future strategy. What is our strategy? Bill Stevens, our President, said it best in the Fall 1988 issue of CONNECTIONS:

"In the downstream, EUSA's straightforward objective is to be the most effective competitor in an exceptionally tough marketplace. A focused effort is underway to enhance the quality image of Exxon products and services to differentiate them from those of competitors. This addresses the fundamental requirement of the downstream effort: to anticipate and identify customers' needs quickly and accurately, and to move swiftly to meet them."

Bill's statement recognizes that customers are the sole reason we are in business. And we remind ourselves of this as we develop marketing plans to manage our five "P's."

Success in our business is determined by the edge that raises the value of our offering above that of competition in the eyes of customers. The bigger the edge, the better. Our enormous strength in technology *is* an Exxon edge. Whether we derive that by reducing our costs or increasing our sales, our strongest motive is to use new technology to improve our prominence and success in the marketplace.

Let's examine the five "P's" and see where technology might lead us.

Products

Customers look for products that meet their needs and provide efficient service--performance that reduces maintenance and waste. Examples are gasolines that measure up to the demands of sophisticated, modern engines; motor oils that reduce wear, corrosion, and fouling; metal-rolling oils that eliminate production rejects.

Our fuels and specialty products are constantly improved with customer needs in mind. Surprisingly, the average life cycle of our products is a very short three years. This emphasizes the need to generate and advance new product ideas quickly.

Increasingly, we see that product advances must apply new understandings of chemistry and physics. We continue to look for new additives to provide differentiable performance and have begun to look for new ways to derive or create performance advances in the base fuels and specialties themselves.

Place

Our customers tell us that their time is precious and that convenience is critical. Thus, if our stores are not in locations that customers find convenient, we will not do much business.

Another "place" factor is our offering--full and self-service, repairs, convenience products, car wash, and so on. Another is layout--how the offering is placed on the property to promote smooth traffic flow and purchasing convenience. Yet another factor is style--the look and the feel of the store that make our customers like being there.

Many outside of Marketing are surprised to learn there is a great deal of science behind "place." Using complex models of traffic flow, demographics, and purchasing behavior to design our sites, we "marry" the social sciences and engineering.

continued on page 2

GREENHOUSE SCIENCE

by Brian Flannery

Shortly after I joined Exxon in 1980, I was asked to study the enhanced Greenhouse Effect. Nearly a decade ago, Corporate Research believed that this issue would some day have profound importance for the petroleum industry. We felt then--and now--that CR could best serve Exxon by gaining comprehensive understanding through participating in the science. With a background in theoretical astrophysics and modeling and a longstanding interest in earth science, I felt that this would be an exciting challenge.

Today, headlines and international panels address greenhouse concerns. Our program, begun when many people thought that greenhouse was an issue for the next century, has led increasingly to interactions with other concerned employees, affiliates, corporate management, federal agencies, and the international community organizing to respond to the issue.

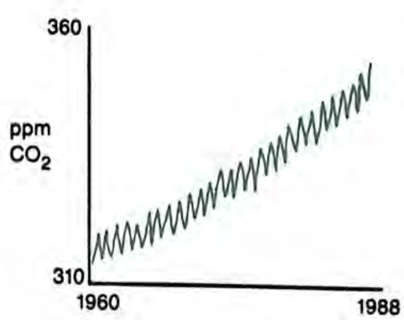
The idea that man might change the atmosphere enough to alter climate is neither obvious nor preposterous: it is a fit subject for scientific inquiry. We now know that concentrations of trace atmospheric gases are growing at a rate that could impact human and natural systems through global warming and associated climate change.

We also know that the modeled projections are far from certain: potential impacts could be small and manageable or they could be profound and irreversible. Uncertainty arises from incomplete scientific understanding--and missing data--to describe the role of fundamental processes such as cloud formation and oceanic circulation, that are known to be important in predicting climate change. Available data display such large natural fluctuations that, today, observations neither confirm nor refute the possibility of climate change from an enhanced Greenhouse Effect. The complexity of the effect and the lack of data caution us that the science is unlikely to provide definitive forecasts for decades.

Emissions of important greenhouse gases, such as carbon dioxide, methane, chlorofluorocarbons, and nitrous oxide, occur from basic, everyday human activities including energy generation from burning coal, oil, gas, and wood; agriculture; land use, especially deforestation; and manufacturing. Projections indicate that emissions will increase to meet the economic aspirations of a growing global population.

Proposed actions to address climate change require significant international cooperation and human effort. Today, CO_2 emissions contribute about half the forcing leading to a potential enhancement of the Greenhouse Effect. Since energy generation from fossil fuels dominates modern CO_2 emissions, strategies to limit CO_2 growth focus near term on energy efficiency and long term on developing alternative energy sources. Practiced at a level to significantly reduce the growth of greenhouse gases, these actions would have substantial impact on society and our industry--near term from reduced demand for current products, long term from transition to entirely new energy systems. Obviously, the issue directly affects Exxon's long-term planning including many R&D programs.

At CR, our program goals are to contribute to scientific understanding and to maintain a critical awareness of both scientific developments and society's efforts to address the issue. We perform scientific research, support selected external studies, contribute to Exxon's environmental assessments, and participate in appropriate institutional forums.



Our internal research program forms the core of our activities. In 1990, the U.S. government will spend nearly $190 million to study climate change. Obviously, we need not compete with that level of research or with resources that include institutional-scale modeling and satellite observations. Instead, we utilize simpler models to study essential physics and chemistry in a way that lets us assess the role of particular processes--such as the influence of the marine biosphere. These models also serve as a tool to analyze the effectiveness of proposed policies to limit change.

Impacts on Exxon will come sooner from society's efforts to reduce potential risks from climate change than from change itself. Proposals before Congress call for reductions in U.S. emissions of CO_2 by as much as 20% by the year 2000. Internationally, some proposals call for even more stringent reductions. Recognizing the potential for such responses to alter profoundly the strategic direction of the energy industry, we have briefed Exxon corporate and regional management, describing the current state of the science and efforts to address the greenhouse issue. We have provided similar briefings to interested Exxon employees, to affiliates, and to petroleum and other industry groups.

The Greenhouse Effect surged to the center of attention last year when the hot summer and drought brought home the potential consequences of climate change. Now that the drought has ended (and been acknowledged as a natural weather fluctuation), media attention has decreased. Nonetheless, the Greenhouse Effect remains prominent on the international environmental agenda. Next year the Intergovernmental Panel on Climate Change will issue reports on science, impacts, and response strategies as a framework for a proposed 1992 international convention to limit climate change.

While uncertainty exists, science supports the basic idea that man's actions pose a serious potential threat to climate. Efforts to minimize that risk will influence the future direction of the energy industry.

EXHIBIT 27

on - file

Date 8/3/88

To: Dick

From: **Joseph M. Carlson**

Attached is a draft on the Greenhouse effect. As you can see, most of it is taken from the Sage II material. I haven't attempted to recheck any of the facts, given Brian's absence. The first two items on the last page are intended to address the question "what do you think is the direct impact on Exxon's business." I haven't checked them with Corporate Planning as yet.

Joe

THE GREENHOUSE EFFECT

ISSUE

THE GREENHOUSE EFFECT REFERS TO ATMOSPHERIC GASES WHICH RETAIN REFLECTED SOLAR RADIATION, WHICH IS ESSENTIAL TO THE SUPPORT OF LIFE ON EARTH. CURRENT CONCERN IS ASSOCIATED WITH THE "ENHANCED" GREENHOUSE EFFECT, OR THE POSSIBLE INCREASE IN GLOBAL SURFACE TEMPERATURES DUE TO AN INCREASED RATE OF BUILD-UP OF GREENHOUSE GASES.

BACKGROUND

- THE GREENHOUSE EFFECT MAY BE ONE OF THE MOST SIGNIFICANT ENVIRONMENTAL ISSUES FOR THE 1990s.

- GASES THAT FAVOR ABSORPTION OF INFRARED (IR) RADIATION: CARBON DIOXIDE, WATER VAPOR, METHANE, NITROUS OXIDE, CHLORO-FLUOROCARBONS, AND HALOGENS.

- THE PRINCIPAL GREENHOUSE GASES ARE BY-PRODUCTS OF FOSSIL FUEL COMBUSTION.

"ENHANCED" GREENHOUSE EFFECT

- MOLECULES OF CO_2 WHICH ARE EFFICIENT ABSORBERS OF REFLECTED SOLAR IR CAN CAUSE DISPROPORTIONATE WARMING OF THE ATMOSPHERE.

- THIS WARMING INCREASES THE EARTH'S SURFACE TEMPERATURE, IN TURN INCREASING WATER VAPORIZATION.

- WATER VAPOR MOLECULES ARE ALSO EFFICIENT IR ABSORBERS AND GREATLY MAGNIFY THE ORIGINAL CO_2 EFFECT. OTHER ATMOSPHERIC GASES LIKE TRACE QUANTITIES OF CHLORO-FLUOROCARBONS CAN TRIGGER THE WATER VAPOR WARMING CYCLE.

- THERE IS NO CONSENSUS ON THE NET EFFECT OF THESE PROCESSES.

- THERE IS SCIENTIFIC AGREEMENT ON TWO POINTS:
  - ATMOSPHERIC CO_2 IS INCREASING AND COULD DOUBLE IN 100 YEARS.

- FOSSIL FUELS CONTRIBUTE ABOUT FIVE BILLION TONS/YEAR OF CO_2. DEFORESTATION ADDS TWO-FIVE BILLION TONS PER YEAR.

CLIMATE MODELS

o MOST DEBATE CENTERS ON PROJECTING FUTURE IMPACT USING CLIMATE MODELS.

o THESE MODELS ARE EXTREMELY COMPLEX AND REQUIRE TRACKING CO_2 INTERACTIONS IN THE ATMOSPHERE AND BIOSPHERE AND MUST ADDRESS THE ROLE OF TRACE GASES, OCEANS, CLOUDS, BIOMASS AND LARGE ICE FORMATIONS AT THE POLES. THESE INTERACTIONS ARE NOT WELL UNDERSTOOD.

- THE CLIMATE MODELS ARE NOT VERY RELIABLE BECAUSE APPROXIMATIONS ARE USED TO REPRESENT POORLY UNDERSTOOD INTERACTIONS.

o CLIMATE MODELS PREDICT A 1.5° C TO 4.5° C GLOBAL TEMPERATURE INCREASE IN 100 YEARS - DEPENDING ON THE PROJECTED GROWTH IN FOSSIL FUEL USE.

- Such warming could result in partial polar ice cap melting with associated sea level rise and since CO_2 and H_2O vapor aid plant growth, there could be an acceleration or alteration in vegetation growth patterns favoring selected species.

- It is too early to specify the severity of the potential impacts of the enhanced Greenhouse effect.

- Actual measurements of northern hemisphere average temperatures show no clear pattern over a 20-year period from 1960 to 1980. When projected at a rate corresponding to about 2° C increase over 100 years, the trend does not escape from the uncertainty band for another 10 years.

<u>Current Mitigation Efforts</u>

- Reduction in chloro-fluorocarbon emissions to protect ozone in the upper atmosphere.

- o PROTECTION OF MAJOR GLOBAL FOREST RESOURCES.

- o CONTINUING THE EMPHASIS ON EFFICIENCY IN ENERGY GENERATION AND USE.

<u>WORLDWIDE RESEARCH</u>

- o NATIONAL AND INTERNATIONAL RESEARCH PROGRAMS ARE BEING ESTABLISHED TO MONITOR AND EVALUATE THE GREENHOUSE PHENOMENON.

- o IN THE U.S., ABOUT $25 MILLION PER YEAR IS BUDGETED FOR DIRECT CO_2 GREENHOUSE RESEARCH.

<u>EXXON RESEARCH</u>

- o IN THE LAST FIVE YEARS EXXON HAS SUPPORTED BOTH IN-HOUSE AND THEORETICAL STUDIES AND OUTSIDE RESEARCH PROGRAMS AT KEY INSTITUTIONS.
  - LAMONT DOHERTY GEOLOGICAL OBSERVATORY

- Columbia University Climate Center (total funds for both about $.6 million)

o Exxon scientists are interacting with key government agencies including the United Nations' Environmental Program, IPECA, OECD, DOE, and U.S. EPA.

o Exxon is providing leadership through API in developing the petroleum industry position.

Exxon Position

o Emphasize the uncertainty in scientific conclusions regarding the potential enhanced Greenhouse effect.

o Urge a balanced scientific approach.

- DUE TO CURRENT SCIENTIFIC UNCERTAINTY, EXXON IS NOT CONDUCTING SPECIFIC IMPACT STUDIES WITH RESPECT TO PARTICULAR COMPANY OPERATIONS OR GEOGRAPHIC REGIONS.

- EXXON HAS NOT MODIFIED ITS ENERGY OUTLOOK OR FORECASTS TO ACCOUNT FOR POSSIBLE CHANGES IN FOSSIL FUEL DEMAND OR UTILIZATION DUE TO THE GREENHOUSE EFFECT.

- RESIST THE OVERSTATEMENT AND SENSATIONALIZATION OF POTENTIAL GREENHOUSE EFFECT WHICH COULD LEAD TO NONECONOMIC DEVELOPMENT OF NONFOSSIL FUEL RESOURCES.

EXHIBIT 28

#2

Information
Council
for the Environment

May 15, 1991

(name)
(title)
(company)
(address)
(city), (state) (zip)

Thank you for requesting additional information on global climate change.

The science of global climate change is very complex. We are still learning how many of the components of our atmosphere interact with each other. We do know that years ago the Earth was warmer; vegetation thrived, and there was more carbon dioxide in the atmosphere than there is now. We also know that during the last ice age, carbon dioxide levels were lower than they are now.

We believe it is wrong to predict that higher levels of carbon dioxide will bring a catastrophic global warming.

The Information Council for the Environment was created to help foster better public understanding of global warming and to ensure that any legislation passed by Congress is based on scientific evidence.

The environment must be protected. We want a clean environment and we want a green Earth. *We also believe we must conduct more scientific research before we can accurately understand the complex forces of global climate change.*

Change often begins with one person. You can make a difference by sharing what you've learned with others.

Thank you for caring enough to request this additional information.

Dr. Patrick Michaels

Science Advisory Panel:

DR. ROBERT C. BALLING, JR.
Director, Office of Climatology
Arizona State University
Tempe, AZ

DR. SHERWOOD B. IDSO
Adjunct Professor of
Botany and Geography
Arizona State University
Tempe, AZ

DR. PATRICK J. MICHAELS
Virginia State Climatologist/
Professor of
Environmental Sciences

Information Council for the Environment

May 15, 1991

X
X
X
X

Thank you for requesting more information about global climate change. I've been asked to respond to your request as a member of the Information Council for the Environment's Science Advisory Panel.

I'll give you some background on my credentials. I am a professor at the University of Virginia. My area of expertise is environmental sciences. I am also one of many scientists who believe the vision of catastrophic global warming is distorted. I have enclosed a copy of a letter and a [illegible] to help you better understand why we believe we should not act in haste.

The enclosed letter, which was sent to President Bush in February, was co-written by Dr. Robert Balling of Arizona State University and myself. As you'll note, we urge the President not to support expensive legislation.

I'm sure you'll agree after you review the information I've enclosed, global warming is an issue we are still learning about. In fact, just two months ago, a panel of scientists who advise the United Nations suggested a 10-year research effort to answer the many uncertainties about global warming. To quote the article, "A 10-year delay in taking action to curb global warming would mean little further increase in the level of warming predicted by the end of the next century..."

But there's more to this issue. Right now, there are costly proposals in Congress--including one that would impose a new tax on energy. The intended purpose is to reduce carbon dioxide emissions and global warming.

What can you do?

1. Make sure you're informed. Your request for this information is a good first step.

2. If you'd like to know more, return the enclosed postcard and we'll send you more information on global climate change.

Thank you for caring enough to send for this information.

Dr. Patrick Michaels

Information
Council
for the Environment

#1

May 15, 1991

(name)
(title)
(company)
(address)
(city), (state) (zip)

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Thank you for caring enough to send for this information.

Dr. Patrick Michaels

P.O. Box 414998 / Kansas City, MO 64141-4998 / 1-800-346-6269

Information
Council
for the Environment

May 15, 1991

X
X
X
X

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Information
Council
for the Environment

#2

May 15, 1991

(name)
(title)
(company)
(address)
(city), (state) (zip)

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DR. PATRICK J. MICHAELS
Virginia State Climatologist/
Professor of
Environmental Sciences
University of Virginia

P.O. Box 414998 / Kansas City, MO 64141-4998 / 1-800-346-6269

May 2, 1991

Bill Brier
Edison Electric Institute
701 Pennsylvania Avenue N.W.
Washington, DC 20004-2696

<u>Information Council for the Environment Test Market Ad Materials</u>

Enclosed are the newspaper and radio ads as they will be running in Fargo, Flagstaff, and Bowling Green when our test campaign begins on May 12. We are still in production on a Bob Balling radio ad titled "Kentucky Colder" to be run only in Bowling Green. That ad will be completed next week and we'll send you your copy when we receive it.

Here's a listing of what you'll find in this packet:

1. Five newspaper ads
2. Schedule of the radio spots and newspaper ads for each market
3. Four sixty-second radio commercials (on tape), two scripts
4. Public Relations tour schedule*
5. Copy of letters that respondents requesting information will receive

*Schedule includes Fargo and Flagstaff. Bowling Green schedule with Dr. Pat Michaels will be completed next week.

The advertising will begin with full-page newspaper ads in each of the markets on May 12. The campaign will conclude on Sunday, June 9. Three full-page, two-color newspaper ads will run each of the four weeks of this campaign.

The cassette tape contains the four radio ads that will run in Flagstaff. The first two weeks of the schedule will feature the Dr. Bob Balling commercials exclusively. The final two weeks of the radio campaign will be an equal rotation of Dr. Balling and Bruce Williams.

The commercial rotations in Fargo and Bowling Green will differ. The scripts of the Rush Limbaugh commercials apply only to Fargo. These commercials will air in only the Rush Limbaugh radio program (11 AM to 1 PM, Monday through Friday.) In Fargo, Bruce Williams commercials will also run in only his Monday through Friday, 6 PM to 9 PM program. Dr. Balling commercials will air in all other Fargo radio schedules. We will send you the tape of the Rush Limbaugh radio commercials next week.

In Bowling Green, we will rotate three Dr. Balling commercials for the entire length of the radio schedule. The "Kentucky Colder" commercial will receive increased scheduling during the first two weeks of the campaign. The radio schedule will reach approximately 85% of our adult 25-54 target audience approximately 19 times in the four weeks of this campaign. This is a four-week, 1,600 gross rating point radio schedule.

The combined newspaper and radio reach is estimated to be 97% of our adult 25-54 target audience, with a combined frequency of 35.

We will begin follow-up research on Saturday, June 15, to determine the results of this campaign. Those results will be reported to all of our sponsors by August 5, 1991.

We appreciate all the help you've provided to make this test possible. Don't hesitate to call me if we can be of further assistance.

Fred

Fred Lukens

FL/sm

cc: Gale Klappa

INFORMED CITIZENS FOR THE ENVIRONMENT

Mission

The mission of the Informed Citizens for the Environment is to develop an effective national communications program to help ensure that action by the Administration and/or Congress on the issue of global warming is based on scientific evidence.

Strategies

1. Reposition global warming as theory (not fact).

2. Target print and radio media for maximum effectiveness.

3. Achieve broad participation across the entire electric utility industry.

4. Start small, start well, and build on early successes.

5. Get the test concepts developed and implemented as soon as possible.

6. "Test market" execution in early 1991.

7. Build national involvement as soon as "test market" results are in hand — summer 1991.

8. Go national in the late fall of 1991 with a media program.

9. Use a spokesman from the scientific community.

Our Plan

1. Build support for the concept of the ICE strategy among our neighbors.

2. Match Southern Company's commitment by having four or five of our neighbors join us in raising $125,000 by January 31, 1991.

3. Raise total commitments of $525,000 by January 31, 1991 to allow the test market project to proceed on schedule.

PUBLIC RELATIONS TOUR

Monday, May 20, 1991

11:00 a.m.	Meet with editors and writers at the Arizona Daily Sun. Dr. Robert Balling from Arizona State University or Dr. Sherwood Idso from the U.S. Water Conservation Laboratory will replace Dr. Michaels for the Flagstaff meetings.
1:00 p.m.	Tape appearance on North Arizona Outlook, weekly public affairs program on KNAZ-TV.
3:00 p.m.	Appearance on KNAU-AM radio talk show.

Client: Information Council for the Environment

Subject: Rush Limbaugh/2

Media: Rush Limbaugh Show Length: 60

Contact: T. Helland/K. Olsen

COPY

simmons advertising, inc.
125 south 4th street / P.O. box 1457
grand forks, north dakota 58206
(701) 746-4573 / fax: (701) 746-8067

GLOBAL WARMING. I KNOW YOU'VE BEEN SEEING MORE AND MORE STORIES ABOUT THE GLOBAL WARMING THEORY. STORIES THAT PAINT A HORRIBLE PICTURE. STORIES THAT SAY THE POLAR ICE CAPS WILL MELT. STORIES THAT SAY WE'RE HEADED FOR CATASTROPHE. WELL GET REAL! STOP PANICKING! I'M HERE TO TELL YOU THAT THE FACTS SIMPLY DON'T JIBE WITH THE THEORY THAT CATASTROPHIC GLOBAL WARMING IS TAKING PLACE. TRY THIS FACT ON FOR SIZE. MINNEAPOLIS HAS ACTUALLY GOTTEN COLDER. SO HAS ALBANY, NEW YORK. AND THE DEPARTMENT OF AGRICULTURE SAYS THAT ON BOTH COASTS OF THIS COUNTRY, WINTER TEMPERATURES ARE FIVE TO TEN DEGREES COOLER THAN PREVIOUSLY REPORTED. SO FOLKS, GRAB HOLD OF YOURSELVES AND GET THE WHOLE STORY BEFORE YOU MAKE UP YOUR MIND. RIGHT NOW, YOU CAN GET A FREE PACKET OF EASY-TO-UNDERSTAND MATERIAL ABOUT GLOBAL WARMING. JUST CALL THIS NUMBER: 1-800-346-6269 EXTENSION 505. THAT'S THE INFORMATION COUNCIL FOR THE ENVIRONMENT. AFTER YOU READ THE FREE MATERIALS THEY SEND YOU, YOU'LL HAVE A BETTER PICTURE OF WHAT THE FACTS ARE ALL ABOUT. THAT'S 1-800-346-6269 EXTENSION 505. CALL TODAY. BECAUSE THE BEST ENVIRONMENTAL POLICY IS BASED ON FACT.

May 2, 1991

Bill Brier
Edison Electric Institute
701 Pennsylvania Avenue N.W.
Washington, DC 20004-2696

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Fred Lukens

FL/sm

cc: Gale Klappa

This report summarizes results of a benchmark survey of public awareness and opinion on issues related to global warming conducted in Chattanooga, Tennessee, Fargo, North Dakota, and Flagstaff, Arizona.

Methodology

The survey is based on a total of 1500 interviews, 500 in each of the three cities included in the sample. All interviews were conducted by telephone between February 13 and February 22, 1991. Other important points include the following:

- For each sample of 500 the margin of error is +/-4.4 percentage points at the midpoint of the 95% confidence interval;
- All interviews were conducted by trained, professional interviewers under the supervision of the Cambridge Reports Field Department;
- After the interviewing was completed, a 10% sample of the interviews was independently validated to ensure that proper interviewing techniques were followed;
- All interviews were returned to Cambridge Reports for coding and data processing.

Objectives

The survey and analysis were conducted to identify the following:

- Current awareness of and familiarity with the global warming issue;
- Recent exposure to information concerning global warming, including the types of media and sources in which the information appeared;
- Responses to various messages concerning global warming;
- Assessments of the credibility of various spokespersons and groups on topics related to global warming;
- Key audiences and media for messages concerning global warming.

technical sources also favor choosing the title "Information Council on the Environment" as the title for ICE, since this organization is perceived as a technical source, while "Informed Citizens for the Environment" carries both technical and activist connotations.

As a general strategy, we recommend that ICE concentrate on comparing possible solutions to the global warming problem, focusing in particular on the proper role of government, the need for research, and the costliness of inappropriate or premature legislation. The audience for these messages needs to see its personal stake in the issue if they are to become actively engaged and committed.

More specifically, the results of this study point toward two possible target audiences. One possible target audience includes those who are most receptive to messages describing the motivations and vested interests of people currently making pronouncements on global warming--for example, the statement that some members of the media scare the public about global warming to increase their audience and their influence. People who respond most favorably to such statements are older, less-educated males from larger households, who are not typically active information-seekers, and are not likely to be "green" consumers. Members of this group are skeptical about global warming, predisposed to favor the ICE agenda, and likely to be even more supportive of that agenda following exposure to new information. They are not, however, accustomed to taking political action. They are good targets for radio advertisements.

Another possible target segment is younger, lower-income women. These women are more receptive than other audience segments to factual information concerning the evidence for global warming. They are likely to be "green" consumers, to believe the earth is warming, and to think the problem is serious. However, they are also likely to soften their support for federal legislation after hearing new information on global warming. These women are good targets for magazine advertisements.

A campaign strategy reaching out to these target groups can help to change attitudes where change is most likely to occur, and also to strengthen support among favorable members of the public.

- Overall, a plurality of respondents choose the most conservative role for the federal government. Over one-third (36%) of the total sample (three cities combined) say the government should finance more research, while 30% support passage of legislation, and 24% would pass some laws but avoid costly programs.

- Similar to responses on other measures, Flagstaff residents (39%) are more likely than residents of Chattanooga or Fargo (25% each) to back federal legislation without any qualification concerning cost.

Specific responses to an open-ended question indicate that depletion of the ozone layer dominates top-of-mind concerns about global warming.

- Asked to describe global warming in their own words, just over one-quarter of all respondents cite destruction of the ozone layer, followed closely by changes in the weather and rises in temperature caused by pollution.

- Only 6% of all respondents name the greenhouse effect when asked to describe what global warming means to them.

Audience profile

In addition to perceptual and attitudinal measures, we also asked respondents about certain behaviors which might make them more or less receptive to information on global warming, and may also indicate the likelihood that they might take action on global warming issues. These behavioral measures are included frequently in the analyses discussed in this report, and include political activism, environmental activism, and likelihood of information-seeking.

- Looking at results for one measure of political activism, just under one-quarter (24%) of all respondents either contacted an elected official, wrote to an editor, or worked for a political candidate during the last year. Political activism is more common in Flagstaff (31%) than in either Chattanooga (22%) or Fargo (18%).

- Overall, 36% of all respondents have contributed to or been active in an environmental cause during the past year, and 22% identify strongly with the label "environmentalist." Combining these two measures, we find that 13% of all respondents in this survey meet the Cambridge Reports definition for "green" consumers--very close to our most recent national figure of 12% (March 1991).

Finally, the two statements referring directly to scientists say that scientists don't know whether carbon dioxide is causing global warming, and that some of the scientists predicting global warming said twenty years ago that the earth was getting colder.

- On average, respondents are as likely to agree with statements about motivations behind public information on global warming as they are to agree with statements about the evidence for global warming.

- On average, respondents are less likely to agree with statements about scientists and their theories than they are to agree with statements about motivations for public information or statements about evidence for global warming.

- Respondents are most likely to agree with the statement that recent satellite data shows the earth is getting warmer.

- Percentages of "don't know" responses reveal that members of the public feel more comfortable expressing opinions on others' motivations and tactics than they do expressing opinions on scientific issues. Nearly all respondents provide ratings for statements on motivations, while somewhat fewer express opinions on evidence, and still fewer are willing to pass judgment on scientists.

To explore these three types of messages further, we calculated an index for each set of statements (motivation, evidence, and scientists), based on results of the factor analysis. We then divided the sample into low, medium, and high agreement with each index, or set of items, to identify groups most likely to agree or disagree with each type of message.

- A plurality of Chattanooga residents agrees strongly with motivational statements saying that some groups scare the public about global warming to promote their own economic interests, while Flagstaff residents are most likely to disagree with these statements, and Fargo residents most often take a moderate position.

- Based on results for the evidence index, Fargo residents are least likely to agree that current evidence supports global warming, while Flagstaff residents are more likely to accept the evidence. Chattanooga residents are closely divided between low, moderate, and high agreement, although they are more likely than others to give "don't know" responses.

A factor analysis performed on the fourteen credibility ratings indicates that respondents group information sources into four types: industry spokespersons (local electric company, coal industry, Electric Information Council, and Paul Harvey); activist spokespersons (Ralph Nader, Sierra Club, Carl Sagan, Informed Citizens for the Environment); technical spokespersons (Information Council for the Environment, federal environmental officials, environmental scientist, Informed Citizens for the Environment); and individual spokespersons (Bruce Williams, Steven Schneider, Rush Limbaugh). (The second title for ICE–Informed Citizens for the Environment–is perceived as combining attributes of activist and technical sources, and is treated as a member of both groups in the analysis.)

- Technical sources receive the highest overall credibility ratings, followed closely by activist sources.
- Industry sources and individual spokespersons receive lower overall credibility ratings than either activist or technical sources.

Results also include extreme variations in recognition among the different information sources in the list. In fact, combining responses for those who have not heard of a source, do not know the source's credibility on global warming, or cannot rate the source as credible or not credible, the percentage not rating individual sources ranges from 13% (local electric company) to 92% (Steven Schneider).

- Industry sources are rated by more respondents than other types of sources, with the local electric company receiving the most ratings, and Paul Harvey second.
- Individual spokespersons (Bruce Williams, Steven Schneider, Rush Limbaugh) have lower overall recognition than other types of sources, receiving ratings from an average of only 15% of all respondents.
- In general, recognition for activist and technical sources falls in between recognition for industry sources and recognition for individual spokespersons.

- Those who are most likely to find activists credible typically are already familiar with global warming issues, and are likely to seek further information on the topic. They believe the earth is warming, rate the problem as serious, and support action through federal legislation. Demographically, they are most likely to be male, between 36 and 45 years of age, from higher education and income groups, or to be "green" consumers.

- Technical sources receive highest credibility ratings from younger females (especially those from 18 to 25 years of age) with lower incomes and some college education. Members of this group are not familiar with global warming, although they are likely to seek further information, and they are good targets for television advertising. They believe in global warming and support immediate federal legislation. They tend to rate global warming as a serious problem, and to rate it as even more serious after exposure to information on the topic.

Attitude change

As we reported earlier in this report, majorities of respondents see global warming as a problem which is at least somewhat serious, while a plurality endorse a limited role for the federal government in dealing with the problem. To identify audience members who are most likely to undergo attitude change in response to new information, we repeated these two items late in the interview, after respondents had heard the series of statements concerning global warming.

Comparing results on these key attitude measures, we find that exposure to information about global warming, regardless of its slant, leads to increases in perceived seriousness of global warming as a problem--most of those who "switch" attitudes on seriousness of global warming rate the problem as more serious after hearing the statements in the interview. However, the same messages lead to attitude change in both directions on the proper role for the federal government in dealing with global warming--respondents are just as likely to switch to less extreme positions (advocating further research) as they are to switch to more extreme positions (advocating legislation). In general, Chattanooga residents are more likely to change their positions than are residents of either Fargo or Flagstaff.

- Overall, nearly two in ten respondents (19%) rate global warming as more serious after hearing the statements in the interview. Notably, Chattanooga residents (24%) are most likely to switch to a more serious rating, compared with Fargo (19%) or Flagstaff (14%).

Similarly, we looked at associations between attitude change during the interview and the types of messages with which respondents tend to agree.

- Across the board, perceived seriousness of global warming increases with exposure to the statements in the interview.
- The same respondents who express skepticism on global warming issues nevertheless tend to rate the problem as more serious after hearing the statements in the interview.
- Respondents who are most dubious about scientists are likely to change toward supporting research, and away from supporting legislation.
- Those who agree that some sources scare the public for their own ends are more likely to switch toward support of research, and away from support of legislation.
- Those who agree most strongly that the evidence supports global warming are nevertheless more likely to switch toward support of research, and less likely to increase their support for federal legislation on global warming.

Key media

As noted above, three in ten respondents (31%) have heard or seen something about global warming during the last 30 days. To identify existing sources for awareness of global warming, we asked this group to identify the medium that carried the information, as well as whether they saw a news story, a paid advertisement, or both.

- The most common medium for information on global warming is television. Nearly half of Chattanooga residents recalling recent information on global warming name television as a source, compared with fewer than four in ten in Fargo and Flagstaff.
- Residents of the three cities are equally likely to have heard something about global warming on the radio, or to have read something about global warming in a magazine or newspaper.
- Nearly nine in ten of those recalling recent information on global warming say they saw or heard a news story, while one in ten recall both a paid advertisement and a news story.

- Respondents who switch to a less serious rating of global warming are more likely to have received their own information from radio or newspapers, compared with those who switch to a more serious rating.
- Respondents who switch from favoring legislative solutions toward favoring research funding are slightly less likely to have gotten information on global warming from television, compared with those who switch toward favoring legislation.
- Respondents who switch positions either way--toward research, or toward legislation--are unlikely to have gotten information on global warming from radio.
- Those who switch toward research are more likely to receive information on global warming from magazines, compared with those who switch toward legislative solutions.
- Respondents who switch toward favoring research and respondents who switch toward favoring legislation are equally likely to have received information on global warming from newspapers.

Conclusion: communication strategies

The results reviewed above support a series of conclusions concerning the types of sources and messages to which audiences are likely to respond most favorably.

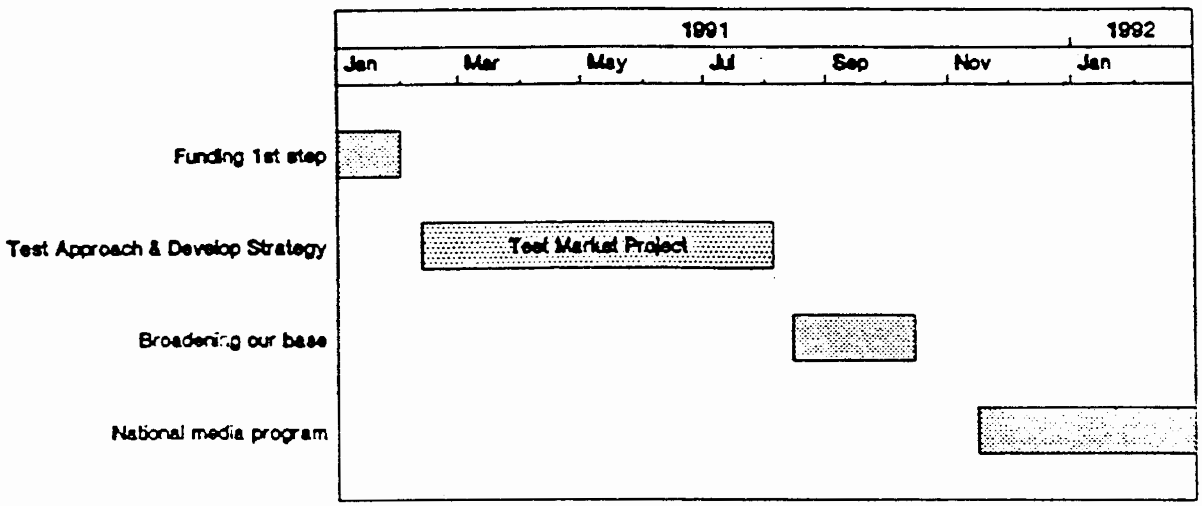
- Technical and expert sources have the highest credibility among a broad range of members of the public.
- The Information Council for the Environment can be seen as an expert technical source.
- Moderate credibility of expert or industry sources is associated with a shift toward the ICE agenda.

Therefore, an "approachable" technical expert can present a good case for a cost-effective solution that meets the joint economic and environmental interests of consumers and industry.

Informed Citizens for the Environment

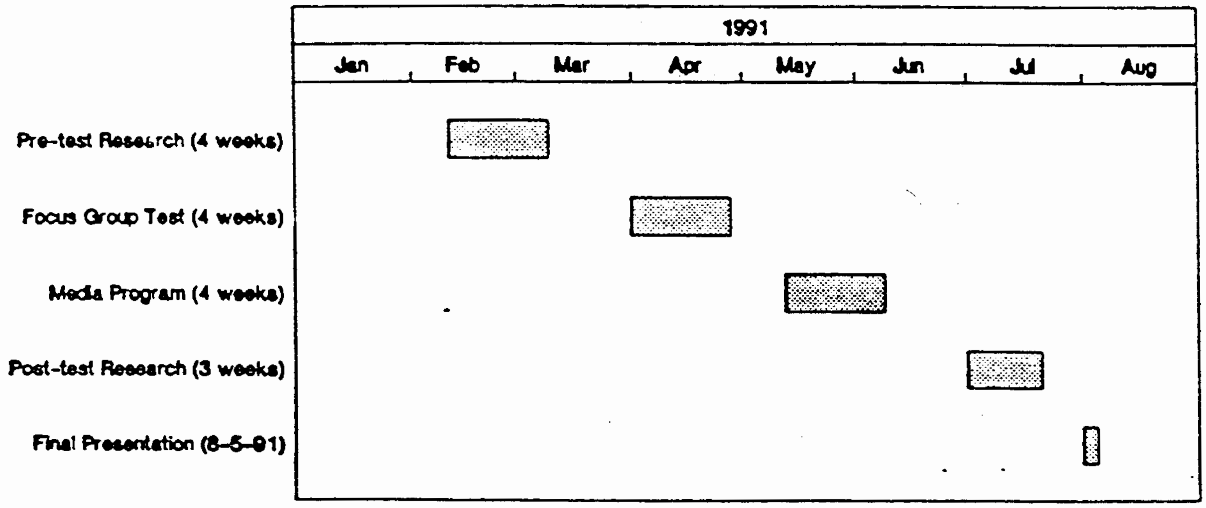
INFORMED CITIZENS FOR THE ENVIRONMENT

Timeline



INFORMED CITIZENS FOR THE ENVIRONMENT

Test Market Project Timeline



I.C.E.

Test Market Proposal

DATES: *February, 1991 - August, 1991*

OBJECTIVES:

1) *Demonstrate that a consumer-based media awareness program can positively change the opinions of a selected population regarding the validity of global warming.*
2) *Begin to develop a message and strategy for shaping public opinion on a national scale.*
3) *Lay the solid groundwork for a unified national electric industry voice on global warming.*

PROGRAM STRATEGIES:

1) *Select test markets that meet the following criteria:*
   a) *market derives majority of electricity from coal*
   b) *market is home to a member of the House Energy & Commerce Committee or House Ways & Means Committee*
   c) *market is smaller than #50, which translates into lower media costs*
2) *Determine most advantageous population, within specific markets, to base media awareness program.*
3) *Pre-test opinions of selected population regarding global warming.*
4) *Focus Group test I.C.E. name and creative concepts.*
5) *Proceed with media awareness program, utilizing radio/newspaper advertising and a public relations campaign.*
6) *Post-test opinions of selected population regarding global warming.*
7) *Program evaluation.*
8) *If successful, implement program nationwide.*

RESEARCH STRATEGY: Determine most advantageous population, both attitudinally and demographically. Ascertain general level of understanding and measure degree of opinion shifts.

PUBLIC RELATIONS STRATEGY: The public relations campaign will involve the research, writing and preparation of background materials for use with the media. A minimum of eight discussion points will be communicated to the media.

CREATIVE STRATEGY: The radio creative will directly attack the proponents of global warming by relating irrefutable evidence to the contrary, delivered by a believable spokesperson in the radio broadcast industry.

The print creative will attack proponents through comparison of global warming to historical or mythical instances of gloom and doom. Each ad will invite the listener/reader to call or write for further information, thus creating a data base.

MEDIA STRATEGY: A radio/newspaper execution is recommended for the following reasons:

a) believability

b) ability to use high frequency (radio) and detailed copy (newspaper)

c) cost effectiveness

d) production flexibility

FUNDING: For the test markets, splitting costs evenly among five participating utilities is recommended. If the program is implemented on a national basis, it might be better to determine proportionate shares based on coal-produced kWh.

The test market funds will be collected as follows:

First 1/3 of commitment	2/1/91
Second 1/3 of commitment	3/1/91
Remainder of commitment	4/1/91

TIMELINE:	*Pre-test Research (4 weeks)*	*2/11/91 - 3/10/91*
	(3 weeks)	
	Focus Group Test (4 weeks)	*4/1/91 - 4/28/91*
	(2 weeks)	
	Media Awareness Program (4wks)	*5/13/91 - 6/9/91*
	(3 weeks)	
	Post-test Research (3 weeks)	*7/1/91 - 7/21/91*
	(2 weeks)	
	Final Presentation	*8/5/91*

BUDGET: *$510,000 (three markets)*

Chattanooga, Tennessee
Test Market

MEDIA (1200 GRPs/8 full-page ads)

$ 75,000

PUBLIC RELATIONS

$ 24,000

RESEARCH (500 interviews in each of two surveys/Focus Group)

$ 43,000

PRODUCTION (Radio/Newspaper/Phone Number/Brochure/Postage)

$ 54,000

TOTAL. $196,000

Champaign, Illinois
Test Market

Terry Bruce/House Energy & Commerce Committee

MEDIA (1200 GRPs/8 full-page ads)

$ 53,000

PUBLIC RELATIONS

$ 24,000

RESEARCH (500 interviews in each of two surveys)

$ 43,000

PRODUCTION (Radio/Newspaper/Phone Number/Brochure/Postage)

$ 54,000

TOTAL. $174,000

Flagstaff, Arizona
Test Market

MEDIA (1200 GRPs/8 full-page ads)

$ 25,000

PUBLIC RELATIONS

$ 24,000

RESEARCH (500 interviews in each of two surveys)

$ 43,000

PRODUCTION (Radio/Newspaper/Phone Number/Brochure/Postage)

$ 54,000

TOTAL. $146,000

Fargo, North Dakota
Test Market

Byron Dorgan/House Ways & Means Committee

MEDIA (1200 GRPs/8 full-page ads)

$ 47,000

PUBLIC RELATIONS

$ 24,000

RESEARCH (500 interviews in each of two surveys/Focus Group)

$ 43,000

PRODUCTION (Radio/Newspaper/Phone Number/Brochure/Postage)

$ 54,000

TOTAL. $168,000

__Potential Program Names__

Informed Citizens for the Environment

Information Council for the Environment

Intelligent Concern for the Environment

Informed Choices for the Environment

Climatic Record in Midwest States

Minnesota

Greg Spoden State Climatologist	612/296-4214
Dr. Dick Skaggs Univ. of Minn. Dept of Geography	612/625-6643
Dr. Don Baker Univ. of Minn. Prof. of Soil Science	612/625-6235

1990 was Minneapolis' 4th warmest year.
1991 has been above average
"It certainly did not show cooling" (GS)

Temperature record started in as pioneer date in the 1820s at Ft. Sneeling and up to current dates from a farm in Farmington.
Long time warming trend, statistically increasing climate temperature since 1867.

Temperature decrease from 1819 to 1867.
Increase from 1867 through present.
There was a cooling in 1940-1970, but it doesn't show statistically in the record. (DB)

The temperature record is a superior record in urban North America. (DB)

articles:

Journal of Climatic Change
Volume 7, 1985 p. 225-236

Journal of Climate Change
Volume 7, 1985 p. 403-414

Bulletin of American Meteorology
Volume 41, 1960 p. 18-27

Washington D.C. 20004-2696
Telephone 202-508-5300

EDISON ELECTRIC INSTITUTE

M. WILLIAM BRIER
Vice President, Communication

2 1 199

May 15, 1991

O. Mark De Michele
President & CEO
Arizona Public Service Company
P.O. Box 53999
Phoenix, AZ 85072-3999

Dear Mark:

I am writing to update you on some changes in the Information Council for the Environment's (ICE) advertising and promotional activities in the three test cities including Flagstaff. You will find the attached material similar to what I sent you earlier.

However, you should note changes in the "How Much . . ." ad which will be running Flagstaff. It is a revised version and contains no graphics -- it's straight copy.

If you have any questions, please let me know.

Sincerely,

Bill

Bill Brier

w/o enclosures
Gale Klappa
Vice President
Southern Company

INFORMATION COUNCIL FOR THE ENVIRONMENT

NEWSPAPER ROTATION

	Flagstaff	Fargo	Bowling Green
1.	Frost line	Mpls colder	Kent. colder
2.	How much (?)	Frost line	Kent. colder
3.	Frost line	Mpls colder	Frost line
4.	How much (?)	Frost line	Kent. colder
5.	Mpls colder	Mpls colder	Frost line
6.	Serious problem	Serious problem	Serious problem
7.	Mpls colder	How much (money bag)	Frost line
8.	How much (?)	Serious problem	How much
9.	Frostline	How much (money bag)	Serious problem
10.	Serious problem	Serious problem	How much
11.	Mpls colder	How much (money bag)	Serious problem
[illegible]	How much (?)	Serious problem	How much

RADIO PLACEMENT

Flagstaff	Fargo	Bowling Green
Dr. Balling #1	Dr. Balling #1	Dr. Balling #1
Dr. Balling #2	Dr. Balling #2	Dr. Balling #2
Bruce Williams #1	Rush Limbaugh #1	Dr. Balling #3
Bruce Williams #2	Rush Limbaugh #2	
	Bruce Williams #1	
	Bruce Williams #2	

PUBLIC RELATIONS TOUR

TUESDAY MAY 14, 1991

10:45 a.m.	Appearance on WBKO-TV's "Midday" hosted by Beverly Kirk.
1:00 p.m.	Meet with editors and writers at the Bowling Green Daily News.
2:30 p.m.	Tape appearance on WKYU-TV's "Outlook" hosted by Barbara Deeb. Tape will also be broadcast on WKYU-FM's "Midday Edition."

PUBLIC RELATIONS TOUR

WEDNESDAY, MAY 15, 1991

12:30 p.m.	Meet with editors and writers at The Fargo Forum.
2:00 p.m.	Tape appearance on KX4 News Conference on KXJB-TV. Program is hosted by Kathy Coyle and airs on Sundays.
4:00 p.m.	Appear on KTHI-TV's On The Line hosted by Steve Poitras. Half-hour program.
5:00 p.m.	Meeting with editorial staff at WDAY-TV. Tape interview for evening news.

I.C.E.
FULFILLMENT MATERIALS

1st Request (Quantities of 5000)

* Dr. Michaels letter #1
* Postcard
* Bush letter
* Colder Minneapolis article
* The Greenhouse Effect...To What Degree?

2nd Request (Quantities of 2000)

* Dr. Michaels letter #2
* The Science of Global Warming

Pls note

MAY - 1[redacted]

M. WILLIAM BRIER
Vice President Communication

FEDERAL EXPRESS

Received
APS
Northeast
Division

Arizona Public Service Company
400 North 5th Street
Phoenix, AZ 85004

Dear Mark:

As I promised, attached is information on the newspaper and radio ads that will begin appearing in three test markets including Flagstaff on May 12. You should also note that the campaign includes public relations activities involving the Arizona Daily Sun, KNAZ-TV and KNAU-AM on May 20.

Of perhaps greater interest is the pre-test telephone interviews with 500 adults in Flagstaff (the results are also attached). The data indicates that:

- 89% say that they have heard of global warming
- 82% claim some familiarity with global warming
- 80% claim the problem is somewhat serious while 45% claim it is very serious
- 39% back federal legislation without any qualification of cost
- 22% consider themselves "green" consumers

With this high level of awareness and concern in Flagstaff it will be interesting to see how the science approach sells. My concern is that the absence in the messages of reasonable approaches to solving the problems of global warming may reduce their effectiveness.

In any case the research results should be useful in providing data that will allow the industry to fine tune its messages. Hopefully we can share this information, in a meaningful way, with members of your policy committee at an appropriate time.

I have informed the Information Council for the Environment (ICE) that you reserve the right to distance yourself from these activities. If you have any questions, please let me know.

Sincerely,

E. Brie

Enclosures

cc w/o enclosures:
Gale Klappa
Southern Company

PUBLIC RELATIONS TOUR

WEDNESDAY, MAY 15, 1991

12:30 p.m.	Meet with editors and writers at The Fargo Forum.
2:00 p.m.	Tape appearance on KX4 News Conference on KXJB-TV. Program is hosted by Kathy Coyle and airs on Sundays.
4:00 p.m.	Appear on KTHI-TV's On The Line hosted by Steve Poitras. Half-hour program.
5:00 p.m.	Meeting with editorial staff at WDAY-TV. Tape interview for evening news.

FARGO MARKET

May 1991

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2	3	4
5	6	7	8	9	10	11
Forum: Minneapolis 12	KVOX FM 6x WDAY FM 5x KLTA FM 7x KOWB FM 3x KOWB AM 3x WDAY AM 4x 13	KVOX FM 6x WDAY FM 5x KLTA FM 7x KOWB FM 3x KOWB AM 3x WDAY AM 4x 14	Forum: Frost KVOX FM 6x WDAY FM 5x KLTA FM 7x KOWB FM 3x KOWB AM 3x WDAY AM 4x 15	KVOX FM 6x WDAY FM 5x KLTA FM 7x KOWB FM 3x KOWB AM 3x WDAY AM 4x 16	Forum: Pick-up Minneapolis KVOX FM 6x WDAY FM 5x KLTA FM 6x KOWB FM 3x KOWB AM 3x WDAY AM 4x 17	18
Forum: Pick-up Frost 19	KVOX FM 5x WDAY FM 4x KLTA FM 6x KOWB FM 3x KOWB AM 3x WDAY AM 4x 20	KVOX FM 5x WDAY FM 4x KLTA FM 6x KOWB FM 3x KOWB AM 3x WDAY AM 4x 21	Forum: Minneapolis KVOX FM 5x WDAY FM 4x KLTA FM 5x KOWB FM 3x KOWB AM 3x WDAY AM 4x 22	KVOX FM 5x WDAY FM 4x KLTA FM 5x KOWB FM 3x KOWB AM 3x WDAY AM 4x 23	KVOX FM 5x WDAY FM 4x KLTA FM 5x KOWB FM 3X KOWB AM 3x WDAY AM 4x 24	Forum: Serious Problem 25
Forum: Pick-up How Much 26	KVOX FM 4x WDAY FM 3x KLTA FM 5x KOWB FM 3x KOWB AM 3x WDAY AM 4x 27	KVOX FM 4x WDAY FM 3x KLTA FM 5x KOWB FM 3x KOWB AM 3x WDAY AM 4x 28	Forum: Pick-up Serious Problem KVOX FM 4x WDAY FM 3x KLTA FM 5x KOWB FM 3x KOWB AM 3x WDAY AM 4x 29	KVOX FM 4x WDAY FM 3x KLTA FM 5x KOWB FM 3x KOWB AM 3x WDAY AM 4x 30	Forum: How Much KVOX FM 4x WDAY FM 3x KLTA FM 6x KOWB FM 3x KOWB AM 3x WDAY AM 4x 31	

FLAGSTAFF MARKET

June 1991

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						KAFF FM 6x 1
Arizona Daily Sun: Serious Problem 2	KVNA AM 6x KVNA FM 6x KMGN FM 6x KAFF FM 7x 3	KVNA AM 6x KVNA FM 6x KMGN FM 6x KAFF FM 7x 4	Arizona Daily Sun: Minneapolis Colder KVNA AM 6x KVNA FM 6x KMGN FM 6x KAFF FM 7x 5	KVNA AM 6x KVNA FM 6x KMGN FM 6x KAFF FM 7x 6	KVNA AM 6x KVNA FM 6x KMGN FM 6x KAFF FM 7x 7	8
Arizona Daily Sun: How Much 9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

If you have any questions, please call Simmons Advertising, Inc. (701)-746-4573

FARGO MARKET

June 1991

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
						1
Forum: Pick-up Serious Problem 2	KVOX FM 5x WDAY FM 4x KLTA FM 6x KOWB FM 3x KOWB AM 3x WDAY AM 4x 3	KVOX FM 5x WDAY FM 4x KLTA FM 6x KOWB FM 3x KOWB AM 3x WDAY AM 4x 4	Forum: How Much KVOX FM 5x WDAY FM 4x KLTA FM 7x KOWB FM 3x KOWB AM 3x WDAY AM 4x 5	KVOX FM 5x WDAY FM 4x KLTA FM 7x KOWB FM 3x KOWB AM 3x WDAY AM 4x 6	KVOX FM 5x WDAY FM 4x KLTA FM 7x KOWB FM 3x KOWB AM 3x WDAY AM 4x 7	8
Forum: Pick-up Serious Problem 9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

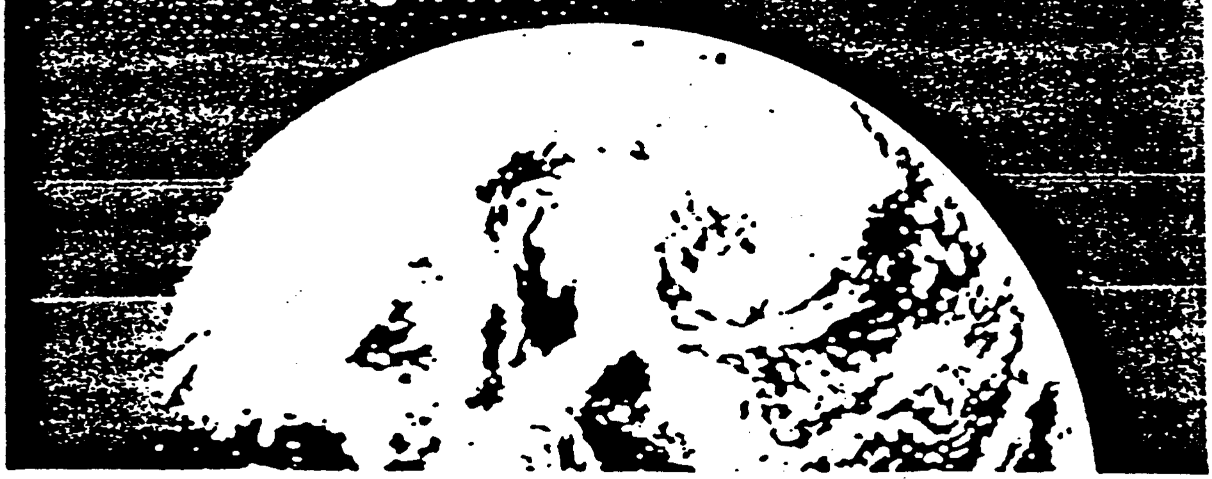
FLAGSTAFF MARKET

May 1991

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2	3	4
5	6	7	8	9	10	11
Arizona Daily Sun: Frost 12	KVNA AM 6x KVNA FM 6x KMGN FM 7x KAFF FM 8x 13	KVNA AM 6x KVNA FM 6x KMGN FM 7x KAFF FM 8x 14	Arizona Daily Sun: How Much KVNA AM 6x KVNA FM 6x KMGN FM 7x KAFF FM 8x 15	KVNA AM 6x KVNA FM 6x KMGN FM 7x KAFF FM 8x 16	Arizona Daily Sun: Frost KVNA AM 6x KVNA FM 6x KMGN FM 7x KAFF FM 8x 17	18
Arizona Daily Sun: How Much 19	KVNA AM 5x KCNA FM 5x KMGN FM 6x KAFF FM 7x 20	KVNA AM 5x KVNA FM 5x KMGN FM 6x KAFF FM 7x 21	Arizona Daily Sun: Minneapolis KVNA AM 5x KVNA FM 5x KMGN FM 6x KAFF FM 7x 22	KVNA AM 5x KVNA FM 5x KMGN FM 6x KAFF FM 7x 23	Arizona Daily Sun: Serious Problem KVNA AM 5x KVNA FM 5x KMGN FM 6x KAFF FM 7x 24	25
Arizona Daily Sun: Minneapolis 26	KVNA AM 5x KVNA FM 5x KMGN FM 5x KAFF FM 6x 27	KVNA AM 5x KVNA FM 5x KMGN FM 5x KAFF FM 6x 28	Arizona Daily Sun: How Much KVNA AM 5x KVNA FM 5x KMGN FM 5x KAFF FM 6x 29	KVNA AM 5x KVNA FM 5x KMGN FM 5x KAFF FM 6x 30	Arizona Daily Sun: Frostline KVNA AM 5x KVNA FM 5x KMGN FM 5x KAFF FM 6x 31	

If you have any questions, please call Simmons Advertising, Inc. (701)-746-6573

The most serious problem with catastrophic global warming is–it may not be true.



Some forecasters say the Earth's temperature is rising. They say that catastrophic global warming will take place in the years ahead.

But the U.S. Department of Agriculture—in the first update in 25 years of its "Plant Hardiness Report" —determined that on both coasts of this country, winter temperatures are 5 to 10 degrees cooler than previously reported.

The evidence can be seen in the increase in cold damage to Florida orange groves and California eucalyptus. And a moving frost line has led to a shorter growing season in some parts of the South.

Now, most of us aren't climatologists. But facts like these simply don't jibe with the theory that catastrophic global warming is taking place. Which seems to say we need more research. And more evidence

If you care about the Earth—but want to keep a cool head about it—now is your chance to get more facts.

Call the Information Council for the Environment, 1-800-346-6269 extension 522. We'll send you a free packet of information on global climate change. Or just mail us the coupon below.

Because the best environmental policy is a policy based on fact.

Please send me your FREE information packet on global climate change.

Information
Council
for the Environment
1-800-346-6269

Who told you the earth was warming... Chicken Little?

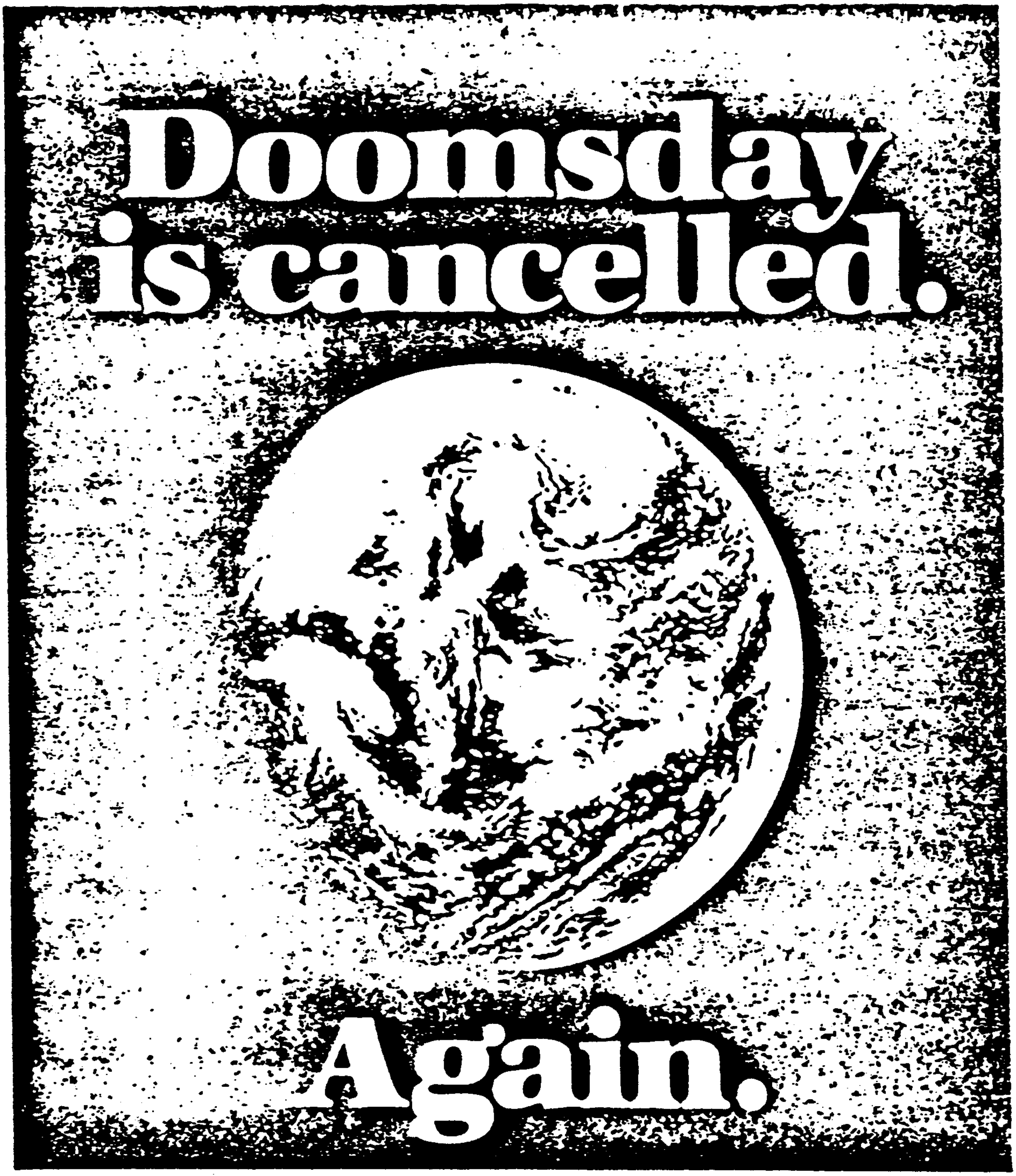
Chicken Little's hysteria about the sky falling was based on a fact that got blown out of proportion.

It's the same with global warming. There's no hard evidence it is occurring. In fact, evidence the Earth is warming is weak. Proof that carbon dioxide has been the primary cause is non-existent. Climate models cannot accurately predict far-future global change. And the underlying physics of climatic change are still wide open to debate.

If you care about the earth, but don't want your imagination to run away with you, make sure you get the facts.

Write Informed Citizens for the Environment, P.O. Box 1513, Grand Forks, North Dakota 58206, or call toll-free 1-701-746-4573. We'll send today's facts on global warming.

Informed Citizens



The twentieth century has seen many predictions of global destruction. In the 1930's, some scientists claimed we were in the middle of a disastrous warming trend. In the mid 1970's, others were sure we were entering a new Ice Age. And so on.

It's the same with global warming. There's no hard evidence it is occurring. In fact, evidence the Earth is warming is weak. Proof that carbon dioxide has been the primary cause is non-existent. Climate models cannot accurately predict far-future global change. And the underlying physics of the climatic change are still wide open to debate.

If you care about the environment, but don't care to be pressured into spending money on problems that don't exist, make sure you get the facts.

Write: Informed Citizens for the Environment, P.O. Box 1513, Grand Forks, North Dakota 58206 or call (701) 746-4573. We'll send you the facts about global warming.

Informed Citizens for the Environment

EXHIBIT 29

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

UNITED NATIONS
1992

FCCC/INFORMAL/84
GE.05-62220 (E) 200705

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

The Parties to this Convention,

Acknowledging that change in the Earth's climate and its adverse effects are a common concern of humankind,

Concerned that human activities have been substantially increasing the atmospheric concentrations of greenhouse gases, that these increases enhance the natural greenhouse effect, and that this will result on average in an additional warming of the Earth's surface and atmosphere and may adversely affect natural ecosystems and humankind,

Noting that the largest share of historical and current global emissions of greenhouse gases has originated in developed countries, that per capita emissions in developing countries are still relatively low and that the share of global emissions originating in developing countries will grow to meet their social and development needs,

Aware of the role and importance in terrestrial and marine ecosystems of sinks and reservoirs of greenhouse gases,

Noting that there are many uncertainties in predictions of climate change, particularly with regard to the timing, magnitude and regional patterns thereof,

Acknowledging that the global nature of climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response, in accordance with their common but differentiated responsibilities and respective capabilities and their social and economic conditions,

Recalling the pertinent provisions of the Declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 16 June 1972,

Recalling also that States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction,

Reaffirming the principle of sovereignty of States in international cooperation to address climate change,

Recognizing that States should enact effective environmental legislation, that environmental standards, management objectives and priorities should reflect the environmental and developmental context to which they apply, and that standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries, *Recalling* the provisions of General Assembly resolution 44/228 of 22 December 1989 on the United Nations Conference on Environment and Development, and resolutions 43/53 of 6 December 1988, 44/207 of 22 December 1989, 45/212 of 21 December 1990 and 46/169 of 19 December 1991 on protection of global climate for present and future generations of mankind,

Recalling also the provisions of General Assembly resolution 44/206 of 22 December 1989 on the possible adverse effects of sea-level rise on islands and coastal areas, particularly low-lying coastal areas and the pertinent provisions of General Assembly resolution 44/172 of 19 December 1989 on the implementation of the Plan of Action to Combat Desertification,

Recalling further the Vienna Convention for the Protection of the Ozone Layer, 1985, and the Montreal Protocol on Substances that Deplete the Ozone Layer, 1987, as adjusted and amended on 29 June 1990,

Noting the Ministerial Declaration of the Second World Climate Conference adopted on 7 November 1990,

Conscious of the valuable analytical work being conducted by many States on climate change and of the important contributions of the World Meteorological Organization, the United Nations Environment Programme and other organs, organizations and bodies of the United Nations system, as well as other international and intergovernmental bodies, to the exchange of results of scientific research and the coordination of research,

Recognizing that steps required to understand and address climate change will be environmentally, socially and economically most effective if they are based on relevant scientific, technical and economic considerations and continually re-evaluated in the light of new findings in these areas,

Recognizing that various actions to address climate change can be justified economically in their own right and can also help in solving other environmental problems,

Recognizing also the need for developed countries to take immediate action in a flexible manner on the basis of clear priorities, as a first step towards comprehensive response strategies at the global, national and, where agreed, regional levels that take into account all greenhouse gases, with due consideration of their relative contributions to the enhancement of the greenhouse effect,

Recognizing further that low-lying and other small island countries, countries with low-lying coastal, arid and semi-arid areas or areas liable to floods, drought and desertification, and developing countries with fragile mountainous ecosystems are particularly vulnerable to the adverse effects of climate change,

Recognizing the special difficulties of those countries, especially developing countries, whose economies are particularly dependent on fossil fuel production, use and exportation, as a consequence of action taken on limiting greenhouse gas emissions, *Affirming* that responses to climate change should be coordinated with social and economic development in an integrated manner with a view to avoiding adverse impacts on the latter, taking into full account the legitimate priority needs of developing countries for the achievement of sustained economic growth and the eradication of poverty,

Recognizing that all countries, especially developing countries, need access to resources required to achieve sustainable social and economic development and that, in order for developing countries to progress towards that goal, their energy consumption will need to grow taking into account the possibilities for achieving greater energy efficiency and for controlling greenhouse gas emissions in general, including through the application of new technologies on terms which make such an application economically and socially beneficial,

Determined to protect the climate system for present and future generations,

Have agreed as follows:

Article 1

DEFINITIONS*

For the purposes of this Convention:

1. "Adverse effects of climate change" means changes in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare.

2. "Climate change" means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

3. "Climate system" means the totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions.

4. "Emissions" means the release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time.

5. "Greenhouse gases" means those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation.

6. "Regional economic integration organization" means an organization constituted by sovereign States of a given region which has competence in respect of matters governed by this Convention or its protocols and has been duly authorized, in accordance with its internal procedures, to sign, ratify, accept, approve or accede to the instruments concerned.

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* Titles of articles are included solely to assist the reader.

7. “Reservoir” means a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored.

8. “Sink” means any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere.

9. “Source” means any process or activity which releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere.

Article 2

OBJECTIVE

The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

Article 3

PRINCIPLES

In their actions to achieve the objective of the Convention and to implement its provisions, the Parties shall be guided, inter alia, by the following:

1. The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof.

2. The specific needs and special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change, and of those Parties, especially developing country Parties, that would have to bear a disproportionate or abnormal burden under the Convention, should be given full consideration.

3. The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost. To achieve this, such policies and measures should take into account different socio-economic contexts, be comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation, and comprise all economic sectors. Efforts to address climate change may be carried out cooperatively by interested Parties.

4. The Parties have a right to, and should, promote sustainable development. Policies and measures to protect the climate system against human-induced change should be appropriate for the specific conditions of each Party and should be integrated with national development programmes, taking into account that economic development is essential for adopting measures to address climate change.

5. The Parties should cooperate to promote a supportive and open international economic system that would lead to sustainable economic growth and development in all Parties, particularly developing country Parties, thus enabling them better to address the problems of climate change. Measures taken to combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade.

Article 4

COMMITMENTS

1. All Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall:

(a) Develop, periodically update, publish and make available to the Conference of the Parties, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties;

(b) Formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to mitigate climate change by addressing anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, and measures to facilitate adequate adaptation to climate change;

(c) Promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors, including the energy, transport, industry, agriculture, forestry and waste management sectors;

(d) Promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol, including biomass, forests and oceans as well as other terrestrial, coastal and marine ecosystems;

(e) Cooperate in preparing for adaptation to the impacts of climate change; develop and elaborate appropriate and integrated plans for coastal zone management, water resources and agriculture, and for the protection and rehabilitation of areas, particularly in Africa, affected by drought and desertification, as well as floods;

(f) Take climate change considerations into account, to the extent feasible, in their relevant social, economic and environmental policies and actions, and employ appropriate methods, for example impact assessments, formulated and determined nationally, with a view to minimizing adverse effects on the economy, on public health and on the quality of the environment, of projects or measures undertaken by them to mitigate or adapt to climate change;

(g) Promote and cooperate in scientific, technological, technical, socio-economic and other research, systematic observation and development of data archives related to the climate system and intended to further the understanding and to reduce or eliminate the remaining uncertainties regarding the causes, effects, magnitude and timing of climate change and the economic and social consequences of various response strategies;

(h) Promote and cooperate in the full, open and prompt exchange of relevant scientific, technological, technical, socio-economic and legal information related to the climate system and climate change, and to the economic and social consequences of various response strategies;

(i) Promote and cooperate in education, training and public awareness related to climate change and encourage the widest participation in this process, including that of non-governmental organizations; and

(j) Communicate to the Conference of the Parties information related to implementation, in accordance with Article 12.

2. The developed country Parties and other Parties included in Annex I commit themselves specifically as provided for in the following:

(a) Each of these Parties shall adopt national[1] policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs. These policies and measures will demonstrate that developed countries are taking the lead in modifying longer-term trends in anthropogenic emissions consistent with the objective of the Convention, recognizing that the return by the end of the present decade to earlier levels of anthropogenic emissions of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol would contribute to such modification, and taking into account the differences in these Parties' starting points and approaches, economic structures and resource bases, the need to maintain strong and sustainable economic growth, available technologies and other individual circumstances, as well as the need for equitable and appropriate contributions by each of these Parties to the global effort regarding that objective. These Parties may implement such policies and measures jointly with other Parties and may assist other Parties in contributing to the achievement of the objective of the Convention and, in particular, that of this subparagraph;

[1] This includes policies and measures adopted by regional economic integration organizations.

(b) In order to promote progress to this end, each of these Parties shall communicate, within six months of the entry into force of the Convention for it and periodically thereafter, and in accordance with Article 12, detailed information on its policies and measures referred to in subparagraph (a) above, as well as on its resulting projected anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol for the period referred to in subparagraph (a), with the aim of returning individually or jointly to their 1990 levels these anthropogenic emissions of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol. This information will be reviewed by the Conference of the Parties, at its first session and periodically thereafter, in accordance with Article 7;

(c) Calculations of emissions by sources and removals by sinks of greenhouse gases for the purposes of subparagraph (b) above should take into account the best available scientific knowledge, including of the effective capacity of sinks and the respective contributions of such gases to climate change. The Conference of the Parties shall consider and agree on methodologies for these calculations at its first session and review them regularly thereafter;

(d) The Conference of the Parties shall, at its first session, review the adequacy of subparagraphs (a) and (b) above. Such review shall be carried out in the light of the best available scientific information and assessment on climate change and its impacts, as well as relevant technical, social and economic information. Based on this review, the Conference of the Parties shall take appropriate action, which may include the adoption of amendments to the commitments in subparagraphs (a) and (b) above. The Conference of the Parties, at its first session, shall also take decisions regarding criteria for joint implementation as indicated in subparagraph (a) above. A second review of subparagraphs (a) and (b) shall take place not later than 31 December 1998, and thereafter at regular intervals determined by the Conference of the Parties, until the objective of the Convention is met;

(e) Each of these Parties shall:

(i) coordinate as appropriate with other such Parties, relevant economic and administrative instruments developed to achieve the objective of the Convention; and

(ii) identify and periodically review its own policies and practices which encourage activities that lead to greater levels of anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol than would otherwise occur;

(f) The Conference of the Parties shall review, not later than 31 December 1998, available information with a view to taking decisions regarding such amendments to the lists in Annexes I and II as may be appropriate, with the approval of the Party concerned;

(g) Any Party not included in Annex I may, in its instrument of ratification, acceptance, approval or accession, or at any time thereafter, notify the Depositary that it intends to be bound by subparagraphs (a) and (b) above. The Depositary shall inform the other signatories and Parties of any such notification.

3. The developed country Parties and other developed Parties included in Annex II shall provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties in complying with their obligations under Article 12, paragraph 1. They shall also provide such financial resources, including for the transfer of technology, needed by the developing country Parties to meet the agreed full incremental costs of implementing measures that are covered by paragraph 1 of this Article and that are agreed between a developing country Party and the international entity or entities referred to in Article 11, in accordance with that Article. The implementation of these commitments shall take into account the need for adequacy and predictability in the flow of funds and the importance of appropriate burden sharing among the developed country Parties.

4. The developed country Parties and other developed Parties included in Annex II shall also assist the developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse effects.

5. The developed country Parties and other developed Parties included in Annex II shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties. Other Parties and organizations in a position to do so may also assist in facilitating the transfer of such technologies.

6. In the implementation of their commitments under paragraph 2 above, a certain degree of flexibility shall be allowed by the Conference of the Parties to the Parties included in Annex I undergoing the process of transition to a market economy, in order to enhance the ability of these Parties to address climate change, including with regard to the historical level of anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol chosen as a reference.

7. The extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments under the Convention related to financial resources and transfer of technology and will take fully into account that economic and social development and poverty eradication are the first and overriding priorities of the developing country Parties.

8. In the implementation of the commitments in this Article, the Parties shall give full consideration to what actions are necessary under the Convention, including actions related to funding, insurance and the transfer of technology, to meet the specific needs and concerns of developing country Parties arising from the adverse effects of climate change and/or the impact of the implementation of response measures, especially on:

(a) Small island countries;

(b) Countries with low-lying coastal areas;

(c) Countries with arid and semi-arid areas, forested areas and areas liable to forest decay;

(d) Countries with areas prone to natural disasters;

(e) Countries with areas liable to drought and desertification;

(f) Countries with areas of high urban atmospheric pollution;

(g) Countries with areas with fragile ecosystems, including mountainous ecosystems;

(h) Countries whose economies are highly dependent on income generated from the production, processing and export, and/or on consumption of fossil fuels and associated energy-intensive products; and

(i) Landlocked and transit countries.

Further, the Conference of the Parties may take actions, as appropriate, with respect to this paragraph.

9. The Parties shall take full account of the specific needs and special situations of the least developed countries in their actions with regard to funding and transfer of technology.

10. The Parties shall, in accordance with Article 10, take into consideration in the implementation of the commitments of the Convention the situation of Parties, particularly developing country Parties, with economies that are vulnerable to the adverse effects of the implementation of measures to respond to climate change. This applies notably to Parties with economies that are highly dependent on income generated from the production, processing and export, and/or consumption of fossil fuels and associated energy-intensive products and/or the use of fossil fuels for which such Parties have serious difficulties in switching to alternatives.

Article 5

RESEARCH AND SYSTEMATIC OBSERVATION

In carrying out their commitments under Article 4, paragraph 1 (g), the Parties shall:

(a) Support and further develop, as appropriate, international and intergovernmental programmes and networks or organizations aimed at defining, conducting, assessing and financing research, data collection and systematic observation, taking into account the need to minimize duplication of effort;

(b) Support international and intergovernmental efforts to strengthen systematic observation and national scientific and technical research capacities and capabilities, particularly in developing countries, and to promote access to, and the exchange of, data and analyses thereof obtained from areas beyond national jurisdiction; and

(c) Take into account the particular concerns and needs of developing countries and cooperate in improving their endogenous capacities and capabilities to participate in the efforts referred to in subparagraphs (a) and (b) above.

Article 6

EDUCATION, TRAINING AND PUBLIC AWARENESS

In carrying out their commitments under Article 4, paragraph 1 (i), the Parties shall:

(a) Promote and facilitate at the national and, as appropriate, subregional and regional levels, and in accordance with national laws and regulations, and within their respective capacities:

(i) the development and implementation of educational and public awareness programmes on climate change and its effects;

(ii) public access to information on climate change and its effects;

(iii) public participation in addressing climate change and its effects and developing adequate responses; and

(iv) training of scientific, technical and managerial personnel;

(b) Cooperate in and promote, at the international level, and, where appropriate, using existing bodies:

(i) the development and exchange of educational and public awareness material on climate change and its effects; and

(ii) the development and implementation of education and training programmes, including the strengthening of national institutions and the exchange or secondment of personnel to train experts in this field, in particular for developing countries.

Article 7

CONFERENCE OF THE PARTIES

1. A Conference of the Parties is hereby established.

2. The Conference of the Parties, as the supreme body of this Convention, shall keep under regular review the implementation of the Convention and any related legal instruments that the Conference of the Parties may adopt, and shall make, within its mandate, the decisions necessary to promote the effective implementation of the Convention. To this end, it shall:

(a) Periodically examine the obligations of the Parties and the institutional arrangements under the Convention, in the light of the objective of the Convention, the experience gained in its implementation and the evolution of scientific and technological knowledge;

(b) Promote and facilitate the exchange of information on measures adopted by the Parties to address climate change and its effects, taking into account the differing circumstances, responsibilities and capabilities of the Parties and their respective commitments under the Convention;

(c) Facilitate, at the request of two or more Parties, the coordination of measures adopted by them to address climate change and its effects, taking into account the differing circumstances, responsibilities and capabilities of the Parties and their respective commitments under the Convention;

(d) Promote and guide, in accordance with the objective and provisions of the Convention, the development and periodic refinement of comparable methodologies, to be agreed on by the Conference of the Parties, inter alia, for preparing inventories of greenhouse gas emissions by sources and removals by sinks, and for evaluating the effectiveness of measures to limit the emissions and enhance the removals of these gases;

(e) Assess, on the basis of all information made available to it in accordance with the provisions of the Convention, the implementation of the Convention by the Parties, the overall effects of the measures taken pursuant to the Convention, in particular environmental, economic and social effects as well as their cumulative impacts and the extent to which progress towards the objective of the Convention is being achieved;

(f) Consider and adopt regular reports on the implementation of the Convention and ensure their publication;

(g) Make recommendations on any matters necessary for the implementation of the Convention;

(h) Seek to mobilize financial resources in accordance with Article 4, paragraphs 3, 4 and 5, and Article 11;

(i) Establish such subsidiary bodies as are deemed necessary for the implementation of the Convention;

(j) Review reports submitted by its subsidiary bodies and provide guidance to them;

(k) Agree upon and adopt, by consensus, rules of procedure and financial rules for itself and for any subsidiary bodies;

(l) Seek and utilize, where appropriate, the services and cooperation of, and information provided by, competent international organizations and intergovernmental and non-governmental bodies; and

(m) Exercise such other functions as are required for the achievement of the objective of the Convention as well as all other functions assigned to it under the Convention.

3. The Conference of the Parties shall, at its first session, adopt its own rules of procedure as well as those of the subsidiary bodies established by the Convention, which shall include decision-making procedures for matters not already covered by decision-making procedures stipulated in the Convention. Such procedures may include specified majorities required for the adoption of particular decisions.

4. The first session of the Conference of the Parties shall be convened by the interim secretariat referred to in Article 21 and shall take place not later than one year after the date of entry into force of the Convention. Thereafter, ordinary sessions of the Conference of the Parties shall be held every year unless otherwise decided by the Conference of the Parties.

5. Extraordinary sessions of the Conference of the Parties shall be held at such other times as may be deemed necessary by the Conference, or at the written request of any Party, provided that, within six months of the request being communicated to the Parties by the secretariat, it is supported by at least one third of the Parties.

6. The United Nations, its specialized agencies and the International Atomic Energy Agency, as well as any State member thereof or observers thereto not Party to the Convention, may be represented at sessions of the Conference of the Parties as observers. Any body or agency, whether national or international, governmental or non-governmental, which is qualified in matters covered by the Convention, and which has informed the secretariat of its wish to be represented at a session of the Conference of the Parties as an observer, may be so admitted unless at least one third of the Parties present object. The admission and participation of observers shall be subject to the rules of procedure adopted by the Conference of the Parties.

Article 8

SECRETARIAT

1. A secretariat is hereby established.

2. The functions of the secretariat shall be:

(a) To make arrangements for sessions of the Conference of the Parties and its subsidiary bodies established under the Convention and to provide them with services as required;

(b) To compile and transmit reports submitted to it;

(c) To facilitate assistance to the Parties, particularly developing country Parties, on request, in the compilation and communication of information required in accordance with the provisions of the Convention;

(d) To prepare reports on its activities and present them to the Conference of the Parties;

(e) To ensure the necessary coordination with the secretariats of other relevant international bodies;

(f) To enter, under the overall guidance of the Conference of the Parties, into such administrative and contractual arrangements as may be required for the effective discharge of its functions; and

(g) To perform the other secretariat functions specified in the Convention and in any of its protocols and such other functions as may be determined by the Conference of the Parties.

3. The Conference of the Parties, at its first session, shall designate a permanent secretariat and make arrangements for its functioning.

Article 9

SUBSIDIARY BODY FOR SCIENTIFIC AND TECHNOLOGICAL ADVICE

1. A subsidiary body for scientific and technological advice is hereby established to provide the Conference of the Parties and, as appropriate, its other subsidiary bodies with timely information and advice on scientific and technological matters relating to the Convention. This body shall be open to participation by all Parties and shall be multidisciplinary. It shall comprise government representatives competent in the relevant field of expertise. It shall report regularly to the Conference of the Parties on all aspects of its work.

2. Under the guidance of the Conference of the Parties, and drawing upon existing competent international bodies, this body shall:

(a) Provide assessments of the state of scientific knowledge relating to climate change and its effects;

(b) Prepare scientific assessments on the effects of measures taken in the implementation of the Convention;

(c) Identify innovative, efficient and state-of-the-art technologies and know-how and advise on the ways and means of promoting development and/or transferring such technologies;

(d) Provide advice on scientific programmes, international cooperation in research and development related to climate change, as well as on ways and means of supporting endogenous capacity-building in developing countries; and

(e) Respond to scientific, technological and methodological questions that the Conference of the Parties and its subsidiary bodies may put to the body.

3. The functions and terms of reference of this body may be further elaborated by the Conference of the Parties.

Article 10

SUBSIDIARY BODY FOR IMPLEMENTATION

1. A subsidiary body for implementation is hereby established to assist the Conference of the Parties in the assessment and review of the effective implementation of the Convention. This body shall be open to participation by all Parties and comprise government representatives who are experts on matters related to climate change. It shall report regularly to the Conference of the Parties on all aspects of its work.

2. Under the guidance of the Conference of the Parties, this body shall:

(a) Consider the information communicated in accordance with Article 12, paragraph 1, to assess the overall aggregated effect of the steps taken by the Parties in the light of the latest scientific assessments concerning climate change;

(b) Consider the information communicated in accordance with Article 12, paragraph 2, in order to assist the Conference of the Parties in carrying out the reviews required by Article 4, paragraph 2 (d); and

(c) Assist the Conference of the Parties, as appropriate, in the preparation and implementation of its decisions.

Article 11

FINANCIAL MECHANISM

1. A mechanism for the provision of financial resources on a grant or concessional basis, including for the transfer of technology, is hereby defined. It shall function under the guidance of and be accountable to the Conference of the Parties, which shall decide on its policies, programme priorities and eligibility criteria related to this Convention. Its operation shall be entrusted to one or more existing international entities.

2. The financial mechanism shall have an equitable and balanced representation of all Parties within a transparent system of governance.

3. The Conference of the Parties and the entity or entities entrusted with the operation of the financial mechanism shall agree upon arrangements to give effect to the above paragraphs, which shall include the following:

(a) Modalities to ensure that the funded projects to address climate change are in conformity with the policies, programme priorities and eligibility criteria established by the Conference of the Parties;

(b) Modalities by which a particular funding decision may be reconsidered in light of these policies, programme priorities and eligibility criteria;

(c) Provision by the entity or entities of regular reports to the Conference of the Parties on its funding operations, which is consistent with the requirement for accountability set out in paragraph 1 above; and

(d) Determination in a predictable and identifiable manner of the amount of funding necessary and available for the implementation of this Convention and the conditions under which that amount shall be periodically reviewed.

4. The Conference of the Parties shall make arrangements to implement the above-mentioned provisions at its first session, reviewing and taking into account the interim arrangements referred to in Article 21, paragraph 3, and shall decide whether these interim arrangements shall be maintained. Within four years thereafter, the Conference of the Parties shall review the financial mechanism and take appropriate measures.

5. The developed country Parties may also provide and developing country Parties avail themselves of, financial resources related to the implementation of the Convention through bilateral, regional and other multilateral channels.

Article 12

COMMUNICATION OF INFORMATION RELATED TO IMPLEMENTATION

1. In accordance with Article 4, paragraph 1, each Party shall communicate to the Conference of the Parties, through the secretariat, the following elements of information:

(a) A national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, to the extent its capacities permit, using comparable methodologies to be promoted and agreed upon by the Conference of the Parties;

(b) A general description of steps taken or envisaged by the Party to implement the Convention; and

(c) Any other information that the Party considers relevant to the achievement of the objective of the Convention and suitable for inclusion in its communication, including, if feasible, material relevant for calculations of global emission trends.

2. Each developed country Party and each other Party included in Annex I shall incorporate in its communication the following elements of information:

(a) A detailed description of the policies and measures that it has adopted to implement its commitment under Article 4, paragraphs 2 (a) and 2 (b); and

(b) A specific estimate of the effects that the policies and measures referred to in subparagraph (a) immediately above will have on anthropogenic emissions by its sources and removals by its sinks of greenhouse gases during the period referred to in Article 4, paragraph 2 (a).

3. In addition, each developed country Party and each other developed Party included in Annex II shall incorporate details of measures taken in accordance with Article 4, paragraphs 3, 4 and 5.

4. Developing country Parties may, on a voluntary basis, propose projects for financing, including specific technologies, materials, equipment, techniques or practices that would be needed to implement such projects, along with, if possible, an estimate of all incremental costs, of the reductions of emissions and increments of removals of greenhouse gases, as well as an estimate of the consequent benefits.

5. Each developed country Party and each other Party included in Annex I shall make its initial communication within six months of the entry into force of the Convention for that Party. Each Party not so listed shall make its initial communication within three years of the entry into force of the Convention for that Party, or of the availability of financial resources in accordance with Article 4, paragraph 3. Parties that are least developed countries may make their initial communication at their discretion. The frequency of subsequent communications by all Parties shall be determined by the Conference of the Parties, taking into account the differentiated timetable set by this paragraph.

6. Information communicated by Parties under this Article shall be transmitted by the secretariat as soon as possible to the Conference of the Parties and to any subsidiary bodies concerned. If necessary, the procedures for the communication of information may be further considered by the Conference of the Parties.

7. From its first session, the Conference of the Parties shall arrange for the provision to developing country Parties of technical and financial support, on request, in compiling and communicating information under this Article, as well as in identifying the technical and financial needs associated with proposed projects and response measures under Article 4. Such support may be provided by other Parties, by competent international organizations and by the secretariat, as appropriate.

8. Any group of Parties may, subject to guidelines adopted by the Conference of the Parties, and to prior notification to the Conference of the Parties, make a joint communication in fulfilment of their obligations under this Article, provided that such a communication includes information on the fulfilment by each of these Parties of its individual obligations under the Convention.

9. Information received by the secretariat that is designated by a Party as confidential, in accordance with criteria to be established by the Conference of the Parties, shall be aggregated by the secretariat to protect its confidentiality before being made available to any of the bodies involved in the communication and review of information.

10. Subject to paragraph 9 above, and without prejudice to the ability of any Party to make public its communication at any time, the secretariat shall make communications by Parties under this Article publicly available at the time they are submitted to the Conference of the Parties.

Article 13

RESOLUTION OF QUESTIONS REGARDING IMPLEMENTATION

The Conference of the Parties shall, at its first session, consider the establishment of a multilateral consultative process, available to Parties on their request, for the resolution of questions regarding the implementation of the Convention.

Article 14

SETTLEMENT OF DISPUTES

1. In the event of a dispute between any two or more Parties concerning the interpretation or application of the Convention, the Parties concerned shall seek a settlement of the dispute through negotiation or any other peaceful means of their own choice.

2. When ratifying, accepting, approving or acceding to the Convention, or at any time thereafter, a Party which is not a regional economic integration organization may declare in a written instrument submitted to the Depositary that, in respect of any dispute concerning the interpretation or application of the Convention, it recognizes as compulsory ipso facto and without special agreement, in relation to any Party accepting the same obligation:

(a) Submission of the dispute to the International Court of Justice; and/or

(b) Arbitration in accordance with procedures to be adopted by the Conference of the Parties as soon as practicable, in an annex on arbitration.

A Party which is a regional economic integration organization may make a declaration with like effect in relation to arbitration in accordance with the procedures referred to in subparagraph (b) above.

3. A declaration made under paragraph 2 above shall remain in force until it expires in accordance with its terms or until three months after written notice of its revocation has been deposited with the Depositary.

4. A new declaration, a notice of revocation or the expiry of a declaration shall not in any way affect proceedings pending before the International Court of Justice or the arbitral tribunal, unless the parties to the dispute otherwise agree.

5. Subject to the operation of paragraph 2 above, if after twelve months following notification by one Party to another that a dispute exists between them, the Parties concerned have not been able to settle their dispute through the means mentioned in paragraph 1 above, the dispute shall be submitted, at the request of any of the parties to the dispute, to conciliation.

6. A conciliation commission shall be created upon the request of one of the parties to the dispute. The commission shall be composed of an equal number of members appointed by each party concerned and a chairman chosen jointly by the members appointed by each party. The commission shall render a recommendatory award, which the parties shall consider in good faith.

7. Additional procedures relating to conciliation shall be adopted by the Conference of the Parties, as soon as practicable, in an annex on conciliation.

8. The provisions of this Article shall apply to any related legal instrument which the Conference of the Parties may adopt, unless the instrument provides otherwise.

Article 15

AMENDMENTS TO THE CONVENTION

1. Any Party may propose amendments to the Convention.

2. Amendments to the Convention shall be adopted at an ordinary session of the Conference of the Parties. The text of any proposed amendment to the Convention shall be communicated to the Parties by the secretariat at least six months before the meeting at which it is proposed for adoption. The secretariat shall also communicate proposed amendments to the signatories to the Convention and, for information, to the Depositary.

3. The Parties shall make every effort to reach agreement on any proposed amendment to the Convention by consensus. If all efforts at consensus have been exhausted, and no agreement reached, the amendment shall as a last resort be adopted by a three-fourths majority vote of the Parties present and voting at the meeting. The adopted amendment shall be communicated by the secretariat to the Depositary, who shall circulate it to all Parties for their acceptance.

4. Instruments of acceptance in respect of an amendment shall be deposited with the Depositary. An amendment adopted in accordance with paragraph 3 above shall enter into force for those Parties having accepted it on the ninetieth day after the date of receipt by the Depositary of an instrument of acceptance by at least three fourths of the Parties to the Convention.

5. The amendment shall enter into force for any other Party on the ninetieth day after the date on which that Party deposits with the Depositary its instrument of acceptance of the said amendment.

6. For the purposes of this Article, “Parties present and voting” means Parties present and casting an affirmative or negative vote.

Article 16

ADOPTION AND AMENDMENT OF ANNEXES TO THE CONVENTION

1. Annexes to the Convention shall form an integral part thereof and, unless otherwise expressly provided, a reference to the Convention constitutes at the same time a reference to any annexes thereto. Without prejudice to the provisions of Article 14, paragraphs 2 (b) and 7, such annexes shall be restricted to lists, forms and any other material of a descriptive nature that is of a scientific, technical, procedural or administrative character.

2. Annexes to the Convention shall be proposed and adopted in accordance with the procedure set forth in Article 15, paragraphs 2, 3 and 4.

3. An annex that has been adopted in accordance with paragraph 2 above shall enter into force for all Parties to the Convention six months after the date of the communication by the Depositary to such Parties of the adoption of the annex, except for those Parties that have notified the Depositary, in writing, within that period of their non-acceptance of the annex. The annex shall enter into force for Parties which withdraw their notification of non-acceptance on the ninetieth day after the date on which withdrawal of such notification has been received by the Depositary.

4. The proposal, adoption and entry into force of amendments to annexes to the Convention shall be subject to the same procedure as that for the proposal, adoption and entry into force of annexes to the Convention in accordance with paragraphs 2 and 3 above.

5. If the adoption of an annex or an amendment to an annex involves an amendment to the Convention, that annex or amendment to an annex shall not enter into force until such time as the amendment to the Convention enters into force.

Article 17

PROTOCOLS

1. The Conference of the Parties may, at any ordinary session, adopt protocols to the Convention.

2. The text of any proposed protocol shall be communicated to the Parties by the secretariat at least six months before such a session.

3. The requirements for the entry into force of any protocol shall be established by that instrument.

4. Only Parties to the Convention may be Parties to a protocol.

5. Decisions under any protocol shall be taken only by the Parties to the protocol concerned.

Article 18

RIGHT TO VOTE

1. Each Party to the Convention shall have one vote, except as provided for in paragraph 2 below.

2. Regional economic integration organizations, in matters within their competence, shall exercise their right to vote with a number of votes equal to the number of their member States that are Parties to the Convention. Such an organization shall not exercise its right to vote if any of its member States exercises its right, and vice versa.

Article 19

DEPOSITARY

The Secretary-General of the United Nations shall be the Depositary of the Convention and of protocols adopted in accordance with Article 17.

Article 20

SIGNATURE

This Convention shall be open for signature by States Members of the United Nations or of any of its specialized agencies or that are Parties to the Statute of the International Court of Justice and by regional economic integration organizations at Rio de Janeiro, during the United Nations Conference on Environment and Development, and thereafter at United Nations Headquarters in New York from 20 June 1992 to 19 June 1993.

Article 21

INTERIM ARRANGEMENTS

1. The secretariat functions referred to in Article 8 will be carried out on an interim basis by the secretariat established by the General Assembly of the United Nations in its resolution 45/212 of 21 December 1990, until the completion of the first session of the Conference of the Parties.

2. The head of the interim secretariat referred to in paragraph 1 above will cooperate closely with the Intergovernmental Panel on Climate Change to ensure that the Panel can respond to the need for objective scientific and technical advice. Other relevant scientific bodies could also be consulted.

3. The Global Environment Facility of the United Nations Development Programme, the United Nations Environment Programme and the International Bank for Reconstruction and Development shall be the international entity entrusted with the operation of the financial mechanism referred to in Article 11 on an interim basis. In this connection, the Global Environment Facility should be appropriately restructured and its membership made universal to enable it to fulfil the requirements of Article 11.

Article 22

RATIFICATION, ACCEPTANCE, APPROVAL OR ACCESSION

1. The Convention shall be subject to ratification, acceptance, approval or accession by States and by regional economic integration organizations. It shall be open for accession from the day after the date on which the Convention is closed for signature. Instruments of ratification, acceptance, approval or accession shall be deposited with the Depositary.

2. Any regional economic integration organization which becomes a Party to the Convention without any of its member States being a Party shall be bound by all the obligations under the Convention. In the case of such organizations, one or more of whose member States is a Party to the Convention, the organization and its member States shall decide on their respective responsibilities for the performance of their obligations under the Convention. In such cases, the organization and the member States shall not be entitled to exercise rights under the Convention concurrently.

3. In their instruments of ratification, acceptance, approval or accession, regional economic integration organizations shall declare the extent of their competence with respect to the matters governed by the Convention. These organizations shall also inform the Depositary, who shall in turn inform the Parties, of any substantial modification in the extent of their competence.

Article 23

ENTRY INTO FORCE

1. The Convention shall enter into force on the ninetieth day after the date of deposit of the fiftieth instrument of ratification, acceptance, approval or accession.

2. For each State or regional economic integration organization that ratifies, accepts or approves the Convention or accedes thereto after the deposit of the fiftieth instrument of ratification, acceptance, approval or accession, the Convention shall enter into force on the ninetieth day after the date of deposit by such State or regional economic integration organization of its instrument of ratification, acceptance, approval or accession.

3. For the purposes of paragraphs 1 and 2 above, any instrument deposited by a regional economic integration organization shall not be counted as additional to those deposited by States members of the organization.

Article 24

RESERVATIONS

No reservations may be made to the Convention.

Article 25

WITHDRAWAL

1. At any time after three years from the date on which the Convention has entered into force for a Party, that Party may withdraw from the Convention by giving written notification to the Depositary.

2. Any such withdrawal shall take effect upon expiry of one year from the date of receipt by the Depositary of the notification of withdrawal, or on such later date as may be specified in the notification of withdrawal.

3. Any Party that withdraws from the Convention shall be considered as also having withdrawn from any protocol to which it is a Party.

Article 26

AUTHENTIC TEXTS

The original of this Convention, of which the Arabic, Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited with the Secretary-General of the United Nations.

IN WITNESS WHEREOF the undersigned, being duly authorized to that effect, have signed this Convention.

DONE at New York this ninth day of May one thousand nine hundred and ninety-two.

Annex I

Australia
Austria
Belarus[a]
Belgium
Bulgaria[a]
Canada
Croatia[a] *
Czech Republic[a] *
Denmark
European Economic Community
Estonia[a]
Finland
France
Germany
Greece
Hungary[a]
Iceland
Ireland
Italy
Japan
Latvia[a]
Liechtenstein*
Lithuania[a]
Luxembourg
Monaco*
Netherlands
New Zealand
Norway
Poland[a]
Portugal
Romania[a]
Russian Federation[a]
Slovakia[a] *
Slovenia[a] *
Spain
Sweden
Switzerland
Turkey
Ukraine[a]
United Kingdom of Great Britain and Northern Ireland
United States of America

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[a] Countries that are undergoing the process of transition to a market economy.

* *Publisher's note*: Countries added to Annex I by an amendment that entered into force on 13 August 1998, pursuant to decision 4/CP.3 adopted at COP.3.

Annex II

Australia
Austria
Belgium
Canada
Denmark
European Economic Community
Finland
France
Germany
Greece
Iceland
Ireland
Italy
Japan
Luxembourg
Netherlands
New Zealand
Norway
Portugal
Spain
Sweden
Switzerland
United Kingdom of Great Britain and Northern Ireland
United States of America

Publisher's note: Turkey was deleted from Annex II by an amendment that entered into force 28 June 2002, pursuant to decision 26/CP.7 adopted at COP.7.

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EXHIBIT 30

THE ENHANCED GREENHOUSE EFFECT

A review of the Scientific Aspects

Update : December 1994

THE ENHANCED GREENHOUSE EFFECT

A review of the Scientific Aspects

Update : December 1994

Author: P. Langcake, SIPM The Hague - HSE/3

THE ENHANCED GREENHOUSE EFFECT

A Review of the Scientific Aspects

Update: December 1994

CONTENTS

P. Langcake, HSE/3

THE ENHANCED GREENHOUSE EFFECT

1. Introduction

The threat of climate change remains the environmental concern with by far the greatest significance for the fossil fuel industry, having major business implications. It has been the focus of continuing scientific and political attention since the late 1980s. The UN Framework Convention on Climate Change, which was the showpiece of the UN Conference on Environment and Development in Rio (UNCED) came into force in March 1994 having been ratified by the requisite 50 signatory nations. Implementation of the Convention will ensure that the momentum of action to address potential global warming is maintained.

The purpose of this paper is to review major developments in scientific understanding and the implications for policy formulation.

2. The Nature of the Issues

The features which make potential human-induced global warming such a problematic and controversial issue are recalled in Figure 1. Each element in this scheme, together with the crucial interactions between the elements is subject to substantial uncertainty. The consequences of global warming could be dramatic, as could the economic effects of ill-advised policy measures. Furthermore, the time scales (decades to hundreds of years) which must be addressed far exceed normal planning experience and the global dimension raises intractable questions of international relations such as equity, trade relationships and conflicting national priorities.

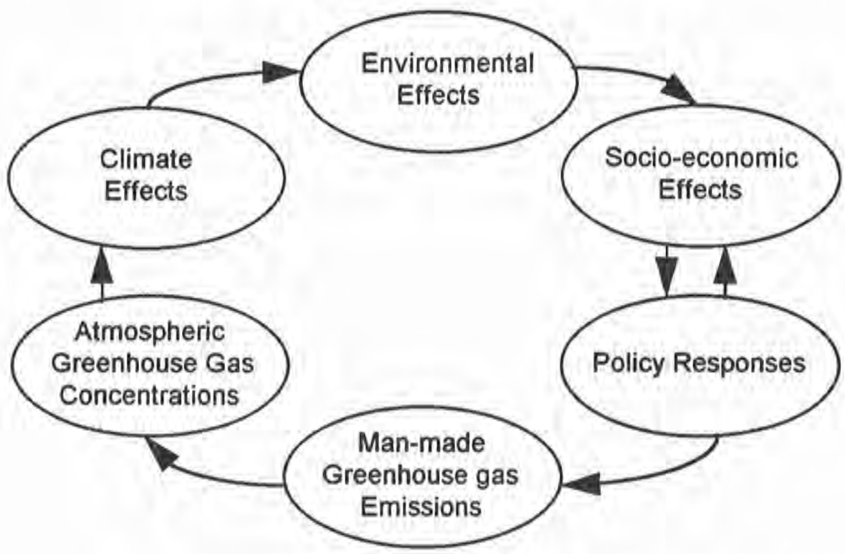

Figure 1: Global Warming, the Circle of Uncertainty

3. Expressions of Scientific Opinion

The Intergovernmental Panel on Climate Change (IPCC) represents the most coherent, authoritative and influential expression of scientific views on Climate Change. IPCC was established in 1988 under the auspices of the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) and comprises several hundred leading independent experts from numerous countries. It should be recognised that IPCC was established by governments and the summaries of its deliberations are the work of officials or official nominees. The conclusions of the IPCC (first reports completed in 1990) can be regarded as the mainstream view: they provided the essential underpinning for government positions at the Rio conference. Post-Rio the IPCC has been kept in existence.

There are three Working Groups.

WG1 is concerned with the "Science of Climate Change'. It produced a "Supplementary Report to the IPCC Scientific Assessment" in 1992 and was due to produce a Special Report in November 1994. WGs II and III are concerned with "Impacts and Response Strategies" and "Cross-cutting Issues" respectively. The latter includes economic impacts and scenarios for future emissions. All three WGs will produce major new reports in 1995.

Although the IPCC position is often referred to as the scientific consensus, there is a range of views among IPCC scientists about the magnitude of the threat from global warming and its causes. Furthermore, there is a significant minority outside IPCC (which includes distinguished scientists) who take a contrary view, generally believing the concerns over global warming to be exaggerated and misguided. The views of these "sceptics" have received increasing attention in recent months (although IPCC members point out that only some of them are actually conducting research in the relevant fields).

4. Agreed Scientific Fundamentals

Notwithstanding the controversy indicated above, there is complete agreement on the following well-known scientific fundamentals:

- Natural Atmospheric Greenhouse Gases affect the retention of energy in the global system by re-reflecting part of the outgoing infra-red radiation from the earth (so called "radiative forcing").

- This maintains the average global temperature approximately 33°C higher than it would be in the absence of atmospheric greenhouse gases and reduces diurnal variation (This is the natural "greenhouse effect").

- The major greenhouse gas is water vapour (this point is often left aside in discussions on global warming). Trace greenhouse gases include carbon dioxide, methane, nitrous oxide, ozone and more recently man-made chloroflurocarbons (CFCs). Calculations of relative contributions are extremely difficult because of differences in atmospheric lifetimes, indirect effects and overlapping radiative effects but roughly speaking water vapour accounts for three quarters of the natural greenhouse effect with all other greenhouse gases making up the remainder.

- The concentration of greenhouse gases (other than water vapour) have increased rapidly since the industrial revolution. Expressing all these gases in terms of their CO_2 equivalent Global Warming Potential (GWP - a subject itself of some controversy) the increase is around 40% over pre-industrial levels. This has led to an increase in radiative forcing of about 1% of the total incoming radiation. While this may appear small, it is important since living organisms can only tolerate a relatively small range of temperature.

- This increase in radiative forcing will have some effect on the processes which determine global climate.

- Human activities have contributed to the increase in atmospheric greenhouse gas concentrations (AGGCs).

- The rate of increase in the concentration of atmospheric greenhouse gases is faster than previously experienced during the history of human civilisation (although not unprecedented on a geological time scale).

- Natural factors other than those directly contributing to AGGCs (volcanic activity, solar orbit, patterns of ocean circulation etc.) and human activities other than fossil fuel consumption (deforestation, agricultural practices, atmospheric pollution, hydrological projects, urbanisation, etc.) can also significantly affect climate causing warming or cooling.

Starting from this broad area of agreement, the controversies arise mainly from differences of view about the potential consequences of the increase in AGGCs and the interpretation of past and present climate observations.

5. Conclusions of the IPCC

The most recent statement of IPCC conclusions concerning the science of global warming is given in the 1992 assessment which re-examined the position presented in the full 1990 report in the light of further research and comment. IPCC conclusions are based on a comprehensive review of climatological, palaeoclimatological and experimental observations together with heavy dependence on the output of elaborate computer models which simulate global climate (General Circulation Models - GCMs).

To model future climate, it is necessary to make some estimate of future emissions of greenhouse gases and the resulting concentrations in the atmosphere. The IPCC calculations are based on a series of projections representing a simple extrapolation of existing trends (the reference case, mistakenly called "business as usual" by some - see later) and various levels of mitigating action (Figure 2).

The reference case leads to an approximate doubling of pre-industrial carbon dioxide concentrations by the year 2030. Clearly the nature of these projections, called scenarios by IPCC, is critical for the outcome of the modelling and is a matter of lively debate.

The 1992 Assessment confirmed (in the view of IPCC) the principal conclusions reached in 1990:

- Greenhouse gas concentrations in the atmosphere are increasing substantially, due to human activities (but see later comments in section 6).

- Evidence from observations and more particularly from GCMs indicates that global mean surface temperature will increase by 1.5 to 4.5°C, depending on the model, with a doubling of the equivalent carbon dioxide concentration (which, as indicated, would occur in approximately 2030 if present trends were to continue unaltered).

- There are many uncertainties with regard to the timing, magnitude and regional patterns of climate change.

- Global mean surface air temperature has increased by 0.3 to 0.6°C over the last 100 years. This warming is consistent with model predictions but also is within natural climate variability (see Figures 3 and 7).

- Alternatively this variability and other human factors (see below) could have offset a still larger human induced greenhouse warming.

- The unequivocal detection of the enhanced greenhouse effect is not likely for a decade or more (there is no clear evidence yet of a "greenhouse signal").

The 1992 report also contained new conclusions, including:

* Depletion of ozone in the lower stratosphere (largely associated with CFCs) results in a decrease in radiative forcing comparable in magnitude to the contribution of CFCs.

* Cooling by sulphur dioxide aerosols (partly resulting from man-made pollution) may have offset a significant part of the greenhouse warming in the Northern Hemisphere.

* Rates of increase of methane and CFC concentrations in the atmosphere have decreased. The latter is largely attributable to international agreements to restrict CFCs, but the reason for the former is not known.

* The anomalously high global temperatures of the late 1980s continued into 1990-1991 which are the warmest years on record (subsequent years 1992 and 1993 have been more in line with the longer term means).

6. Additional Significant Recent Developments

The latest IPCC WG I Supplementary Report (available to us in draft form) covers only those factors which cause radiative forcing of climate change. Revision of Global Warming Potentials of the long lived greenhouse gases to include indirect as well as direct effects indicates an increased importance of methane over a shorter (20 years) time span than previously thought. Improved estimates are made of the cooling effect of atmospheric particles (sulphate aerosols, aerosols from biomass burning and dust from volcanic eruptions). The IPCC latest views on the radiative forcing by various factors is shown in Figure 4. It should be emphasised that the cooling effect of particles and aerosols represent temporary and regionally distributed masking of the radiative forcing due to the long lived greenhouse gases (CO_2 etc.) produced over many decades.

The major volcanic eruption at Mount Pinatubo in 1991 is considered to have caused significant interference with short term climate, notably by emitting substantial quantities of dust particles into the atmosphere which have a cooling effect that could mask global warming for a limited period.

A recent observation is that there has been a remarkable and unpredicted slowing in the rate of increase of atmospheric carbon dioxide concentrations over the last 18 months, thus deviating from the trend which gave rise to climate change concerns. It is too early to say whether or not this is simply a minor perturbation. Some leading scientists active in the field attribute it to indirect effects from the Mount Pinatubo eruption (temporary cooling due to dust particles affecting biosphere respiration more than photosynthesis; see footnote [1]) or to transient effects associated with the El Nino process; see footnote [2]). Similar unexplained variations in the rate of atmospheric CO_2 increase have occurred before (e.g. in 1982). Latest measurements show that in late 1993, the rate of increase has risen again. These observations emphasise the limited state of knowledge concerning the carbon cycle and its inherent feedback mechanisms.

Other important scientific developments include new information from Greenland ice cores which suggests that substantial changes in climate occurred more frequently and rapidly in the past than previously realised and increasing awareness of the key role of ocean circulation patterns in determining regional climate. These patterns appear to be relatively unstable and potentially subject to disturbance.

7. Areas of Controversy and Alternative Scientific Views

Scientific criticism of the IPCC view falls under the following headings:

a. Understanding of the carbon cycle and the relationship with anthropogenic carbon emissions.

b. Reliability and interpretation of temperature records.

c. Understanding of climate processes and particularly the way they are represented in GCMs.

d. Consequences of global warming.

e. Ecosystem responses to climate change.

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1 The terrestrial biosphere component of the carbon cycle is largely determined by the balance between respiration of biota (which emits carbon dioxide) and photosynthesis (which consumes atmospheric carbon dioxide). In general respiration is more sensitive to temperature than photosynthesis; hence it is argued that a rapid cooling effect would be expected to lead to a short term reduction in atmospheric carbon dioxide until the balance of the processes is restored.

2 The El Nino Southern Oscillation phenomenon is an irregular oscillation of the coupled ocean/atmosphere system in the tropical Pacific Ocean, occurring approximately every 3 to 5 years. During the peak of an El Nino, sea surface temperatures in the eastern tropical Pacific can be several degrees warmer than the climatological mean. El Nino events are associated with major climatological effects, such as failure of the Indian Monsoon. An opposite phase of cold events is referred to as La Nina. These phenomena are also associated with changes in the exchange of carbon dioxide between ocean and atmosphere.

The nature of the criticism under each heading is summarised below.

a. Understanding of the carbon cycle and the relationship with anthropogenic carbon emissions

Man-made carbon dioxide emissions are small compared with the amounts of carbon in the total carbon cycle (Figure 5). A small shift in the balance of processes governing this cycle could therefore account for changes in atmospheric carbon dioxide concentrations, or overwhelm any effects from human activity.

The carbon fluxes and sinks shown in Figure 5 represent the best estimates prepared by WG I (see Table 1). Of these, only the amount of carbon in the atmosphere and the amount of CO_2 released from fossil fuel combustion is known with any degree of accuracy. Even the uncertainty in the stated uncertainty ranges of the remaining figures is not known.

Table 1. Annual average anthropogenic carbon budget for 1980 to 1989

CO_2 sources		**GtC/yr.**
(1)	Emissions from fossil fuel and cement production	5.5 ± 0.5
(2)	Net emissions from changes in tropical land-use	1.6 ± 1.0
(3)	Total anthropogenic emissions = (1) + (2)	7.1 ± 1.1
Partitioning amongst reservoirs		
(4)	Storage in the atmosphere	3.2 ± 0.2
(5)	Ocean uptake	2.0 ± 0.8
(6)	Uptake by Northern Hemisphere forest re-growth	0.5 ± 0.5
(7)	Additional terrestrial sinks (CO_2 fertilisation, nitrogen fertilisation, climatic effects) - [(1) + (2)] - [(4) + (5) + (6)]	1.4 ± 1.5

The recent figures recognise that forest regrowth in temperate regions plus the "missing sink" (widely presumed to be net carbon storage in the rest of the biosphere) represent significant sinks. Moreover, the cold deep waters of the ocean are potentially capable of absorbing all the CO_2 that would be released if all known reserves of fossil fuel were to be burned (albeit over a timescale of hundreds of years).

What is clear is that currently, only about half of the anthropogenic CO_2 released accumulates in the atmosphere. How this relationship will change as CO_2 emissions and other global variables change is not clear.
Understanding of gases other than CO_2 such as methane and nitrous oxide and the complex role of water vapour is even less well developed.

b. Reliability and interpretation of temperature records

The best available surface temperature record indicates a rise of 0.45°C (±0.08°C) over the last century, but measuring global average temperatures is notoriously difficult. In general coverage of the earth's surface by reliable measuring stations is insufficient with the oceans in particular being under-represented and the coverage is even poorer when the earlier records are examined. The increase of 0.45°C is approximately half of the 1°C increase that has been predicted by various models based on the present rise in AGGCs.

Sceptics further argue that several other factors could have made a significant contribution to the observed temperature increase, including urbanisation, desertification and a decrease in stratospheric turbidity which has occurred over recent years (before the Mount Pinatubo eruption). They claim that when the effects of these factors are subtracted, the rise due to greenhouse gas effects is at most 0.3°C over the last century and could be negligible. Previous major eruptions (e.g. Mt. St. Helens) have also had noticeable effects on short term climate.

The rather imperfect surface temperature record described above does not agree well with more sophisticated temperature measurements made of the middle troposphere by satellite measurements. These allow true mean global temperature measurements to be made on a daily basis. Many models suggest that the global warming signal will be most evident in the middle troposphere , yet these satellite measurements suggest global cooling of -0.06°C /decade over the last 15 years versus ca. + 0.2°C /decade for the surface measurements. Even after empirical corrections for the El Nino Southern Oscillation and known major volcanic eruptions, the satellite data suggest warming of +0.09°C /decade, approximately half the uncorrected surface measurement. Unfortunately the time series for such measurements only goes back some 15 years.

The postulated link between any observed temperature rise and human activities has to be seen in relation to natural climate variability, which is still largely unpredictable. It is pointed out that the temperature variability over the last century is larger than the effect being sought and that the observed rise could be accounted for by a recovery from the Little Ice Age. Climate changes in the recent geological past, such as the relatively warm Roman period and the Little Ice Age, do not appear to have been associated with changes in CO_2 levels.

Other natural phenomena have been put forward as possible explanations for the observed warming. For example changes in solar activity show some correlation with temperature fluctuations and it has also been claimed that the temperature increased during the 1980s because the La Nina process failed to occur from 1975 to 1988. While none of these explanations has so far achieved widespread acceptance in the IPCC scientific community, they serve to emphasise again how incompletely the natural climate system is understood.

Figures 6 and 7 show graphically how temperature has fluctuated in the recent and distant past to provide a perspective against which to consider current anxieties.

c. <u>Understanding of climate processes and particularly the way they are represented in GCMs</u>

GCMs are massive, three dimensional climate models which attempt to describe and predict climate behaviour based on consideration of the input of solar energy and the resulting physical processes in the global system. These models generally describe climate in terms of temperature, precipitation and barometric pressure for grids covering the globe. They are impressive, but the task is formidable, given the need to take into account numerous climate processes and feedback effects that can either amplify or dampen the direct effects of increasing AGGCs. Climate modellers themselves recognise the following main limitations of the GCMs and go as far as to suggest that such models should not be used for making predictions, but merely to help increase our understanding of climate processes:

i. There is insufficient understanding of major feedback mechanisms

These mechanisms include the distribution of water vapour and heat, changes in cloud cover and albedo, exchange between atmosphere and ocean and changes in plant growth and area covered. A better understanding of the role of clouds is critically needed. Some of the complexities of the feedback processes can be illustrated here. Increased temperature will in principle lead to increased water vapour in the atmosphere. However, while water vapour is a greenhouse gas, water droplets in the form of clouds have a completely different effect, both reflecting and absorbing incoming radiation while also trapping outgoing radiation. Different approaches to the modelling of clouds provide estimates of equilibrium warming which vary by a factor of three. In general such feedback has been treated as positive in GCMs but the latest cloud research programme suggests on balance, a net cooling effect. Indeed, satellite measurements show that clouds may absorb 15-20% of incoming radiation, a figure much higher than previously estimated.

ii. Models do not replicate global temperature history well and they must be "tuned" to represent the current situation. Earlier climate models simulated either the atmosphere alone or the oceans alone and were reasonably good at representing today's climate. However, when "coupled" together as GCMs these models had to calculate their own values for the exchange of heat and moisture between ocean and atmosphere. Left to their own devices, the coupled models would "drift" even without changes to the input variables leading to very unrealistic climate representations. Accordingly the fluxes are "adjusted", sometimes by as much as 20-40% of the total incoming radiation. These adjustments are believed to disguise rather than to correct the underlying defects in the models.

When GCMs are used to "backcast", they indicate a pattern of accelerating warming over the past century: in fact the historical record (Figure 6) shows intermittent periods of warming (in the 1930s and 1980s) with long periods of little change and even cooling between the late 1930s and the late 1970s. Also regional predictions (e.g. effects at the poles) are not consistent with observations.

The introduction of factors to represent sulphate and other aerosols that may have masked global warming in recent years is reported to improve the "backcasting" capability of climate models. However, critics warn that the understanding of aerosols is poor (white particles reflect heat, while black particles absorb it) such that this may just be yet another 'tuning knob' to force models to give a better representation of the historical climate record.

iii. <u>GCMs have poor resolving power</u>

Limitations on computer speed and memory limit the resolution of GCM output to grid blocks whose cells are several hundred kilometers to a side. Such resolution is too coarse to reveal effects of certain processes (such as clouds and hydrology). Currently therefore it is not possible to predict how climate might change at the regional or local level and hence what the impact on ecosystems would be at these levels.

iv. <u>Chronology of carbon dioxide fluctuations and temperature</u>

While there is a remarkable correlation between past temperature (as deduced from ice isotopic composition) and the carbon dioxide profile, it is not clear that carbon dioxide changes ever significantly preceded the temperature signal. Clearly, factors such as changes in earth orbital patterns (external forcing) can produce temperature and other climate changes which in turn can lead to fluctuations in atmospheric carbon dioxide concentrations.

In summary there are serious limitations to the ability of models to predict climate change and these limitations are likely to remain for some time. The limitations are both inherent and practical. It is inherent that the climate system is chaotic in nature and therefore not amenable to deterministic prediction. At best climate could only be modelled in terms of probability. This can be observed in the natural variability of the present climate.

Practical limitations will also persist for some time. For example, while the Deep Ocean is critically important because of its ability to exchange both heat and CO_2, there are major uncertainties in our knowledge of its present state. The models themselves have errors in them, the magnitude of which is not known because of the limited availability of the computing power. Moreover, a number of important processes such as the carbon cycle and the impacts of clouds, continental glaciers, solar variability and volcanic activity, are either absent from climate models, or are poorly understood.

d. Consequences of global warming

GCMs and other projections predict various consequences from increased concentrations of greenhouse gases in addition to temperature rise, although different models do not always agree on the nature of these consequences. Climate features affected include increased precipitation and cloudiness, increased frequency and severity of storms and decreased diurnal temperature range. Secondary consequences include sea level rise, decrease of glaciers, disturbance of ecosystems.

The sceptics argue that there is no convincing, statistically significant evidence that climate features have been affected in the way predicted and that progressive refinement of the models has led to less alarming predictions. A good example is sea-level rise. In the 1980s some scientists predicted a 6m sea level rise due to break-up of Antarctic ice sheets. In 1990, the IPCC report suggested 66 cm by 2100 as a "best guess". By 1992, IPPC had reduced this estimate to 48 cm, while some scientists have predicted that sea level would actually fall due to increased snow cover on land.

e. Ecosystem Responses to Climate Change

Various models are available to examine the effect of climate and atmospheric changes on ecosystems, agriculture and the economy. As a general point the changes brought about by man's activities in the absence of climate change, are likely to be at least as important as those induced by climate change.

For terrestrial ecosystems there is widespread agreement that increased plant fertilisation due to raised CO_2 in the atmosphere plus increased nitrogen and other nutrients derived from atmospheric pollutants will increase plant growth. Estimates vary from 0% to 50%. The increase in net carbon storage will be less than this (possibly half) and insufficient to materially offset man-made emissions of CO_2. In the oceans, plant life is not thought to be limited by carbon and there is no CO_2 fertilisation effect.

Models of natural vegetation redistribution have been validated against historical records. Changes in higher latitudes, e.g. tundra ---> conifer forests, are reasonably well understood but in the tropics the changes will depend on moisture/rainfall rather than temperature. Climate models produce wide estimates of such changes and the impact on ecosystems is most uncertain.

Certain ecosystems transitions could be more problematic. For example, dieback of forests (with fire) could produce short term pulses of CO_2, offsetting the increased carbon storage potential of the overall ecosystem.

Agricultural systems are man-made and accordingly man can adapt them to changing climate. Whether this will produce an overall positive or negative effect on the agricultural economy will depend on societal choices, e.g. local self sufficiency versus changes in the patterns of world trade in (and prices for) agricultural products. On balance the effects in economic terms range from slightly positive to somewhat negative. At the regional level, different models can give quite contradictory results. The uncertainty in this part of the cycle (Figure 1) is no less than that in the other parts.

8. Conclusions concerning the Science of Climate Change

The array of arguments outlined in the last section may appear to represent a formidable case against the global warming hypothesis or at least to favour a healthy scepticism. However, many of them raise questions or point to uncertainties rather than offer convincing alternative positions. These arguments will have been familiar to IPCC scientists who have not materially changed their views. Those who conclude that global warming is likely would argue that uncertainty applies both ways - the effects could be larger then predicted.

A definitive, unequivocal position on the science of global warming would require an understanding of the immensely complex systems which determine the world's climate and biogeochemical cycles. This is quite simply beyond current capabilities. It is not surprising that there should be controversy and the only statements which can be made with confidence relate to the fundamentals stated in section 4 which may be summarised as follows:

- Human activities have contributed to an increase in atmospheric greenhouse gas concentrations which must have some effect on the radiation balance which ultimately determines global climate. However, it is not possible to quantify the consequences for global climate with respect to timing, magnitude or regional distribution nor to specify their significance in comparison with natural climate variation.

- It is thus not possible to dismiss the global warming hypothesis as scientifically unsound; on the other hand any policy measure should take into account explicitly the weaknesses in the scientific case.

9. Current Shell Activities

In addition to monitoring scientific and political developments, Shell specialists are involved in a range of national and international initiatives and activities targeted at the critical issues or organisations involved:

The overall objective is to promote an objective debate on the policy issues concerning possible climate change based on an understanding of the science. The Group position is that:
Scientific uncertainty and the evolution of energy systems indicate that policies to curb greenhouse gas emissions beyond 'no regrets' measures could be premature, divert resources from more pressing needs and further distort markets.

This objective is supported by a PA communications plan that will include a new Management Brief (further details from PAE). PL/12 have looked at the relationship between energy systems and CO_2 emissions through the work on evolution of energy systems. This shows that there is considerable potential for technological change on both the energy supply and energy use sides which would limit the increase in CO2. Market forces may drive such developments even in the absence of policy responses to limit CO_2 emissions. This work has been presented to a number of groups of government officials and at international fora such as the International Energy Agency and the World Bank (further details from PL/12).

<u>Activities by Shell include:</u>

- <u>Scientific understanding</u>
  As part of an industry consortium (IPIECA) support has been provided for research on key areas of scientific uncertainty (cloud processes at the UK Meteorological Office; ocean / atmospheric exchange processes at the Lamont Doherty Observatory, Columbia University, USA).

- <u>Integrated Assessment of Science, Economics and Policy</u>
  Shell is a part sponsor of the MIT Global Change Program which brings together a wide range of expertise in a fully integrated multi-disciplinary programme which addresses all of the processes shown in Figure 1.

- IPCC Technical Assessments

  Monitoring of and input to IPCC deliberations is conducted via IPIECA (International Petroleum Industry Environmental Conservation Association): HSE/3 is Vice-Chairman of the Global Warming Committee. Under the aegis of IPIECA, HSE/3, PL/12 and SMDF/7 have been officially accepted as members of the Peer Reviewers Panel for the next IPCC Technical Assessments. Industry viewpoints are also promoted via specialist workshops involving IPCC/COP participants together with industry experts and by liaison with the International Energy Agency (IEA), for example through the Coal Industry Advisory Board (CIAB).

- Direct input to the IPCC process has included participation in IPCC meetings and correspondence (by PL/12) challenging the OECD Economic model and the Scenarios adopted by IPCC and introducing ideas from the Long Term Energy Study. Contributions have also been made to a variety of seminars dealing with implementation of UNCED commitments.

- UN Framework Convention on Climate Change (UNFCCC) / UNCSD

  Shell (particularly Group PA) plays an active part in the International Chamber of Commerce which is the principal industry-wide vehicle for contributing to the UNFCCC process. Group PA also plays an active role in the World Business Council on Sustainable Development (WBCSD) (formed from a merger of WICE and BCSD) which, alongside the ICC, interacts with the UN Commission on Sustainable Development (UNCSD) and develops industry positions, for example on Agenda 21. Liaison with the Global Environment Facility (GEF) is being developed via IPIECA (HSE/4 is a member of the relevant IPIECA post-UNCED Working Group). There are also direct Shell contacts with GEF through involvement in the Brazil Biomass BIG project. Shell is also making an input to the OECD's work on climate change through the Business and Industry Advisory Committee (BIAC).

- National / Regional Policies

  Shell Staff interact with organisations developing national and regional plans to address climate change, either directly or via industry associations. For example in Europe, relevant bodies include EUROPIA, UNICE etc. The importance of making input at the national government level should not be underestimated.

  It is the national governments which determine the policy of UN bodies and which will subsequently implement it nationally. OpCos needing guidance on making an input to the climate change debate in their country are advised to contact HSE/3, PAE or PL/12.

* * * * *

Glossary of Abbreviations

AGGCs	Atmospheric Greenhouse Gas Concentrations
BCSD	Business Council for Sustainable Development
BIAC	Business and Industry Advisory Committee
CFC	Chlorofluoro Carbon
CH4	Methane
CIAB	Coal Industry Advisory Board
CO2	Carbon Dioxide
EUROPIA	European Petroleum Industry Association
GCM	General Circulation Model
GEF	Global Environment Facility
GWP	Global Warming Potential
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPIECA	International Petroleum Industry Environmental Conservation Association
MIT	Massachusetts Institute of Technology
N2O	Nitrous Oxide
OECD	Organisation for Economic Cooperation and Development
UNCED	United Nations Conference on Environment and Development
UNCSD	United Nations Commission on Sustainable Development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICE	Union of Industrial and Employers' Confederations of Europe
WBCSD	World Business Council for Sustainable Development
WICE	World Industry Council for the Environment
WMO	World Meteorological Organisation

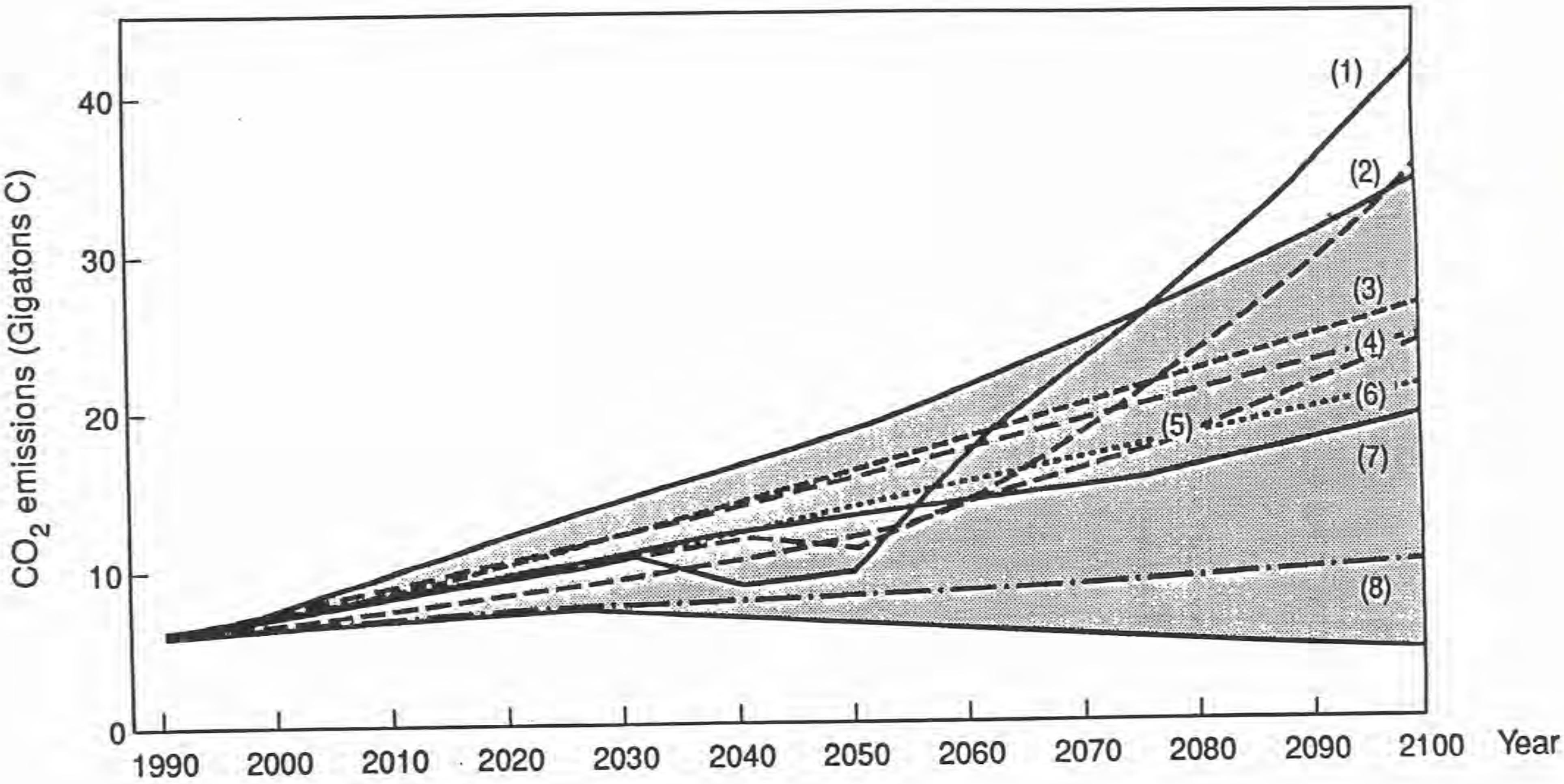


Figure 2
Representative published "emissions scenarios" based on various assumptions about population growth, industrial and economic activity. The shaded area indicates the range of the scenarios in the 1992 IPCC update and curve 7 represents the mid range IPCC scenario IS92a. The other curves are from different individual research groups or organisations.

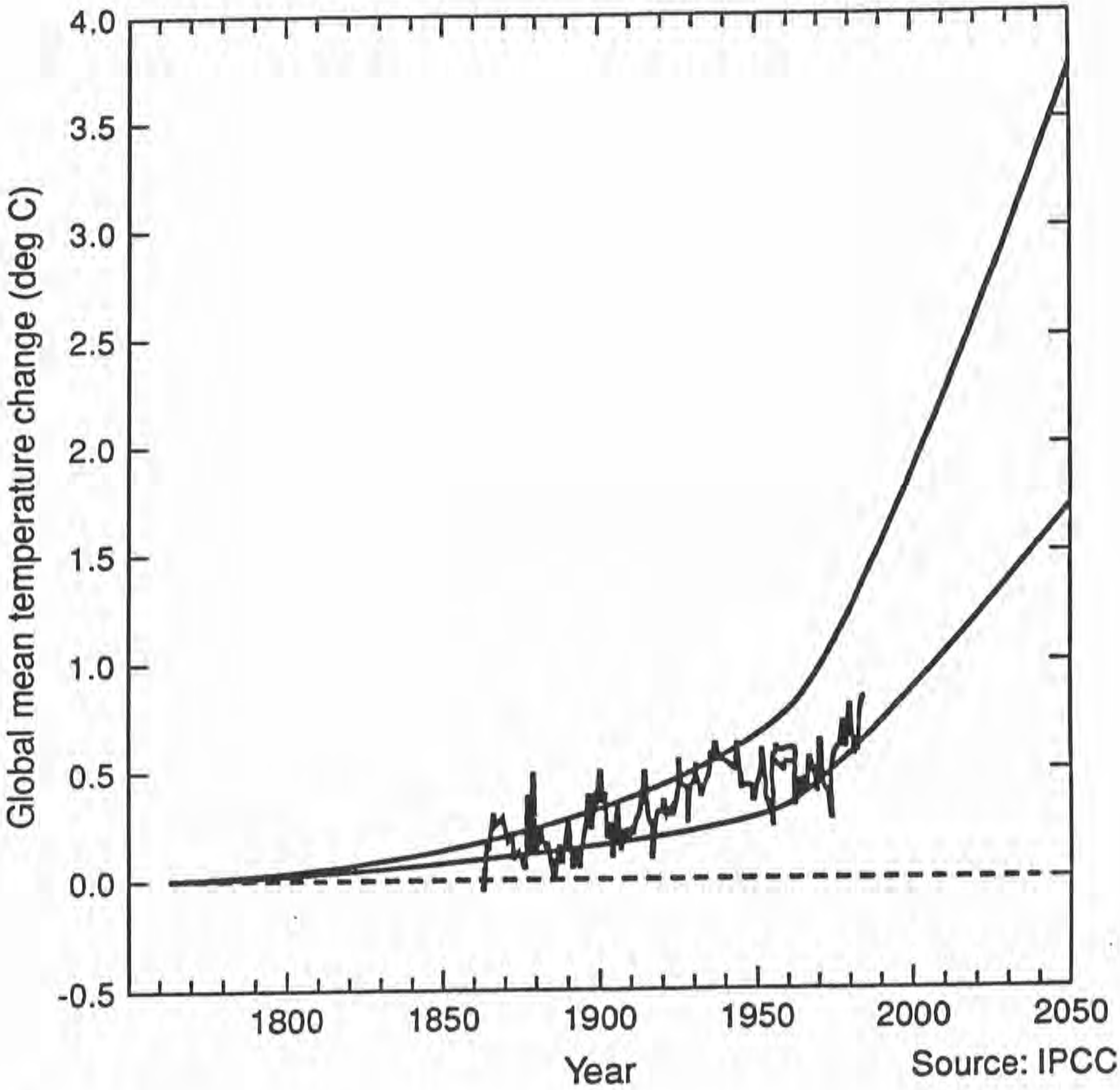
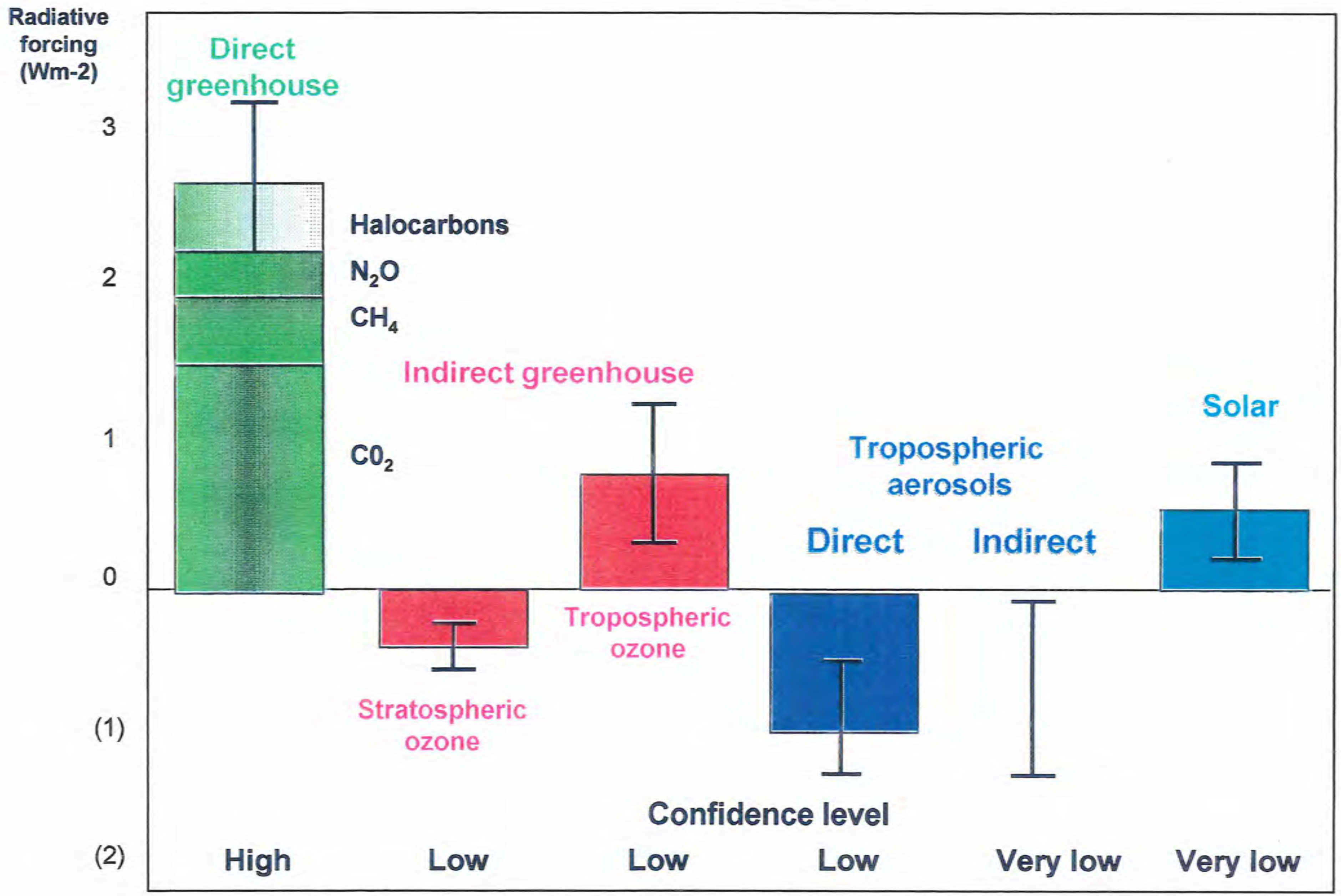


Figure 3
Observed versus predicted global warming. The smooth curves represent the upper and lower IPCC predictions for the warming which would occur with a doubling of pre-industrial CO_2 levels. The irregular curve represents the observed temperature pattern.

Figure 4. Radiative forcing by different factors



Explanation of Figure 4

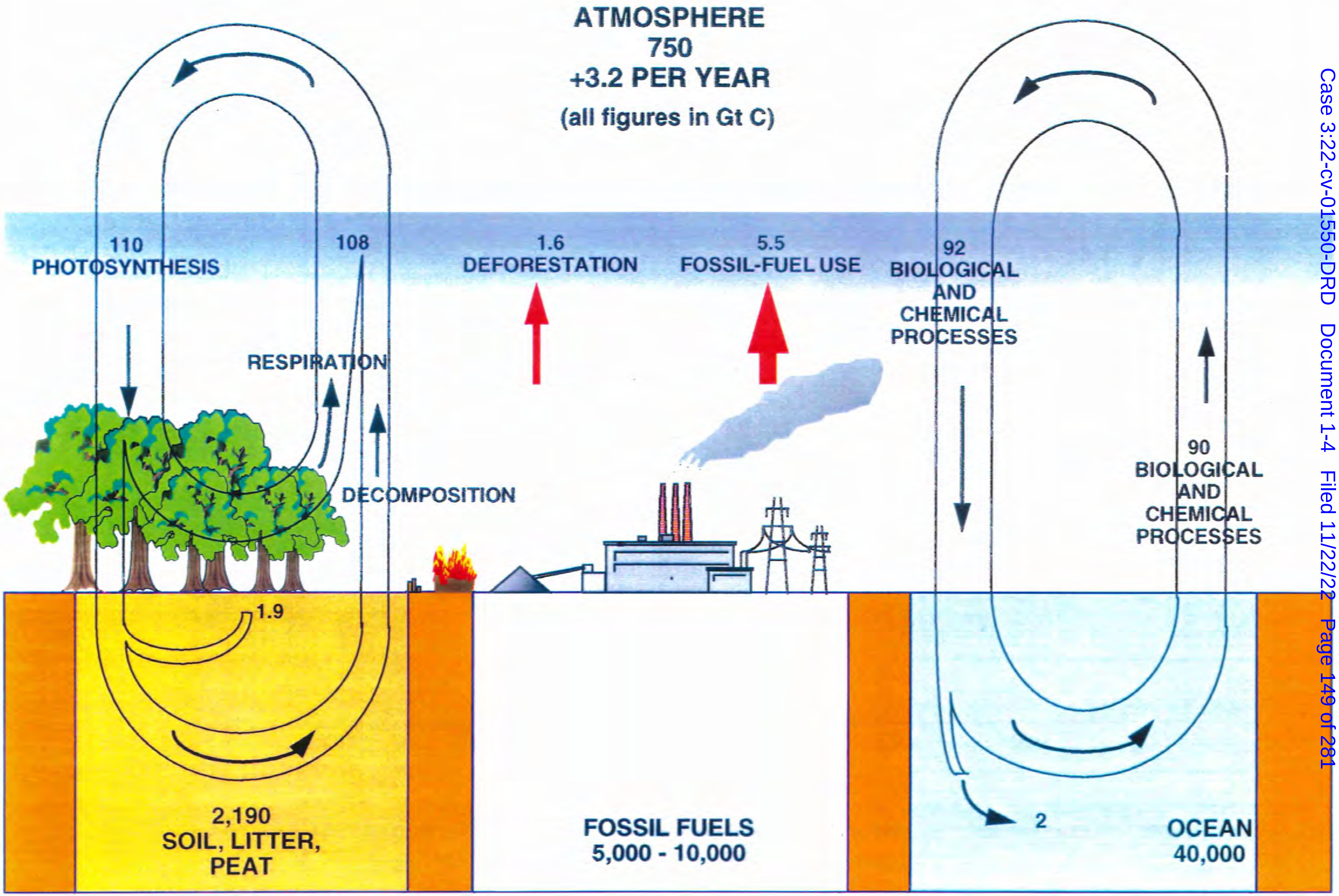
A number of factors contribute to radiative forcing (the enhanced greenhouse effect). Best known are the direct effects of the greenhouse gases themselves(CO_2, CH_4, N_2O, Halo carbons etc.). However, some of these gases, such as CH_4, may have indirect effects through chemical reactions in the atmosphere leading to changes in concentration of other radiatively active gases, especially ozone and water vapour. Tropospheric aerosols have direct effects through reflection of radiation back into space, as well as indirect effects, e.g. through promotion of cloud formation.

The figure shows estimates of the relative contributions to radiative forcing of the different factors. Measurements are made in Wm^{-2} and the bars show the confidence intervals. The total direct enhanced greenhouse gas radiative forcing of 2.5 Wm^{-2} is approximately 1% of incoming solar radiation. This is a small but nonetheless important figure.

Changes in solar radiation are also believed to have made a small contribution to the total radiative forcing.

The combined negative forcing of tropospheric aerosols and stratospheric ozone may have offset the positive direct effects of the greenhouse gases. However, the confidence level in such conclusions is low.

FIGURE 5


ATMOSPHERE
750
+3.2 PER YEAR
(all figures in Gt C)
110
PHOTOSYNTHESIS
108
RESPIRATION
DECOMPOSITION
1.6
DEFORESTATION
5.5
FOSSIL-FUEL USE
92
BIOLOGICAL
AND
CHEMICAL
PROCESSES
90
BIOLOGICAL
AND
CHEMICAL
PROCESSES
1.9
2,190
SOIL, LITTER,
PEAT
FOSSIL FUELS
5,000 - 10,000
2
OCEAN
40,000

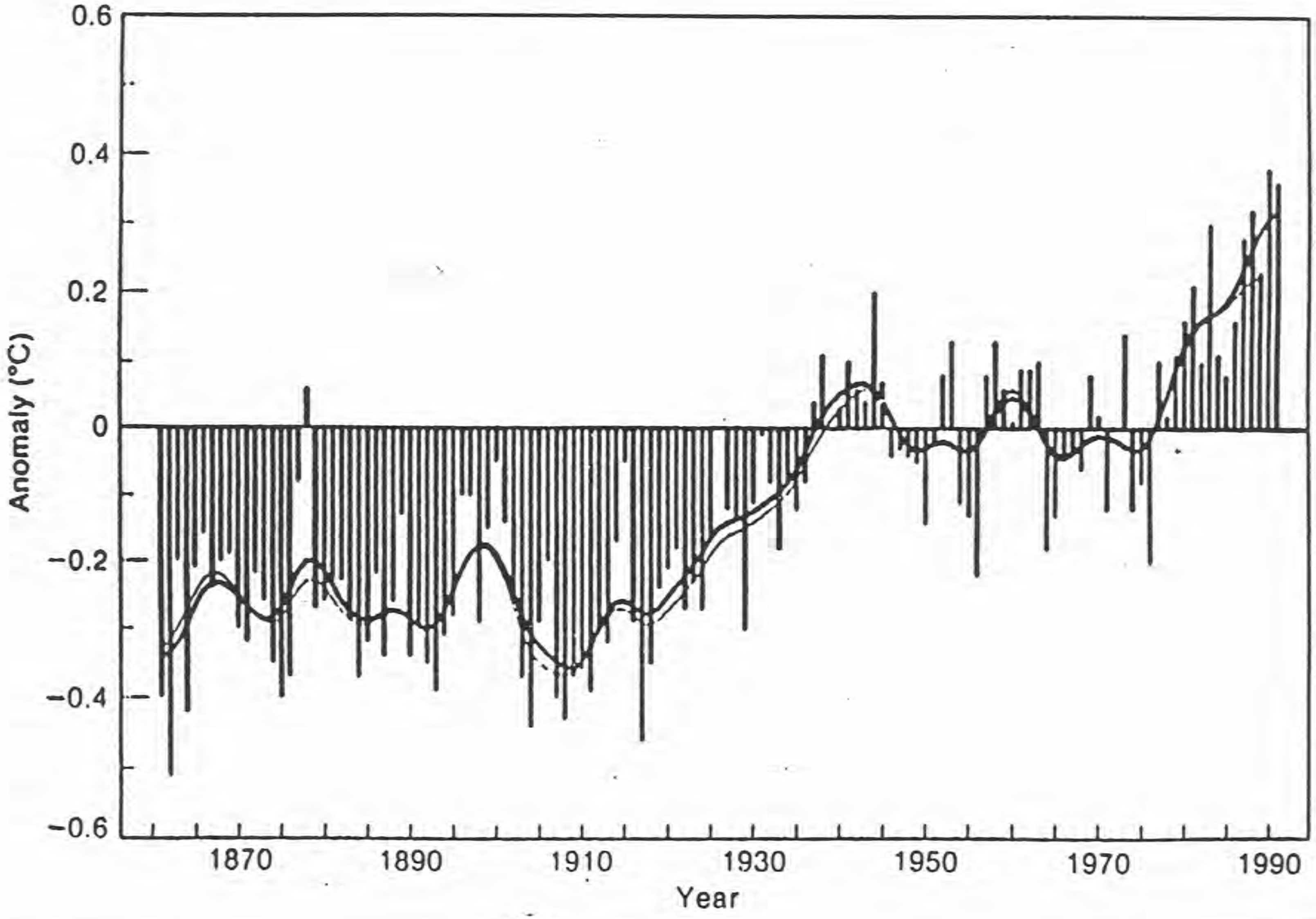
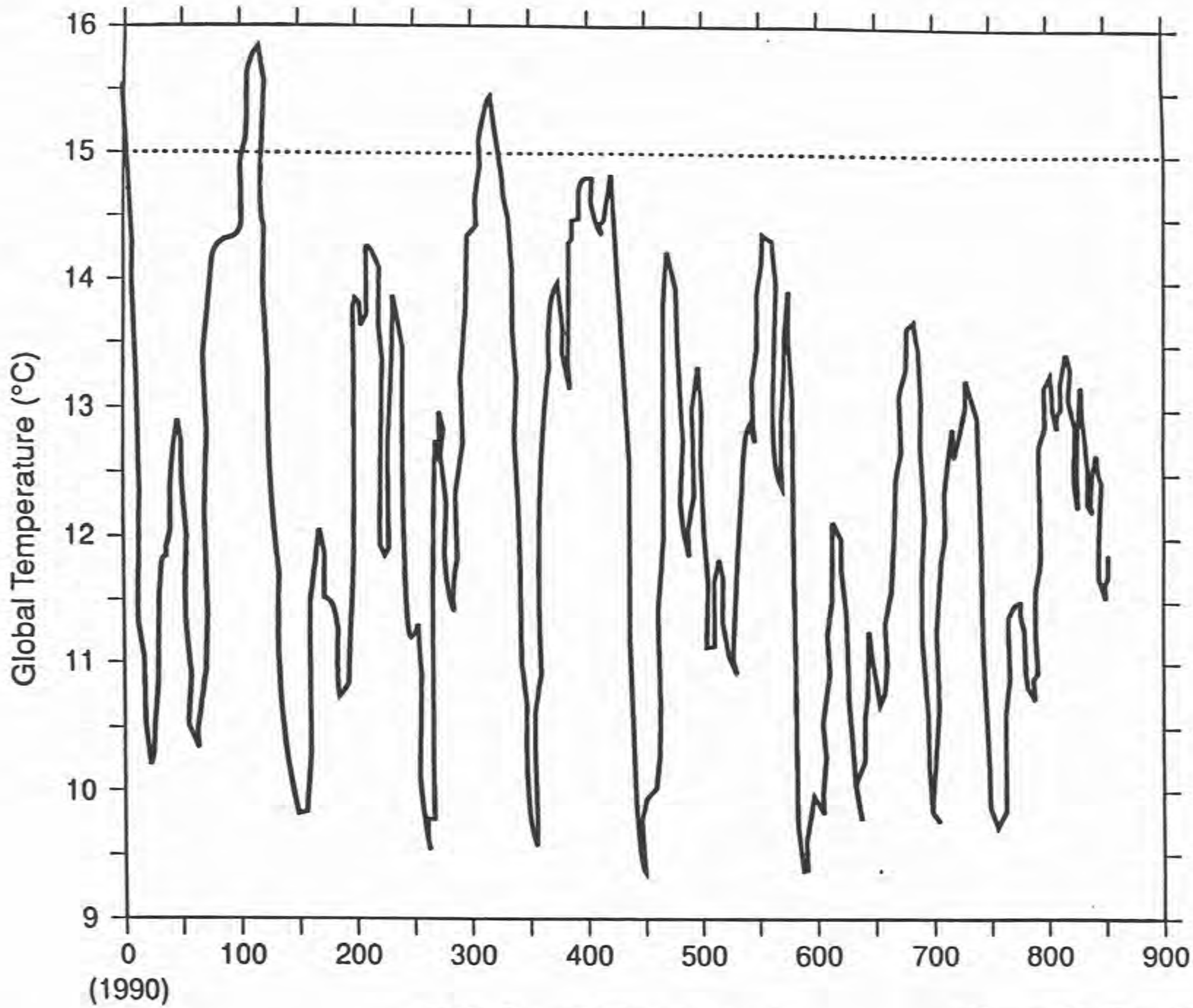


Figure 6. Combined land, air and sea surface global temperature anomalies, 1861-1991, relative to 1951 - 1980

SOURCE : Climate Change 1992. The Supplementary Report to The IPCC Scientific Assessment.



Source: Balling, The Heated Debate

Figure 7
Long term fluctuation of global mean temperature

Production: Shell Reprographics (ODHC/13), The Hague ®

EXHIBIT 31

AIAM
The World's Leading Automakers®

TECH-96-29
1/18/96

TO: AIAM Technical Committee

FROM: Gregory J. Dana
Vice President and Technical Director

RE: **GLOBAL CLIMATE COALITION (GCC) - Primer on Climate Change Science - Final Draft**

Enclosed is a primer on global climate change science developed by the GCC. If any members have any comments on this or other GCC documents that are mailed out, please provide me with your comments to forward to the GCC.

GJD:ljf

Mobil Oil Corporation

ENVIRONMENTAL HEALTH
AND SAFETY DEPARTMENT
P.O. BOX 1031
PRINCETON, NEW JERSEY 08543-1031

December 21, 1995

To: Members of GCC-STAC

Attached is what I hope is the final draft of the primer on global climate change science we have been working on for the past few months. It has been revised to more directly address recent statements from IPCC Working Group I and to reflect comments from John Kinsman and Howard Feldman.

We will be discussing this draft at the January 18th STAC meeting. If you are coming to that meeting, please bring any additional comments on the draft with you. If you have comments but are unable to attend the meeting, please fax them to Eric Holdsworth at the GCC office. His fax number is (202) 638-1043 or (202) 638-1032. I will be out of the office for essentially all of the time between now and the next STAC meeting.

Best wishes for the Holiday Season,

Lenny

L. S. Bernstein

APPROVAL DRAFT

Predicting Future Climate Change: A Primer

In its recently approved Summary for Policymakers for its contribution to the IPCC's Second Assessment Report, Working Group I stated:

> ...the balance of evidence suggests that there is a discernable human influence on global climate.

The Global Climate Coalition's Science and Technical Advisory Committee believes that the IPCC statement goes beyond what can be justified by current scientific knowledge.

This paper presents an assessment of those issues in the science of climate change which relate to the ability to predict whether human emissions of greenhouse gases have had an effect on current climate or will have a significant impact on future climate. It is a primer on these issues, not an exhaustive analysis. Complex issues have been simplified, hopefully without any loss of accuracy. Also, since it is a primer, it uses the terminology which has become popular in the climate change debate, even in those cases where the popular terminology is not technically accurate.

Introduction and Summary

Since the beginning of the industrial revolution, human activities have increased the atmospheric concentration of CO_2 by more than 25%. Atmospheric concentrations of other greenhouse gases have also risen. Over the past 120 years, global average temperature has risen by 0.3 - 0.6°C. Since the Greenhouse Effect can be used to relate atmospheric concentration of greenhouse gases to global average temperature, claims have been made that at least part of the temperature rise experienced to date is due to human activities, and that the projected future increases in atmospheric concentrations of greenhouse gases (as the result of human activities) will lead to even larger increases in future temperature. Additionally, it is claimed that these increases in temperature will lead to an array of climate changes (rainfall patterns, storm frequency and intensity, etc.) that could have severe environmental and economic impacts.

This primer addresses the following questions concerning climate change:

1) Can human activities affect climate?

   The scientific basis for the Greenhouse Effect and the potential impact of human emissions of greenhouse gases such as CO_2 on climate is well established and cannot be denied.

2) Can future climate be accurately predicted?

   The climate models which are being used to predict the increases in temperature which might occur with increased atmospheric concentrations of greenhouse gases are limited at present both by incomplete scientific understanding of the factors which affect climate and

APPROVAL DRAFT

by inadequate computational power. Improvements in both are likely, and in the next decade it may be possible to make fairly accurate statements about the impact that increased greenhouse gas concentrations could have on climate. However, these improvements may still not translate into an ability to predict future climate for at least two reasons:

- limited understanding of the natural variability of climate, and
- inability to predict future atmospheric concentrations of greenhouse gases.

The smaller the geographic area considered, the poorer the quality of climate prediction. This is a critical limitation in our ability to predict the impacts of climate change, most of which would result from changes in a local or regional area.

3) Have human activities over the last 120 years affected climate, i.e. has the change been greater than natural variability?

Given the limitations of climate models and other information on this question, current claims that a human impact on climate has already been detected, are unjustified. However, assessment of whether human activities have already affected climate may be possible when improved climate models are available. Alternatively, a large, short term change in climate consistent with model predictions could be taken as proof of a human component of climate change.

4) Are there alternate explanations for the climate change which has occurred over the last 120 years?

Explanations based on solar variability, anomalies in the temperature record, etc. are valid to the extent they are used to argue against a conclusion that we understand current climate or can detect a human component in the change in climate that has occurred over the past 120 years. However, these alternative hypotheses do not address what would happen if atmospheric concentrations of greenhouse gases continue to rise at projected rates.

<u>Can Human Activities Affect Climate?</u>

The Sun warms the Earth and is the source of energy for the climate system. However, as shown in Figure 1, the process by which this occurs is complicated. Only about half of the incoming radiation from the Sun is absorbed by the Earth's surface. About a quarter is absorbed by the atmosphere, and the remainder is reflected back into space by clouds, dust and other particulates without being absorbed, either by the surface or atmosphere.

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The energy absorbed by the Earth's surface is reradiated to space as longwave radiation. A fraction of this reradiated energy is absorbed by greenhouse gases, a phenomenon known as the Greenhouse Effect. Greenhouse gases are trace gases - such as water vapor, CO_2, methane, etc. - which have the ability to absorb longwave radiation. When a greenhouse gas molecule absorbs longwave energy, it heats up, then radiates energy in all directions, including back down to the Earth's surface. The energy radiated back to the Earth's surface by greenhouse gas molecules is the Greenhouse Effect that further warms the surface. The warmer the surface of the Earth, the more energy it reradiates. The higher the concentration of greenhouse gases, the more energy they will absorb, and the more they will warm the Earth. The average temperature of the Earth depends on the balance between these two phenomena. Naturally occurring greenhouse gases, predominantly water vapor, account for 95-97% of the current Greenhouse Effect. They raise the average temperature of Earth's surface by about 30°C. Without this natural Greenhouse Effect, the Earth would probably be uninhabitable. The science of the Greenhouse Effect is well established and can be demonstrated in the laboratory.

Human activities can affect the energy balance at the Earth's surface in three ways:

- combustion, agriculture and other human activities emit greenhouse gases and can raise their concentration in the atmosphere, which would directionally lead to warming;

- combustion emits particulates, and gases such as sulfur dioxide which form particulate matter in the atmosphere, which would directionally lead to cooling; and

- changes in land-use, such as removing forests, can change the amount of energy absorbed by the Earth's surface, the rate of water evaporation, and other parameters involved in the climate system, which could result in either warming or cooling.

These three factors create the potential for a human impact on climate. The potential for a human impact on climate is based on well-established scientific fact, and should not be denied. While, in theory, human activities have the potential to result in net cooling, a concern about 25 years ago, the current balance between greenhouse gas emissions and the emissions of particulates and particulate-formers is such that essentially all of today's concern is about net warming. However, as will be discussed below, it is still not possible to accurately predict the magnitude (if any), timing or impact of climate change as a result of the increase in greenhouse gas concentrations. Also, because of the complex, possibly chaotic, nature of the climate system, it may never be possible to accurately predict future climate or to estimate the impact of increased greenhouse gas concentrations.

The usual approach to discussing the impact of the increased atmospheric concentrations of greenhouse gases on climate is to convert them to an equivalent amount of CO_2, then discuss the effect of some fixed increase in equivalent CO_2. Most of the discussion is about doubled equivalent CO_2. The conversion to equivalent CO_2 introduces a number of errors, because the effects of some greenhouse gases depend on their location in the atmosphere, but since the convention is well established, it will be used in this discussion. A more accurate approach is to refer to increased radiative forcing, which is the increase in energy radiated to the Earth's surface, taking into account all of the complexities in the physics of greenhouse gases.

Can Future Climate Be Accurately Predicted?

Climate models, called General Circulation Models (GCMs), are used to predict the change in temperature, rainfall, cloud cover and other climate parameters that would result from a change in equivalent CO_2 and sometimes aerosols. The estimates of climate parameters are then used to predict impacts of climate change, such as frequency and severity of tropical storms, effects on agriculture and biodiversity, etc. While most discussions of models focus on their predictions of changes in average temperature, factors such as changes in maximum and minimum temperature, soil moisture content, and prevalence of conditions which favor the formation of tropical storms are far more important in determining potential climate change impacts.

GCMs are three-dimensional grid models which cover the whole Earth, the atmosphere to a sufficient height to include all climate processes, and the oceans in multiple depth layers. GCMs are also referred to as coupled atmosphere-ocean climate models. Most of the debate about the prediction of climate change centers around the quality of both the models and the input data they use, and the degree to which both can be improved. The concerns about these models can be grouped into five categories:

(1) limits in scientific understanding of climate processes,

(2) how they model "feedbacks,"

(3) how they describe the initial conditions, i.e., the current state of the climate,

(4) how well we understand the natural variability of climate, including the possibility that the climate system is chaotic, and

(5) the computational power required to accurately model climate.

A sixth concern, not directly related to GCMs, but important to the question of whether future climate can be accurately predicted, is whether future atmospheric concentrations of greenhouse gases can be accurately predicted. The problem has two components, economic and scientific. The economic question is whether we can accurately predict both the future

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level of global economic activity and the technology which will be employed. Past predictions in both areas have been highly inaccurate. The scientific question is whether we understand the fate of greenhouse gases well enough to accurately predict the effect their emissions will have on atmospheric concentrations. For example, only about half of the CO_2 emitted from human activities ends up in the atmosphere. The remainder is believed to be absorbed by increased plant growth or in the oceans. Estimates of the amount of CO_2 absorbed by these two sinks are highly uncertain. There is also a great deal of scientific debate on what, if any, impact higher temperatures and related climate change will have on the rate of CO_2 absorption by plants and the ocean.

Limited Scientific Understanding of Climate Processes

Quantifying what we don't know about climate processes is an impossible task. However, the huge volume of important new findings about the processes that are critical to climate generated over the past few years make it obvious that there is a great deal more to be learned about the basic science of climate. For example, in 1995, Prof. Cess and his co-workers at the State University of New York published a paper on the energy balance around clouds which indicated that the values being used in climate models were incorrect by 25%. Cess *et al.* were unable to identify the physical processes which led to this different estimate of energy absorption. Since clouds are a critical part of the climate system, a correct characterization of their properties is essential. Other recent studies indicate that vegetation may be absorbing much more CO_2 than previously believed, allowing less of it to accumulate in the atmosphere.

Feedbacks

Climate models predict that the direct effect of doubling equivalent CO_2 from pre-industrial levels is relatively small. Global average temperature would rise by 0.5 - 1°C, an amount which is not generally considered to represent a problem. However, even that rise in temperature would cause a variety of changes, some of which would act to further increase temperature, others of which would act to decrease temperature. These secondary changes are called "feedbacks." The popular usage is that a positive feedback is one which acts to further increase temperature, and a negative feedback is one which acts to decrease temperature. The technical definition is that a positive feedback is one which exaggerates the initial perturbation, which could either increase or decrease temperature, and a negative feedback is one which decreases the initial perturbation. Since the popular usage is so common, it will be used in this paper.

The most important positive feedback is the impact which rising temperatures will have on the amount of water vapor in the atmosphere. Water vapor is the most important natural greenhouse gas in the atmosphere, accounting for the majority of the natural Greenhouse

Effect. As temperature increases, more water evaporates, the concentration of water vapor in the atmosphere rises, the Greenhouse Effect is enhanced, and temperatures rises further. An example of a negative feedback is that more evaporation of water results in the formation of more clouds. Low level clouds reflect sunlight, preventing its energy from reaching the Earth's surface, thus providing a cooling effect. As noted below, high level clouds provide a positive feedback.

Modeling feedbacks is one the major challenges in developing accurate climate models. The role of clouds is a particularly difficult modeling task. Low level clouds reflect sunlight and therefore are a negative feedback. However, clouds are made up of water vapor and therefore also absorb radiation. For high level clouds the absorption of radiation is more important than the reflection of radiation; they provide a positive feedback. Better estimates of the energy balance around clouds are becoming available, and preliminary modeling results indicate that the use of these better estimates improves the ability of GCM's to match current conditions.

Prediction of Current Conditions

GCMs are supposed to be theory-based models, not empirical models. As such they should be able to match current climate conditions using only the independent variables that determine climate (solar radiation, greenhouse gas concentrations, the current temperature of the oceans, etc.) as inputs. GCMs fail this test because they do not accurately predict the transfer of energy from the oceans to the atmosphere, a critical climate parameter. To correct this error, most GCMs are adjusted with "flux corrections," that on a point-by-point basis adjust the amount of heat being transferred from the oceans to the atmosphere to match actual conditions. The "flux corrections" can be quite large, as much as 10 - 20 times the effect of doubling equivalent CO_2. Having to make this large a correction to obtain model results which provide a reasonable description of the baseline is a cause for serious concern.

Flux corrections are correcting for one of two possible errors: missing climate processes, or errors in the description of the climate processes used in the model. New data, such as a better description of the energy balance around clouds, should lead to improvements in models and a reduction in the flux corrections.

Whether modeling capability will improve to the point where the flux corrections can be eliminated or reduced to a more reasonable level is an open question. To eliminate the flux corrections it is necessary to accurately model all climate processes and have an accurate description of initial conditions. Distribution of heat in the oceans is poorly understood, and the cost of collecting the necessary data makes it unlikely that a better understanding will be developed anytime soon.

Natural Variability and the Possibility that Climate is Chaotic

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Thus far, GCMs have been described as relatively mechanical models - plug in the right processes and initial conditions and the model will describe climate. However, climate has natural variability, on both long and short time scales. The existence of Ice Ages and the warm periods between them is proof of climate's natural variability on very long time scales. But climate is also naturally variable on shorter time scales. For example, the milder temperatures in the North Atlantic at about 1000 AD allowed the Vikings to settle Iceland and Greenland, and explore the North American coast. The colder temperatures of the Little Ice Age after 1400 wiped out the Viking settlement in Greenland and nearly did the same to Iceland. This was climate variability on a time scale of several centuries. To accurately model future climate, we need an good estimate of the natural variability of climate on still shorter periods, decades to a century, which is currently unavailable.

Understanding the natural variability of climate on a decadal time scale and its causes would greatly improve our understanding of current climate data. Reasonable temperature records exist for only the last 120 years. Data on factors which could be causes for the variability of climate, such as changes in ocean circulation, is either non-existent or available for much shorter time periods. Until we have a better understanding of natural variability, it will be impossible to determine whether a part of the rise in average temperature experienced over the past century is due to human activities.

In addition, climate may be a chaotic system, which is extremely sensitive to very small changes in initial conditions. Weather is known to be chaotic, and since climate is the long-term average of weather, it, too, may be chaotic. In discussing the ability of GCMs to simulate climate, IPCC WG I, in section 6.2.6 of its Second Assessment Report, does not use the term chaotic, but states

> The models produce a high level of internal variability, as observed (Chapter 5), leading to a spread of possible outcomes for a given scenario, especially at the regional level.

This is a functional definition of chaotic behavior. The reference to Chapter 5 is to a discussion of the ability of models to describe observed climate over the last 120 years. If climate is chaotic, our ability to predict future climate or the effect of anthropogenic changes such as the increase in greenhouse gas emissions will be limited.

<u>Computational Limits</u>

GCMs are huge models which require supercomputers to run in any reasonable time. Computational limitations require that they use large grid sizes, typically 500 km. on a side. These cells are larger than many of the important physical features in the system they are trying to model, for example, the width of the Gulf Stream. Computational limits also mean that some critical factors, such as the atmospheric interactions between greenhouse gases and the chemistry of aerosol formation, are not included in the model. The rapid increase in computational power may make it possible to overcome these limitations in the future, but at present they severely limit the quality of GCM predictions.

Capabilities of GCMs

Even with flux corrections, GCMs still cannot describe climate features on a 1000 mile scale which are critical to any discussion of the impacts of climate change. Also, there is considerable concern about the ability of GCMs to predict future climate because the flux correction is constant with changing equivalent CO_2. There is no reason to assume that the flux correction should remain the same if climate changes in response to increased CO_2. As a result, statements such as: "Doubling CO_2 will lead to x°C. increase in temperature." do not seem justified.

While climate models currently are incapable of accurate predictions of future climate, rapid improvement in their capability is possible. Better understanding of climate processes, such as the role of clouds, could significantly improve the models as could the ever increasing power of computers. Whether we can ever accurately predict future climate is still uncertain because of two problems. First, as mentioned above, climate may be chaotic. Second, even if climate is not chaotic, a model's predictions are only as good as the input data used. Our ability to predict future greenhouse gas emission rates depends on being able to predict the future level of global economic activity and the technology which will be used to generate that activity. Past predictions in both areas have been highly inaccurate.

A critical problem in climate modeling is the prediction of regional climate change. Most of the impacts of climate change will be felt on the regional or local level. The change in global average temperature and rainfall will not help predict the effect of climate change on farmers in the mid-West. The ability to predict regional climate change is poorer than the ability to predict global climate change. The IPCC sums up the situation as follows:

> Confidence is higher in hemispheric-to-continental scale projections of coupled atmospheric-ocean models than in the regional projections, where confidence remains low.

Have Human Activities Over the Last 120 Years Affected Climate?

As part of its contribution to the IPCC (Intergovernmental Panel on Climate Change, the UN body charged with assessing the peer-reviewed literature on the science, impacts and economics of climate change) Second Assessment Report, WG I (Working Group I, the sub-group assessing science), after considering the uncertainties in the scientific information, concluded:

> Nevertheless, the balance of evidence suggests that there is a discernable human influence on global climate.

This statement is stronger than those which appeared in the draft of the underlying report, where the authors stated:

> Any claims of positive detection and attribution of significant climate change are likely to remain controversial until uncertainties in the total natural variability of (the) total climate system are reduced.

As used by the IPCC,

> "Detection of change" is the process of demonstrating that an observed change in climate is highly unusual in a statistical sense, but does not provide a reason for the change. "Attribution" is the process of establishing cause and effect relations, including the testing of competing hypotheses.

At the conclusion of the WG I Plenary Session that approved the statement on a human impact on climate, the authors of the underlying report were instructed to modify their report to bring it into agreement with the summary statement. This process is the reverse of what is called for by the IPCC rules of procedure and normal scientific practice.

WG I considered four types of information in evaluating whether the observed change in climate was in fact "highly unusual in a statistical sense," and whether it could be attributed to human influences. A discussion of each type of information follows. Specific scientific studies are mention in three cases; they are the studies which have received the most publicity, but are not the only studies in the category.

1) Model-based estimates of natural variability - The Max Planck Institute (MPI), a German government laboratory and developer of one of the GCMs, ran their model for 1000 years into the future with only random perturbations to assess "natural" variability of temperature. They then determined, with 95% confidence, that the changes in temperature observed over the last 100 years could not be explained by their measure of "natural" variability. German politicians and press have reported this result as meaning that there is 95% confidence that the temperature changes of the last 100 years have been caused by human emissions of greenhouse gases, a significant overstatement of the scientific finding.

   The MPI finding does not prove that the temperature changes of the last 100 years are due to human greenhouse gas emissions for two reasons:

- Models are simplifications and therefore less variable than the real world. Actual "natural" variability of temperature is almost certain to be larger than the estimate from the MPI computer study.

- The temperature change of the past 100 years may be due to natural changes in climate. Changes of this magnitude have occurred naturally in the past without any human influence. Section 3.6.3 of IPCC WG I's contribution to the Second Assessment Report states:

  "The warming of the late 20th century appears to be rapid, when viewed in the context of the last millennium. But have similar, rapid changes occurred in the past? That is, are such changes a part of the natural climate variability? Large and rapid changes did occur during the last ice age and in the transition toward the present Holocene period which started about 10,000 years ago. Those changes may have occurred on the time scale of a human life or less, at least in the North Atlantic, where they are best documented. Many climate variables were affected: atmospheric temperature and circ, precipitin patterns and hydrological cycle, temperature and circulation of the ocean."

2) Pattern-based studies - The Hadley Centre, a U.K. government laboratory and the developer of another GCM, has added sulfate aerosol effects to its model and calculated temperature from 1860 to 2050. The addition of aerosol effects provides an improved, but still relatively poor, match for observed temperature from 1860 to the present, and addresses one of the key concerns about climate models, their inability to "backcast" the temperature record. The study ties the increase in temperature over the past 100 years to emissions of greenhouse gases and aerosols.

There are two concerns about the Hadley Centre's work:

- They considered only the direct effect of sulfate aerosols, i.e., their scattering of incoming sunlight. They did not consider the indirect effects of the aerosols - their impact on cloud formation - which could have an equally large impact on temperature.

- Adding historical sulfate aerosol effects to the model requires a large number of assumptions about fuel usage rates and emission factors which cannot be tested. The validity of this approach is suspect.

The draft IPCC report discussed the Hadley Centre study and similar work and concluded:

> While some of the pattern-based studies discussed here have claimed detection of a significant climate change, no study to date has positively attributed all or part of that change to anthropogenic causes. Nor has any study quantified the magnitude of a greenhouse gas effect or aerosol effect in the observed data ...

This statement may also change as a result of the instructions given to authors to bring their report into agreement with the summary statement.

3) Studies of the vertical temperature profile of the atmosphere - Climate models predict that an increase in greenhouse gases should lead to a warmer troposphere but a cooler lower stratosphere. The fact that this pattern has been observed is being used to argue for the fundamental correctness of climate models and for the validity of their predictions that human emissions of greenhouse gases will cause changes in climate. However, the effect may be due to stratospheric ozone depletion rather than to the buildup of greenhouse gases in the troposphere. IPCC WG I's part of the Second Assessment Report (Section 8.4.2.1) cites two studies which could be interpreted as supporting this conclusion. If stratospheric ozone depletion is the cause it is "a human forcing of climate" but a different one from the buildup of greenhouse gases in the troposphere. Model agreement with the stratospheric ozone effect does not "prove" that the model is correct in predicting the effects of greenhouse gases in the troposphere.

4) Statistical models fitted to observations - T. R. Karl and three other researchers at National Climatic Data Center (NCDC) evaluated U.S. climate data since 1910 using an index of specific weather events which included: above normal minimum temperatures, above normal precipitation from October to April, below normal precipitation from May to September, and a greater than normal proportion of precipitation coming from heavy rainfalls. These are the types of climate "signature" that many scientists believe will be the first indication of climate change. Karl *et al.* concluded that there is a 90 - 95% probability that climate in the U.S. since 1976 has been affected by the increase in greenhouse gases in the atmosphere.

MIT researchers question the choice of factors included in the NCDC index, since the index is strictly empirical and has not been developed from basic principles. However, the parameters in the index are variables which other researchers have claimed could change as the result of climate change. As in the case of the other studies claiming to show that there has already been a human impact on climate, one can question whether the observed changes are the result of greenhouse gases or other climate influences.

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The limitations which prevent climate models from accurately predicting future climate also limit their ability to assess whether a human impact on climate has already occurred. Claims that human activities have already impacted climate are currently unjustified. However, the improvements in climate models could make an assessment of human impacts on climate possible. Alternatively, a sufficiently large, short term change in climate consistent with model predictions could be used as proof of a human impact on climate.

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Are There Alternate Explanations for the Climate Change Which Has Occurred Over the Last 120 Years?

Several arguments have been put forward attempting to challenge the conventional view of greenhouse gas-induced climate change. These are generally referred to as "contrarian" theories. This section summarizes these theories and the counter-arguments presented against them.

Solar Variability

Contrarian Theory

Solar radiation is the driver for the climate system. Any change in the intensity of the solar radiation reaching the Earth will affect temperature and other climate parameters. Dr Robert Jastrow, Director of the Mt. Wilson Observatory, and others have shown a close correlation between various sun spot parameters, which they believe are a measure of solar intensity, and global average temperature for the past 120 years, the period for which reasonable quality data exist for both sun spots and global average temperature. The correlation has been pushed back to about 1700 using less accurate data for both temperature and sun spots. In addition, observations of Sun- like stars indicate that they show the amount of variability in radiation intensity needed to account for recent changes in the Earth's climate.

More recently, Tinsley and Heelis at the Univ. of Texas have proposed a mechanism by which changes in solar activity can impact on climate in by a mechanism other than the direct change in the intensity of solar radiation impacting on the Earth's atmosphere.

Counter-arguments

Direct measures of the intensity of solar radiation over the past 15 years indicate a maximum variability of less than 0.1%, sufficient to account for no more than 0.1°C temperature change. This period of direct measurement included one complete 11 year sun spot cycle, which allowed the development of a correlation between solar intensity and the fraction of the Sun's surface covered by sun spots. Applying this correlation to sun spot data for the past 120 years indicates a maximum variability on solar intensity of 0.1%, corresponding to a maximum temperature change of 0.1°C, one-fifth of the temperature change observed during that period.

If solar variability has accounted for 0.1°C temperature increase in the last 120 years, it is an interesting finding, but it does not allay concerns about future warming which could result from greenhouse gas emissions. Whatever contribution solar variability makes to climate change should be additive to the effect of greenhouse gas emissions.

The Tinsley and Heelis proposed mechanism may revive the debate about the role of solar variability. To date is has not entered the climate change debate.

APPROVAL DRAFT

Role of Water Vapor

Contrarian Theory

In 1990, Prof. Richard Lindzen of MIT argued that the models which were being used to predict greenhouse warming were incorrect because they predicted an increase in water vapor at all levels of the troposphere. Since water vapor is a greenhouse gas, the models predict warming at all levels of the troposphere. However, warming should create convective turbulence, which would lead to more condensation of water vapor (i.e. more rain) and both drying and cooling of the troposphere above 5 km. This negative feedback would act as a "thermostat" keeping temperatures from rising significantly.

Counter-arguments

Lindzen's 1990 theory predicted that warmer conditions at the surface would lead to cooler, drier conditions at the top of the troposphere. Studies of the behavior of the troposphere in the tropics fail to find the cooling and drying Lindzen predicted. More recent publications have indicated the possibility that Lindzen's hypothesis may be correct, but the evidence is still weak. While Lindzen remains a critic of climate modeling efforts, his latest publications do not include the convective turbulence argument.

APPROVAL DRAFT

Anomalies in the Temperature Record

Contrarian Argument

The temperature record of the last 120 years cannot be explained by greenhouse gas emissions, which rose steadily through that period. If greenhouse gases were the explanation for recent climate, one would have expected temperature also to have risen steadily through the period. However, temperature rose from 1870 to 1930, then the leveled off to 1940, dropped between 1940 and 1970, and has been rising since 1970.

Counter-arguments

While atmospheric concentrations of greenhouse gases have risen steadily since 1870, their total increase has been too small for greenhouse warming to be distinguishable above the cooling effect of aerosols and the variability caused by all of the other factors which affect climate (volcanic eruptions, solar variability, random variability possibly due to the chaotic nature of climate, etc.). This does not mean that a further increase in greenhouse gas concentrations will not add to measurable warming.

Contrarian Argument

Satellite measurements covering over 98% of the globe indicate that global average temperature has decreased slightly over the past 15 years, during a time when land-based temperature measurements indicated a series of record high temperatures.

Counter-arguments

Satellites measure the average temperature of a column of air from the surface to about 6 km. above the surface, while the land-based measurements are surface measurements. Also, the land-based measurements are for land only. The oceans, which cover 70% of the Earth's surface, are not included. The oceans would be expected to warm more slowly than the land surface, lowering global average temperature.

While raw data from the satellite measurements indicate a cooling of 0.06°C/decade, correcting the raw data for known effects (volcanos and periodic warming of the Eastern tropical Pacific Ocean as part of the El Nino cycle), yields 0.09°C/decade warming. The corrected satellite measurements still do not agree with the land-based temperature record, but they both show warming.

APPROVAL DRAFT

Detailed temperature records do not agree with predictions about greenhouse warming. Prof. Patrick Michaels of the University of Virginia presented a series of hypotheses about how greenhouse warming should affect temperature. Only two will be discussed in detail.

First, if greenhouse gases were responsible for the increase in global average temperature, one would expect daytime maximum temperatures to increase. What is actually happening is that daytime maximum temperatures are staying constant, while nighttime temperatures are increasing. Michaels argues that the increase in nighttime temperatures is due to the urban heat island effect.

Second, one would also expect Northern Hemisphere temperatures to have increased more than Southern Hemisphere temperatures, since greenhouse gas concentrations are higher in the Northern Hemisphere. However, Southern Hemisphere temperatures have increased more than Northern Hemisphere temperatures. Michaels argues that the smaller increase in the Northern Hemisphere is due to cooling by aerosols, a position which is now becoming generally accepted.

While some scientist argue that greenhouse warming has already occurred, most say that it cannot be separated from all of the other factors affecting climate, including the urban heat island effect and aerosol cooling. Thus, the fact that the recent temperature record does not agree in detail with a greenhouse gas warming scenario does not diminish the potential threat from substantially higher atmospheric concentrations of greenhouse gases.

Conclusions about the Contrarian Theories

The contrarian theories raise interesting questions about our total understanding of climate processes, but they do not offer convincing arguments against the conventional model of greenhouse gas emission-induced climate change. Jastrow's hypothesis about the role of solar variability and Michaels' questions about the temperature record are not convincing arguments against any conclusion that we are currently experiencing warming as the result of greenhouse gas emissions. However, neither solar variability nor anomalies in the temperature record offer a mechanism for off-setting the much larger rise in temperature which might occur if the atmospheric concentration of greenhouse gases were to double or quadruple.

Lindzen's hypothesis that any warming would create more rain which would cool and dry the upper troposphere did offer a mechanism for balancing the effect of increased greenhouse gases. However, the data supporting this hypothesis is weak, and even Lindzen has stopped presenting it as an alternative to the conventional model of climate change.

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EXHIBIT 32

Changing Weather?
Facts and Fallacies About Climate Change

A Report Prepared by Accu-Weather, Inc.

Summary Fact Sheet

Does climate change naturally? Yes.

- Significant long-term changes in the Earth's climate have occurred in the past and, no doubt, will occur again.
- The authors have found that scientific evidence disputes the hypothesis that extreme weather events, allegedly associated with global warming, are already present. The authors are not alone in this opinion.
- Historical and observational data and an understanding of the theoretical issues of climate suggest that man's activities do not appear to be a significant agent of climate change.

Is the slight increase in temperature over the past century significant? No.

- Global air temperatures, as measured by satellites and land-based weather stations, show an increase of only some 0.45 degrees Celsius over the past century, well within limits of natural variation. However, biases such as urban heat islands may skew the data to indicate more warming than actually occurred. Moreover, much of the observed temperature increase during the past century occurred before the increase in greenhouse gas emissions.

Is the weather more variable today than it was 50 to 100 years ago? No.

- The authors conclude that the development and intensity of tropical storms is not directly related to sea surface temperatures. In fact, they found no correlation between the intensification (or maximum intensity) of tropical storms and sea surface temperature.
- That many people today think the weather is more extreme than it used to be is at least partially the result of the media's ability to report worldwide events virtually instantaneously, including the weather. In the past, few people in the United States were aware of these events.
- Similarly, the perceived increase in catastrophic weather is in part the result of the fact that more people live in coastal areas today, raising the likelihood that when a storm or flood strikes, property damage will be great.
- The number of U.S. deaths caused by natural weather disasters has declined during the latter part of this century, while the dollar value of property damage has increased dramatically. The reason is that people have continued to settle or vacation in coastal areas prone to flooding and hurricanes, increasing property values. At the same time, however, weather forecasters have improved their ability to track storms and alert people to potential danger, allowing them time to evacuate or take safety precautions.

Greenhouse gases have increased. Has global warming begun? No.

- There is no consistent, obvious signal announcing the presence of catastrophic global warming in any of the data the authors examined.

- There is a general consensus in the scientific community that there has been a gradual increase of about 0.45 degrees Celsius in the average global temperature since the late 1800s. However, that increase is certainly within the limits of natural variability.

- Most important, a significant fraction of the air temperature increase occurred between 1916 and the mid-1940s -- before the rapid increase in carbon dioxide emissions. Indeed, there is very little evidence of any warming in the global air temperature during the past one to two decades.

- Analysis of current temperature data in the Southern and Northern Hemispheres indicates that sources such as aerosols are not masking a substantial global temperature increase.

Do climate models accurately predict the Earth's future climate? No.

- The climate system is so complex that a model incorporating all the possible variables for all parts of the globe could not be run on even today's fastest, most advanced super-computers.

- Currently, no one understands all the myriad physical processes at work in the atmosphere, so no general circulation model has been able to fully incorporate these processes in its calculations. Models are, therefore, incomplete.

- Scientists do not fully understand the physics of the climate system and today's general circulation models have very low levels of resolution. This limitation severely restricts the modeler's ability to predict regional climate.

- Newer, more complex computer models indicate that increases in atmospheric carbon dioxide may result in significantly smaller temperature increases than first thought.

Will the climate continue to change? Yes.

- Hurricanes, tornadoes, floods and droughts with a similar intensity and frequency to those that have occurred in the past can be expected to occur in the future.

- With world population growing and people continuing to build in previously uninhabited areas, world governments, the insurance industry and others need to prepare to handle extreme weather events.

- Research is needed to improve climate models, as well as our understanding of the factors that influence climate. Observational studies also are needed in order to better document the Earth's variable climate.

A complete copy of the Accu-Weather report is available from the Global Climate Coalition, 1331 Pennsylvania Avenue, NW, Suite 1500 - North Tower, Washington, D.C. 20004-1703, (202) 367-3158.

EXHIBIT 33

Global warming: who's right?

Facts about a debate that's turned up more questions than answers

EXXON CORPORATION
Fall 1996

From the chairman

Climate change: don't ignore the facts

The issue reaches into every home and pocketbook around the world.

by Lee R. Raymond
Chairman, Exxon Corporation

In the debate over global climate change, one of the most critical facts has become one of the most ignored – the undeniable link between economic vitality and energy use.

Achieving economic growth remains one of the world's critical needs, and with good reason. It creates more and better jobs, improves our quality of life and enables us to safeguard the environment. When economies grow, their energy consumption rises. It's no accident that nations with the highest standard of living have the highest per-capita use of energy, about 85 percent of which comes from fossil fuels.

Today, however, a multinational effort, under the auspices of the United Nations, is under way to cut the use of fossil fuels, based on the unproven theory that they affect the earth's climate.

In July, the U. S. administration, without full public discussion and debate, and to the surprise of nearly everyone, proposed the concept of a binding international agreement requiring developed nations to reduce greenhouse gas emissions after the year 2000, and committed the United States to such an agreement. This policy, if implemented, has ominous economic implications that could touch pocketbooks and impair lifestyles throughout and even beyond the industrialized world.

'Achieving economic growth remains one of the world's critical needs...'

Developing nations, which will account for most of the growth in greenhouse gas emissions, are excluded from most emission-reduction proposals, but they're not immune to their impact. In our increasingly integrated world economy, policies that limit growth in industrialized nations affect trade with developing nations and hinder their economies as well.

This would have profound implications since developing nations face real and immediate problems. The World Bank says one-third of the world's population lacks adequate sanitation and more than one billion people are without safe drinking water – conditions that inevitably lead to disease and suffering. Solving these problems as populations increase requires economic growth, which, in turn, requires rising energy use.

Politicization stirs fears

Proponents of the global warming theory say that higher levels of greenhouse gases – especially carbon dioxide – are causing world temperatures to rise and that burning fossil fuels is the reason. (See *Global Warming – What to Think? What to Do?,* page 4.) Yet scientific evidence remains inconclusive as to whether human activities affect global climate.

While the atmospheric concentration of greenhouse gases is increasing, 96 percent of the carbon dioxide entering the atmosphere is produced by nature and is beyond our control. Even a small increase in these natural-source emissions could negate any cuts made in the 4 percent of emissions caused by humans. Moreover, forecasts show that even if developed nations reduced their carbon dioxide emissions to zero today, the overall level of atmospheric concentrations of CO_2 would continue to rise because of growth in the developing world.

Unfortunately, huge economic consequences and scientific uncertainty have not prevented activists from politicizing the issue and trying to stir up unreasonable fears. They say the industrialized world should cut back on the use of fossil fuels and that developed nations should agree to legally binding actions by the end of next year. This stance overlooks the need for longer-term research to determine whether human activity impacts global climate.

High costs ignored

In advocating this course of action, proponents ignore the significant costs of mandated reductions in energy use. Every credible forecast predicts continued economic growth and increased consumption of fossil fuels in both industrial and developing nations. The International Energy Agency has said that regardless of what assumptions it makes about economic growth, energy prices and energy efficiency, it sees global energy demand growing substantially.

Meeting unrealistic targets for reductions in greenhouse gas emissions will require extreme measures involving increased central government control over energy use. Such measures would include higher energy taxes, fuel rationing and other steps designed to limit energy consumption.

Studies by authoritative organizations such as DRI and Charles River Associates show that taxes required to reduce fossil fuel use to 1990 levels would be substantial. They could add about 60 cents to the price of a gallon of gasoline in the United States, more than quadrupling the federal excise tax on motor fuel, and could raise the price of residential and commercial fuels by 50 percent. The effect of such taxes could be slower economic growth, job losses and impaired ability to compete in foreign markets.

Worldwide fuel rationing

The U.S. administration has also called for the use of "tradable permits" for fuel usage – another term for rationing.

As consumers, we should ask pointed questions about how a worldwide rationing program would work. What international agency would decide how much of what fuel each nation may have "permits" to use? Within each country, who would decide how much gasoline an individual or business could use every month, or how much heating oil one could have for home heating?

Better understanding needed

With these considerations in mind, what's the best way to manage the issue of potential global climate change?

First, we must understand it better, and that's why Exxon is conducting its own research and supports that of others dealing with related science, economics and policy options.

In addition, a constructive approach should consider these points:

- Taking drastic action immediately is unnecessary since many scientists agree there's ample time to better understand climate systems and develop the best long-term strategies.
- Mandating reductions in fossil fuel use now is needlessly expensive. It would force replacement of major portions of energy-consuming capital stock, such as power plants and other facilities, before the end of their useful life. It would be far less costly to replace this equipment when it would normally be retired.
- Policy proposals should undergo careful analysis and disclosure of their economic, social and competitive impacts, and their acceptability and consequences should be tested in thorough and open public debates.
- If action is needed, it should come in the form of truly global measures that include developing nations, since they will account for most of the growth in greenhouse gas emissions.
- Increased efficiency in energy supply and demand should be encouraged by liberalizing trade, opening world markets and reducing government intervention and subsidies. The world needs more opportunities for technology transfer through market mechanisms such as investment. This will help to improve energy efficiency and emissions control in developing countries.
- Natural means of carbon dioxide absorption should be part of the analysis of the issue and any policy approach. Measures could include slowing deforestation and encouraging sound forest management practices.
- Voluntary, market-based steps, along with a better understanding of how humans and ecosystems can adapt to potential climate change, offer the best hope for setting policies that are rational, scientifically sound and cost-effective.

'...poorly considered action on climate change could inflict severe economic damage...'

Dealing with facts

Whatever choices we ultimately make about global climate change, let's build on a foundation of facts. Perhaps the most important is the worldwide need to achieve continued economic growth while minimizing the impact on the environment.

Economic vitality, energy use and environmental protection are strongly interrelated, and the world needs all three. Economic growth improves the quality of life and helps pay the costs of protecting the environment. A strong economy in turn depends on the availability of abundant, competitive, affordable and increasingly cleaner supplies of energy, with price and availability being determined in a freely operating marketplace.

Precipitous, poorly considered action on climate change could inflict severe economic damage on industrialized nations and dramatically change your way of life. Those who say otherwise are drawing on bad science, faulty logic or unrealistic assumptions. We must reject policies that will clearly impose a heavy burden of costs but offer benefits that are largely speculative and undefined.

Lee Raymond

Global warming

We face more questions than answers on almost every aspect of this issue.

by Jonathan H. Adler

Is the world getting too warm?

Residents of parts of central Texas, where the mercury hit 100 degrees F last *February*, might think so.

Across the Atlantic, the British Meteorological Office reported that 1995 was the hottest year on record.

Some say that not only is the earth's temperature rising, but to find out why we need only look in the mirror.

Specifically, it's argued, the burning of oil and other fossil fuels has increased the level of certain gases in the earth's atmosphere. This has enhanced the natural "greenhouse effect," which in turn has caused global warming.

The United Nations issued a summary report, observing in part that "a pattern of climatic response to human activities is identifiable in the climatological record."

But none of this is as clear-cut as it may seem.

While parts of Texas overheated in February, the Northeast endured a brutal winter that dumped more than 75 inches of snow on New York City.

(Some scientists say blizzards and droughts are signs of global warming.)

The British Meteorological Office's declaration of 1995 as the hottest year on record was based on incomplete data and did not meet universal acceptance.

The designation was founded on measurements for only the first 11 months of the year. The figures for December were estimates. In reality, temperatures at the end of the year throughout the Northern Hemisphere took the steepest plunge on record.

Global weather satellites, which have taken the earth's temperature since 1979, found that 1995 was actually an average year.

In addition, Australian researchers reported that temperature data in the Southern Hemisphere did not support the hottest-year conclusion.

As far as the U.N. declaration goes, the full underlying report acknowledged great uncertainty about climate change. It stopped short of blaming human activity for any recent trends.

So what should we think about global warming? Let's start with what's known and agreed on.

The greenhouse effect is real.

The natural greenhouse effect is unquestionably real and definitely a good thing. It's what makes the earth's atmosphere livable.

Certain atmospheric gases, such as water vapor, carbon dioxide (CO_2) and methane, trap solar radiation in the same way a greenhouse traps heat. In this way the gases help warm the planet. If they didn't, the earth would be frigid, desolate and uninhabitable.

The concentration of greenhouse gases in the earth's atmosphere is increasing.

Atmospheric concentrations of greenhouse gases have been on the rise. Since the beginning of the Industrial Revolution, carbon dioxide in the atmosphere has risen by about 28 percent.

The earth's temperature has been rising.

Since 1881, global average temperatures have risen approximately half a degree centigrade.

Both sides in the debate agree on these three points. The arguing begins with the search for cause and effect.

Here are the issues:

Increases in global temperature may or may not be a sign of global warming caused by human activity.

The rise in temperature since the late 19th century could be part of the natural fluctuations that occur over long periods of time. Such fluctuations took the earth in and out of ice ages for millennia.

Satellite measurements, which can record tiny temperature fluctuations caused by the reflection of sunlight off the moon, have shown absolutely no warming trend over the past 17 years. *(See chart, next page.)*

Finally, most of the recorded temperature rise occurred prior to World War II. But it was during the postwar economic boom that human activity produced a significant increase in greenhouse gas emissions.

Predictions of global warming are based on computer models that have proved to be inaccurate.

Most of the predictions cited in the news have been generated by complex computer programs known as general circulation models, or GCMs.

Scientists use these models to simulate the earth's climate and the factors that affect it. These factors range from contours of the planet surface and ocean circulation to the hydrological cycle and albedo (a measurement of sunlight reflected by the earth).

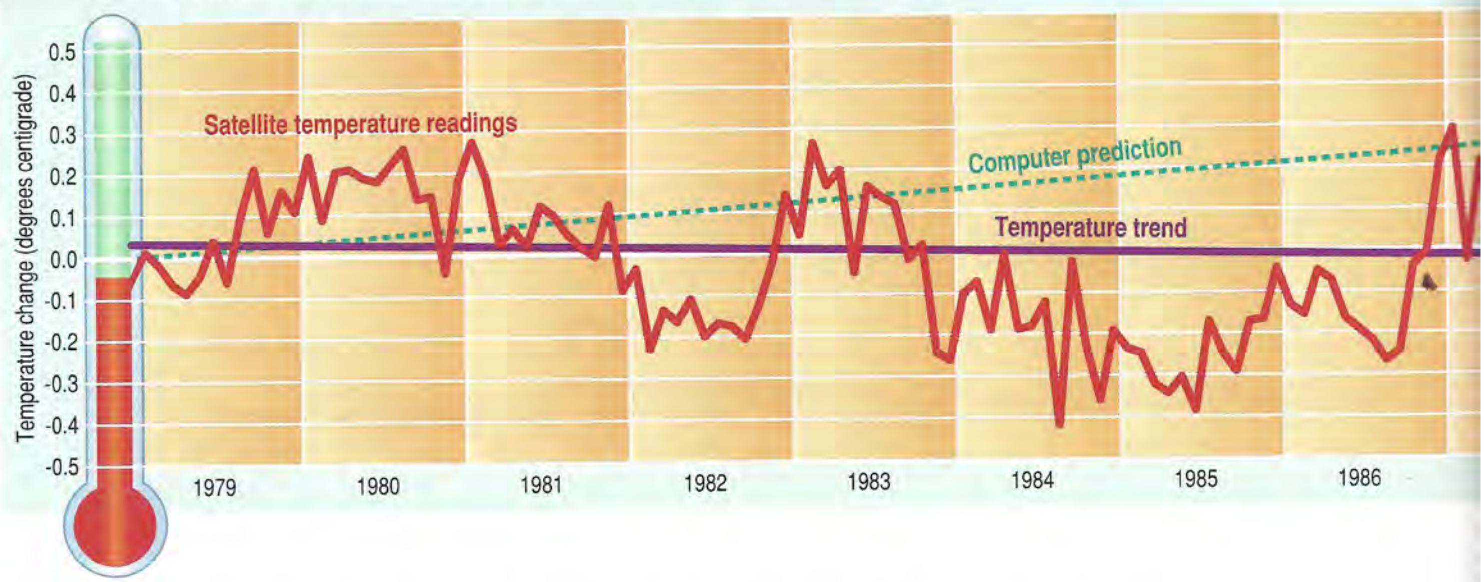
Some scientists point out that computer-based models have been unable to represent current temperatures and climate accurately and are therefore a questionable guide to the next 50 to 100 years. The world has not warmed nearly as much as the models say it should have by now.

The greatest difficulty has been programming the models to accurately

What to think? What to do

Taking the world's temperature

Contrary to computer predictions, precise satellite measurements show no warming trend.



include the many variables affecting climate.

Modelers have had a particularly hard time accounting for the effects of two critical variables – clouds and precipitation. Clouds can have both warming and cooling impacts, and most models significantly underestimate precipitation.

Dr. David Legates, a climatologist at the University of Oklahoma, adds that computer simulations of precipitation are "exceptionally poor," in part because they are unable to replicate actual weather.

As models have improved, predicted temperatures have fallen.

Computer models are becoming more consistent at estimating current temperatures. In the process, they've begun forecasting less extreme temperature rises caused by the accumulation of greenhouse gases.

For example, computer simulations have only just begun to estimate the impact of sulfate aerosols – dispersed particles that could mitigate warming caused by increases in carbon dioxide. When this is added to the models, the result is the lowest projected temperature change generated by a computer model to date.

The model upon which the U.N. based its most recent report predicts a warming of 0.9 to 3.5 degrees C by the year 2100. The lower-bound warming estimate is approximately half that predicted just four years ago.

We need to know more about the effect of solar cycles on global temperature.

Although they're getting better, current computer models may still overestimate observed warming. One possible reason for this is the sun.

As *Science* magazine reported earlier this year, several recent studies have found a correlation between temperature changes and solar cycles.

According to *Science*, "the sun could have been responsible for as much as half of the warming of the past century. If so, the role of greenhouse gases would dwindle – as would estimates of how much they will warm the climate in the future as they continue to build up."

To date, solar cycles have not been incorporated into global climate computer models.

Is global warming good or bad?

Let's say human activity *does* contribute to warming the planet. What would that warming mean?

The earth's climate has changed dramatically over the course of history, and one should not assume that any climatic change is inherently bad. "What matters is *how* the climate changes," notes University of Virginia climatologist Patrick Michaels.

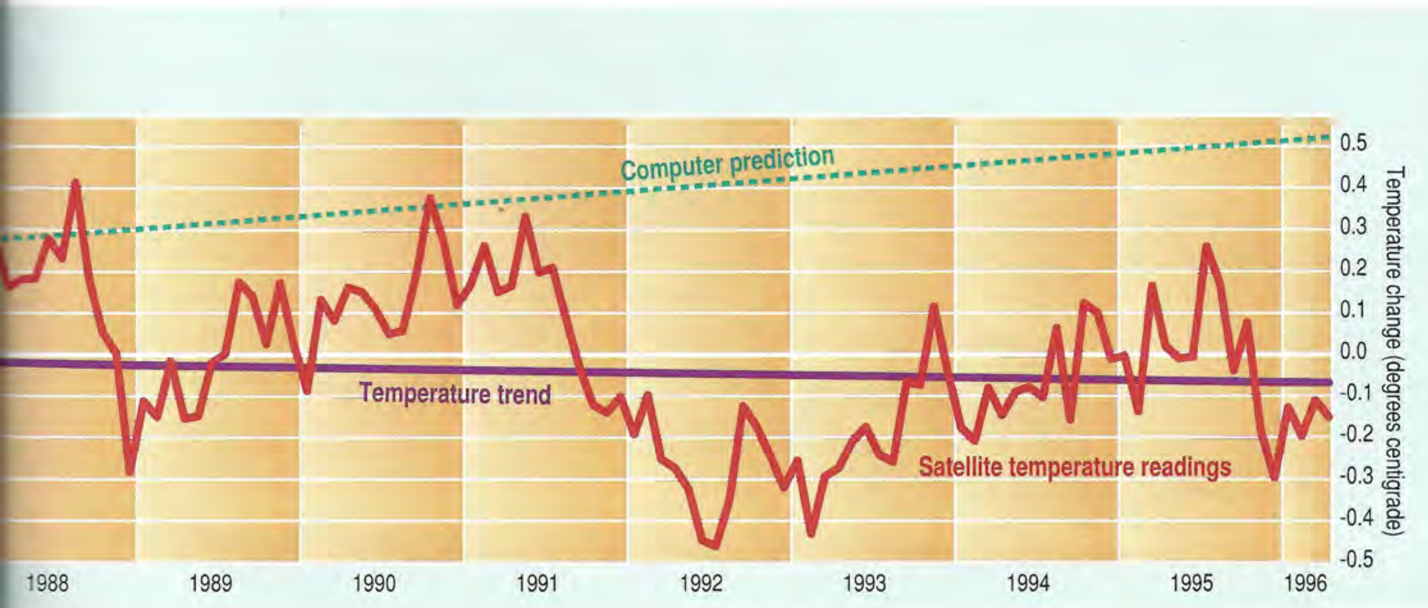
If warming is focused in the summer, we could certainly expect worse droughts and more heat waves.

But warming that occurs mostly during the winter would reduce extreme cold, increase cloud cover and moderate temperature fluctuations. This sort of warming is more likely to raise soil moisture levels than to produce severe droughts.

To the extent that questions about the effects of global warming have been answered, the indications are that a warmer world would be far more benign than many imagine.

Nighttime warming should expand growing seasons, at the same time that higher levels of carbon dioxide accentuate the growth of plants, according to the research of Sherwood Idso at Arizona State University. Thus, an enhanced greenhouse world would be one with more agricultural productivity.

Research at Stanford University's Hoover Institution suggests that a



moderate warming would reduce mortality rates in the U.S., so a slightly warmer climate would be more healthful.

Some claim that global warming will increase the number and severity of tropical storms. On a worldwide basis, precipitation could increase if the world warms up, but tropical storms are still a question mark.

Recent climate modeling suggests that the number of hurricanes and their average wind speed will decline. Slightly warmer winters will also mean that winter storms may be deprived of the frigid polar air masses upon which they depend.

Finally, although changing weather patterns could mean disruption, the human capacity for adaptation has been established throughout recorded time. That adaptability should be taken into account in considering the potential effects of global warming as well.

Clearly, considerable uncertainty exists about future climate change. We are faced with more questions than answers on almost every aspect of this issue, including whether possible changes could be both good and bad.

What steps should we take...and when?

Global questions about global warming

When facing a clear and obvious danger, most citizens expect their government to pursue a course of action that assures their safety and security. But does this mean governments should adopt policies now aimed at dramatically reducing greenhouse gas emissions – at huge economic costs to society?

There is still a tremendous amount of uncertainty about how the climate will change in the 21st century. More certain is the fact that seeking to achieve dramatic reductions in greenhouse gas emissions will require steep cuts in the use of energy from fossil fuels and greatly disrupt the world economy.

Given this uncertainty, what, if any, policy steps should governments take to address global warming?

Some considerations:

Most of the future growth in greenhouse gas emissions will come from developing countries, not the industrialized world.

Although the United States is the world's largest emitter of greenhouse gases, this will change as the economies of China and India expand. Over the next century the U.S. will account for only 10 percent or so of global greenhouse gas emissions.

Yet in 1992 the United States and more than 150 other nations accepted a non-binding aim for industrial nations to reduce their greenhouse gas emissions to 1990 levels by the year 2000.

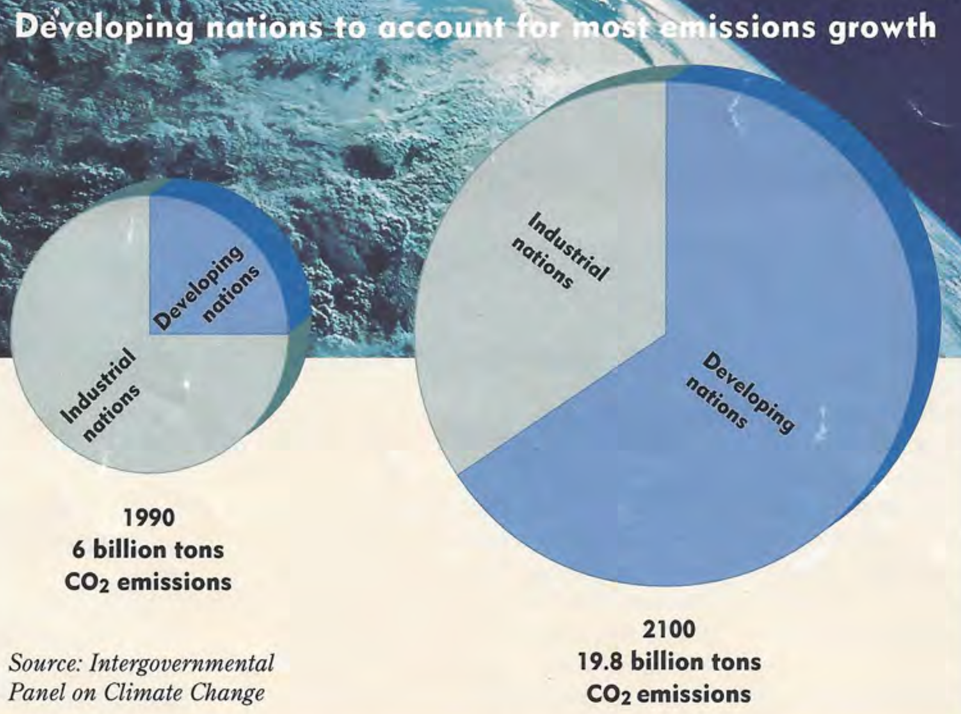
A very limited number of countries will meet this aim. Nevertheless, at a follow-up conference in Berlin last year, delegates from around the world agreed to develop more rigid policy goals for industrial nation emissions beyond the year 2000. Certain political representatives heralded this as an important step toward addressing global climate change.

In July 1996, most delegates at a conference in Geneva reaffirmed this objective, as well as their desire to achieve a legally binding international agreement at a meeting in Japan in December 1997.

However, if predictions of future emissions are right, this agreement will do little about the problem since most of the growth in emissions will occur in the developing world.

"Unless the developing countries

Developing nations to account for most emissions growth



Source: Intergovernmental Panel on Climate Change

participate, it would be impossible to hold global emissions to current levels even if the United States and the [other industrial nations] were to be removed from the picture entirely," says economist W. David Montgomery, an expert on climate change policy.

Developing nations, intent upon growing their own economies to improve living conditions for their citizens, are unwilling to commit to any emissions reductions.

The cost of reducing greenhouse gas emissions could be staggering.

If model predictions are accurate, extreme measures would be necessary on a worldwide basis to prevent global warming.

Researchers at the Worldwatch Institute argue that nations will have to cut emissions to "60 to 80 percent below today's rate" to change the course of predicted global warming significantly. The cost of doing so would be enormous.

For example, a Department of Energy study estimates that reducing carbon dioxide emissions by only 20 percent from 1990 levels within 10 years would eventually cost the United States $95 billion annually.

Another study concludes that applying a carbon tax of $200 per metric ton could raise gasoline prices as much as 60 cents a gallon and boost residential and commercial fuel prices more than 50 percent.

Drastic measures now will not yield significant benefits.

Cutting the emission of greenhouse gases can be viewed as a form of insurance against a potential greenhouse world. But what exactly would these costly premiums buy?

Studies show the projected temperature in the middle of the next century will scarcely be affected whether policies are enacted now or 20 years from now.

In any case, the prestigious journal *Nature* published a recent study that suggests dramatic action now may be premature. Technological advances will make greenhouse emissions reductions easier in the future – if the developing science confirms that such steps are in fact needed.

Notwithstanding the tremendous uncertainty surrounding global warming, delegates from around the world have scheduled several U.N.-sponsored meetings to chart a course for taking drastic action. Specifically, they will seek to negotiate targets and timetables for reducing greenhouse gas emissions in developed countries. Then they will try at the December 1997 meeting in Japan to agree on those plans.

The biggest remaining question is which will we begin to feel first: the possible heat of global warming or the weight of global warming policy?

EXHIBIT 34

REINVENTING ENERGY

MAKING THE RIGHT CHOICES

American
Petroleum
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PREFACE

Why this book, and why now?

Americans want to make the right choices—the right energy choices and the right choices for the environment.

But too often, both individual and public policy decisions are made in an atmosphere of hype and hyperbole rather than reasoned debate. The facts needed to make the right choices can be hard to come by. Amid the assertions and counterassertions, developing a perspective based on reality can be difficult. As a nation we run the very real risk of being mislead into making the wrong choices—choices that will slow our economy and force us to change the way we live.

How then can we make the right energy decisions? By learning the facts about how and why we Americans now use oil as our predominant energy source. The facts about our oil reserves, and how much oil we have to meet our needs. The facts about energy efficiency, and how we make wise energy choices. The facts about the environmental impact of oil use. And the facts about the alternative energy sources that are available. That's what this project was about—bringing together the facts.

Why this book now? The 1994 election dramatically changed the political landscape. And when the status quo is threatened, as it is now, hype and hyperbole have a field day. Some provisions in federal laws that have been passed previously, such as the Clean Air Act amendments of 1990 and the Energy Policy Act, are proving to be unpopular and difficult to implement, and Congress may reconsider them. Other actions by the states, such as electric vehicle and alternative fuel mandates, continue to be controversial.

To make the right energy choices, we owe it to ourselves to examine the facts, reveal the realities obscured by the myths and look objectively at the topic of reinventing energy.

Can we reinvent the energy we use—especially the oil and oil products we rely upon every day—to meet our new environmental standards? We believe it's not only possible, it's right. Here's why.

INTRODUCTION

Reinventing Energy

What does "reinventing energy" mean?

Americans now enjoy a lifestyle that is the envy of much of the world. The natural resources of this nation, the ingenuity and industriousness of its peoples, and the freedom of a democratic form of government and a market economy have combined to produce a record of economic prosperity unmatched in modern history. The automobile has enriched the daily lives of Americans, providing freedom, mobility, convenience and economic opportunities. Abundant U.S. energy resources and technological creativity have been a key to this prosperity and freedom.

The way Americans use energy, however, does not remain static. People have been reinventing how society uses energy since the dawn of civilization. From the discovery that natural oil seeps could be burned for lighting to the adoption of overshot waterwheels that provide power even during floods, technological insight has markedly improved humanity's lot. The evolution from one type of energy to the next is both natural and inevitable, governed by factors such as cost, availability of resources, innovations such as new machinery and consumer preferences.

As energy use has changed, so has the shape and structure of society. As gasoline-powered automobiles replaced horse-drawn carts and then trolley cars for urban transportation, middle-class workers could afford to live in new suburbs.

This evolutionary process of one energy form and transportation mode succeeding another has occurred since people first found that energy could make work easier and provide a more comfortable life.

But some environmentalists and policymakers now question the role of energy—especially oil—to support the American lifestyle. They believe that Americans are making the wrong energy choices, and the resulting pattern of society is one characterized by too many personal automobiles that get too few miles to a gallon of gasoline and strand us all too frequently in gridlock. They believe that Americans pay too little at the pump for their mobility and that, as a result, they pay too much in congestion and pollution. They are concerned that oil and natural gas use is not sustainable, because, as geologically finite resources, logically we'll run out someday. Many warn that exhaustion of oil resources is fast approaching, a view widely shared by the public. They believe that the use of fossil fuels contributes to global climate change, warming the earth's atmosphere over time as a result of industrial activity and vehicle emissions.

Because of these concerns, some environmental activists now advocate government policies that require Americans to make different, potentially wrenching energy choices. In particular, they want Americans to agree that oil is an unacceptable fuel and, therefore, to move away from oil use.

This isn't a matter to be decided lightly. Since oil—especially gasoline—supports the current pattern of our lives, dramatically reducing usage will require both economic and personal sacrifices. Americans deserve to have the facts fully before them before policy decisions are made that change the way we live.

Forcing the use of less oil means restructuring society

To find the facts that will help Americans make knowledgeable energy choices, we must first make sure we're asking the right questions. Is the debate about oil use based on real fears of running out of oil, genuine concerns about global climate change or pollution? Or is it really a critique of the consumer-oriented free market society?

Aaron Wildavsky, in *Speaking Truth to Power: The Art and Craft of Policy Analysis*, gives his perspective:

> "Physical pollution is imbued with cultural significance, and the debate over the integrity of our physical environment complements the debate on so abstract a word as culture. I suggest a small experiment: talk to convinced environmentalists about whether there is a physical shortage of oil in the world. If there isn't you will soon discover, there ought to be. Soon you will see that they rightly love the idea of shortage, for if the supply is running out all sorts of changes from installing solar-energy converters to outlawing large 'gas-guzzling' cars may be mandated. In a word, the controversy over energy policy is a dispute about how we should live."[1]

This is a very different issue—and one that should be discussed openly in a broad public debate before forcing the cost of reducing our reliance on oil and the inconvenience of lifestyle changes on American society.

The purpose of this paper is to discuss the issues that are commonly raised to demand reductions in U.S. oil use, not to tally the pros and cons of American society as we now enjoy it. This study will show that when facts—not commonly held misperceptions—are used, there is no persuasive basis for forcing Americans to dramatically change their lifestyles to use less oil.

A clear picture will lead to the right choices—choices that balance economic and environmental goals. Americans must not base such important decisions on what Robert J. Samuelson has called "psycho-facts: beliefs that, though not supported by hard evidence, are taken as real because their constant repetition changes the way we experience life."[2]

Let's look at the facts about the energy we use and how energy decisions are made, starting with a historical perspective.

Both energy and technology are continuously evolving

Your car and the fuel you use aren't the same as your parents' first car or the fuel they used. The gasolines marketed in the United States in 1995 are the products of years of research and development, both in automotive technology and in manufacturing cleaner-burning fuels. These new generation gasolines will be the fuel for America's future.

Such evolutionary progress is the thread that runs through the history of technology.

Technology brought the machines that transformed an agrarian society into a commercial society, then an industrial society, and now an information-based society. Each changing era has been made possible by the evolving use of energy to power our technology. Each new discovery—the electric light bulb, the internal combustion engine, the fax machine—has brought natural changes to how Americans live and work.

The evolutionary process is neither smooth nor predictable. Technology advances through thousands of minor refinements to processes and machinery, with an occasional leap forward as a serendipitous discovery makes apparent previously unthought of possibilities.

Aside from waterwheels and windmills, the world entered the 18th century without any self-powered machinery. Thomas Newcomen, a small-town blacksmith, labored for 14 years to produce the world's first fossil fuel engine. Installed in a coal mine in 1712, Newcomen's atmospheric engine, powered by coal, delivered about five horsepower of energy to pump water out of the mine. The Newcomen engine remained unchallenged as the world's only self-powered machine for about 60 years. Even under the best of conditions, however, it converted less than 1 percent of the coal energy it consumed into useful pumping power.[3]

Clearly, the Newcomen engine wasn't powerful enough to kick off industrialization. That didn't occur until James Watt began producing his steam engine in 1775. The Boulton & Watt engine used a condenser to cool steam, and was capable of producing the same power output as the Newcomen engine with 75 percent less coal. Put another way, fuel efficiency rose from less than 1 percent in Newcomen's engine to around 4.5 percent in Watt's design.[4] Watt also developed the rotary engine, expanding the potential uses of machine power by enabling steam engines to drive factory machinery. Between 1790 and 1800, more steam engines were built than in the preceding 90 years, setting off the Industrial Revolution.[5]

These steam engines changed society. Factories moved to the city as mills no longer needed to be situated near fast-running streams, and workers moved with them. But steam engines were not the answer to every energy need. Powered by coal, they were too heavy to drive a self-powered carriage.

Engine technology didn't lurch forward again until 1876, when Nikolaus Otto, a self-taught German engineer, developed an engine that used exploding petroleum gases instead of condensing steam to drive the piston. After decades of engineering refinement to solve the problems of fuel handling, ignition, control and cooling, Otto's concept became the internal combustion engine. This engine design was viable because of the potent energy in gasoline, kerosene and other fuels made from oil. It made possible automobiles, airplanes and hundreds of other 20th-century applications—and the society that has evolved around them.

Advances in energy technology have powered economic growth

Advancing technology and more efficient energy usage have contributed to economic growth. Using 1987 dollars, the 1724 Newcomen engine cost approximately $6,125 per horsepower, about 2,000 times as much as the $3 per horsepower typical cost for gasoline automotive engines today.[6]

Currently, oil provides 40 percent of the nation's energy, and natural gas meets another 23 percent. Because of the many positive attributes of oil not shared by other energy sources, oil products—such as gasoline, diesel and jet fuel—are the fuel of choice for 97 percent of U.S. transportation needs. The U.S. Department of Energy projects that the nation's energy future will continue to center around oil.

But new technologies and innovations are being developed every day. Americans will benefit when the fuels that can meet today's environmental standards are allowed to compete on all their merits, including cost and convenience, in the marketplace. This common sense approach will give Americans the most secure and sustainable future.

Balancing economic growth and environmental quality is an ongoing challenge

Economic prosperity has allowed Americans to devote more and more resources to preserving and improving the environment. Not all of the gains from technological progress have been without cost. As the economy grew and the population expanded, some side effects became apparent, generating concerns about the environmental impact of human activity. Our freedom of mobility also produced legitimate concerns about congestion, smog and whether our planet has the "carrying capacity" to sustain the lifestyle we've created for ourselves.

In the 1970s, government started to address these concerns, including the fuels that powered our economy. No fuel is a panacea. All energy sources have advantages and disadvantages. For example, gasoline-powered cars are convenient and inexpensive to run. But vehicle emissions, while a tiny fraction of emissions 30 to 40 years ago, are still considered a problem. These emissions are concentrated in the 10 percent of gasoline-powered cars that are high-emitters—a problem that could be greatly resolved by identifying these cars and encouraging their repair. On the other hand, electric vehicles produce zero emissions from their tailpipes, but power plants produce emissions as they produce electricity. Moreover, electric vehicles travel a much shorter distance than gasoline-powered cars before they need recharging; they also cost more. Other forms of energy for transportation—from natural gas to methanol to solar power—have their own unique economic, technological or environmental advantages and disadvantages. So a perfect solution for fuels, like other environmental issues, has yet to be found.

Government has a role in minimizing pollution, protecting the nation from the economic effects of interruptions in U.S. oil supplies, and addressing the threat of global climate change. It should establish policies that set goals specifying realistic objectives when dealing with serious health and environmental risks. The private sector has implemented many of these policies, often reinventing our use of energy to balance our needs with environmental concerns. Much progress has been made—and it will continue. But striking the right balance between our economy, our lifestyles and our desire for a better environment is a challenge—and continues to be the subject of intense debate.

Some advocate forcing America away from oil use

Some people are now suggesting that the concerns associated with fossil fuels—especially oil—are so serious that the United States should stop relying on them. Instead of encouraging our use of energy to continue to evolve to meet our nation's needs, they believe that government policies should radically intervene and force American society to reduce its oil use.

Many environmental activists and like-minded government officials in Washington, state capitals and even around the world advocate a mandatory reduction in the use of fossil fuels—coal, oil and maybe even natural gas. In particular, environmentalists have singled out oil and oil products such as gasoline and diesel fuel, and advocate forced cutbacks in their use. They assert that the change is so powerfully justifiable that Americans should be required to use less oil for transportation, heating homes and producing goods—regardless of economic or lifestyle consequences.

Here is a sampling of these views:

> "If the environmental revolution succeeds, it will be based on a shift away from fossil fuels. We eventually have to phase out fossil fuels."
>
> —Lester Brown, president of Worldwatch Institute, an environmental research group[7]

> "To avoid the risk of potentially catastrophic climate shifts in the next century, when the human economy is expected to be several times larger, the world needs to achieve a rate of carbon emissions per dollar of gross world product that is roughly one-tenth the current level. This essentially means an end to the fossil-fuel-based energy economy as we know it."
>
> —Christopher Flavin and Nicholas Lenssen, in the Worldwatch book *Power Surge: Guide to the Coming Energy Revolution*[8]

> "The [BTU] tax is part of a broad spectrum of economic tools that the Administration is considering for its long-term campaign to break the nation of its dependency on fossil fuels."
>
> —Energy Secretary Hazel R. O'Leary, as reported in the *National Journal*[9]

> "It ought to be possible to establish a coordinated global program to accomplish the strategic goal of completely eliminating the internal combustion engine over, say, a 25-year period."
>
> —Vice President Al Gore, in his best-selling book *Earth in the Balance*[10]

> "The supply-side emphasis of U.S. energy policy has subsidized the overuse of fossil fuels, creating grave environmental risks, particularly climactic change."
>
> —Amory Lovins and Joseph Romm of the Rocky Mountain Institute[11]

> "We must bring environmentally damaging activities under control to restore and protect the integrity of the earth's systems we depend on. We must, for example, move away from fossil fuels to more benign, inexhaustible energy sources to cut greenhouse gas emissions and the pollution of our air and water."
>
> —Union of Concerned Scientists[12]

> "Energy is the cornerstone of economic development. But energy production and consumption can also pose threats to the long-term quality of life across the globe...The environmental community (in conjunction with industry) has developed by consensus a set of top priority energy initiatives—specific actions that will put the United States on the road toward a sustainable energy future...Reduce U.S. oil consumption by 50 percent and total carbon dioxide emissions in the transportation sector by 40 percent by the year 2010."
>
> —Sustainable Energy Blueprint endorsed by the Natural Resources Defense Council, Friends of the Earth, Public Citizen, Environmental Action, the American Wind Energy Association, and the Alliance to Save Energy[13]

"Oil has to go, fossil fuels have to go."
—Paul Gilding, the international head of Greenpeace[14]

What are the concerns about oil use?

What lies behind these passionate statements that society must move away from fossil fuel use—these assertions that we must give up the oil that has powered our cars, fueled our industries and warmed our homes for decades? Why are these environmentalists and government leaders so concerned? Do their concerns have enough merit to trigger a restructuring of American society?

Four main worries have emerged:

- the fear we're running out of oil;
- the belief that we're not paying enough to cover the social costs of energy—like congestion and pollution—and, therefore, we're using too much;
- the assumption that we'll never be able to solve our nation's pollution problems without reducing oil use; and
- the concern about the long-term effects of using oil on global climate change and on the ability of future generations to meet their energy needs.

Are these concerns justified? What are the facts?

Fortunately for Americans, and the world as a whole, these concerns—while genuinely and, often, deeply held—are misperceptions. They are based on a misreading of the facts about oil, the environment and energy markets. Put into perspective, the reality of the nation's energy challenges are much more positive than many environmentalists would have America believe.

The purpose of this study is to lay out the facts about oil and about America's energy future. These facts, which will be covered in detail in ensuing chapters, contradict the pessimistic perceptions of oil's critics. Here's a sampling:

- **Fact:** The world has plenty of oil to provide the energy that will be needed for the foreseeable future. Over the long-run, the operation of the marketplace and the incentives it creates will ensure that replacement fuels will be developed long before any physical exhaustion occurs.

  The production of oil worldwide is growing, not shrinking, and proved world oil reserves (the most conservative estimate of known, recoverable oil under existing economic and operating conditions) are at a record high. By the end of 1993, proved world oil reserves stood at 1 trillion barrels. This is enough to support 1993 production levels for more than 45 years, or to support growing oil consumption and economic growth for 20 to 25 years—even if the industry never found another barrel. By comparison, proved reserves were 700 billion barrels in 1985 and 656 billion barrels in 1975.

  But this conservative estimate clearly understates the world's oil resources. When probable reserves are included, between 1.4 trillion and 2.1 trillion barrels of oil remain to be produced worldwide—enough to sustain current world consumption for 63 to 95 years. This estimate is still conservative, for it assumes that between 4.1 trillion and 5.4 trillion barrels will forever be left in the ground as unrecoverable.

  Technical advances in oil recovery could add 60 billion to 80 billion barrels to this resource estimate—3 to 4 years of consumption—for **each** 1 percent increase in the average recovery rate.[15] And we haven't even begun to tap unconventional, and currently uneconomic, sources of oil, such as from shale in the Western United States and from tar sands in Alberta, Canada. All told, there simply is no imminent threat of exhaustion of conventional oil resources, let alone the massive volumes of unconventional supply that could be obtained at higher oil prices.

While reassuring, however, these facts are somewhat beside the point. There have been numerous energy transitions in history, as when England moved from wood to coal, or when the United States moved from whale oil to kerosene for lighting in the 19th century, or when the United States shifted from coal to oil in this century. These shifts did not occur because of resource exhaustion. As a resource grows scarce, its price rises, signaling private markets to substitute more abundant alternatives. Therefore, markets offer a mechanism for ensuring the sustainability of economic growth.

As energy economist Richard Gordon says, "The evidence clearly supports the proposition that human ingenuity has long prevailed over resource scarcity and suggests this situation will persist for at least the next half century."[16]

- **Fact:** Oil imports are likely to increase, so the potential for short-run disruptions of oil supplies is a legitimate concern—although less of a concern than many people think. Since the 1970s, many industrial oil users have developed increased capacity to switch to other fuels if oil prices or availability makes switching desirable.

To the extent that the security of oil supplies and the potential for short-run economic disruptions remains an issue, it needs to be addressed apart from the question of fuel choice. The Strategic Petroleum Reserve in the United States can provide a 66-day supply to replace imported oil at current consumption rates. Likewise, Japan, Germany and other oil-importing countries can tap similar oil reserves in an emergency.

Concern over the geographical concentration of oil supplies in the Middle East should lessen since governments around the world are seeking rapid development of their oil reserves, diversifying the supply of oil. The increasing economic interdependence of oil-producing and oil-importing countries creates a growing mutual interest in mitigating supply disruptions. During the Persian Gulf War of 1990-1991, fought in the middle of the world's largest oil producing region, no supply disruptions occurred.

Of course, the best way to enhance U.S. security and ensure adequate oil resources would be to open U.S. prospects for exploration and development—as long as the development was conducted in an environmentally safe way, with a minimum footprint on the environment.

- **Fact:** Americans are **not** energy wastrels. They use energy about as efficiently as other countries. The close association of energy use and economic growth over time—in the United States and in other industrialized countries that also rely on markets—points toward efficient use rather than waste. The international comparisons of energy intensity, on which many allegations of U.S. energy waste are mistakenly based, fail to account for the fact that the United States has a vast geography, different climate and more energy-based manufacturing structure than many other industrialized countries.

Given these comparisons, Americans do not "overconsume" energy.

In the United States and other market-based economies, energy markets ensure that the consuming public will pick the right fuels for its needs and make

In the 1992 best-seller *Reinventing Government,* David Osborne and Ted Gaebler argue the importance of "governing with foresight."[19] The authors contend that governments need to plan for the future to prevent problems, cope with the rapid pace of change in today's world and fend off the tremendous pressure on politicians to "sell out the future."[20]

In *Mandate for Change*, a study published in 1993 by the Progressive Policy Institute[21] to offer guidance to the incoming Clinton Administration, Osborne argued that the federal government doesn't spend enough time or money on prevention. He quotes from *Future Shock*, the 1970 book by Alvin Toffler: "Instead of anticipating the problems and opportunities of the future, we lurch from crisis to crisis. Our political system is 'future-blind'."[22]

In *Mandate for Change*, Osborne compares the federal government to an enormous holding company owning dozens of businesses around the globe. Top management in this context would concentrate on steering the corporation, setting policy and ensuring that each business had the tools and incentives to do its job. Osborne says: "In other words, management would steer, but not row. This should be the primary goal of the federal government: to steer American society to health, not to provide direct services."[23] Osborne calls this "catalytic government."

But who sets the course when the goals government is steering toward are far afield from society's historical base? Alvin Toffler argues that we "need political systems capable of sifting through this noise [of mass communications and special interests] to find the common interest—processes that could bring together many different constituencies to hammer out a collective vision of the future." He calls this "anticipatory democracy."[24]

Does our government have the perspective, knowledge and wisdom to decide whether oil should continue to play the key role in our economy? Is there another energy source that can better satisfy society's requirements, and can our government help us find it?

Making the right energy choices will lead to economic and environmental progress

A potential flaw in the "Steer, Don't Row" approach for government policy is that of direction, detail and timing. Can governmental planners and environmental gurus ever have enough information, a clear enough crystal ball, to simultaneously choose the appropriate direction, the means to get there and the time frame for achieving specific milestones?

Some in the environmental community seek very active intervention. In *Reinventing Government*, Osborne and Gaebler note that "Structuring the market to achieve a public purpose is in fact the opposite of leaving matters to the 'free market'— it is a form of intervention in the market."[25] When government policymakers use "public leverage" to shape private market decisions, they are making energy choices for consumers, picking the technologies that private companies and individuals should adopt, mandating compliance with their choices and narrowing the options available to American consumers.

But the historical record of government intervention in energy markets indicates that there is little reason to expect government to make the right choices. As Michael Rothschild sums up in his book, *Bionomics: Economy as Ecosystem*: "The punctuated equilibrium of unexpected, erratic change across an immense variety of technologies is terribly frustrating for those who want to plan and control the economy. The intrinsic unpredictability of technological evolution makes a mockery of every effort to plan the future."[26]

Past U.S. experience in energy policy would seem to bear this out. The billions of dollars allocated to be spent in the 1980s on the effort to develop synthetic fuels is the most egregious example of government efforts to pick a winning technology. More recently, government agencies have advocated the increased use of ethanol and the electric car, without the facts to support the assertion that either is superior to existing fuels and technologies in environmental or economic performance.

The wrong energy choices made by government intervention in energy markets increase costs, hurt the nation in terms of lost economic growth, stifle innovation, limit consumer choice and slow progress in achieving other societal objectives. Policies that mandate replacing oil with specific alternative fuel technologies freeze progress at the current level of technology, and reduce the chance that innovation will develop better solutions.

But it is certainly appropriate for government to set environmental goals for society. In the past, the government had a clear role in setting fairly prescriptive environmental goals for industry and individuals to meet. That this was appropriate is not a matter of debate in this study.

But making the right energy choices means continuing both economic **and** environmental progress and learning from past mistakes. The wrong energy choices make it hard—if not impossible—for the United States to compete in a global economy increasingly focused on cost reductions, efficiencies and overall competitiveness. This is what's at stake. Relying on either the government or the marketplace is not the solution. Relying on both—and recognizing the contributions each can make—is imperative.

Making the right choices—choices based on realities, not misperceptions—can bring America an energy future bright with hope. In this decade, energy—particularly oil—is truly being reinvented to meet new environmental standards. If all fuels are allowed to compete in the marketplace on a fair basis—on their individual advantages and disadvantages—we can achieve a good balance between economic growth and environmental concerns.

NOTES TO INTRODUCTION

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19 David Osborne and Ted Gaebler, *Reinventing Government: How the Entrepreneurial Spirit Is Transforming the Public Sector* (Reading, Mass.: Addison-Wesley Publishing Co., 1992), 229.

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21 The Progressive Policy Institute is a project of the Democratic Leadership Council, an organization which then-Governor Bill Clinton helped to create and which he headed from March 1990 to August 1991.

22 David Osborne, *Mandate for Change*, Public Policy Institute (New York: Berkley Publishing Group, 1993), 280.

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24 Ibid., 230.

25 Osborne and Gaebler, 283.

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CHAPTER 1

Are we running out of oil?

Many Americans believe that the United States—and the world—are rapidly running out of oil. Because oil by its very nature is an exhaustible resource and Americans use a lot of it, some people picture the day when their local service station will have a sign out, "No more gasoline—ever."

Many environmentalists assert that the United States and other industrialized countries have made a dire error by building economies powered almost exclusively by fossil fuels. Their solution is to phase out oil use by forcing the development and use of alternative fuels, preferably renewable fuels such as solar and wind energy. By making this change now, they believe, we could prevent society from running into the limits to growth set by the planet's finite natural resource base and provide for the needs of future generations.

The facts paint a different picture—and one that is far from gloomy. The mere potential for exhaustibility does not imply the inevitability of exhaustion. Like the hypochondriac whose tombstone reads "I told you I was dying," the predictions of oil's demise will someday prove accurate and oil will lose its market to a competing energy alternative. But, contrary to a widely held misperception, that day isn't even on the horizon. When it comes, it will more likely be due to an advance in technology—the invention of a "better mousetrap"—than to resource exhaustion.

We don't need to be worried about running out of oil for several reasons. First, those who are concerned don't consider the role of energy markets. Markets provide a mechanism for ensuring the sustainability of resource supply by providing the signals needed—rising prices—to generate substitutes as any given resource becomes progressively scarcer.

Second, world proved reserves of oil are higher now than ever before. Despite the conservative bias of the estimates, conventional resources could support current levels of production for at least another half century, and perhaps much longer if technological progress continues.

Finally, some environmentalists assert that even if world supplies are ample for our needs, the U.S. should turn to alternative fuels because Americans are relying too much on imported oil. They contend that imports—now satisfying 50 percent of oil requirements and likely to rise to 60 percent early in the next century—jeopardize our nation's security. But imports of oil are not essentially different from imports of computer chips or any other product. Policies adopted since the 1970s limit the impact of short-term supply disruptions. Even in 1990-91, when the Persian Gulf War was fought in the middle of the world's largest oil-producing region, the disruption to world supply was very short term. Moreover, most other Organization for Economic

Cooperation and Development countries depend more on oil imports than the United States. Germany and Japan, for instance, depend on imports for 97 percent and 100 percent of their consumption, respectively.

But Americans continue to worry. Will future generations have energy supplies if we use the oil we need now? Can we continue to use oil without running out ourselves? Can we rely on oil without putting our economy at risk to blackmail by non-U.S. producers? Or can we continue to enjoy a lifestyle based on the freedom and mobility that gasoline-powered automobiles provide us?

Let's examine the facts in more depth.

Some people suffer from the Malthusian fear of resource exhaustion

The view that limited natural resources—not just oil but other resources as well—would eventually constrain economic growth has been espoused and disproved repeatedly over the past 200 years. From the onset of the Industrial Revolution, economic growth increased human welfare at a pace never before seen in human history. For almost as long, however, predictions that this growth was unsustainable have persisted. All of them have been wrong.

Thomas Malthus, writing in 1798, feared that "the power of the population is infinitely greater than the power in the earth to produce subsistence for man…," elaborating: "Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetic ratio." In his famous *Essay on Population*, published in 1826, Malthus explained that a rapidly growing population would collide with a "fixed" amount of farmland available for growing food. He believed the inevitable result would be a world population living at subsistence levels, perpetually on the edge of starvation. But he was wrong.

In 1826, the world had a population of approximately 1 billion people.[1] From Malthus' perspective, it may have appeared inconceivable that the world could feed two, three or even four times that many people. But more than 5.2 billion people now inhabit this planet, and hunger is receding as a global problem. Similarly, from our limited perspective in 1995, it's difficult to envision how in the year 2100 we'll be able to feed a world population of between 6 billion and 19 billion people (according to a range of projections by the United Nations).[2] But a lack of vision shouldn't indict the economic system that has achieved such tremendous improvements in the quality of life for so many.

Erroneous predictions of resource exhaustion continue

The general concern about "fixed" resources, now frequently called exhaustible or non-renewable resources, has continued. In the United States in the early 20th century, the Conservation Movement popularized the notion of impending resource limits to growth. In 1910, Gifford Pinchot wrote:

> "We have timber for less than 30 years…. We have anthracite coal for but 50 years, and bituminous coal for less than 200. Our supplies of iron ore, mineral oil, and natural gas are being rapidly depleted, and many of the great fields are already exhausted. Mineral resources such as these when once gone are gone forever."[3]

Pinchot, like Malthus, was wrong. Almost a century and a half after Malthus' *Essay on Population*, Harold Barnett and Chandler Morse (both from Resources for the Future) published *Scarcity and Growth—The Economics of Natural Resources Availability*, which reviewed almost 100 years of history. They found no evidence of exhaustion of non-renewable resource minerals. Similarly, they found no evidence of growing shortages in agricultural production, which depends on Malthus's "fixed" available farmland. The study found the possible increasing scarcity of only one renewable resource, forestry.

Technological progress forestalls exhaustion

Barnett and Morse tried to explain why the exhaustion of finite resources hadn't occurred, and their central answer was technology. They observed that new technology sometimes resulted from market pressures, such as short-term increases in the price of a commodity. However, in a more fundamental sense, technology was an integral part of the progress of society. They wrote that "the technological progress that has occurred was a necessary condition for the growth that has occurred, and if the former is ruled out the latter cannot appropriately be taken as a given fact."[4]

While resources are finite, they are fixed only in the way that a rubber band is fixed. Resources can be expanded by changes in technology—both by new ways to extract resources at less cost and by new ways to get more work from a barrel of oil or a ton of coal. As summarized by E.S. Zimmerman:

> "Resources are not, they become; they evolve out of the triune interaction of nature, man, and culture, in which nature sets outer limits, but man and culture are largely responsible for the portion of physical totality that is made available for human use....The problem of resource adequacy for the ages to come will involve human wisdom more than limits set by nature."[5]

Technological change is very difficult to predict. In Malthus's time, about half of the U.S. population lived on farms and about 72 percent of those gainfully employed worked on farms.[6] Malthus might have altered his views about the ability of society to feed a growing population if he ever believed, as is the case in the United States today, that the agriculture sector of the economy would employ only 1.7 percent of the labor force and less than 2 percent of the population would live on farms.[7]

Limits to Growth study also lacked foresight of technological advances

Still, in the early 1970s the widely distributed report *The Limits to Growth—A Report of The Club of Rome's Project on the Predicament of Mankind* voiced concerns similar to those of Malthus and the Conservation Movement. The Club of Rome project developed a dynamic computer model of the world through 2100—out as far as 2170 in some cases. Their project attempted to model the world, focusing on population, food supply, industrial output and pollution.

The study's conclusions were alarming: "We can thus say with some confidence that, under the assumption of no major change in the present system, population and industrial growth will certainly stop within the next century, at the latest."[8] In many respects, the analysis was very Malthusian, showing the world system collapsing because of "an overloading of the natural absorptive capacity of the environment. The death rate rises abruptly from pollution and from lack of food. At the same time resources are severely depleted...."[9]

From the perspective of 1995, parts of this 1972 study look silly. While acknowledging the complexity of calculating the future availability of exhaustible resources, the study provided estimates of the number of years that known reserves of important resources would last at current and exponentially growing rates of use.

For example, *The Limits to Growth* said that in 1972 the world had only 9 to 11 years of known gold reserves and 21 to 36 years of known copper reserves.[10] But in 1995, the world still has large known reserves of gold and copper. Furthermore, uses for these commodities are changing. In fact, copper is being displaced in many communication uses by an even more plentiful commodity, sand (silica refined into the form of fiber optic cables).

Similarly, *The Limits to Growth* said that the world had only between 20 and 31 years worth of known petroleum reserves left. But 22 years later, the world has discovered enough oil to have more known reserves than at any time since 1948. Additionally, new reserves are being found throughout the world every year.

Is the use of exhaustible resources compatible with sustainable development?

Malthus, Barnett and Morse, *The Limits to Growth*, and many others raise a variety of issues—future population, food supplies, non-renewable resources, pollution and the environment—that form the basis for the discussion of what is now known as "sustainable development." The World Commission on Environment and Development, formed under United Nations' auspices and more popularly known as the Brundtland Commission, emphasized the notion of sustainable development in its 1987 report, *Our Common Future*.

The Brundtland Commission asserted the need for "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The commission focused on two aspects of sustainable development: the nature of the current generation's responsibility to future generations and substitutability between "natural capital" and other forms of social capital such as physical investment, education, knowledge and social institutions.

A working definition of sustainable development has proved difficult. One polar view is that any use of non-renewable resources should be sharply curtailed because: (1) use may seriously degrade the environment or even cause an ecological catastrophe, and (2) any use of an exhaustible or non-renewable resource compromises the ability of future generations to meet their own needs.

However, this pessimistic view of the future, like the Malthusian one 200 years ago, discounts the fact that responsible use of non-renewable resources creates opportunities for future generations that otherwise would not exist. The World Bank, in its *World Development Report 1992*, addressed these issues and stated:

> "It is not plausible to argue that all natural resources should be preserved....Societies may choose to accumulate human capital (through education and technological advance) or man-made physical capital in exchange, for example, for running down their mineral reserves or converting one form of land use to another. What matters is that the overall productivity of accumulated capital—including its impact on human health and aesthetic pleasure, as well as on incomes—more than compensates for any loss from depletion of natural capital."[11]

The *World Development Report 1992* did not find evidence of increasing scarcity of non-renewables: "The evidence...gives no support to the hypothesis that marketed nonrenewable resources such as metals, minerals, and energy are becoming scarcer in an economic sense."[12] Among the reasons cited were technological change, economizing through use of thinner coatings, development of synthetic substitutes, recycling and energy efficiency.

The report, however, emphasized another concern—the environmental side effects of using natural resources:

> "The world is not running out of marketed nonrenewable energy and raw materials, but the unmarketed side effects associated with their extraction and consumption have become serious concerns. In the case of fossil fuels, the real issue is not a potential shortage but the environmental effects associated with their use, particularly local air pollution and carbon dioxide emissions. Similarly the problems with minerals extraction are pollution and destruction of natural habitat."[13]

Later chapters will address the issues that relate to the use of oil—environmental pollution and the potential for global climate change. But it's important to note here that the difficulty facing countries, individually as well as jointly, is how best to make progress on the entire range of issues that affect their citizens—those that affect current generations as well as those that could help future generations, those that make trade-offs between expenditures that emphasize people versus those that emphasize nature.

As one commentator observed, "While the Rio Earth Summit ended with Western leaders agreeing to devote billions of dollars to sustaining the natural environment, essentially nothing was done for the 7.8 million poor children—many of them in cities—who die each year from what they drink and breathe...."[14] Overblown fears of resource exhaustion or unwarranted concerns about environmental impacts shouldn't drive society to forbid itself the use of valuable resources without a far more careful examination of the facts.

How much oil remains?

Since the dawn of the petroleum industry in the mid-19th century,[15] concern about the imminent exhaustion of the world's petroleum resource base has occurred in waves. From today's perspective, such concerns of exhaustion were premature, if not ludicrous:

> "Hurry, before this wonderful product is depleted from Nature's laboratory!"
>
> —advertisement for "Kier's Rock Oil," 1855
> (four years before the first U.S. oil well was drilled)

> "...the United States [has] enough petroleum to keep its kerosene lamps burning for only four years..."
>
> — Pennsylvania State Geologist Wrigley, 1874

> "...although an estimated two-thirds of our reserve is still in the ground,...the peak of [U.S.] production will soon be passed—possibly within three years."
>
> —David White, Chief Geologist, USGS, 1919

> "...it is unsafe to rest in the assurance that plenty of petroleum will be found in the future merely because it has been in the past."
>
> —L. Snider and B. Brooks, *AAPG Bulletin*, 1936

> "Past...prophecies of 'reserves running out' have been notoriously erroneous, but finite resources have by definition a finite existence. Perceptions of impending shortfall will cast a shadow forward, well into the period between now and 2020. [Consequently] the real cost of energy is likely to rise in the coming decades."
>
> —World Energy Council, *Energy for Tomorrow's World, 1993*

Petroleum **is** an exhaustible resource. Like coal and natural gas, it was originally generated over millions of years by geologic processes in which fluids and gases from organic matter were trapped in the pore space of sedimentary rock formations. Since the amount of natural replacement occurring over even a few hundred years is trivial, the volume of oil-in-place in the earth's crust at the birth of the petroleum industry in the mid-19th century is essentially the upper limit on what can be produced over the industry's lifetime.

So, in a sense we are always "running out" of oil because each barrel produced brings us one barrel closer to reaching that upper limit. The amount of oil remaining at any point in time is the upper limit less the sum total of oil production since the industry's birth.

But what appears to be a simple calculation is far more complicated. The amount of oil produced by the industry is measured with relative precision, but the volume of oil remaining in the ground is unobservable—and therefore highly speculative.[16]

Consequently, estimates of the amount of oil remaining in the earth's crust are extremely uncertain.[17] Location and volume is only partially known, since not all prospective areas of the globe have been explored, and many of those that have been explored are not fully developed. Moreover, resources vary both in quality and form, so that the cost of extracting the resource is highly variable.

Contrary to the common misperception that oil occurs in large underground "pools,"[18] oil occurs in the pore space of rocks,[19] and the characteristics of that rock and the oil it contains determine the effort that will be required for extraction. This gives rise to uncertainty not only about the volume of oil that exists, but also about how much of that volume will be economically and technically feasible to produce.

Over the history of the U.S. petroleum industry, for example, only about a third of the estimated oil in place at known fields has typically been recovered. The remaining two-thirds remains in the ground, a potential recovery target with more advanced technology and/or changes in market conditions—i.e., higher prices.

Despite the obvious problems that these characteristics create for reliable estimation, calculating the remaining recoverable resources has been, and continues to be, a matter of great interest. Over the history of the industry, resources have been categorized by several factors—how much information stands behind the estimate, the cost and difficulty of recovery, and how much can be recovered from a given field with current technology.

Attention to estimates of proved reserves is widespread. But this conservative measure is **not** a measure of remaining oil resources—or even a close approximation. Rather, proved reserves are defined as an estimate of the amount of oil or natural gas believed to be recoverable from known reservoirs under existing economic and operating conditions. They are only a small portion of oil resources—a working inventory, so to speak. As they are used, they are replaced through new exploration and development. Eventually, depletion could limit such replacement. But to date, the experience has been quite the opposite; history has provided a record of steadily growing petroleum reserves.

Despite this recent record of growing resource abundance, renewed warnings of impending resource scarcity again trigger the question: "Is the long predicted 'wolf' of oil scarcity[20] finally at the door?"

Estimating U.S. petroleum resources: a chronological perspective

The U.S. oil industry was born in 1859 with the drilling of the first well in

Titusville, Penn. By the turn of the century, the United States had produced about 1 billion barrels of oil.

Within nine years, the total had doubled, and a 1909 report by the U.S. Geological Survey[21] estimated that between 10 and 24.5 billion barrels ultimately would be produced, which would be exhausted by about 1935. By 1916, a Bureau of Mines geologist asserted in a report to the U.S. Senate[22] that U.S. oil production would peak within five years, and that "with no assured source of [new] domestic supply in sight, the United States is confronted with a national crisis of the first magnitude."

Estimates of both original and remaining resources then crept up during World War I and the early 1920s, although the estimators typically expressed great confidence in the imminence of exhaustion implied by their numbers. White [1919] expected exhaustion in the early 1920s, while Gilbert and Pogue [1918] of the Smithsonian Institution not only predicted imminent exhaustion but were so certain as to say that "there is no hope that new fields, unaccounted in our inventory, may be discovered of sufficient magnitude to modify seriously the estimate...[The war] has merely brought into the immediate present an issue underway and scheduled to arrive in the course of a few years."

To improve credibility, in response to the Federal Oil Conservation Board,[23] the American Petroleum Institute (API) in 1925 prepared an estimate of domestic "proved reserves"—defined as the volume of crude oil that geological and engineering information indicate, beyond reasonable doubt, to be recoverable in the future from an oil reservoir under existing economic and operating conditions. API issued reports on U.S. proved reserves in 1934, in 1936, and then annually until 1979, when the U.S. Department of Energy[24] took over the oil reserve estimation function.

Explicitly excluded was any estimate of (1) future reserve additions at known fields that are probable but not yet proved, and (2) future reserves from undiscovered fields, on grounds that "an estimate of reserves which are to come from fields yet to be discovered involves so many uncertainties that it would be grossly inaccurate and misleading."

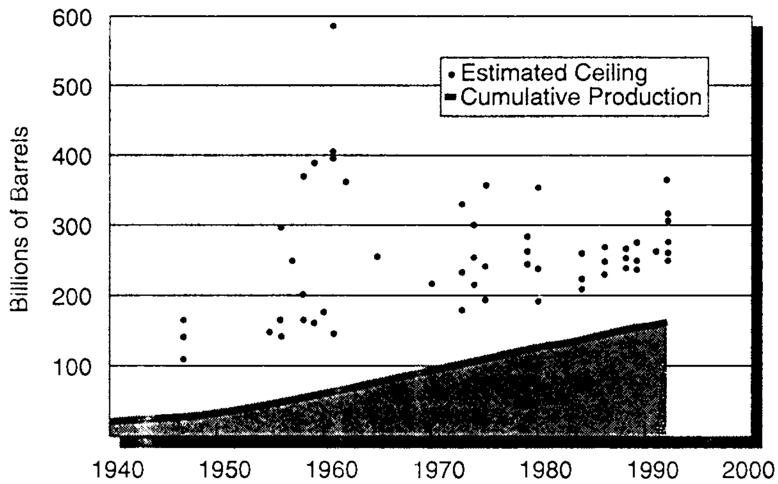
While the narrowness in principle facilitated clarity,[25] it was also obvious that the measure had no bearing on long-run supply potential. In 1945, for example, cumulative crude oil production in the United States stood at about 32 billion barrels, and proved reserves amounted to 20 billion barrels. Between 1945 and the end of 1993, however, 135 billion barrels were produced, and reserves at the end of that time were 23 billion barrels—3 billion barrels **higher** than reserves in 1945. Over the 48-year period, 138 billion barrels of new domestic reserves had been added, more than four times the level of reserves at the beginning of the period.

As narrowly defined by API, proved reserves was simply a measure of working inventories of recoverable oil, principally underlying existing wells within a highly restricted geographical circumference. Proved reserves don't represent total oil resources, just as items on grocery store shelves don't represent our total food supply. Proved reserves represent a **minimum** of the remaining recoverable resource (i.e., the volume remaining to be produced if discoveries and technical change came to a halt, and economic conditions remained unchanged indefinitely).

But both technology and information advanced to permit geologists to make estimates of the total resource base with at least a limited degree of confidence.[26] Figure 1 summarizes the history of estimates of the domestic resource base.

Unlike the "reserves" estimates, resource estimates **were** clearly attempts to estimate the "ceiling" on production for all time. By the late 1940s, most of these estimates, both by industry and government, recognized that the U.S. resource base was far larger than had previously been thought, certainly in the hundreds of billion barrels.[27]

FIGURE 1. Estimates of Total Recoverable U.S. Oil Resources, 1940-1993



The peak of U.S. production occurred in 1970. As actual production fell through the 1970s, official U.S. Geological Service (USGS) estimates dropped downward sharply—to about half of their previous levels.

Current estimates of the ultimately recoverable domestic resource base by the U.S. Department of Energy are between 263 billion and 368 billion barrels, of which we have already consumed about 164 billion barrels. This leaves a domestic resource base of between 99 and 204 billion barrels, which would support production at recent levels for 38 to 78 years.

TABLE 1. Post-1974 Estimates of the Domestic Resource Base

End of	Author	Cumulative Production	Proved Reserves	Other Reserves*	Ultimate Resources†
1974	USGS [1975]	100.0	62.0	50.0-127.0	212.0-289.0
1979	USGS [1981]	120.7	54.8	64.3-105.1	239.8-280.6
1986	AAPG [1989]	146.7	44.0-177.0	33.0-70.0	223.7-323.7
1986	USGS [1989]	146.7	51.2	33.2-69.9	231.1-267.8
1988	USDOE [1990]	152.7	59.6-77.8	25.4-35.2	237.7-265.7
1992	ORP [1992]	164.0	25.0	74.0-179.0	263.0-368.0
1992	USGS [1994]	163.5	51.1	29.4-62.0	244.0-276.6
1992	USGS [1995]	163.5	22.9	116.8	303.2

*Includes probable (not proved) reserves in the vicinity of known fields as well as undiscovered reserves.

†Ultimate resources are contingent on economics and technology as of the date of the estimate. It is not an absolute ceiling, since changing economics and technical progress could capture additional resources.

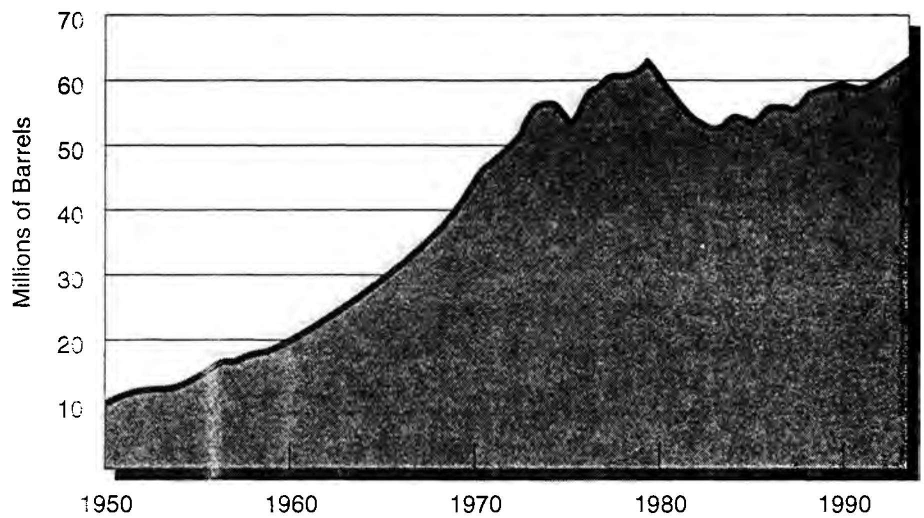
It is worth noting, however, that studies done in the past several years suggest that the remaining resource depends critically on the course of technology, prices and land access over the next several decades. The studies suggest that the ultimate volumes of domestic crude oil recovered could more than double the early estimates.

But access to America's oil resources for exploration and production has been severely curtailed during recent years. Despite advances that reduce the footprint necessary for drilling and production, many environmentalists oppose granting access to the most promising fields on federal lands and offshore. While the United States has known economic resources that could be produced to meet domestic energy needs, access to many of these resources has been blocked, resulting in an artificial limit on U.S. oil supplies.

Estimating resources worldwide

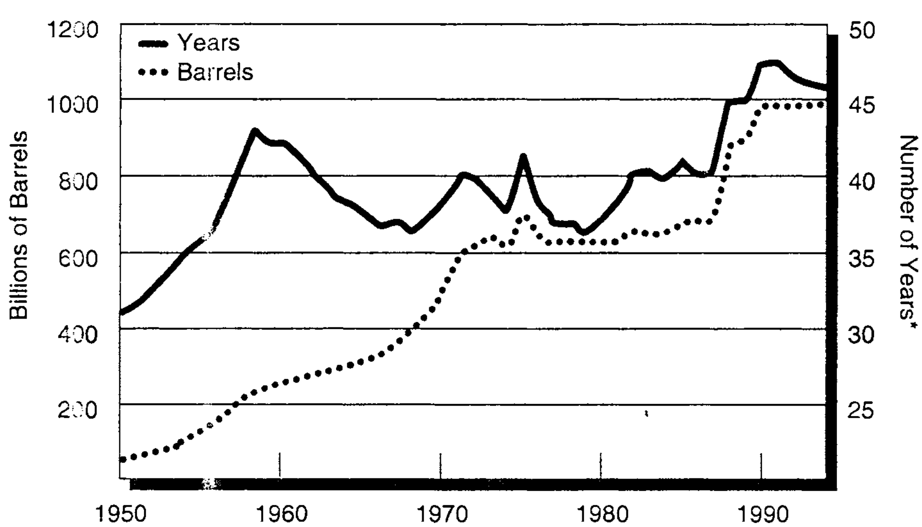
The continued decline in U.S. domestic reserves and production since 1970 is not characteristic of the experience of the rest of the world. Globally, crude oil production rose rapidly after World War II, reaching a peak of about 62 million barrels per day in 1979, fueled principally by the growth in supply from the Persian Gulf Organization of Petroleum Exporting Countries (OPEC).[28]

FIGURE 2. Daily World Oil Production, 1950-1993



In 1950, the world was producing just over 10 million barrels a day. In 1950, proved reserves[29] were 90 billion barrels, sufficient to sustain production at that rate for 24 years. Over the next 43 years, production rates increased nearly sixfold. Moreover, despite the fact that more than 650 billion barrels were produced in those 43 years, proved world reserves expanded more than tenfold to nearly a trillion barrels, enough to sustain 1993 production for another 45 years—even if not another barrel of oil is discovered.

FIGURE 3. Proved World Oil Reserves, 1950-1993



Remaining supply at current consumption rates in year of estimate.

Despite growing world production of crude oil and proved world reserves at an all-time high, many recent long-run forecasts[30] of world oil market trends once again estimate that real prices will rise over the next two decades, owing largely to expected increased resource scarcity early in the next century.

These current "warnings" claim to be more credible than those of the past,[31] mainly on the basis of knowledge from more extensive and technologically superior exploration and development efforts. But these claims are largely based on misperceptions.

The first misperception arises from the fact that while the world experienced serious oil shortages in adapting to the supply restraints imposed by OPEC from 1973 to 1985, this was not a real resource constraint—it was a contrived scarcity. Many people have difficulty understanding this important difference and continue to believe that the events of this era presage resource exhaustion.

Initially, many interpreted the downturn in supply in 1980 as a signal of impending worldwide resource exhaustion.[32] But resource constraints were irrelevant. The loss of supply and the corresponding rise in price were due to two temporary factors:

- Iranian and Iraqi output declined due to disruptions associated with the Iranian revolution and the subsequent Iran-Iraq war.
- Saudi Arabia made a commitment to sustain higher oil prices by acting as the "swing producer"—defending the official price by swinging its output down if prices fell below the target price and up as prices rose. Initially, this policy proved massively rewarding to the Gulf producing countries. Revenue surged in 1980 and 1981 due to the limited short-run capabilities of the world economy to substitute other fuels for oil.

But within several years, demand dropped sharply as higher prices triggered massive conservation, major new sources of non-OPEC supply and a slowdown of worldwide economic growth. By mid-1985, the disastrous fiscal consequences of such a policy were apparent as Saudi Arabian oil revenues nearly vanished with the steady erosion of their exports.[33] The Saudis subsequently abandoned their role as swing producer,[34] and chose to use their resources to aggressively win back their lost market share.[35] Prices fell, worldwide demand growth resumed and non-Gulf output leveled off with a sharp decline in worldwide upstream investment.

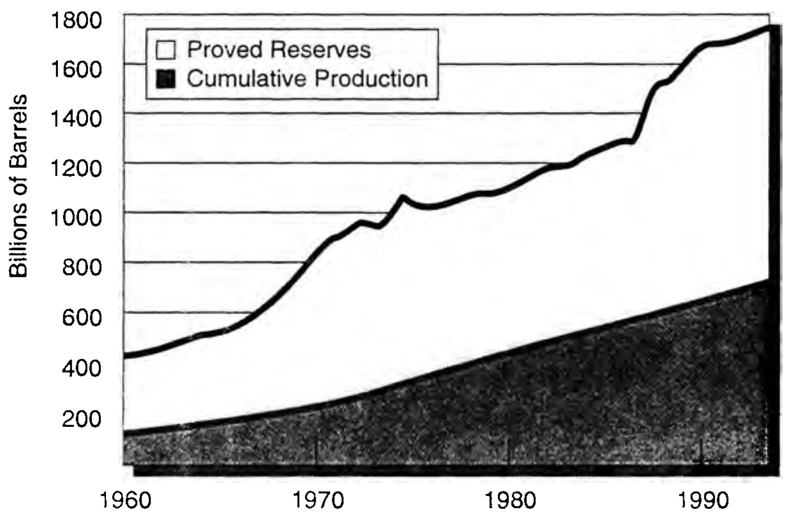
Another major misperception is that world production is slowing due to resource scarcity. While worldwide production flattened in the early 1990s with the slowdown in the economic activity of industrialized countries, recently demand has begun growing again, and worldwide production is expected to surpass its 1979 peak within the next two years.[36]

Production has peaked in two of the major world oil producing areas—the United States and the former Soviet Union. But in both areas factors other than resource constraints have been at work. In the United States, constraints on land access have been a major cause of declining production, and in the former Soviet Union, political and institutional barriers have reduced upstream investment.

By the end of 1993, cumulative worldwide production reached about 700 billion barrels, as seen in Figure 4. But proved reserves—the most conservative estimate of available oil resources—rose faster than production.

Consequently, the known "floor" on the ultimate recovery of world oil resources by the end of 1993 stood at more than 1.7 trillion barrels, about two-thirds of which remained to be produced. By the end of 1993, proved reserve levels were about 10 times their level in the late 1940s, sufficient to support production at 1993 rates for at least 45 years, more than double that of the late 1940s.

FIGURE 4. Proved World Oil Reserves and Cumulative Production, 1960-1993



Proved reserves represent only a partial measure of world oil resources

As in the United States, the world's total resource base is far larger than proved reserves alone. According to a paper presented by the USGS at the most recent World Petroleum Congress,[37] the ceiling on the world's ultimate recoverable oil resources is now estimated at 2.3 trillion barrels (with a band of uncertainty between 2.1 and 2.8 trillion), of which 700 billion barrels have already been produced.[38]

FIGURE 5. Estimates of Total Recoverable World Oil Resources, 1910-1993

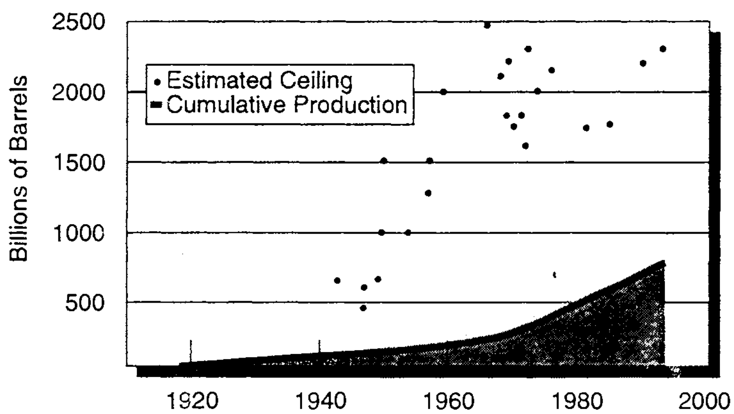


TABLE 2. Estimates of the World Oil Resource Base, 1920-1994

End of	Author	Cumulative Production (billions of barrels)	Remaining Resources (billions of barrels)	Ultimate Resources (billions of barrels)
1919	White [1920]	8	35	43
1942	Pratt et al. [1942]	42	558	600
1946	Duce	52	348	400
1946	Pogue	52	503	555
1948	Weeks	58	552	610
1949	Levorsen	62	1438	1500
1949	Weeks	62	948	1010
1953	Macnaughton	79	921	1000
1956	Hubbert	96	1154	1250
1956	Weeks [1958]	96	1082	1500
1958	Weeks [1960]	109	1891	2000
1965	Hendricks	172	2308	2480
1967	Ryan [1967]	197	1887	2090
1968	Shell	211	1589	1800
1968	Weeks	211	1989	2200
1969	Hubbert	226	1499	1725
1970	Moody	243	1557	1800
1971	Warman	261	1339	1600
1971	Weeks	261	2029	2290
1973	Moody, Esser [1974]	297	1703	2000
1975	Halbouty [1976]	339	1792	2131
1980	Masters et al. [1984]	448	1274	1722
1984	Masters et al. [1987]	524	1220	1744
1989	Masters et al. [1991]	629	1542	2171
1992	Masters et al. [1994]	699	1574	2273

Consequently, between 1.4 trillion and 2.1 trillion barrels remain to be produced worldwide. This amount would sustain current rates of world consumption from 63 to 95 years. Importantly, this assumes that between 4.1 trillion and 5.4 trillion barrels are left in the ground as unrecoverable.[39] Technical change could—and in all likelihood will—extend this lifetime. Every 1 percent increase in the average recovery rate would add between 60 billion and 80 billion barrels to resource estimates, or enough to last an extra three to four years.

New geophysical imaging technologies permit more precise mapping and better characterization of the resource base. New drilling materials, equipment and methods allow far more flexible access to complicated geologic structures. In addition, far more of the potential area for new petroleum discoveries has now been explored, although major areas of the earth still remain lightly explored. Unlike optimistic estimates in periods of growing worldwide discoveries, the current resource estimates are even more credible, since the forecasts have been made against a background of a long dearth of new discoveries of giant fields worldwide.

The USGS estimate of remaining resources is nearly 70 percent higher than the more commonly cited proved reserve numbers. This is because the USGS definition of remaining resources includes not just proved reserves, but probable reserves at known fields and resources yet to be discovered as well. While still conservative, the USGS estimate is broader than the more commonly cited figures and yet narrower than some official estimates reported for the Middle East.

How long will the world's oil last?

The most common inference is that currently identified reserves could sustain 1993 rates of production for 50 years, and new discoveries could extend that production for perhaps another 21 years—a total of 71 years. While such simple calculations provide an intuitively handy way to gauge potential resources, they can also be misleading.

Here's why: The USGS estimates for undiscovered resources are estimated as a range, with 21 years of oil the middle forecast. There is a chance that fewer reserves will be discovered, and a chance that more undiscovered reserves exist in the world—maybe as much as 1,005 barrels. So how long will the world's oil last? There is a 95 percent probability that remaining oil resources (discovered and undiscovered) could sustain production at 1993 levels for at least 63 years. At the optimistic end, there is a 5 percent chance that oil resources could sustain production at the same rate for 93 years.

But this calculation is almost certainly still too conservative, because it doesn't include technical change that allows more oil to be recovered from a given field, or that causes more oil to be discovered for a given level of drilling effort. Particularly in mature producing regions such as the United States and the former Soviet Union (FSU), increasing rates of recovery at known fields are likely to be a major source of additions to supplies. More than two-thirds of the original oil in place and three-fourths of the remaining oil in place is currently in the uneconomic category. If technology improves—and experience tells us that it probably will—more of this uneconomic oil could be recovered. Each 1 percent increase in average recovery adds nearly 67 billion barrels to the world's recoverable resources.

Unconventional resources are even larger

In addition to the world's abundant conventional oil resources, huge supplies of unconventional sources of oil are well known, although they currently are not economically feasible to produce. The principal unconventional resources are oil shale, heavy and extra-heavy oil and bitumen (natural tar). These unconventional oil resources are about three times as large as the volume of original conventional oil in place, and about 10 times the volume of remaining recoverable conventional oil worldwide.[40] While most of these resources are still too costly to compete with conventional oil, much of it would be more competitive with conventional oil than many of the "alternative fuels" being advanced by government policy.

TABLE 3. Known Unconventional Crude Oil Resources

	(billions of barrels)		
Source	United States	Non-U.S.	World
Heavy and extra-heavy oil	31	574	605
Recoverable bitumen	7	429	436
Oil shale	5,600	8,283	13,883
Total unconventional	5,638	9,286	14,924

Dependence on imports will continue to grow

The fact that world resources are abundant should take care of concerns that we are running out. But the world will also become more dependent on the resources concentrated in the Middle East, where two-thirds of proved reserves are located.[43] This increased reliance on imports will be quite striking for the United States in particular. According to the U.S. Department of Energy (DOE), imports will increase from about 40 percent of total American oil consumption in 1990 to almost 60 percent in 2010, a record high.

FIGURE 6. Distribution of Proved Oil Reserves,[41] 1948-1993

Good news, bad news

This situation presents the world with both opportunity and challenge. The good news is that world oil resources are abundant, and, if anything, likely to become even more so. On the other hand, there is no guarantee that the world will avail itself of the economic opportunity afforded by such abundance. Major new investment will be required to translate this resource potential into real production, and a plethora of hazards can be expected to intimidate producers.

One of the greatest hazards to the prospect of such investment is often seen to be the concentration of reserves and potential new resources in the still turbulent Middle East. This combined with growing political risks associated with capacity additions in two of the top three world supply sources—the United States and the former Soviet Union (FSU)—could seriously compromise the prospects for such investment. Investments in the Middle East are threatened by periodic disruptions due to political turmoil, as well as strong competing demands for military equipment and a reluctance in several major countries to permit significant direct foreign investment in the oil sector. It may also be threatened by sanctions imposed by consuming country restrictions on the operations of their companies in the Middle East.[42] In the United States, current environmentally motivated constraints prevent development of the bulk of the remaining world class domestic resources, in Alaska and offshore. In the case of the FSU, political uncertainty clouds any substantial new investment.

Over the long term, a risk of intermittent disruptions attributable to military conflict in the Middle East remains, as well as a gradual rise in dependence on the Persian Gulf supply. These situations revive concerns about recurrence of political and economic vulnerability to hostile actions by those countries, such as occurred twice during the 1970s. Similarly, continued deterioration of the petroleum sectors of the United States and the former Soviet Union may seriously aggravate these concerns by reducing the diversification of world supply that has served so well to limit the market power of OPEC suppliers since 1980.

Given these obstacles, there remains enormous potential for both producer and consumer countries to squander the economic opportunities afforded by resource abundance.

The role of markets and governments

These dangers have been the basis for a consistent effort by Organization for Economic Cooperation and Development governments to intervene in energy markets to limit economic vulnerability to oil shocks. There have been a number of different approaches in the past 15 years. Some have worked reasonably well, others have proved counterproductive and still others have yet to be tested. Private companies also realize the risk, and most have developed mechanisms to manage it.

During the 1970s, governments, especially the United States, based their policies on the premise that energy was too important to be left to markets. Consequently, they adopted policies to attempt to micromanage supplies and prices to limit vulnerability to future disruptions. Prices were controlled, and refiners were given "entitlements" to artificially "cheap" domestic supplies. It is now widely recognized that the gasoline lines, regional supply shortages, reduced domestic supply and artificially high growth of imports were the result not of physical shortages stemming from embargoes or resource constraints, but of misguided government price and allocation schemes. Clearly, the world market during that time was imperfect, since a cartel (OPEC) was exerting its market power via restrictions on its own supply. This imperfection was widely recognized as the rationale for government intervention. What was not widely recognized, however, was that such a market imperfection was a necessary, but certainly insufficient, condition for direct government controls on the industry. Government never had nor could have had sufficient information, authority or policy instruments to allocate resources better than the market, even a flawed market. In retrospect, such controls aggravated a bad situation by stimulating consumption and discouraging domestic production.

In the 1980s, governments finally abandoned these attempts at micromanagement in favor of more targeted programs, such as the accumulation of strategic oil stocks by the United States, Germany and Japan, as well as development and maintenance of traditional military and diplomatic capabilities to ensure freedom of commerce in the Persian Gulf. Under this regime, world demand and non-OPEC supply drastically undermined OPEC's market share in the first half of the decade. Saudi Arabia and its Gulf allies (Qatar, Kuwait and the United Arab Emirates) raised production rapidly to recapture market share, provoking both Iran and Iraq to military threats and actions against their Gulf neighbors. Military operations were required to safeguard shipping in the final months of the Iran/Iraq war, and to successfully liberate Kuwait following the Iraqi invasion in 1990. During the resultant Gulf War, despite the interruptions of supplies from Kuwait and Iraq, both the magnitude and duration of the disruption to western economies was extremely modest.

There is a stark contrast in the approaches of western governments, particularly the United States, between the 1970s and 1980s—namely the contrast between failure and success. The micromanagement so characteristic of the 1970s aggravated the problems they were intended to address. By contrast, the actions of the 1980s, consisting principally of reliance on natural market forces to discipline OPEC, supported by accumulations of strategic reserves and the traditional government policy instruments of diplomacy and military readiness, have succeeded in securing and expanding an institutional framework for growing world trade in oil.

Apart from the changes in consuming-country government policy that have reduced oil vulnerability, a number of private actions have also contributed to reducing vulnerability. First, financial institutions and instruments, such as spot and futures markets, significantly redistribute and manage the risks associated with disruptions far more efficiently than any instruments available in the 1970s. For this reason alone, the costs associated with any disruption today would be far lower than those of the 1980s. Second, the chances of a deliberate, financially motivated supply shock by OPEC or some other group have been reduced by a number of new trade and investment linkages between OPEC states and Western governments, such as significant downstream integration projects in Europe and the United States by major producers including Saudi Arabia and Kuwait, as well as Venezuela.

For all these reasons, the prospects for world petroleum supply growth in the next several decades are far brighter than ever before. But many dispute this conclusion, arguing that the military commitment to defense of growing trade with the Gulf states is unjustified, and that reduced consumption of oil or the development of alternative fuels should be mandated. This argument may be attractive superficially, but it is flawed fundamentally.

No neat, predictable relationship exists between dependence and vulnerability. The military commitment to defense of the Gulf is no less pressing if imports are 50 percent of consumption than if they are 95 percent. A disruption will cause world prices to rise, everywhere, since oil is a fungible commodity, traded in a world market. As one expert has argued:

> "There is no direct relationship between the deployment of U.S. forces in the Middle East and our importation of Middle East oil...The fact that the Middle East is the world's principal oil supply source played a role in locating some of our forces there. But this would have been so regardless of our own oil imports from the region...The one time we did have substantial military expenditures in the region, during operations Desert Shield and Desert Storm in 1990-91, we were fully reimbursed by our allies, ...a clear indication that these operations were international in scope and not related to our level of Middle East imports. In fact, our current role in the Middle East is primarily a function of our superpower status, not our oil import dependency."[43]

The big picture: an abundance of oil

No one should suggest that there are no risks associated with growing world trade in petroleum from the Persian Gulf. There are such risks, they are sizable, and they need to be taken seriously. It is precisely because of this seriousness that we must not tolerate costly efforts aimed at reducing consumption or mandating inferior alternatives. Such approaches distract the attention of government from the true problem—establishing an international military and diplomatic framework for secure commerce, thereby unleashing the mutual economic benefits that resource abundance offers to the world.

NOTES TO CHAPTER 1

1 This estimate for 1830 is from the *Encyclopedia Americana*, 1983, s.v. "Population."

2 United Nations, Department of International Economic and Social Affairs, Long-Range World Population Projections, ST/ESA/SER.A/125, 1992, 28.

3 Gifford Pinchot, *The Fight for Conservation*, 1910.

4 Harold J. Barnett and Chandler Morse, *Scarcity and Growth: The Economics of Natural Resource Availability* (Baltimore and London: Johns Hopkins University Press for Resources for the Future, 1963), 10.

5 E.S. Zimmerman, *World Resources and Industries*, 1951.

6 Department of Commerce, Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1970—Part 1* (Washington, D.C.: U.S. Government Printing Office, 1975), 134, 457.

7 Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States 1991* (Washington, D.C.: U.S. Government Printing Office, 1991), tables 631 and 1106.

8 Donella H. Meadows et al., *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* (New York: Universe Books, 1972), 126.

9 Ibid.

10 Ibid., 56-59.

11 World Bank, *World Development Report 1992: Development and the Environment* (New York: Oxford University Press, 1992), 8.

12 Ibid., 37.

13 Ibid.

14 William Claiborne, "Greens, Browns Find Common Ground in the World's Cities," *Washington Post*, 26 September 1994.

15 While the dawn of the petroleum industry in the United States is usually considered the drilling of Drake's well in Titusville, Penn., in 1859, petroleum is actually one of the oldest substances used continuously by mankind. Greek legends indicate an understanding of the properties of "burning water," used as a weapon in sea battles. Noah is said to have caulked his ark with pitch gathered from the shores of the Dead Sea. Nehemiah used "napthar" for altar fires. Ancient Syrians mixed petroleum with ashes for use as fuel. Zoroastrians worshipped in the glow of burning gas at Baku on the Caspian Sea. Native Americans, and later European settlers in the area of New York, Pennsylvania, and Ohio, used crude oil for medicinal purposes. George Washington acquired a parcel of land in western Pennsylvania known to contain a natural seep which he called a "burning spring." All these former uses were supplied by naturally occurring seeps. Later, in the 19th century, oil was occasionally found by accident in drilling shallow brine wells in search of salt, and such oil was principally used for lighting. It was the technology of drilling such shallow brine wells that inspired Drake to drill his first oil well.

16 There are a number of reasons why oil and gas deposits pose uncertainties quite different from other mineral resources. First, there are no known technologies for establishing the existence of such resources short of drilling the prospect. Other minerals are often identified by outcroppings or by exploratory techniques less expensive than oil drilling. Second, even if a well confirms the existence and real extent of an oil or gas resource, the amount recoverable depends on the mobility of the resource within the formation and the technology and production methods used.

17 This uncertainty is greater for oil than for other resources, such as coal, since the petroleum resource is mobile within the source rock, and the degree to which this mobility can be exploited is a major factor in determining the rate of recovery of the resource from that source.

18 The industry often compounds the misperception with its own terminology. "Pools" is a good example of such a poor choice of technical terms.

19 The word "petroleum" literally means "rock oil," from the Latin "petra," meaning "rock," and "oleum," meaning oil.

20 Metaphor used by J. Akins, "The Oil Crisis: This Time the Wolf Is Here," *Foreign Affairs*, April 1973.

21 See D. Day, "The Petroleum Resources of the United States," in *Papers on the Conservation of Mineral Resources*, *USGS Bulletin* 394, 1909.

22 Response by Secretary of the Interior to Senate Resolution. Appears in U.S. Congress, Senate, 64th Cong., 1st sess., Doc. 310, 2 February 1916.

23 The Federal Oil Conservation Board had been set up by President Coolidge in 1924 to "study the government's responsibilities [and] enlist the full cooperation of representatives of the oil industry [to] safeguard the national security through conservation of our oil." The security concern stemmed from the realization that 80 percent of the oil used in World War I had been supplied by the United States, combined with the fear that domestic resources were nearing depletion.

24 Actually, DOE prepared estimates for 1978 and 1979 as well, for purposes of comparison with API estimates. There had been a long-standing suspicion within government that industry estimates were deliberately estimated too low (see Wildavsky and Tenenbaum [1981] for a history of these suspicions). In fact, the DOE exercises for overlapping years (1977, 1978, and 1979) were only very slightly different from those prepared by the industry for those years.

25 The narrowness of the measure also enhanced the feasibility of accurate reporting by the companies involved, insofar as a broader measure would often have revealed longer run development strategies that individual companies would be reluctant to share with competitors.

26 Due both to geophysical advances and to new insights into patterns of occurrence (see explanations of the "Realms" hypothesis in C. Masters et al., "World Petroleum Assessment and Analysis," in *Proceedings of 14th World Petroleum Congress,* Stavenger, Norway, 1994).

27 Nonetheless, there remained a strong popular misconception, even among high-level officials in government, who clearly interpreted the remaining resource base as simply the volume of current reserves.

28 Composed of Saudi Arabia, Kuwait, Iraq, Iran and Qatar.

29 Proved reserves here are taken from *Oil and Gas Journal, Worldwide Issue*, various years. While these are the most widely cited reserve estimates, they are generally the official estimates for each country. However, there is a very wide assortment of definitions and motives for such official estimates across countries. In particular, standardized financial reporting requirements give rise to United States reserve estimates far more narrow than those of most other countries.

30 See, for example, International Energy Agency (1994), U.S. Department of Energy (1994), World Energy Conference (1993), Energy Modeling Forum (1991).

31 For example, the 1921 USGS/AAPG study claimed that "fortunately estimates of our oil reserves can be made with far greater completeness and accuracy than ever before."

32 For example, Meadows et al.

33 Porter (1991) traces the history leading up to the collapse of the swing producer policy, and the consequences of a range of potential scenarios for future supply from the Gulf.

34 Nazer (1986) clearly articulates the Saudi repudiation of its previous swing producer policy. As a consequence of this strategy, the Gulf states did recapture nearly 10 percent of the petroleum market from 1985 to 1993, but after nearly a decade were still far short of the share they controlled in the early 1970s. Many of the losses proved to be permanent or long term, as oil was backed out of many traditional uses in favor of other fuels, and many of the new non-OPEC supply sources continued to expand even at the lower post-1985 prices.

35 Gately (1994) shows that continuation of this market share strategy dominates any return to swing producer policy from the standpoint of maximizing the present value of revenues to the major Gulf producer countries over a wide range of market conditions.

36 See International Energy Agency (1994).

37 See C. Masters et al. , "Distribution and Quantitative Assessment of World Crude Oil Reserves and Resources," in *Proceedings of 11th World Petroleum Congress,*

London, England, 1983; id., "World Resources of Crude Oil, Natural Gas, Natural Bitumen, and Shale Oil," in *Proceedings of 12th World Petroleum Congress*, Chichester, England, 1987; id., "World Resources of Crude Oil and Natural Gas," in *Proceedings of 13th World Petroleum Congress*, Buenos Aires, Argentina, 1991; id., "World Petroleum Assessment and Analysis," in *Proceedings of 14th World Petroleum Congress*, Stavenger, Norway, 1994; id.

38 One important feature of USGS assessments is an attempt to standardize the known resources (proved and probable reserves) in such a way as to retain comparability across countries.

39 Assuming an average recovery efficiency of 34 percent of original oil in place.

40 Of course, these estimates include only oil resources. There are similar arguments that apply to the development of natural gas resources, whose occurrence is also widely regarded as having been severely underestimated, both domestically and worldwide.

41 The definition of proved reserves in the U.S. is quite narrow by world standards; that used in the Persian Gulf, for instance, is quite liberal. Moreover, we know that the bulk of the massive increase in world oil reserves since 1985 was overwhelmingly the result not of drilling activity, but rather a round of several huge revisions by each of the major Gulf countries since 1985. On the one hand, these revisions may be reflective of gamesmanship in OPEC quota allocations. On the other hand, the countries making these revisions in the late 1980s (Iran, Iraq, Kuwait, Saudi Arabia, and the UAE) are some of the most prolific yet relatively unexplored areas of the world, so it is at least possible that these revisions offset previous understatements.

42 For example, the U.N. embargo on trade with Iraq, or the 1995 executive orders banning U.S. companies from any commercial relationships with Iran.

43 John H. Lichtblau, "Oil and National Security" (New York: Petroleum Industry Research Foundation, Inc., 1993), 3.

[redacted]

CHAPTER 2

Do markets lead to efficient energy choices?

Those who believe that Americans should move from petroleum—the sooner the better—argue that the nation is "addicted" to this fuel, its ease of use and ample supply. As a result, they argue that we are wasteful drivers, workers and homeowners—and that, as a nation, we could be significantly more efficient energy users. But all the reasons for this so-called "wasteful addiction" do not stand up to scrutiny. The facts are:

- Americans use energy as efficiently as other countries.
- Energy markets encourage—not discourage—efficiency, and American businesses and consumers respond to these signals as they do in all their budget decisions.

During the past several years, the U.S. economy has created jobs far more quickly than either Japan or Western Europe—a record that points toward efficient, effective choices of energy, labor, capital and other economic resources. The U.S. economy is succeeding, not failing. Over the last several decades, standards of living have been improving, not deteriorating.

Nonetheless, some groups counter that America's seemingly good economic performance is really an illusion, based on lifestyles that overconsume energy and other natural resources. These groups include the Sierra Club, the National Audubon Society, the Worldwatch Institute and the World Resources Institute.[1]

They argue that Americans must radically change their lifestyles in order to stop overconsuming natural resources and avert environmental catastrophe.

They propose drastically reducing—if not eliminating—auto usage, thus changing the very way Americans live. Groups such as the Worldwatch Institute and the World Resources Institute argue that cars, and the mobility cars provide, are environmentally destructive—no matter how clean technology makes automotive fuels. According to the Worldwatch Institute, "No car, no matter how smart or fuel-efficient, can eliminate land-gobbling sprawl—one of the most devastating consequences of ever-increasing reliance on motor vehicles, and one of its strongest reinforcing factors."[2] The World Resources Institute says that government somehow must reverse decades of suburbanization and "interest mainstream Americans in the kind of high-density urban developments where walking, bicycling, and public transportation are both possible and enjoyable."[3]

We must examine the premise that underlies this reasoning.

This chapter will look at the energy efficiency of Americans compared with other industrialized nations in the world, at how energy markets work and the way Americans make choices about energy.

Energy intensity

Some claims of U.S. energy waste are based on the notion of average energy intensity—how much total energy (measured in "British Thermal Units" or BTUs[4]) some 260 million Americans use at home, on the road and on the job divided by the U.S. economy's total production, or Gross National Product (GNP), measured in dollars.

These critics wrongfully charge all Americans with wasting energy by mistaking energy intensity for energy efficiency:

> "Our chief economic competitors, Japan and Germany, are twice as energy efficient as we are."[5]
>
> "The U.S. spends 11 to 12 percent of its GNP on energy, compared to 5 percent for Japan; this difference gives typical Japanese exports an automatic 5 percent cost advantage."[6]
>
> "The nation lags far behind many European countries when it comes to energy efficiency. Europe uses about half as much energy as the United States per capita...."[7]

These claims point out that Japan, (former West) Germany and Europe average fewer BTUs of energy than Americans, whether measured as BTUs per dollar of GNP or BTUs per capita.[8] The fallacy of using this comparison to measure relative efficiency becomes clearer when evaluating the energy intensity of a family—that is, adding all the energy the family members use during the year at home, at work, on the road, on vacation, etc. This measure of total energy use is then divided by how much money the family earns per year. The result is the number of BTUs the family uses, on average, for each dollar of income the family earns. (At the national level, GNP measures not only total production, but also all of the income received by all Americans. Therefore, using a family's income in the intensity calculation is equivalent to using the GNP for the nation's intensity calculation.)

Suppose the family includes two wage-earners, both of whom commute to-and-from work daily. That commuting is reflected in the family's energy intensity. Suppose further that next door lives a retired couple. As a result, the neighbor's energy intensity is considerably less. But, it would be ludicrous to conclude that the working family "wastes" energy while the retired couple does not.

As another example, consider the energy used by two family-run businesses: a family farm in Indiana and a small accounting firm in New York, each returning an annual $75,000 profit. Since profit, in addition to being a form of income, measures a firm's contribution to GNP, both the Indiana farm and the New York firm are the same size economically. However, the farm might easily use four times the number of BTUs to earn its $75,000 profit than the New York firm, because operating tractors and harvesting equipment require more energy than running financial software on desktop computers. Again, the conclusion should not be that rural farmers "waste" energy while urban accountants "conserve" it.

Similarly, the United States is not wasteful simply because it uses energy more intensively than some other industrialized nations. There are good reasons why economic efficiency pushes Americans toward a greater average energy intensity.

Energy intensity is not the same thing as energy efficiency

The question "Do Americans use energy efficiently?" is really many questions. Here are two: Do American consumers use energy efficiently? Do American homeowners use energy efficiently?

Let's consider how Americans use energy at work. The issue is how efficiently—that is, how economically—Americans meld energy with their labor and other productive resources, such as capital and raw material. If Americans are as good as the Japanese or the Germans at minimizing total resource costs (and still accomplishing the job), then it would be fair to say that Americans are as energy efficient (and as labor efficient, as capital efficient, etc.) as anyone else.

Even when Americans use energy efficiently, it would be physically possible to use less energy by using more capital or labor and, thus, reduce the energy intensity of a production process. That adjustment only makes economic sense if the additional labor or capital costs less than the amount of energy "conserved." If energy was being used efficiently in the first place, then the adjustment will raise—not lower—total resource costs.

As a hypothetical example, suppose developing innovative technology or adding insulation enabled General Electric to manufacture a new refrigerator that used 10 percent less energy than a conventional refrigerator. Energy intensity obviously would be less. But developing new technologies or adding insulation costs money. Economic efficiency would suffer if the increased cost of improving the refrigerator exceeded the value of the energy it saved over its useful life. In other words, saving $50 worth of energy over the refrigerator's useful life[9] by using $100 of additional insulation "conserves" energy and reduces energy intensity, but it adds up to economic waste and inefficiency.[10] The same $50 energy conservation would only make sense if the additional insulation cost less than $50.

Americans have good reasons to be more energy intensive

It doesn't take an economist to understand intuitively **why** greater resource intensity makes good sense at home and at work. To do this, exclude energy for the time being and consider a different resource—land. Americans are more land intensive than either the Japanese or the Germans since, obviously, land is far more abundant in the United States than in either of those two countries.[11]

The typical American household has three times the floor space as the typical Japanese household. Again, to use economic terminology, the U.S. housing industry is more land intensive than its Japanese counterpart, since it uses more land to build a typical home or apartment. But this does not mean that American homeowners and landlords "waste" land.

When Americans leave their homes for work, they are apt to get their paychecks from companies and industries that are much more land intensive than the companies employing Japanese workers. For instance, U.S. farms in the Midwest routinely encompass hundreds, even thousands, of acres and use only a handful of people. Most Japanese farms have only a fraction of the acreage compared with an American farm. So U.S. farms are the more land intensive. Yet, American farmers are renowned the world over for their productivity and efficiency. Compare meat prices in U.S. and Japanese grocery stores to verify this point!

More abundant land resources also affect the way Americans get to work and how much energy they use, on average, in doing so. More land means lower population densities. In turn, Americans are more likely to drive cars. For intuitively obvious rea sons, again, it makes sense for residents of Tokyo to take subways, but not for residents of Billings, Mont., or Bloomington, Ind.

Energy resources, like land resources, are also more abundant in the United States than they are in Japan. While Japan must import virtually all of its energy, Americans are self-sufficient in coal and almost so in natural gas. Americans produced 80 percent of their oil supplies as recently as the late 1960s and even today produce about half of the oil they use. Therefore, many U.S. energy users are geographically much closer to energy producers than their Japanese counterparts. Fewer miles mean lower transport costs. Furthermore, much domestic oil and natural gas can be cheaply transported from producing wells by pipeline. Japan, by comparison, must load supplies on and off ships. America's energy prices reflect these lower transportation costs compared with Japan's energy prices.

Cheaper, more abundant resources—whether energy, land or something else—offer an obvious competitive advantage. Energy- and land-intensive industries are more likely to offer employment opportunities to Americans than to the Japanese or Germans.

These same job-creating industries also tend to increase national resource intensity statistics. The Office of Technology of the U.S. Congress observes that, "The higher aggregate [energy] intensity of U.S. industry is partly a result of its larger proportion of heavy, energy-intensive sectors such as refining, chemicals, pulp and paper, steel, and aluminum."[12] Furthermore, the Office of Technology points out, a superficial look at the statistics can easily give the erroneous impression that a U.S. industry is more wasteful than its smaller Japanese counterpart. "For example, Japanese pulp and paper manufacturers use less energy than U.S. companies to produce a ton of paper, in part because Japan imports, rather than produces, a greater portion of its pulp."[13] Aluminum provides another example. Not only does the United States produce far more of that energy-intensive metal than Japan, but it also is more heavily involved than Japan in primary aluminum production rather than the less energy-intensive secondary production.[14]

The U.S. aluminum industry tends to be both larger and more energy intensive than Japan's for the same reason that farms tend to be both larger and more land intensive in the United States than in Japan: greater resource abundance.

The United States' greater abundance of energy makes it sensible for Americans to continue using that resource more intensively in the home. For instance, more abundant, lower-cost energy makes it cheaper for the typical American homeowner, who already has more floor space to heat and cool, to set the thermostat at 68 degrees Fahrenheit. The typical, smaller Japanese home has a thermostat setting of 50 degrees.

Equating intensity with efficiency leads to absurd conclusions

Imagine telling American renters and homeowners that they could "easily" cut their energy use in half by turning their thermostats down to 50 degrees in the winter and eliminating two-thirds of their floor space—steps that would put them on a statistical par with the average Japanese household. Or, imagine telling Kansas wheat farmers that merely by copying the Japanese, they could "easily" cut energy consumption in half. Comparable Japanese wheat farmers simply **do not exist**. Or, imagine telling the residents of Biloxi, Miss. or Manchester, N.H., that they could cut in half the energy they use for commuting by taking trains and subways instead of cars.

Those who make the mistake of equating energy intensity with energy efficiency offer silly advice for "conserving" energy without even looking beyond the United

States. For instance, Americans living in New York State are even less energy intensive than the Japanese. Based on that fact and faulty logic, Americans in 49 states and the District of Columbia could be advised, "Do what New Yorkers do and cut your energy bills by **more** than half."

Arkansas, for example, is 1⅓ times more energy intensive than the U.S. national average, 2⅓ times more energy intensive than Japan and 2½ times more energy intensive than New York State. Yet, no Arkansas newspaper editorial would say: "New Yorkers use less than half of the energy we use. Therefore, we could easily cut our energy use by over half simply by copying New Yorkers."

No one would offer such advice because Americans living in Arkansas obviously cannot "easily" do what New Yorkers do. People living in a relatively sparsely populated state like Arkansas cannot take buses or subways as easily as many New Yorkers can (not just in New York City but in upstate urban areas such as Buffalo, Rochester and Albany). Mass transit contributes to New York State's lower energy intensity. But that statistical relationship offers neither evidence that New Yorkers use energy wisely, while the people of Arkansas waste it, nor practical guidance for other Americans.

Americans are competitive in world markets

If it were true that this country's higher intensity means energy waste, proof should be seen in the increasingly competitive global marketplace. The United States should be losing sales and jobs to Japan, Germany and several other industrialized countries. Yet, the United States, not Japan, is the world's leading exporter. During the 1980s, the U. S. economy created private sector jobs nearly six times faster than Western Europe, nearly three times faster than Germany and nearly 1½ times faster than Japan.[15]

If Americans, or anyone, wasted energy, they should have experienced faster economic growth when events in the Middle East during the 1970s gave them no choice but to cut down on their energy use—and their alleged energy waste. Instead, the United States, along with Japan and Western Europe, found that less energy use meant less economic growth. Once again, the facts point toward efficient energy use, not waste. [The appendix to this chapter gives a fuller treatment of the historical record.]

Do Americans waste energy because of "market failure"?

Some claim that Americans use too much energy because they make uninformed energy choices. Opinions vary about the reasons for this alleged failure. One school of thought holds that Americans cannot do basic energy arithmetic, causing them to underestimate savings and overestimate costs regarding conservation. Another blames energy markets for providing Americans with the wrong numbers to use in doing the arithmetic. The reasoning goes that Americans will arrive at the wrong "answers" on energy if prices "understate" all of the costs. Low prices steer Americans toward overconsumption—a problem this second school of thought says is compounded by government "bonuses" and "subsidies" that reward energy use.[16]

"Market failure": the broader issues

Claims that energy markets "fail" are really claims that many markets fail. After all, if Americans cannot fathom the basics of energy, there are many other commodities equally or more complex. Alternatively, if energy prices don't cover all of the costs, wouldn't the prices for lumber, steel, plastic, food and many other commodities be susceptible to similar failings?

People, of course, are fallible. However, the alleged "failure" in energy markets supposes that people repeat their mistakes. Markets and competition, however, help most people stop making the same mistakes again and again.

Competition provides more than one line of defense against repeated mistakes. If consumers fail to understand why a more efficient refrigerator or furnace makes good financial sense, the manufacturers have an economic interest in getting their story across, whether by advertising or other means. In addition, interested third parties, such as the publishers of *Consumer Reports*, make their living by helping to educate consumers. Only if consumers' initial failure is compounded by the failure of many others can there be long-term market "failure." If an energy market "failure" occurs, it's not just consumers who must share the blame; the "failure" extends far beyond energy.

Here are major reasons often given to support the claim that Americans are uninformed about energy:

- **Consumer irrationality.** *"The problem with both rational-economic and attitudinal models of energy-using activities appears to be that they are too simple to grasp the real-world complexities of such activities."*[17] If consumers are irrational and so don't even try to do what's sensible financially, there is no need to search further for an explanation for the alleged poor energy choices. But if most consumers are "irrational," won't they make poor choices about most things? Then won't most markets fail? Something is clearly amiss with the "irrationality" hypothesis because a wealth of economic evidence shows that people are able to choose successfully, in accordance with their interests.

- **Underestimating potential future energy savings.** *"Information regarding the technical and economic viability of such [efficient energy] technologies under full-scale, actual usage conditions is often scarce. The absence of such data leads to greater perceived risks and a reluctance to adopt such systems."*[18] If Americans are starved for information on energy technologies, shouldn't they be similarly starved for information on the rapidly changing technologies for computer hardware and software, video equipment, medical equipment and numerous other goods? As with energy, all of these technologies are complex, and learning about any of them costs time and money. However, it's also in the interest of thousands of companies—whether they make computers, video equipment or more efficient furnaces—to get their story across. That helps explain why Americans—far from being "reluctant"—embrace new technologies as rapidly as anyone.

- **Passing up energy efficient appliances unless they "pay for themselves" very quickly.** *According to Lee Shipper, "domestic energy use could be cut by 25-30 percent using measures that paid for themselves in five-seven years."*[19] Suppose that a durable, more efficient furnace costs $1,000 but, if purchased, would cut annual fuel bills by $200. The yearly fuel savings of $200 would "pay for" the $1,000 additional furnace cost in five years—a "rate of return" than is far more generous than what a consumer could get in interest by putting $1,000 in a bond or savings account.[20] Nonetheless, claims Shipper, many consumers pass up such opportunities year after year. Consumers this myopic would presumably pass up all sorts of things that cost little now but would yield great benefits in the future—everything from vocational education to retirement savings plans. Therefore, if "myopia" causes poor energy choices, the "failure" should extend far beyond the energy market.

- **Banks will not make loans to consumers for the purpose of buying energy efficient equipment.** Suppose that Shipper's "myopic" consumer would be willing to buy a more efficient furnace but does not have a spare $1,000 in a savings account and therefore needs a loan. Such consumers, claim many observers, often run into a "market barrier." Banks will not loan the $1,000. Now, instead of consumers, bankers are the ones who make the same mistake over and over again. Banks could offer loans at 10 percent, receive $100 in interest and still enable consumers to come out ahead financially. The consumer could take the $200 in fuel savings and use it to pay both the $100 in annual interest and reduce the loan amount by $100 a year. With the fuel savings paying the loan, the consumer would not be any more strapped for cash. Then, after 10 years, the loan would be repaid and all of the $200 in fuel savings would stay in the consumer's pocket for as long as the furnace lasts. Yet, supposedly, bankers repeatedly pass up opportunities to make profitable loans to finance energy-saving appliances. While bankers certainly make mistakes periodically, why should they keep making the same mistake—especially when they would be among the principal victims? If bankers are this incompetent, then any market reliant on financing should be "failing" along with the energy market.

- **Home builders and appliance manufacturers make energy-efficiency choices, not the consumers who pay the utility bills.** *"Aiming to keep the selling costs of new homes and office buildings as low as possible, residential and commercial developers construct buildings that do not incorporate the most economically efficient lighting, air conditioning, appliances, and electric motors simply because energy-saving equipment costs more than standard fare up front."*[21] This claim may appear plausible on the surface but it supposes that Americans buy new homes and office buildings that cost more, not less, to carry financially on a monthly basis. The buyer of the efficient home or office building could add the cost of buying the more efficient appliances to the mortgage. The savings on the monthly utility bills (if the energy savings are as great as alleged) would be more than enough to "pay for" the additional monthly interest payment on the mortgage.[22] Surely, the buyer of an office building would rather pay the bank $1,000 more a month on the mortgage if that would save $2,000 a month for heating, lighting and air conditioning. Some buyers probably make mistakes, but how much sense does it make to think that most buyers of office buildings routinely pass up such savings?

In short, market "failure" caused by Americans who never learn from past mistakes in making energy choices also means that competition fails—and fails in many markets besides energy. In view of the overall success of competitive, free-market economies, such claims should bear the burden of proof. After reviewing the claims made in several studies, Ronald Sutherland concluded:

> "The conservation literature argues that numerous cost-effective conservation measures could be undertaken, but they are not because market barriers discourage such investments. A review of these barriers indicates that, in general, they do not discourage investment and they are not market failures. A conventional investment model suggests that business investments in energy efficiency are made with the same decision rules as any other investments."[23]

Do energy markets fail because of faulty prices?

Some claim that Americans do not make wrong energy choices because of poor math skills, a reluctance to embrace new technologies, recalcitrant bankers or other "barriers." They believe low prices that do not reflect energy's real costs deceive Americans. Nowhere is this failure more pronounced, they say, than at the gasoline pump.

Here are a few of these claims:

> "The average price of gasoline at the pump in 1991 was about $1.15 a gallon, but...the true cost—including road construction and repair, subsidies, free parking, the expense of maintaining a military presence in the Middle East, climate risks, health and environmental cleanup costs—could exceed several dollars a gallon. Over the course of a year, these 'hidden' energy subsidies could amount to between $100 billion and $300 billion....Cars dominate our transportation system today largely because their use is so heavily subsidized."
>
> —Steve Nadis and James J. MacKenzie, *Car Trouble* (Boston: World Resources Institute, 1993), 20, 155

> "Close scrutiny shows that Americans pay $2.25 in hidden costs every time we buy a gallon of gas for $1.20...If American business and consumers used the true costs of driving in making travel plans, it's inevitable that millions more would ride the rails."
>
> —Stephen B. Goddard, "The Driving Costs of Transportation," *St. Louis Post-Dispatch*, July 8, 1994

> "The suburban commuter who drives downtown to work every day...pays only about 25 percent of the true cost of that trip....If we confront Americans with the full social costs of driving, people will tend to drive cleaner, more fuel-efficient cars at less congested times of the day."
>
> —Elmer Johnson, "When Cars and Cities Collide," *Detroit Free Press*, February 3, 1994

In other words, this school of thought alleges that Americans would drive much less if they faced prices at the gasoline pump that reflected all of the costs associated with driving.[24]

However, Americans confront the costs of driving at many places besides the gasoline pump: at the car dealer, auto insurance agency, auto repair shop, state licensing bureau, parking garage, toll booth and property tax window (many states and local governments charge property taxes on cars). As the World Resources Institute notes, the average motorist driving 15,000 miles paid $5,170 a year to own and operate a car in 1990.[25] Car payments remind millions of Americans each month that driving is anything but cheap, especially considering that the average cost of a new car in 1994 was $20,000.[26]

These data show that driving is not "cheap," as the market "failure" argument claims. Americans must be finding that driving provides them with substantial benefits to be worth its substantial costs.

The fact that driving is expensive also conflicts with the notion that American motorists evade the costs of their driving. Consider, for instance, the claim that "cheap" gasoline allows American motorists to escape paying for the air pollution they cause. In truth, motorists pay hefty sums, at both the new car dealer and at the pump, to curb harmful emissions. Department of Commerce data indicate that expenditures for pollution abatement by the automobile industry and consumers has added more than $1,800 (in 1992 dollars) to the average cost of a vehicle.[27] Looked at another way, even before driving off the car dealer's lot, motorists prepay the equivalent of 45 cents per gallon to curb air pollution.[28] In addition, each time motorists drive up to the pump, they now buy gasoline that is more costly to make, by several cents per gallon, because of recent government environmental regulations. Sooner or later, higher costs show up at the pump. With stricter and more costly regulations on the way, motorists are likely to pay even more.

Claims are also made that "cheap" gasoline allows motorists to avoid paying for other things, such as "the need to wage war to keep foreign pipelines open." If American motorists weren't dependent on Persian Gulf oil, goes this reasoning, President Bush and the Congress could have turned a blind eye to Saddam Hussein's invasion of Kuwait in 1990. However, it's silly to think that adding an additional 20 cents or 30 cents in federal excise tax on a gallon of gasoline would allow the President and the Congress to ignore the Persian Gulf. Europe, Japan and the emerging economies of the "Third World" would still be buying much of their oil from the Persian Gulf—and still tempting a future Hussein to capture that oil wealth and spend it on weapons of mass destruction. A future U.S. president could not ignore that threat, even if American motorists used no Persian Gulf oil.

As things now stand, notes syndicated columnist Robert J. Samuelson, defense spending "as a share of GDP [gross domestic product]...will soon be lower than any time since 1940." Samuelson concludes, "I doubt whether further cuts are wise."[29]

Those claiming "market failure" include many more items motorists should pay for at the pump but don't—such as congestion, subsidized parking, roads and accidents. However, a close look at such items shows that either motorists pay for them in some other way (for example, through their insurance premiums in the case of accidents) or that the solution for such problems doesn't lie with the price at the pump. For instance, congestion is certainly a problem, but slapping a higher excise tax on gasoline wouldn't do much to address it. Motorists would pay the same price at the pump whether or not they used the gasoline to drive during "rush hour." So, there would be little incentive for drivers to leave their cars at home during rush hour and take mass transit instead.

A far more direct and efficient, although politically unpopular, approach would be to charge motorists for use of highways in much the same way that Washington, D.C.'s subway system charges its customers: higher prices during rush hour than at other times. A recent report by the National Research Council discusses this approach.[30] Millions of Americans already pay what amount to "rush hour" fees for numerous other products and services provided by the private sector. For instance, movie theaters commonly charge higher admission prices for evenings than they do for matinees. Movie theaters do not solve the "problem" of too many patrons for too few seats on Saturday night by raising ticket prices for all of their shows.

Again, it is important to note that if energy markets, such as the market for gasoline, "fail" because prices are too low to cover all costs, then many markets should be failing for the same reason. It would be astonishing if energy markets, and only energy markets, suffered from this problem. The Sierra Club, National Audubon Society, Worldwatch Institute and World Resources Institute are among the groups that claim many other markets are failing, in pretty much the same way that these groups see energy markets failing.

The Worldwatch Institute, as one example, claims that many markets establish prices that do not cover all costs. Consequently, Americans are encouraged to overconsume a host of products and resources. According to the institute, a chinook salmon from the Columbia River now selling for about $50 should have a price of around $2,150 to cover all costs. Under this rationale, a hamburger produced on pasture cleared from rain forests should cost about $200.[31]

The Sierra Club, as another example, claims that many markets besides gasoline are built on "pervasive subsidies" and, therefore, cause Americans to make environmentally destructive choices for a wide range of natural resources. Only drastic change can put things right. According to the club's director: "We must recognize that much of our present wealth, our capital, is really based on subsidies...We must be willing to walk away from our bad investments, write them off, make better ones and begin building [a] new economy."[32]

Markets *do* lead to efficient energy choices

The argument that Americans waste energy does not pass muster when examined closely. Those who wish to move the nation away from the low-cost convenience of petroleum to fuel our nation's energy future, it turns out, have a much broader agenda: to radically change the way Americans live. That means "reducing consumption levels overall"[33] and reducing, even eliminating, driving.

Scant evidence exists to support the notion of an impending apocalypse or the prescription of radical surgery in American lifestyles. Much evidence shows instead that, in the case of energy, Americans use it as efficiently—although more intensively—as the Japanese, the Germans and other nationalities around the globe. Energy markets work as well as other markets. Wise energy choices outnumber foolish ones.

The evidence also shows that Americans make wise choices about most things. That is why, instead of rushing headlong towards environmental catastrophe as several groups claim, Americans in 1995 enjoy a cleaner, more healthful environment than ever before. To be sure, environmental problems remain and need to be addressed, with the help of thoughtful government policies. But the trend has been towards environmental improvement, not catastrophe.

Appendix

The historical record provides two "experiments" that test for energy "waste." During the two oil import disruptions of the 1970s, Americans had little choice but to restrain their energy use. If they had been wasting energy, Americans could eliminate that waste and thereby preserve their other uses of energy that were truly important to their lifestyles, and save money as well.

The record shows, however, that Americans—and others around the globe—found the cuts to be painful, not beneficial. Therefore, the two "experiments" conducted by history point towards energy efficiency, not waste.

The United States and other industrialized countries suffered sharp reductions in the rate of economic growth when they put the brakes on energy use during the era of high world oil prices precipitated by the 1973-1974 oil embargo and the 1978-1979 Iranian revolution. Table 1 shows economic and energy use growth rates for six developed countries, including the United States, during two eras: (1) the low world oil price period of 1950-1973 and (2) the high world oil price period of 1973-1984. All six countries put the brakes on their energy use during the high world oil price era, and all six countries saw substantial reductions in economic growth rates.

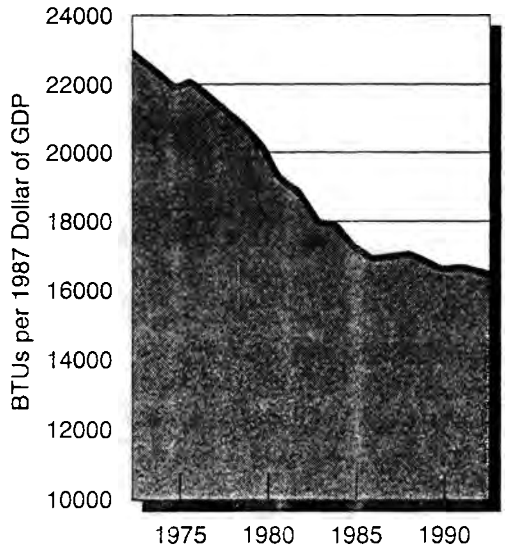
The United States and France, for instance, virtually stopped energy growth altogether during the 1973-1984 period, and both countries saw annual economic growth rates plunge into the low 2 percent range. All three countries that reduced total energy use (indicated by negative energy "growth" rates)—Germany, the Netherlands and the United Kingdom—saw their rates of economic growth fall below 2 percent a year.

Japan, too, cut back its annual rate of energy growth during the 1973-1984 period, and it, too, saw its economic rate of growth cut sharply. However, Japan's extraordinary energy and economic growth rates during the 1950-1973 period—exceeding 9 percent a year—suggest that much of its earlier growth may have been due to rebuilding after the physical destruction suffered during World War II. Except for rebuilding economies to their pre-war levels, even the most efficient and innovative countries generally cannot sustain economic growth rates above 4 percent or 5 percent a year. Therefore, Japan might have witnessed a sharp reduction in its rates of energy and economic growth even if turmoil had never occurred in the Persian Gulf during the 1970s. Even so, the historical experience shows that the general rule of "less energy growth, less economic growth" holds true for Japan as it does for Europe and for the United States.

The record also indicates that striving for efficiency rather than thoughtless waste is the general rule. For instance, during the last two decades (from 1973 through 1993) Americans have lowered their energy intensity by almost a third [see Figure 1] while increasing their economic production by more than three-fifths [see Figure 2]. Other nations show similar reductions in energy intensity during the past quarter century.[34]

FIGURE 1

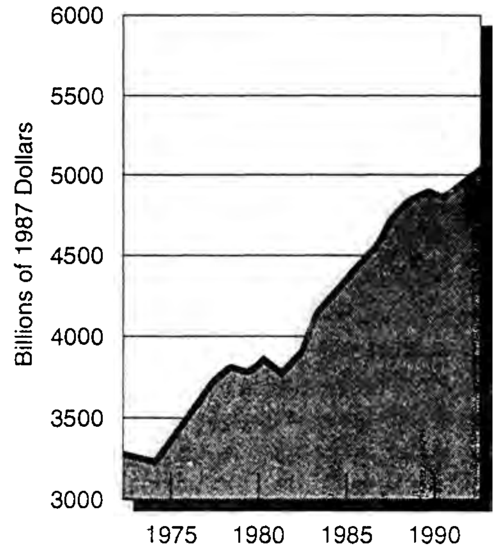
U.S. Energy Consumption, 1973-1993



Source: U.S. Department of Energy

FIGURE 2

U.S. Gross Domestic Product, 1973-1993



Source: U.S. Department of Commerce

NOTES TO CHAPTER 2

1 Here are some statements by environmental groups asserting that the U.S. economy is based on "overconsumption" of natural resources:

> "Our natural resource industries are supported and encouraged to over-harvest our resources, to destroy land and water and the living systems by pervasive subsidies."
>
> —Sierra Club director Carl Pope as quoted in "Polluting Should Be Expensive," *Cleveland Plain Dealer*, 11 June 1994

> "The days of the frontier economy—in which abundant resources were available to propel economic growth and living standards—are over. We have entered an era in which global prosperity increasingly depends on using resources more efficiently, distributing them more equitably, and reducing consumption levels overall."
>
> —Worldwatch Institute, *State of the World 1994, A Worldwatch Institute Report on Progress Toward a Sustainable Society* (New York: W.W. Norton & Co., 1994), 4

> "When viewed from a broad perspective, our auto-related woes are merely one element of a whole range of human activities—including population growth, energy use, agriculture, forestry, industrial processes, resource consumption, and waste disposal—that are not sustainable over the long haul."
>
> —Steven J. Nadis and James J. MacKenzie, *Car Trouble, World Resources Institute Guide to the Environment* (Boston: Beacon Press, 1993), 166

2 Worldwatch Institute, 81.

3 Nadis and MacKenzie, 156.

4 A BTU is the quantity of heat needed to raise the temperature of one pound of water by one degree Fahrenheit at or near 39.2 degrees Fahrenheit. According to the U.S. Department of Energy, the net heat content of a quantity of fuel is "the amount of usable heat energy released when a fuel is burned under conditions similar to those in which it is normally used." *Monthly Energy Review*, November 1994, 169.

5 Anna Aurilio and Chris Lockwood, "It's Time to Shift National Energy Priorities," *St. Louis Post-Dispatch*, 20 January 1994.

6 Amory Lovins, "Balancing Energy Supply and Demand," in *Meeting the Energy Challenges of the 1990s: Experts Define the Key Policy Issues*, GAO/RCED-91-66 (Washington, D.C.: GAO, 1991), 40. Cited by Jerry Taylor, *Energy Conservation and Efficiency: The Case Against Coercion* (Washington, D.C.: Cato Institute, 9 March 1993).

7 "Oil Is Still the Tail That Wags U.S.," *Contra Costa (Calif.) Times*, 14 February 1994.

8 Measuring energy intensity as BTUs per capita instead of BTUs per dollar of GNP (or GDP) amounts to pretty much the same thing, especially when per capita income levels are roughly comparable among Japan, the United States and industrialized countries in Western Europe. Both GNP and GDP are measures of income in addition to being measures of economic production.

9 The energy savings should be expressed as a "present value" figure that can be compared with the additional "up front" expenditure of $100 for the premium refrigerator. This "present value" figure is not the annual energy savings estimate consumers see posted on refrigerators (and other energy-using appliances) at retail stores. A present value estimate takes into account the fact that energy savings will accrue for many years since the refrigerator will last—and offer energy savings—for many years.

10 The $50 cost for insulation measures the value of all the resources—labor, capital, raw materials, energy—used by companies that make insulation. If a refrigerator manufacturer uses too much insulation to save too little energy, it in effect wastes the economic resources used up to make insulation.

11 For instance, Japan's entire population—about one-half that of the United States—lives in an area the size of New Mexico.

12 U.S. Congress, Office of Technology Assessment, *Industrial Energy Efficiency,* OTA-E-560 (Washington, DC: U.S. Government Printing Office, August 1993), 6.

13 Ibid., 6.

14 According to recent United Nations data, annual U.S. total (both primary and secondary) aluminum production from 1981 through 1990 ranged from nearly four times to nearly six times that of Japan. Annual U.S. primary aluminum production during that same time span was as much as 80 times that for Japan. See: United Nations, Department of Economic and Social Information and Policy Analysis, Statistical Division, *Statistical Yearbook: 1990/91* (United Nations: New York, 1993), 618-619.

15 Organization for Economic Co-operation and Development, *The OECD Jobs Study: Evidence and Explanations*, 1994, vol. I, table 1.1, 3.

16 For instance, one environmentalist has written: "We [Americans] are not irrationally in love with our cars. Just the reverse. We are behaving like the most rational possible economic beings. Offered generous bonuses—hidden and direct—to drive, that's exactly what we do." Jessica Mathews, "The Myth of the American Car Culture," *The Washington Post*, 31 March 1991.

17 John B. Robinson, "The Proof of the Pudding: Making Energy-Efficiency Work," *Energy Policy* (September 1991), 635.

18 Roger Carlsmith et al., "Energy Efficiency: How Far Can We Go?" ORNL/TM-11441, Oak Ridge National Laboratory, January 1990, 29. Cited by Taylor, 19.

19 *The Economist*, 31 August 1991, 12. Cited by Norman and Rusin, "Using Less Oil and Other Fossil Fuels — Arguments in Favor," internal American Petroleum Institute discussion paper, November 17, 1993, 17. Americans may require an even faster payback before they will conserve energy. "According to Amory Lovins, the clearest manifestation of pervasive market failure is that most customers require payback horizons of one to two years for energy savings." Taylor, 13.

20 At the end of the five years, the person buying the furnace once again has $1,000. A person who passes up the furnace has the $1,000 plus the compound interest on that money—about $276, assuming an annual interest rate of 5 percent. At the end of seven years the "rational" person has both the more efficient furnace and more money in the bank with additional fuel—and money—savings on the horizon.

21 James J. MacKenzie, "Toward a Sustainable Energy Future: The Critical Role of Rational Energy Pricing," *Issues and Ideas*, World Resources Institute, May 1991, 4. Cited by Norman and Rusin, API unpublished paper, op. cit., 13.

22 To see why this is so, suppose a new house costs $100,000 with standard appliances but $110,000 with energy efficient appliances. The energy efficient appliances would cut annual fuel bills for heating and cooling from $4,000 a year down to $2,000. Suppose, for ease of computation, that mortgage rates are 10 percent a year and that the buyer finances the whole amount. If the builder offers the $100,000 home, the total annual payment would be $14,000: $10,000 for the mortgage plus $4,000 for the utilities. If the builder instead offers the more efficient $110,000 home, the total annual payment is $1,000 less at $13,000: $11,000 for the mortgage plus $2,000 for the utilities. In short, if the energy savings on the appliances amount to more than the interest on the appliances' additional "up front" cost, the buyer pays less each year to carry the more efficient home.

23 Ronald J. Sutherland, "Market Barriers to Energy-Efficiency Investments," *The Energy Journal* (3 November 1991), 15.

24 Here are some more recent claims that gasoline pump prices cover only a small fraction of driving's costs:

> "Setting a more realistic price for driving during the next 10 years would require gas taxes at least double Europe's current levels."
>
> —Worldwatch Institute, *State of the World 1994*, 96

> "Truth is, drivers pay less than two-thirds of the cost of building and maintaining roads. The remaining $30 billion comes from general funds and property taxes. And this subsidy is just the tip of the iceberg. The unpaid social costs, borne equally by non-drivers, are 10 to 20 times greater. Even that amount, although it includes the costs of noise damage, congestion, accidents and air and water pollution, does not include the cost of farmland, the economic damage to cities or the splitting of

neighborhoods by highways."
—Jessica Mathews, "Missing Link," *The Washington Post*, 15 August 1994

"A huge gap has opened up between the perception that driving costs next to nothing and the very large price we actually pay to drive."
—Study by the Conservation Law Foundation

25 Nadis and MacKenzie, 9.

26 "In Detroit, Newer, Better — and Costlier," *The Washington Post*, 5 January 1995, D9.

27 Donald Norman, "Comments on 'The Going Rate: What It Really Costs to Drive,'" internal API discussion paper, 14 October 1992, 4. Estimates higher than the $1,800 cited by Norman are referenced in "Washington Behind the Wheel: Congress, Bureaucrats Add $3,000 to Car Costs," *Investor's Business Daily*, 2 August 1994.

28 This figure allocates the $1,800 extra cost over 100,000 miles, after which the vehicle is assumed to be scrapped. If the vehicle averages 25 miles per gallon, it will burn 4,000 gallons during its useful life. Spreading the $1,800 extra vehicle cost over the 4,000 gallons works out to about 45 cents a gallon.

29 Robert J. Samuelson, "Here's How to Balance the Budget," *The Washington Post*, 15 February 1995, A19.

30 Several recent newspaper articles discuss the concept of peak-hour pricing for highways and/or a report on the topic by the National Research Council. See: "Should U.S. Freeways Be Free?" *Investor's Business Daily*, 20 July 1994; "Electronic Road Pricing System for Singapore," *Financial Times*, 11 May 1994; "Tolls Seen Easing U.S. Traffic Jams/Pollution," *Reuters*, 14 June 1994; "Report Says Charging Tolls Would Ease Traffic Jams," *AP*, 14 June 1994; "Easing Gridlock," *Journal of Commerce*, 28 June 1994; "Charging More Tolls Studied as Solution to Traffic Woes," *The Washington Post*, 26 June 1994.

31 Worldwatch Institute, 32, 34, 96.

32 "Polluting Should Be Expensive," *Cleveland Plain Dealer*, 11 June 1994.

33 Worldwatch Institute, 4.

34 John Merline, "How's Mother Earth Managing?" *Investor's Business Daily*, 21 April 1995.

[redacted]

CHAPTER 3

Is the environment getting cleaner?

Environmental groups too often paint a grim picture of the state of nature in today's world. They forecast inexorable deterioration of the earth and the quality of life of the people who inhabit it—unless Americans act now and make radical lifestyle changes to reduce the use of oil and other fossil fuels.

But reality starkly contrasts with the gloomy warnings these groups routinely issue in an effort to impart a sense of urgency to their call for change. In truth, environmental quality has gotten much better in the 25 years since the first call for rising environmental consciousness. America's air and surface waters—rivers, lakes and streams—are cleaner. Our nation is addressing the contamination of soil and groundwater caused by past practices.

Moreover, this progress has been achieved without sacrificing the mobility that is the hallmark of the American lifestyle and emulated the world over. It has been achieved by fine-tuning the personal transportation that makes our way of life possible—not by re-making our way of life to accommodate the mass transportation of more populous, less prosperous nations.

The U.S. petroleum industry has contributed enormously to the environmental progress of the last 25 years, changing both its products and operating methods to help preserve and protect the earth for future generations. Today's petroleum-based fuels have no equal with respect to affordability and convenience, and they are nearly on an environmental par with alternative fuels. In short, petroleum-based fuels are the best choice overall and thus remain America's transportation mainstay for good reason—now and for the foreseeable future.

The environmental movement stems from a perceived crisis

Americans consider a bountiful and healthful environment as their birthright. Until the 1960s, they took that birthright for granted.

But in 1962, Rachel Carson sounded an alarm with *Silent Spring*, predicting mass extinction of species and destruction of entire ecosystems if people persisted in releasing pesticides and other chemicals into the environment. Over the next few years, the news media sought, found and publicized causes of concern about the state of the environment—for example, the air of major industrial cities such as Pittsburgh was black with soot, and the ecosystems of waterways such as Lake Erie and the Houston Ship Channel were thought to be dying. Nature provided her own dramatic punctuation of the point when Cleveland's Cuyahoga River, a dumping ground for toxic wastes, erupted in flames.

Thus, events conspired to spur government action. In 1969, in response to the perceived environmental crisis, Congress passed the National Environmental Policy Act. It required detailed environmental impact statements for many kinds of industrial development and directed the President to form a three-person Council on Environmental Quality patterned after the Council of Economic Advisors. The new Council on Environmental Quality assessed the situation this way:

> "The basic causes of our environmental troubles are complex and deeply embedded. They include: our past tendency to emphasize quantitative growth at the expense of qualitative growth; the failure to take environmental factors into account as a normal and necessary part of decision-making; the inadequacy of our institutions for dealing with problems that cut across traditional political boundaries; our dependence on conveniences, without regard for their impact on the environment; and more fundamentally, our failure to perceive the environment as a totality and to recognize the fundamental interdependence of all its parts, including man himself."[1]

By the end of 1970, Congress had passed the Clean Air Act and created two federal agencies to address health and environmental concerns: the Environmental Protection Agency and the Occupational Safety and Health Administration. Over the next decade, Congress passed the Clean Water Act (1972); the Federal Insecticide, Fungicide and Rodenticide Act (1972); the Marine Protection, Research and Sanctuaries Act (1972); the Endangered Species Act (1973); the Safe Drinking Water Act (1974); the Resource Conservation and Recovery Act (1976); the Toxic Substances Control Act (1976); and the Comprehensive Environmental Response, Compensation and Liability Act (1980)—usually referred to as Superfund.

In the 1980s, funding for some environmental programs was cut back and Congress reauthorized most environmental laws with little change. (The exception was the 1986 Emergency Planning and Community Right to Know Act, an expansion of the original Superfund law.) Then came a new decade and a new surge of environmental legislation. In 1990, Congress enacted Clean Air Act amendments and the Oil Pollution Act. The National Energy Policy Act, whose provisions require the use of alternative fuels for some motorists, followed in 1992.

The U.S. government documents environmental progress

The Clean Air Act has yielded most of America's documented environmental progress. The law directs EPA to set National Ambient Air Quality Standards (NAAQS) for the six most prevalent pollutants, which it calls "criteria" pollutants. Levels of five of the six criteria pollutants declined from 1970 to 1993:[2] These were lead, by 98 percent; particulates, by 78 percent; sulfur dioxide, by 30 percent; ozone, by 24 percent; and carbon monoxide, by 24 percent. Only emissions of nitrogen oxides increased—by 14 percent. At the end of 1993, more than three-quarters of all Americans lived where air quality met the federal standards for all six "criteria" pollutants.

Moreover, noted EPA, "these reductions [in criteria pollutants] occurred even during an increase in vehicle miles travelled and [an increase] in industrial output."[3] Between 1970 and 1993, America's population increased by 50 million people and the gross domestic product rose from $2.9 trillion to $5.1 trillion (in 1987 dollars).[4]

Another measure of America's environmental progress is the decline in releases of toxic chemicals to the environment, which EPA tracks with its annual Toxics Release Inventory (TRI). Required by the Emergency Planning and Community Right-to-Know Act, the TRI originally covered some 300 chemicals; in 1995, EPA enlarged the

TRI to include more than 600.

The most recent TRI data released by EPA are for calendar year 1992.[5] The trends are generally favorable. Since 1988, air emissions have decreased by 32 percent, water releases have declined by 12 percent, and releases to land have declined by 34 percent. During the same period, underground injection of chemicals held steady and underground injection of waste declined by 46 percent.[6]

Another part of the TRI is EPA's voluntary 33/50 program—so-called because it aims to reduce releases of 17 chemicals 33 percent by 1992 and 50 percent by 1995. As of 1992, the program was ahead of schedule. Releases of the 17 targeted chemicals declined "more than 40 percent since 1988, exceeding by more than 100 million pounds the program's 1992 interim reduction goal of 33 percent."[7]

Other government data show that municipal waste centers are recovering more of the materials—paper, aluminum, glass, plastic and yard waste—that people once simply had hauled away.[8] Water quality is improving, too. For example, banning the sale of detergents containing phosphorous has resulted in a 40 percent decline in the amount of phosphorous discharged into the Chesapeake Bay each year.[9]

Non-government organizations report similar trends. For example, the Pacific Research Institute (PRI), a non-profit policy group, recently released an *Index of Leading Environmental Indicators*.[10] Based on 20 years of government data, PRI researchers concluded that the United States has made progress in 8 of 10 major environmental categories. The researchers found that the residue of harmful chemicals in fish and birds is declining; the amount of land set aside for parks, wilderness, and wildlife is increasing; and some species are declining in number, but others are proliferating.[11]

Changes in cars and fuels play a key role in environmental progress

Government action sparked the environmental progress of the last 25 years. But that progress came about because of action by the two industries that make America's personal mobility possible—the petroleum and automobile industries. This achievement occurred without wrenching lifestyle changes.

On the one hand, the government's attempts to encourage Americans to use alternatives such as electric cars have had limited impact: gasoline and diesel fuel comprise 97 percent of America's transportation fuels.[12] On the other hand the petroleum and automobile industries have had great success in fine-tuning the combination that has been America's transportation mainstay for more than half a century: personal cars powered by internal combustion engines running on gasoline.

Gasoline and other petroleum-based fuels have become progressively cleaner over the course of the last 25 years. The process began in 1970, when EPA established a schedule for reducing lead in gasoline. Unleaded gasoline production went from zero in 1974 to 27 percent of U.S. production in 1980 to 55 percent of U.S. production in 1983 to 98 percent of U.S. production in 1992.[13] Today, all gasoline sold in the United States is lead-free. EPA calls the resulting reduction of the level of lead in the air—and in children's blood—"our greatest success."[14]

To attain the octane levels needed for gasoline, the petroleum industry substituted other chemicals for lead. Those chemicals tended to make gasoline evaporate more readily, thereby increasing emissions that contributed to air pollution. In the late 1980s, the petroleum industry addressed this problem by changing manufacturing methods and reducing highly volatile ingredients such as butane.

In 1989, 14 major oil companies and the three major American automobile companies created the Auto/Oil Air Quality Improvement Research Program to "develop data to help legislators and regulators meet the nation's clean air goals...."[15] This program, the largest and most comprehensive of its kind ever attempted, ran more than 2,200 emissions tests, using 29 fuel formulas in 53 vehicles, over the next five years.

> "The test measured tailpipe, evaporative, and running-loss emissions, and quantified the concentration of 151 different organic compounds.... The emissions data were then employed to conduct air-quality modeling studies for New York City, Los Angeles, and Dallas-Fort Worth, using state-of-the-science models and emissions inventories developed with standard procedures."[16]

Building on this approach, the 1990 Clean Air Act amendments recognized the potential of petroleum-based fuels to help clean the air. The law also required further changes in fuels, including diesel fuel containing less sulfur and gasoline containing more oxygen to reduce high levels of carbon monoxide in the air, a cold weather problem in high-altitude cities such as Denver and Albuquerque. In 1992, the petroleum industry began supplying more than 40 cities with gasoline containing more oxygen during winter.

To help reduce emissions that combine with heat and light to form ground-level ozone that leads to smog, the Clean Air Act amendments have required more radical changes in gasoline: changing the chemical structure and proportions of hydrocarbons to reduce reactivity and increasing the concentration of additives such as methyl tertiary butyl ether (MTBE) to promote cleaner burning. Along with natural gas, this "reformulated gasoline" is distinguished from other petroleum-based fuels in that it is defined as an "alternative fuel" by the 1990 Clean Air Act amendments.

The first generation of reformulated gasoline, introduced in January 1995, cuts emissions of hydrocarbons and air toxics more than 15 percent; contains more oxygen and less benzene; is free of lead and other heavy metals; and includes detergents to help keep engines clean. The next generation of reformulated gasoline, scheduled to be introduced in the year 2000, will reduce emissions still more: hydrocarbons by 25 percent, toxic chemicals by 20 percent and nitrogen oxides by 5 percent.

The law requires reformulated gasoline in the nine metropolitan areas with the most smog: Baltimore, Chicago, Hartford, Houston, Los Angeles, Milwaukee, New York, Philadelphia and San Diego. Some areas with less serious air quality problems, such as Louisville, Dallas-Fort Worth and Washington, D.C., have also elected to use it.

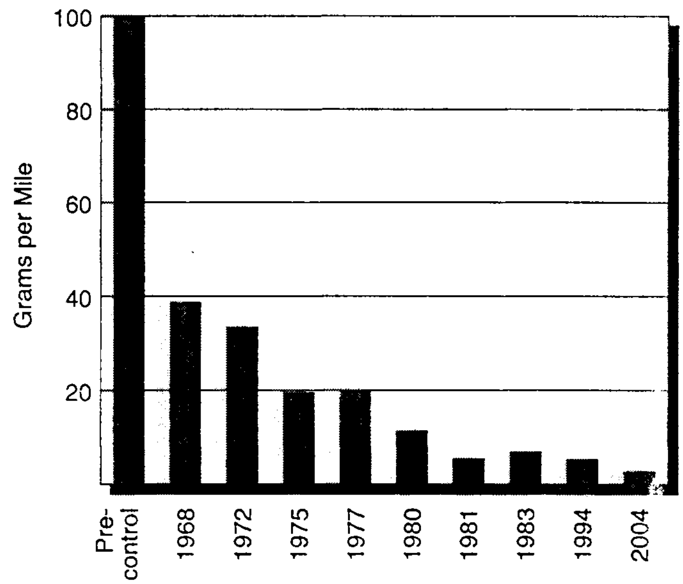
Tailpipe emissions approach the vanishing point

The government has also required changes in automobile design to help clean the air—changes that are on the verge of eliminating virtually all tailpipe emissions. Since the advent of pollution controls such as catalytic converters, tailpipe emissions have dropped by 96 percent. Additional changes now being introduced will cut the remaining emissions in half—for a total reduction of 98 percent in automobile tailpipe emissions since introduction of the first pollution control devices.

Because of the far-reaching changes in cars and fuels in the last 25 years, automobiles and light trucks are no longer the primary or even the secondary cause of summertime smog in many American cities. This has led the American Automobile Association (AAA) to characterize declines in smog-forming emissions from cars as "improvements unmatched by other sources."[17]

Based on its own statistics, EPA would probably agree with this assessment. In

FIGURE 1. Automobile Tailpipe Emissions



1988, the agency wrote:

> "Ozone is one of the most intractable and widespread environmental problems. Despite significant efforts including controls on refineries and cars, no major urban area in the country, with the exception of Minneapolis, is in attainment with the national health-based standards for ozone."[18]

Yet between 1983 and 1992, 42 of the 94 cities with formerly high ozone levels attained the federal standard.[19]

Today, the most promising means of further reducing automobile emissions focus on specific targets—for example, using roadside sensors to identify cars whose pollution controls are malfunctioning. Another possibility is buying and scrapping the older or more poorly maintained cars that produce most of the pollution. In addition, new cars could be equipped with more effective catalytic converters—converters that begin working as soon as the engine starts running, when emissions are highest.

In short, there is no need to force a shift to different transportation technologies. America can continue to make environmental progress while relying on the personal cars and petroleum-based fuels that make our mobility possible in the first place.

The petroleum industry spends more on the environment than EPA

The magnitude of the petroleum industry's environmental expenditures reflects the scope of its contribution to America's environmental progress. In 1993, U.S. oil companies spent $10.6 billion on environmental protection—$41 for every man, woman and child in America.[20] This figure represents more than half the profits of the top 300 oil and natural gas companies, and nearly twice EPA's expenditures that year.

By the year 2000, the petroleum industry could be making more than 10 percent of all U.S. expenditures on the environment—more than U.S. oil companies are expected to spend on drilling for new domestic oil supplies.[21]

The nature of the petroleum industry's environmental expenditures is changing as well. Spending for ongoing activities to limit pollution rose 42 percent in four years—from $6.3 billion in 1990 to $9 billion in 1993. In 1990, the largest share of those expenditures was to reduce water pollution. By 1993, expenditures to reduce air pollution were in the lead.[22]

A 1993 National Petroleum Council study found that U.S. refiners could spend as much as $152 billion (in 1990 dollars) between 1991 and 2010 to comply with environmental regulations. That includes $106 billion to modify refineries and operating procedures to comply with existing and anticipated air, water, solid waste, and safety and health regulations—and $46 billion to continue compliance activities already in progress. By the year 2000, the additional annual cost of supplying gasoline, jet fuel, home heating oil and diesel fuel to American consumers could reach $18 billion.

The same National Petroleum Council report estimated that between 1991 and 2000, U.S. refineries will spend some $37 billion on new capital equipment—two-thirds of that during the first five years. During those years, cash flow will be $25 billion less than required expenditures.

The increase in environmental expenditures has been greatest in the refining sector but has affected operating methods in all four major sectors of the industry: exploration and production, refining, transportation and marketing.

Industry has lessened the environmental impact of exploration and production

Thanks to computers, the telltale signs of finding and producing oil are becoming harder to find. With the same technology physicians use to peer inside the human body—CAT scans and magnetic resonance imaging (MRI)—geologists visualize the flow of oil through subterranean rock formations.

Horizontal drilling has also helped limit the environmental impact of finding and producing oil. Turning the drill so it bores virtually parallel instead of perpendicular to the earth's crust produces more energy from fewer wells. Wells are slimmer now, too—as little as four inches in diameter. The result is less waste and less pollution.

The Resource Conservation and Recovery Act, which directs EPA to set federal standards for disposing industrial wastes, classifies most exploration and production wastes as non-hazardous. Onshore, this allows water produced and used during the drilling process to be reinjected into the earth. Wastes are stored in steel or lined tanks instead of open pits. Where still used, pits are often covered with netting to protect wildlife.

The coexistence of wildlife and drilling operations is one measure of the success of the petroleum industry's rising environmental consciousness. Fifty years ago, only 15 rare whooping cranes wintered in the Aransas National Wildlife Refuge on the Texas Gulf Coast; today, 143 cranes winter there—often feeding near oil wells within the refuge itself. In California, a working oil field is also a 6,000-acre ecological preserve—home to several endangered species of plants and animals. Even the Audubon Society permits oil drilling on Avery Island, its acclaimed bird sanctuary off the Louisiana coast.

Recognizing that offshore drilling poses special risks, oil companies joined with the U.S. Coast Guard and the U.S. Department of the Interior's Minerals Management Service to develop special environmental guidelines for it. The resulting program earned the National Ocean Industries Association 1994 Safety in Seas Award.

Refineries retool to limit pollution

The increase in environmental legislation and regulation in the last 25 years has significantly affected the operating methods of refineries and the products they manufacture—fuels, motor oils, lubricants and chemicals for the production of plastics, clothing, medicines and scores of other consumer products.[23]

In 1993, U.S. refineries processed 1.6 trillion pounds of crude oil, with little more than 1 percent (about 18 billion pounds) ending up as waste. About half of all refinery wastes are water. Eight of the 30 materials included in API's survey of waste-management practices, conducted each year since 1987, are classified as hazardous wastes.[24] Between 1987 and 1993, refinery-generated hazardous wastes declined by 25 percent.[25]

Like many industrial plants, refineries also release relatively small amounts of toxic chemicals into the environment. In 1992, refineries released 101.5 million pounds of such chemicals—about 2 percent of the toxic chemicals either generated or used in the course of their operations.[26] Among all U.S. industries, chemicals ranked first and petroleum refining ranked seventh in volume.

The major release from refineries is ammonia, created when nitrogen is removed from crude oil. Most of the other chemicals from refineries are two types of hydrocarbons: olefins, such as ethylene and propylene (formed when crude oil is refined), and aromatics, such as benzene, toluene and xylene (present in crude and also created during refining).

For the most part, refineries emit chemicals into the air or inject them underground—a practice that has declined sharply in recent years. At the end of 1993 (the most recent available data), just one refinery still practiced underground injection.

For refineries, and the U.S. industrial sector as a whole, recycling of chemicals has increased and releases of chemicals into the environment has declined. Between 1988 (the year EPA uses as a baseline) and 1993, refinery releases of chemicals included in EPA's annual TRI declined by 32 percent.[27]

Transporting oil safely by water and land

By nature, transporting liquid cargo such as oil entails environmental risks—specifically, spills. The degree of damage to the environment is commensurate with the size of the spill. Though large spills are rare, traces of them can persist for a decade or more. While there is no evidence that they produce lasting environmental damage, subtle changes in ecosystems have been observed in areas where large spills have occurred—for example, off the coast of Brittany in France.

In recent years, the U.S. petroleum industry's record on oil spills has improved dramatically. In the absence of large tanker spills, the amount of oil spilled in U.S. waters declined precipitously in the 1990s, U.S. Coast Guard records show.

During the most recent decade for which records are complete, the amount of oil spilled has dropped by 82 percent—from about 11 million gallons in 1984 to less than 2 million gallons in 1993. The average for spills decreased from 6.3 million gallons per year from 1984 through 1988 to 5.6 million gallons per year from 1989 through 1993.[28]

This record is a testament to the effectiveness of the many changes the industry has made in personnel management, equipment design and day-to-day methods of operating ships and pipelines—the two major means by which oil travels in the United States.

To make ship transportation safer, the industry worked with the U.S. Coast Guard to develop electronic navigation systems. Crews undergo more training. Tankers are re-routed to avoid fragile ecosystems. For example, some companies do not allow tankers within 85 miles of a shore until final landing; others do not allow loaded ships to enter certain channels. Double hulls on tankers are being phased-in over 20 years under the provisions of the 1990 Oil Pollution Act.

Methods of building and operating pipelines have also changed. Oil companies have invested in premium technology to enhance safety—for example, using heavier, thicker steel or steel specially treated to resist corrosion near waterways, river crossings and other environmental hot spots.

Computers help test for weak spots in pipelines. One method of finding leaks uses liquids under pressure. Another involves sending "pigs"—6-foot torpedo-shaped "intelligent" tools—through pipelines to detect dents and weak spots. Electromagnetic instruments and ultrasonic devices measure pipeline walls in search of changes that suggest thin or weak spots.

Nonetheless, spills sometimes occur. Since the 1989 spill in Alaska's Prince William Sound—the biggest ever in U.S. waters—the petroleum industry has acted to ensure faster and more effective response to large spills by creating the Marine Spill Response Corporation (MSRC). Between 1990 and 1995, MSRC spent more than $900 million to create regional spill response centers in New Jersey, Florida, Louisiana, California and Washington. MSRC also has 11 equipment staging sites in U.S. coastal waters, Hawaii and the Virgin Islands.

Marketing facilities change equipment and operating practices

Service stations and other marketing facilities, the final link in the process of taking oil from the ground and delivering it to consumers, have also modified their equipment and operating procedures to help protect the environment and human health. The changes include replacing underground storage tanks, installing devices to capture gasoline fumes and serving as collection centers for used motor oil.

In the last 25 years, oil companies have dug up and replaced most of their underground storage tanks—an effort sparked by public concern about leaks that could contaminate groundwater.

> "Originally placed underground as a fire prevention measure, these tanks have substantially reduced the damages from stored flammable liquids. However, an estimated 400,000 underground tanks are thought to be leaking now, and many more will begin to leak in the near future. Products released from these leaking tanks can threaten ground-water supplies, damage sewer lines and buried cables, poison crops, and lead to fires and explosions."[29]

By 1998, all underground storage tanks—most of which are located in service stations—must meet strict standards established by EPA under the Resource Conservation and Recovery Act. These standards include monthly monitoring to detect leaks, upgrading tanks and piping to guard against corrosion, and safeguarding against overfilling and spills—for example, by building dikes around storage tanks to contain spills.

> "At the end of 1993, more than 70 percent of the underground storage tanks operated by API member companies already met 1998 federal standards for preventing corrosion, overfilling, and spills. Forty-two percent also met 1998 standards for detecting leaks."[30]

Service stations and other marketing facilities are also installing devices to prevent the release of gasoline vapors into the open air when gasoline is transferred from storage tanks to delivery trucks and when motor vehicles refuel. At the end of 1993, all facilities included in API's survey either met or exceeded federal and state requirements for such controls.[31]

In addition, many service stations serve as used oil collection centers. In 1993, API member companies operated nearly 8,000 used oil collection centers in 43 states and the District of Columbia—10 times the number they operated in 1990. In all, service stations operated by API member companies have collected some 21 million gallons of used oil since 1991.[32]

Roughly 60 percent of the used oil that is collected is burned as fuel in industrial boilers, furnaces and space heaters in service stations and car repair shops. The rest is re-refined and made into lubricants or used by refineries as a feedstock for products such as jet fuel, home heating oil and gasoline.

The state of the environment does not justify radical lifestyle changes

The state of the environment does not justify the call for the radical lifestyle changes Americans would have to make to substantially reduce the use of oil and other fossil fuels. Such changes would short-circuit innovation and constrain economic growth, undermining rather than heightening human health and safety.

> "The higher the level of economic activity, the larger and more varied are the alternatives pursued. Diversity flourishes. Many more alternatives for doing things than would occur to any one person or organization are tried in different contexts. All of this trial is a discovery process leading to new learning about how to improve safety."[33]

Though some environmentalists persist in portraying cars running on petroleum-based fuels as pollution-spewing spoilers of civilization, the reality is that changes in these cars and fuels have been key to America's environmental progress. Americans have twice as many cars and drive them three times as many miles as they did 40 years ago, yet total tailpipe emissions are barely one-third what they were.

In addition, the petroleum industry has made far-reaching changes in its operating methods—changes that have increased the industry's environmental expenditures and, according to U.S. government statistics, yielded tangible improvements in environmental quality. Levels of all six major pollutants regulated under the Clean Air Act have declined, and lead has declined the most. EPA attributes this decline largely to unleaded gasoline, declaring this achievement the single greatest success of the law.

The net result is that emissions from motor vehicles running on petroleum-based fuels are a declining share of the total emissions pie. Additional changes in cars and fuels scheduled for introduction in the next few years will reduce emissions still more. Environmentalists' claims to the contrary notwithstanding, the reality is that today's petroleum industry produces fuels that perform better and are more cost-effective than the alternatives proposed by critics of oil-based fuels, which are discussed in the next chapter.

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22 American Petroleum Institute, *Petroleum Industry Environmental Performance*, 48.

23 See discussion of changes in cars and fuels earlier in this chapter.

24 "Hazardous wastes" are listed in the Resource Conservation and Recovery Act—for example, API separator sludge—or exhibit one or more of these characteristics: strongly acidic or caustic (corrosive); easy to burn (ignitable); able to release toxic gases (reactive); or containing specific chemicals that can harm the environment (toxic).

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CHAPTER 4

Should we switch to alternative fuels?

Reducing the amount of oil the nation uses is possible only if some other source of energy is available to replace it. In transportation, this means substituting another kind of personal vehicle powered by something other than gasoline or diesel fuel to take us to work, school and the myriad other places Americans travel in their cars.[1]

Proponents of a shift away from oil-based fuels say they should be replaced by "alternative fuels." Electricity, compressed natural gas, liquefied petroleum gas (or propane), methanol, ethanol, fuel cells and hydrogen are among the most mentioned. Supporters of alternatives say they are needed to improve the environment, strengthen the nation's energy security, create jobs and help the economy.

These same proponents also insist that the government must engineer the changeover by providing certain "carrots" and "sticks": financial inducements to entice people to use alternatives and mandates to force their use. Both approaches are already employed on a scale the public may not fully appreciate.

A closer look at what's happening raises questions. Are alternatives really so badly needed that the government must require them? As shown earlier, facts don't support the arguments for restraining oil use—for example, that oil prevents attainment of environmental standards or is running out.

There is also the question of economics. Subsidies and mandates for alternatives now cost consumers, taxpayers and utility ratepayers more than $1 billion per year—a figure that promises to steadily rise with the full implementation of existing programs.[2] Proponents deny that such policies are harmful—and even maintain that they ultimately will help the economy. But alternatives generally cost more today than oil-based transportation. Subsidies and mandates are ways of imposing these higher costs on consumers whether they like it or not. More important, the limited economic, energy security or environmental benefits that might result from forcing the use of alternatives (and thus reducing oil consumption) don't equal the high costs. The public pays more for less, which hurts the economy.

This doesn't mean that alternatives don't have some advantages and serve some specialized purposes, nor is it to claim that they might not one day replace oil-based fuels—without government promotion. But government should not force or subsidize their use. If government seeks to protect the environment or achieve some other important national goal, let it set fuel-neutral standards and allow businesses to meet them in the best, most cost-effective way possible. This solves problems efficiently and enables consumers to make choices about fuels and vehicles.

Like all technology, energy technology inevitably changes. Today, oil-based fuels much of the oil it needs for any prolonged period. The argument that alternatives would provide energy security doesn't pass muster.

Electric vehicles. Battery-powered electric vehicles produce no tailpipe pollution but are not pollution-free. According to Amory Lovins, director of research at the Rocky Mountain Institute, they are "elsewhere emission vehicles—wholly reliant on electricity whose generation pollutes chiefly (but not exclusively) other airsheds."[11] Total hydrocarbon and carbon monoxide emissions for electric vehicles are far lower, even when power plant emissions are counted. However, total sulfur dioxide, nitrogen oxide and particulate emissions may be higher and could pose a health threat.[12] Also, given the fuel burned to produce electricity, electric vehicles may not produce lower greenhouse emissions.[13] (The amount of greenhouse emissions varies according to the fuel consumed by the power plant. For example, electricity generated at a nuclear power plant significantly reduces greenhouse emissions compared with electricity generated at plants that use fossil fuels such as coal or natural gas.)

There are other potential drawbacks to electric vehicles. According to the U.S. General Accounting Office: "Electric vehicles present some unique safety hazards from the chemical constituents and high voltages and operating temperatures of some batteries. Battery mass may also affect vehicle maneuverability and crashworthiness."[14] In addition, batteries have to be disposed or recycled. Moreover, use of lead-acid batteries—the most likely battery technology to be employed in the near term—increases processing and recycling of additional quantities of lead, a neurotoxin, with the risk of more getting into the environment.

Another problem is limited range. Lead acid batteries will take a vehicle only about 80 to 100 miles on a full charge, assuming limited or no use of the heater or air conditioner, no cold weather and operation on roads over flat terrain. According to the U.S. Department of Energy (DOE), "current technology is best suited for [a] range of less than 50 miles between charging."[15]

Electric cars are also far costlier to manufacture than gasoline-powered vehicles. While fuel and maintenance costs may be somewhat less, drivers must replace batteries about every three years at a cost of up to 20 percent or more of the original vehicle price.[16]

Some smaller manufacturers are producing or plan to produce electric vehicles at prices similar to those of gasoline-powered vehicles, but the cars are not comparable. For example, the Solectria Corporation intends to sell a new electric vehicle for about $20,000 that will be smaller than a Geo Metro that costs $9,000.[17] And Renaissance Cars, Inc., plans to market a battery-powered sports car for just under $17,000 (more if the optional top is ordered) that may be unable to reach 60 miles per hour.[18] Other small companies are selling electric vehicles at higher prices. U.S. Electricar, Inc., recently sold several small electric pick-up trucks to a Virginia utility for about $30,000 each. Gasoline versions would have cost about $12,000.[19]

Among major automakers, Chrysler has sold electric vans for $120,000 each. The vans are powered by 30 batteries that cost $50,000 and weigh nearly a ton. Ford plans to lease its "Ecostar" minivan for 30 months for about $100,000.[20]

If larger quantities of electric vehicles are produced in the future, prices will decline, but they are still expected to remain high. For example, DOE says that by 2010, electric vehicles will cost about $10,000 more than gasoline-powered vehicles.[21] DRI/McGraw-Hill and Charles River Associates estimate the difference at $20,000 per vehicle.[22]

Substitution of electric vehicles could reduce oil imports if the additional electricity is produced by domestic fuels. However, if massive numbers of electric vehicles are required, additional electric generation would be needed, which could result in importing some natural gas, possibly from Canada.

Methanol and ethanol. Methanol and ethanol burn little, if any, cleaner than reformulated gasoline.[23] Methanol is an alcohol that can be made from natural gas, coal, wood or biomass. Ethanol is an alcohol made from corn in the United States and from other things, such as sugar cane, elsewhere. When blended in gasoline, ethanol can increase ozone-forming emissions.[24] Both fuels produce slightly fewer carbon dioxide emissions compared with reformulated gasoline.[25]

Both methanol and ethanol pack substantially less energy per gallon than gasoline, which means vehicles equipped with a fuel tank the same size as a gasoline-powered car have significantly less range. A gallon of methanol, for example, will provide only about half the mileage of a gallon of gasoline. Also, because ethanol and methanol are alcohols, they mix with water, which can render them unusable. As a result, both fuels require special handling and cannot be moved through the existing gasoline distribution system.

Methanol is more corrosive than petroleum-based fuels. Methanol buses used experimentally by the Los Angeles Metropolitan Transit Authority during the early 1990s broke down twice as frequently as conventional diesel buses because of corroded fuel system components.[26]

Methanol is somewhat more expensive than gasoline, and ethanol costs about twice as much to produce as gasoline. DOE says that new methanol and ethanol vehicles cost up to $250 more than comparable gasoline vehicles.[27] The National Petroleum Council—an advisory body that reports to the U.S. Secretary of Energy—estimates that, when mass produced, ethanol and methanol vehicles will cost between $200 and $400 more than gasoline vehicles.[28]

If use of substantial amounts of methanol were required, much of it would be imported.[29] The cheapest feedstock for methanol is natural gas, which is most plentiful and inexpensive in the Middle East.

Compressed natural gas and liquefied petroleum gas. Compressed natural gas (CNG) reduces emissions more than reformulated gasoline, although some tests show that it generates slightly higher levels of smog-forming nitrogen oxide emissions. (Recently, however, a Honda Motor Company prototype vehicle running on reformulated gasoline met California's stringent "ultra-low" vehicle emission standard that previously only natural gas-powered vehicles had been able to meet.[30]) Liquefied petroleum gas (LPG), which is produced by processing natural gas or refining oil, produces about the same benefits as CNG, also generating somewhat higher nitrogen oxide emissions. Both fuels produce about 25 percent fewer carbon dioxide emissions than reformulated gasoline.[31]

However, both also contain less energy than gasoline in a given volume. For example, CNG contains only about one-quarter the energy. That's why CNG vehicles must be equipped with large heavy fuel tanks, which sometimes virtually eliminate cargo capacity yet provide a range of only about 150 miles. LPG vehicles also need larger fuel tanks.

Currently, LPG and CNG are far more widely used in the United States than other alternative transportation fuels. More than 350,000 on- and off-road LPG vehicles are being operated; more than 30,000 CNG vehicles are in use.[32] CNG and LPG are both generally less expensive than gasoline and both are well-suited for use in fleets, where centralized refueling is possible. However, vehicle costs are higher. DOE estimates that new CNG vehicles cost between $3,500 to $7,500 more than conventional gasoline vehicles, and new LPG vehicles cost about $1,000 more.[33] The National Petroleum Council expects lower incremental costs when these vehicles are mass produced: $600 to $1,200 more for CNG vehicles and $150 to $675 more for LPG vehicles.[34]

Use of CNG or LPG would decrease oil imports. But if large volumes of these fuels were used, much of it would have to be imported. The U.S. supply of LPG is limited, and most of that supply is committed to high-valued uses in the chemical and other industries. Natural gas is more plentiful. However, if substantially increased volumes were used in transportation, prices of domestic natural gas would rise and fuel providers may seek cheaper foreign supplies. Much would probably come primarily from Canada and Mexico, and secondarily from the Middle East and Pacific Rim.

Other technologies. Fuel-cell-powered vehicles run on electricity generated by a chemical reaction that is produced by combining hydrogen with oxygen. (The hydrogen can be created by passing an electric current through water, a virtually inexhaustible raw material.) In operation, a fuel-cell-powered vehicle produces only electricity and water—no pollution.

Hydrogen-powered vehicles feature an internal combustion engine that burns hydrogen as a fuel, producing nothing but water vapor.

For both vehicles, however, unless the electricity that produces the hydrogen is generated by the sun, a hydroelectric facility or a nuclear energy plant, its creation would produce at least some emissions, including greater carbon dioxide emissions than reformulated gasoline.[35]

Since an equivalent volume of hydrogen contains only one-sixth the energy of gasoline, a fuel-cell- or hydrogen-powered vehicle also requires extra large fuel tanks. A prototype hydrogen-powered Mercedes Benz was estimated to have a cruising range of only about 70 miles between refills.[36]

Neither of these vehicles is likely to become commercially viable unless making electricity from sunlight becomes much less costly.

The benefits of alternatives aren't worth the cost of forcing their use

Proponents say that the environmental, economic, technological and energy security benefits of widespread use of alternatives will be great. Facts don't support this assertion.

Environmental benefits. Some alternatives may be able to reduce emissions compared with conventional gasoline-powered transportation, but there are usually more affordable ways to achieve the same results. Electric vehicles are a good example. In 1998, they will add at least $200 million to the cost of new cars in California, and about $1 billion in 2003, assuming each electric car costs $10,000 more to manufacture than a comparable conventional vehicle. (California requires that "zero-emission" or electric vehicles constitute at least 2 percent of all new car sales in 1998 and at least 10 percent in 2003.)

Yet, in the first few years, electric vehicles will reduce emissions only slightly at best. One reason is that to meet the mandates, more expensive electric vehicles will have to be sold at artificially low prices. The higher costs that can't be passed through will be added to the cost of conventional new cars. This will hurt conventional new car sales, keeping older, high-polluting vehicles on the road longer.[37]

By the year 2010, emission reductions attributable to electric vehicles will remain small—producing, for example, as little as a 2 percent or less reduction in hydrocarbons. For this limited benefit, California consumers will have spent almost $10 billion in higher costs for electric cars between 1998 and 2010 compared with conventional automobiles.[38] Clearly, that's paying too much for too little.

In general, switching to electric vehicles is one of the most expensive ways to reduce emissions. Moreover, none of the alternatives is as cost-effective as reformulated gasoline. According to the well-regarded environmental think tank Resources for the Future, reformulated gasoline will reduce one ton of hydrocarbon emissions at a cost of between $2,000 and $5,000. For natural gas, the cost rises to $12,000 to $22,000; for methanol, $30,000 to $60,000; for electric vehicles, from $29,000 to $108,000.[39]

Economic benefits. Advocates say alternatives will create jobs, strengthen the economy and spur new technology. They contend that reducing imports will obviate the need to fight wars in the Middle East, thus reducing defense expenditures. They also claim that reducing demand for oil will reduce oil prices. They dramatically exaggerate these benefits.

Some jobs definitely will be created in making, distributing and selling alternatives. But they will come at the expense of lost jobs in the traditional automobile and petroleum industries. In addition, alternatives will likely be more expensive than conventional fuel/vehicle technology. Consumers, obviously, will bear these increased expenses, which means they will have less to spend on other products. This, in turn, will reduce demand for these products and cost jobs. Businesses will also have higher transportation costs, which would reduce employment.[40]

There are other adverse effects. For example, countries that now sell oil to the United States would have fewer dollars to buy U.S. goods and services.

The alleged savings that alternatives would provide by reducing imports would be minimal. For example, use of alternatives would probably have little impact on our military presence in the Middle East—and therefore produce little or no savings in defense spending.[41] Even with substantial increases in consumption of alternatives, we are likely to still use and import a lot of oil. So we would continue to have an interest in ensuring the availability of supplies from the region. Furthermore, some military spending is necessary irrespective of how much oil is imported from the Middle East because we have strategic interests there—such as preventing the proliferation of weapons of mass destruction.

Also, even if imports fell to zero, it would be in our national interest to ensure the free flow of oil to our allies and to others around the world. A disruption of the supplies they depend on could drive up world prices, harming their economies **and our own**, since we depend on them to buy our exports. A disruption would also drive up the price of U.S. oil, which is set by the international market.[42]

More consumption of alternatives, unless quite substantial, is also unlikely to reduce world oil prices and save Americans money. The world now consumes about 70 million barrels of oil per day. The United States consumes less than one-quarter of that.[43] In the foreseeable future, existing laws and regulations in this country promoting alternatives won't decrease U.S. demand for oil, let alone world demand, by more than a very small percentage.

Forcing technology development. Supporters want government to mandate alternatives, which they claim will force the development of new technology. The assumption is that government must step in because, if left alone, industry will overlook promising new technology and fail to develop it. This assumption defies history and common sense. The advancing technology we enjoy today is largely the product of private initiative, and the government's track record directing the development of energy technology is abysmal.

According to Michael McKenna, an energy consultant writing last year in *Policy Review*, "Since 1980, the United States [government] has spent more than $50 billion of taxpayer money to develop energy technologies that have either failed technically or lacked market appeal." A case in point was the nearly $6 billion the government spent between 1980 and 1992 to develop renewable energy such as solar, geothermal, biomass and wind-generated energy, hydropower and others. Despite the massive investment, energy production from these sources fell by nearly 10 percent by the end of that period.[44]

The classic example of government's misguided attempts to advance new technology is the Synthetic Fuels Corporation, established in 1980 by the Carter administration after a major oil supply disruption during the Iranian revolution. The aim of the program was to produce some 2.5 million barrels per day of synthetic fuels (synfuels) by 1990. (Synfuels are gas and liquid fuels made from coal or oil shale feedstocks, which the United States has in abundant supply.) Despite the expenditure of billions of dollars and the construction of synfuel plants, the program completely failed. Little fuel was produced, it cost far more than conventional fuels, and, as a result, in 1986, Congress terminated the program.[45]

Another example of costly government failure in technology development is the Public Utility Regulatory Policy Act of 1978 (PURPA), also under Carter. That law requires power companies to produce alternative, especially renewable, forms of energy, and it forces utilities to buy the alternatives even though they cost more. According to Resource Data International, Inc., a consulting firm in Boulder, Colo., because of PURPA consumers will pay $37 billion more for electricity between 1995 and 2000 than otherwise.[46] Yet, during this time, DOE projects that renewables will supply only a small increase in the percentage of electricity.[47]

For several reasons, government shouldn't try to pick "winners"—that is, choose the best future technology. It may not have the technical expertise to recognize superior technology. It may not have the market experience to know what will satisfy the consumer. But, more importantly, it cannot foresee the future. No one can plan technological change. It is "characterized as much by false starts, missed opportunities, and lucky breaks as by brilliant insights and clever strategic decisions."[48] When government does force some specific form of technology, such as electric vehicles, it is making a low-odds wager with the public's money. All too often it picks incorrectly, and, by interfering with the market, it places obstacles in the way of developing better approaches.

Energy security benefits. Proponents believe greater use of alternatives would make our energy supplies more secure. As discussed earlier, the dangers of our dependence on foreign oil are exaggerated. Trading oil is in the strong interest of both consumers and producers, including OPEC nations. Both sides lose by any disruption of that trade, as both have learned. Nevertheless, should foreign oil supplies be disrupted in the future, we are much better equipped to address and correct the situation than in the past.

First, we know that price controls don't work and, in fact, can only worsen the situation. Letting prices rise creates powerful incentives that encourage consumers to conserve and energy producers to increase supplies.

Second, the United States has a strategic stockpile of oil, the Strategic Petroleum Reserve, that it can use to replace lost supplies and stabilize prices. According to former Congressman Philip Sharp of Indiana, speaking during the Persian Gulf conflict, this reserve "may have prevented a large oil price increase when the tanker war broke out between Iran and Iraq. Its existence may also have limited the price increase we are currently seeing."[49]

Also, whatever merit lies in reducing oil imports, producing more of the nation's own oil and gas reserves would achieve that end better than mandating alternatives. The United States has put off-limits many of its most promising oil and gas reserves in Alaska and offshore. Opening these up, with appropriate environmental safeguards, would increase domestic supplies and reduce imports at far less cost.

Government is pushing alternatives at great cost to the public

Although questions remain about the costs and benefits of alternatives—questions the federal government itself has raised—the federal government and many state governments have programs that mandate or subsidize alternative fuels, and more are proposed. These programs exist because (1) the government believes it knows better than consumers which fuels and vehicles are right for them and (2) the cost, convenience and performance of alternatives, compared with gasoline technology, make them unattractive to consumers. Without mandates and subsidies, alternatives simply couldn't compete, except possibly in certain specialized uses.

The public is paying for these mandates and subsidies. Taxes have risen to finance higher-priced alternatives purchased by government for its vehicle fleets and to replace lost revenues due to various tax breaks for alternatives, including exemptions from federal and state fuel taxes. (These fuel tax exemptions also place more of the burden for highway maintenance on drivers of gasoline-powered vehicles.) Utility rates are up because state regulators are making ratepayers finance utility company programs to promote alternatives.

Proponents of subsidies for alternatives say they are justified because the government is already subsidizing oil heavily. However, the government's own figures show this is untrue.

Mandates. The surest way to establish a market for alternatives, regardless of their costs or problems, is for government to require their sale. The federal government and many state governments are now doing this through various laws and regulations:

- The Energy Policy Act of 1992 requires the federal government, state governments and alternative fuel providers (including utilities) to purchase increasing numbers of alternative fuel vehicles for their own fleets. These requirements affect all large fleets in metropolitan areas with populations of 250,000 or more. For example, by 1999, three-quarters of all new vehicles purchased for federal fleets must be alternative fuel vehicles. For alternative fuel suppliers, the requirement is 90 percent. The act also forces states to buy increasing numbers of alternative fuel vehicles for their fleets, and the requirements could eventually affect municipal and private fleets. By 2010, several million alternative fuel vehicles may have been purchased under various provisions of the Energy Policy Act, involving additional spending of billions of dollars. Failure to meet the requirements is punishable by fines.

- The 1990 Clean Air Act amendments require that ethanol, its ether derivative ETBE or methanol-based MTBE be blended in reformulated gasoline.
- California, New York and Massachusetts require the sale of electric vehicles beginning in 1998. In that year, 2 percent of all cars sold in those states must be "zero-emission" vehicles (meaning electric cars, even though producing power for them generates significant emissions). By 2003, the requirement rises to 10 percent. Manufacturers unable to comply with these requirements, because consumers won't buy the battery-powered cars, will be subject to a fine of $5,000 for every vehicle they fail to sell under the quota.
- At least 17 additional states have laws requiring use of alternatives in fleets. Several other states require use of alternatives "when practical."[50]

Subsidies. Policymakers know that alternative fuels and vehicles cost more than gasoline fuels and vehicles. So they often provide subsidies to encourage marketing and bringing them to consumers at more affordable prices. Although subsidization lowers the cost of alternative fuels to users, other consumers, taxpayers and ratepayers pay the difference in higher taxes, prices and utility rates. Subsidies also saddle the general public with the developmental financing of alternatives, without allowing it to share in the profits.

Government subsidies to advance alternatives are extensive and take many forms: tax exemptions, deductions and credits, Corporate Average Fuel Economy (CAFE) credits, low interest loans, rebates, relaxation of environmental standards, and public funding for research and development. The federal government provides a little more than $1 billion in subsidies annually, a figure that will grow to some $10 billion in about 15 years, when current programs are fully implemented.[51] Several federal laws and regulations provide these subsidies:

- The Energy Policy Act establishes tax deductions ranging from $2,000 to $50,000 per alternative fuel vehicle and $100,000 for each alternative fuels refueling station built. The law establishes a low interest loan program to assist small businesses in buying alternative fuel vehicles. It establishes funding to help states support alternative fuels development, and it provides more than $200 million for research and demonstration programs. In addition, under one section of the law, DOE is paying for "126 alternative fuel scholarships" to teach auto mechanics to promote use of alternative fuel vehicles.[52]
- The Intermodal Surface Transportation Act of 1991 authorizes federal grants for alternative fuel vehicle development. For example, in 1993, a federal grant program under this law paid more than $1.3 million to purchase six alternative fuel vehicles in San Francisco and $2.4 million to build a compressed natural gas refueling station in Cleveland.
- The Alternative Motor Fuels Act of 1988 provides CAFE credits to manufacturers of vehicles that run on alternative fuels. This allows these companies to build and sell more large, higher-profit cars with poorer fuel economy.
- The federal tax code provides excise tax reductions and income tax credits for ethanol worth about $770 million annually.[53] Some corn-producing states provide additional tax credits, deductions or exemptions.

- Besides the U.S. Department of Energy, a host of other federal agencies provide funding for alternative fuels research and development. These agencies include the National Aeronautics and Space Administration, the U.S. Department of Transportation, the EPA and the U.S. Department of Defense.

At least 21 states grant alternatives some form of relief from state motor fuel taxes. Seventeen states have income tax laws rewarding use of alternatives with an exemption, rebate or subsidy.[54] According to one report, California agencies have 55 programs that provided some $327 million in state, regional and local incentives and direct funding between 1992 and 1994.[55]

States also permit or encourage subsidization of alternatives through utility rate adjustments. Maine, for example, has required its public utilities commission to establish a preferential rate for operators of natural gas vehicles. People who don't get the preferential rate subsidize those who do. West Virginia permits state utility officials to raise the rate base to pay for conversion of vehicles to natural gas.[56]

Public utilities have proposed a number of programs to subsidize alternatives. For example, four public utilities in California proposed rate increases to finance more than $600 million in new subsidies that would encourage development of alternatives. (As of this writing, the fate of that request is pending.)[57] Washington Gas Light Co. has petitioned Virginia's State Corporation Commission for a rate increase of nearly $16 million to subsidize the construction of a natural gas refueling station.[58] Virginia Power and the Los Angeles Department of Water and Power have agreed to assist the U.S. Postal Service in an electric car project by funding charging stations at selected postal facilities.[59] Boston Edison plans to help finance the construction of two auto assembly plants to build electric vehicles.[60]

Impact on consumers and the economy. The $10 billion in federal subsidies projected for 2010 translates into a surcharge of $40 for each individual or more than $100 for the average family,[61] excluding state subsidies.

Taxpayers will pay for the subsidies or tax breaks that are financed from tax revenues, and consumers—even consumers who don't buy alternative fuel vehicles—will pay the increased manufacturing costs.

An example is electric vehicles, mandated for sale in California, Massachusetts and New York beginning in 1998. Automakers won't be able to pass through to buyers of untested, unproven electric vehicles all of the higher costs. So to sell the required numbers, auto dealers will have to offer them at prices well below cost and try to recoup their losses by raising the prices of new gasoline-powered cars.

If electric vehicles cost $10,000 more to manufacture in 2003 when 10 percent of new vehicles must be battery-powered (or "zero emission"), and if that incremental cost is added to the cost of new gasoline vehicles, buyers of the new conventional vehicles will pay about $1,000 more each. According to David Montgomery, an economist with Charles River Associates, the higher prices on new conventional cars will substantially cut spendable income, eliminate jobs and reduce tax revenues.[62] They will also slow new-car purchases, keeping older, higher-polluting vehicles on the road longer.

But isn't oil subsidized, too? Proponents of subsidies for alternatives argue they are justified because oil, too, receives subsidies. But the fact is that oil receives a disproportionately small amount of federal energy subsidies. Oil receives 12 percent of those subsidies, yet accounts for 40 percent of the nation's energy. Excluding income taxes, oil returns more money to the government than it receives in subsidies, accord-

21 Department of Energy, Energy Information Administration, *Supplement to Annual Energy Outlook 1994* DOE/EIA-0554(94) (Washington, D.C.: U.S. Department of Energy, Energy Information Administration, 1994), 32.

22 *Economic Consequences of Adopting California Programs for Alternative Fuels and Vehicles* (Washington, D.C.: DRI/McGraw-Hill and Charles River Associates, 1994), 6.

23 Calvert et al., 42.

24 Ibid., 43.

25 Chang et al., 1194.

26 "Alternative Vehicles: L.A. Unhappy with Methanol Buses," *Greenwire*, 22 December 1993, 13.

27 Department of Energy, *Taking an Alternative Route*, 19, 21.

28 National Petroleum Council, *U.S. Petroleum Refining: Meeting Requirements for Cleaner Fuels and Refineries*, (Washington, DC: National Petroleum Council, 1993), Appendix E, E-2.

29 Statement by James J. MacKenzie, World Resources Institute, before the Committee on Energy and Natural Resources, U. S. Senate, 17 October 1989, 8.

30 James Bennet, "New Honda Engine a Threat to Natural Gas," *The New York Times*, 9 January 1995, D1.

31 Chang et al., 1194.

32 Department of Energy, *Taking an Alternative Route*, 23, 25.

33 Ibid.

34 National Petroleum Council, *U.S. Petroleum Refining: Meeting Requirements for Cleaner Fuels and Refineries* (Washington, DC: National Petroleum Council, 1993), Appendix E, E-3.

35 Chang et al., 1194.

36 Matthew L. Wald, "Hydrogen Pushed as Motor Fuel," *The New York Times*, 28 September 1989, D5.

37 *The Cost-Effectiveness of Further Regulating Mobile Source Emissions* (Sacramento: Sierra Research and Charles River Associates, 1994), 134.

38 This number assumes nearly one million electric vehicles sold, each of which costs about $10,000 more than a conventional gasoline-powered vehicle.

39 W. Harrington, M.A. Walls, V. McConnell, "Shifting Gears: New Directions for Cars and Clean Air," *Resources* 115, Discussion Paper 94-26 (Spring 1994).

40 People who support California's electric vehicle mandate maintain that it will provide jobs in the state to replace those lost in the shrinking defense industry. But automakers will be unlikely to manufacturer many electric vehicles in California. They can do it more cheaply in other states, where taxes are lower or idle plant capacity is available.

41 While considerable, these defense costs are sometimes exaggerated. According to the Congressional Budget Office (*The Economic Budget Outlook: Fiscal Years 1994-1998*, p. 35), the United States spent some $49 billion on Operation Desert Storm. Of that amount, the Gulf states reimbursed us about $48 billion.

42 Douglas R. Bohi, "Energy Security and Northeast Transportation Policy," prepared for the American Petroleum Institute, January 1995, 8.

43 Ibid., 4.

44 Michael McKenna, "Power Failure," *Policy Review*, Winter 1994.

45 Raymond A. Piccini, ed., *Petroleum and Public Policy: The Post-World War II Experience*, API Discussion Paper no. 071 (Washington, D.C.: American Petroleum Institute, February 1992), 33-39.

46 Jeff Bailey, "'Purpa' Power: Carter-Era Law Keeps Price of Electricity Up in Spite of a Surplus," *The Wall Street Journal*, 17 May 1995, A1.

47 U.S. Department of Energy, Energy Information Administration, *Annual Energy Outlook 1995* (Washington, DC: Energy Information Administration, 1995), 109. The report projects that the percentage of electricity supplied by renewables will rise from 11.14 percent of the total in 1993 to 11.75 percent in 2000.

48 Richard R. Nelson and Richard N. Langlois, "Industrial Innovation Policy: Lessons from American History," *Science*, 18 February 1983, 85.

49 Congress, House, Representative Philip Sharp of Indiana, *Congressional Record* (13 September 1990), H7596.

50 Department of Energy, Energy Information Administration, *Alternatives to Traditional Transportation Fuels: An Overview*, DOE/EIA-0585/0 (Washington, D.C.: U.S. Department of Energy, Energy Information Administration, 1994), 105-118.

51 Anderson, vi.

52 William H. White, testimony before the U.S. House of Representatives Committee on Commerce, Energy and Power Subcommittee, 6 June 1995, 15. White is a deputy secretary to the U.S. Secretary of Energy.

53 Jill Abramson and Phil Kuntz, "Antitrust Probe of Archer-Daniels Puts Spotlight On Chairman Andreas's Vast Political Influence," *The Wall Street Journal*, 11 July 1995, A10.

54 Department of Energy, *Alternatives to Traditional Transportation Fuels*, 105-118.

55 Sierra Research, *Institutional Support Programs for Alternative Fuels*, 1.

56 American Petroleum Institute, *API Field Operations Report on State Public Utility Commission and Pending Legislative Activity Related to Alternative Fuels (AF) and Electric Vehicles (EV) in the API Eastern Region* (Washington, D.C.: American Petroleum Institute, 1994), Attachment A, 1; 6.

57 Californians Against Utility Company Abuse, "Coalition Calls for Ratepayer Revolt Against Subsidies," press release, n.d., 1.

58 Daniel Southerland, "Mobil Assails Washington Gas Light Plan," *The Washington Post*, 8 November 1994, C3.

59 "U.S. Electricar to Build Six Electric Vehicles for the United States Postal Service," America Online: DMFog, 22 November 1994, 1.

60 Jeffrey Krasner, "Boston Edison Gearing Up Car Plans," *Boston Herald*, 7 December 1994, 50.

61 Anderson, 1.

62 Testimony of W. David Montgomery before the California State Assembly Committee on Transportation, Sacramento, Calif., 14 February 1993, 3.

63 Department of Energy, Energy Information Administration, *Federal Energy Subsidies: Direct and Indirect Interventions in Energy Markets* (Washington, D.C.: U.S. Department of Energy, Energy Information Administration, 1992), 7.

64 Congressional Joint Committee on Taxation, *Schedule of Present Federal Excise Taxes* (Washington, D.C.: Congressional Joint Committee on Taxation, 1994), 34-36.

65 Sam Schurr, *Energy in the American Economy* (Baltimore: Johns Hopkins Press, 1960), 36.

CHAPTER 5

Is global climate change a reason to phase out oil use?

Critics often use their belief that the burning of fossil fuels causes global warming to justify policy measures aimed at curbing oil use. Implementing such policies would dramatically change current patterns of social and economic activity, both here and in other countries because fossil fuels provide most of the energy to power the modern lifestyle. Industrial countries such as ours should examine claims of climate change with an eye toward the facts before forcing a major, wrenching transformation of American society. This is particularly the case now that the Conference of the Parties to the Framework Convention on Climate Change (the "Rio Treaty") have agreed to a negotiating process that could impose additional greenhouse gas emission constraints on industrialized countries.[1]

Additional scrutiny is needed because climate change is enormously complex and there are manifold unknowns. We do not yet know the answers to fundamental scientific questions regarding how and when climate might change. Such answers relate directly to issues of taking potentially painful economic action to avoid a concern that may or may not materialize. Dr. Bert Bolin, the chairman of the Intergovernmental Panel on Climate Change (IPCC), refers to these questions and issues in comments delivered to the first Conference of the Parties in Berlin in March 1995. According to Dr. Bolin:

> "The key issue that is coming to the forefront is: how serious is the climate change that is being envisaged and how rapidly will a change occur? The answer to this question will obviously influence the need and urgency for action. It is not possible to give a very specific answer at this time, since the regional patterns of the expected global climate change cannot yet be derived with sufficient confidence....
>
> "The issue at stake is not to agree on policies for decades into the next century but rather to adopt a strategy whereby needed actions could be formulated as more knowledge becomes available."[2]

Currently, **no** conclusive—or even strongly suggestive—scientific evidence exists that human activities are significantly affecting sea levels, rainfall, surface temperatures or the intensity and frequency of storms. After all, a conclusion that the global climate is changing as a result of human activity would require much more scientific knowledge about the **entire** earth system than exists today. Scientific inquiry has to include the natural geophysical and geochemical cycles responsible for the changing concentrations of atmospheric gases, the systems of winds, the patterns of ocean currents, and the changing weather (including rain, evaporation and clouds), as well as the role of humans and every other plant, animal and biological form of life on the planet.

More than two decades of scientific scrutiny of the global climate has produced uneven results. A recent article in *Discover—The World of Science,* recalls that not so long ago the apocalypse was supposed to be the coming ice age, which would cover portions of North America with an ice sheet and lower the world's sea level a few hundred feet. According to *Discover*:

> "[T]he Science Digest article proclaiming the forthcoming ice age was written a mere 20 years ago and was based on the best scientific information then available. Reports of 'galloping glaciers' and world-wide drops in surface temperatures had led climatologists to begin speculating during the 1960s that Earth might be entering a new period of chill. At then-predicted rates, it would be only some 200 to 2,000 years before temperatures had dropped sufficiently to create ice age conditions. Measurable effects on glaciation, sea level, and precipitation could be expected well before that. Climatologists, as we all know, are no longer predicting an impending ice age. On the contrary, their current worry is global warming."[3]

Dr. Richard S. Lindzen, Alfred P. Sloan Professor of Technology at the Massachusetts Institute of Technology, reached a similar conclusion several years ago. In testimony before the Senate Committee on Energy and Natural Resources, Dr. Lindzen noted that "in the unlikely event that [significant warming] occurs, it most certainly will not be for the reasons currently put forth....In point of fact, there is neither observational nor theoretical basis for expecting substantial warming."[4]

This is not to suggest that concerns about the use of oil, including its potential impact on the global climate, are inconsequential. They are not, and industry continues to find ways to minimize the environmental impact of fossil fuel use.

Much can be done to provide the information needed for the decisions about potential climate change. The Massachusetts Institute of Technology, for example, recently proposed developing a new generation of climate models aimed at narrowing the range of scientific uncertainty about climate systems. The Scripps Institute of Oceanography, as well as others, has proposed studying more closely the link between clouds and ocean activity. The federal government's Global Change Research Program also continues to devote considerable talent and money to this issue. In fiscal year 1993, the U.S. government allocated $1.4 billion for climate research to 18 federal departments and executive offices of the president.[5] For fiscal year 1995, the program has a budget of $2.3 billion, and an additional $230 million is allocated to the U.S. Climate Action Program.[6] Many other nations also are funding a variety of climate research programs.

Ongoing scientific analysis of climate systems, plus greater public awareness of the possible costs and benefits of climate change, are key to properly framing the difficult choices climate policymakers face. But government leaders are not the only contributors to climate change solutions. The market, too, has its place—and it has made contributions. In recent decades, energy-efficient technologies have become increasingly common in industrialized countries. Private companies also are developing new technologies aimed at easing the cost of a possible future transition to a lower energy lifestyle. As technologies improve and societies evolve, others will copy the most successful innovations. This is a far more likely path to sustainability than any path chosen by "the few and the wise."

What are "greenhouse" gases?

Little is known about why the climate changes from decade to decade or even from millennium to millennium. Scientists are focusing on the rising levels of atmospheric gases that absorb and emit radiated energy in different wavelengths, affecting the global heat balance. These gases, called greenhouse gases, let energy from the sun through to the earth's surface. But they also trap outgoing energy, which warms the earth.

Without the natural greenhouse effect, the earth would be largely frozen. Water vapor accounts for about two-thirds of the overall greenhouse effect. Of the remainder, carbon dioxide (CO_2) comprises about half; all other greenhouse gases (methane and nitrous oxide, as well as others such as chlorofluorocarbons) account for the rest.

Concerns about climate change arise because the atmospheric concentrations of several greenhouse gases have grown, and emissions from increased human activities have contributed to their buildup. For example, atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased from the time of the Industrial Revolution (1750-1800) until today.[7]

The increases in carbon dioxide in the atmosphere have generally been associated with fossil fuel use and deforestation. But the science of determining the flows of carbon into and out of the atmosphere is far from exact—and the impact of human activity on that flow is also unclear. For example, carbon dioxide emissions from natural processes are estimated at roughly 190 gigatonnes of carbon (GtC) per year.[8] Human activity, by contrast, accounts for a modest 7 GtC annually.[9] Of this amount, fossil fuel emissions probably account for about 5.5 GtC per year, while deforestation probably accounts for the balance of 1.6 GtC. However, these numbers are only estimates and may contain errors. Scientists on the IPCC believe the fossil fuel estimate could be off by as much as 0.5 GtC a year, and the deforestation estimate could be off by 1.2 GtC per year.[10]

Moreover, climate scientists are not yet able to track exactly what happens to carbon emissions from humans. Approximately 3 GtC per year apparently enter the atmosphere. The other 4 GtC presumably are absorbed by one or more natural carbon sinks, such as oceans.

Other greenhouse gases pose similar "accounting" problems. Nitrous oxide has been associated with seven natural sources, though only six anthropogenic sources have been identified.[11] Natural sources for methane emissions range from wetlands to termites to oceans. Anthropogenic sources of methane include coal mining, natural gas production, rice paddies, animal waste, domestic sewage, landfills and biomass burning. If scientists could isolate each of these sources, on a global scale, they still would face the problem of tracking methane's removal from the atmosphere. This process is complicated and difficult because methane is removed from the atmosphere by interaction with other gases as well as by interaction with the soil. In short, the scientific uncertainty associated with climate science does not surprise those who have become familiar with the complex dynamics greenhouse gases exhibit as they move among various sources and sinks globally.

Why are scientists studying greenhouse gases?

Greenhouse gases are being examined because some scientists are concern that growing concentrations of these gases may affect climate. Initially, some scientists and environmental activists predicted dire consequences. According to a 1988 Special Report by the Environmental and Energy Study Institute, for example:

But there have been technical difficulties in linking the models as well:

> "The result [of linking] was that even when a coupled model was set to simulate existing climate, it would drift away to something quite unreal. In the 1989 version of the NCAR coupled model, for example, wintertime ocean temperatures around ice-bound Antarctica were 4°C above zero, while the tropical ocean was as much as 4°C too cold."[20]

A standard approach used by modelers to avoid drift is to tweak the models—"...adjusting the flows of heat and moisture between ocean and atmosphere to nudge the model into agreement with today's climate. Actually, shove might be a better word than nudge: adjustments have typically been at least as big as the model-calculated fluxes—in some places five times as large."[21] But a study to be published in the *Journal of Climate* by three scientists from the Massachusetts Institute of Technology, cited by Kerr, concluded that "flux adjustments disguise—but may not correct—a model's underlying defects...."[22]

The second major hurdle occurs because gaps exist in the scientific theory needed to understand climate issues. Scientists don't yet fully understand how nature works—how clouds, ocean circulation, atmospheric chemistry, solar variability and other physical factors affect climate. Even the carbon dioxide cycle, one of the core aspects of climate change, is not completely understood; yet net flows into and out of the atmosphere are critical.

How cloud formation might respond to changing conditions and whether increases in humidity would occur (and, if so, at what altitudes and at what latitudes) also are not known with accuracy. As one scientist pointed out:

> "In all current models, upper tropospheric (3 to 12 km above the Earth's surface) water vapor, the major greenhouse gas, increases as surface temperatures increase. Without this feedback, no current model would predict warming in excess of 1.7°C—regardless of any other feedback. Unfortunately, the way these factors (like clouds and water vapor) are handled in present models is disturbingly arbitrary. In many instances, the underlying physics is simply not known. In other instances there are identifiable errors."[23]

In short, climate modelers have attempted to build models that mimic climate and predict changes over 100 years or longer without knowing important components of the science of climate. As a 1991 National Academy of Sciences report stated:

> "One major drawback common to all current [global climate models] is that they lack adequate validated representations of important factors like cloud cover feedback, ocean circulation, and hydrological interactions."[24]

The report also noted that every [global climate model] "incorporates untested and invalidated hypotheses. They may be sensitive to changes in ways that current calculations have not yet revealed."[25] But scientists continue to both improve their models and make new discoveries that one day will help explain the complex process that is climate change. For example, in 1990, global climate models rarely included aerosols—small particles in the atmosphere from sources such as sulphur from fossil fuel use, seasalt or windblown soil dust. But recently a group of scientists concluded that aerosols were critically important to any assessment of climate change because their impact was large and offset the impact of greenhouse gases.[26]

What do the climate models show?

Models are improving. However, the best models can neither explain observed climate changes nor replicate the planet's temperature history. These deficiencies call into serious question the ability of current models to predict future climate change.

Global climate models used to "backcast" history show a pattern of warming that accelerates over the past century. But the historical record doesn't match: It shows intermittent periods of warming. Much of this century's warming occurred before 1940, prior to most of the growth of greenhouse gas concentrations in the atmosphere. More than 70 percent of the amount of warming over the past century took place before the Second World War. Moreover, the actual warming, or increases in temperature, occurred before the buildup of greenhouse gases observed since the mid-1940s.[27]

Much is made of the temperature rise—an increase of 0.46°C over the past 100 years. But whether this rise is unusual remains debatable. A statistical analysis of temperature data inferred from tree rings over the past 1,500 years displayed no trend. "The upward drift over the past century could easily be a cyclical upswing of the type that has occurred many times in the past."[28] In short, the observed warming of 0.46°C over the past century is statistically indistinguishable from a random event.

Moreover, according to at least one noted climatologist, were atmospheric concentrations of carbon dioxide to double, "we might expect a warming of 0.5°C to 1.5°C. The general consensus is that such warming would present few if any problems."[29]

Little is known about the impact of climate change on humanity and ecosystems

Scientists are having difficulty evaluating the potential impact on humanity and ecosystems of any global warming that might occur. As noted in a recent Resources for the Future study:

> "Society has a great interest in the risks posed by global climate change...Unfortunately, this interest is not matched by available knowledge. Physical science aspects of climate change—how much warmer, wetter, or drier, and how variable climate might be in different regions with different atmospheric concentrations of greenhouse gases—are uncertain and likely to remain so for many years to come. And even if one posits particular climatic shifts, the ecological, social, economic, and other human consequences are elusive."[30]

Already developed are long lists of **possible** impacts on the environment—changes in ice and snow, oceans and coasts, the hydrological system, and ecosystems and vegetation, as well as lists of possible impacts on society—changes in water resources, food and agriculture, coastal areas, economic activity, and human settlements and health.[31]

Current climate models cannot assess the impacts of climate on crops, local ecosystems or the people living in a specific area. Hypothetical climate change and possible impacts are sometimes discussed, but because of modeling limitations, no one hypothesis is any more relevant than any other. Even if local climate impacts could be specified accurately, scientists don't know how a change in climate conditions might affect a given ecosystem, plant or animal.

The scientific understanding of climate is itself in a state of flux. We need to know more about how climate factors operate to predict future changes. For many years it was argued that rising global temperatures would raise sea surface temperatures and increase the frequency and severity of tropical storms. According to the United Nations, "Of particular concern is the possibility that climate change could increase the frequency or intensity of severe storms. Tropical storms, such as typhoons and hurricanes, only develop at present over seas that are warmer than about 26°C. In a warmer world the area of sea having temperatures over this value will increase."[32]

However, an article in the *Bulletin of the American Meteorological Society* has since refuted the assertion. Six conditions are necessary for the formation of tropical storms; sea surface temperatures above 26°C is only one. The other five conditions limit, or even offset, the possibility of increased storm activity due to any global climate change. A recent study by Accu-Weather, the world's largest meteorological company, reaches a similar conclusion:

> "No convincing, observational evidence exists that hurricanes, tornadoes, and other extreme temperature and precipitation events are on the rise because of the recent slight increase in the Earth's surface temperature. Rather, the greater attention weather events now receive may simply reflect two non-weather related facts: a) More people live in areas that were once sparsely populated or even uninhabited, and b) local media are now able to quickly report extreme weather events that are occurring, or have just occurred, in distant parts of the globe."[33]

Climate change could have both negative and positive impacts

Scientists recognize that climate change, if it occurred, could have both negative and positive impacts. For example, carbon dioxide fertilization increases with the carbon dioxide concentration in the atmosphere, so many plant species grow better. Concern has been expressed that climates may change faster than ecosystems can adapt and that species extinction might occur.[34] However, less severe climate change may only involve modest changes in local growing conditions, and they could be offset by natural adaptation and by changing where crops are planted.

In 1994, Mendelsohn, Nordhaus, and Shaw[35] completed a detailed study of the possible impact of climate change on U.S. agriculture. The study made a crucial distinction between the traditional approach to analyzing climate change impacts, called the production function or "dumb-farmer scenario," and a scenario that allows farmers to adjust their production techniques and crops to changing conditions. Their analysis showed that if no adjustments occur in what, how and where crops are grown (hence the name "dumb-farmer scenario"), climate change would have negative impacts. But, if farmers are smart enough to change their crop plans, climate change could have a positive impact on U.S. agriculture—even excluding the likely benefits of carbon dioxide fertilization of crops.

Climate change would not affect all regions of the world equally. Considerable evidence indicates that climate change would affect industrialized economies minimally.

For the United States, a 1991 economic study estimated that climate change on more than 85 percent of the economy would be negligible. Perhaps 10 percent of U.S. output—sectors such as construction and recreation—might be moderately affected. Only agriculture and forestry, comprising about 3 percent of U.S. gross domestic product, have a high potential of being affected.[36] More recently, Nordhaus estimated that a doubling of carbon dioxide would reduce U.S. economic output about 1.0 percent to 1.3 percent.[37]

Climate change, however, would seriously affect some regions of the world. Low-lying island nations, for example, are concerned that sea levels might rise under various global warming scenarios. However, any rise would be gradual and over an extended period of time. Most societies (even without government policies) would likely adapt—as did Holland, which to a large degree lies below sea level. The degree of adaptation needed may or may not be significant. For example, dikes could be built or businesses and people could relocate to higher ground. If a change occurred in air temperature (rather than sea level), relatively little adaptation would be needed—especially if average temperature rose slightly only at night and remained the same during the day. This happened during the 1980s, and most people easily adapted. Given these historical patterns, we have no need to worry if the global climate becomes somewhat warmer over a 100-year period.

If climate change was more dramatic, society would take greater steps to adapt. The U.S. government might, as has already been suggested for reasons other than climate change, stop offering low-cost flood insurance for high-risk coastal areas. Damages associated with rising sea levels or increased storms would be less, perhaps significantly less, than hypothesized under current scenarios because areas at high risk would not be covered with expensive vacation condominiums or urban development. Additionally, there might be gradual migration of population, not unlike the substantial shifts in population within the United States that occurred over the last 100 years. Or building standards might be raised, leading to greater investment in insulation or steps taken to aid the adaptation of sensitive ecosystems.

What government action is appropriate, given what we (don't) know?

Given the possibility that, at some time, human activities could alter the climate, policy leaders should consider what action might be both reasonable and effective, and when such actions might most economically be implemented.

A broad range of policy options is available, at least theoretically. Some options are reasonable—such as investing in science to narrow the tremendous range of uncertainties involved in climate science, promoting voluntary adoption of available measures to reduce greenhouse gas emissions and researching more energy-efficient technologies. Other policy options are unreasonable—such as mandating much higher fuel efficiency standards for vehicles, equipment and buildings; imposing additional energy taxes; or seeking to alter lifestyles by placing restrictions on the use of personal vehicles.

This last option is a recurring favorite among those who believe Americans waste energy, import too much oil and, by using it, pollute their local environment while endangering posterity—both by pursuing unsustainable activities and by creating, in the words of Greenpeace, a lethal "climate time bomb."

In the context of known facts, the policy choices need not be as draconian as the doomsayers advocate. Climate policies should not take precedence over more pressing human needs. At a minimum, they should make sense in their own right. As one commentator has observed, "While the Rio Earth Summit ended with Western leaders agreeing to devote billions of dollars to sustaining the natural environment, essentially nothing was done for the 7.8 million poor children—many of them in cities—who die each year from what they drink and breathe...."[38]

Moreover, the costs of government policies to control greenhouse gas emissions should not outweigh the possible benefits. In *Global Warming: The Economic Stakes*, William Cline of the Institute for International Economics analyzes policy options. His analysis makes a number of assumptions that might suggest the need for rigorous government action. For example, he constructs very long time horizons. He includes damages to both human activity and ecological systems, as well as nonlinear damage functions as assumed temperature rises.

However, Cline also argues that large uncertainties exist in our understanding of climate science as well as the potential impacts of climate change. To deal with these uncertainties, he evaluates his model of climate change and greenhouse gas abatement policies by evaluating benefits and costs for 36 scenarios. **In only 10 of the 36 cases are the benefits of greenhouse gas abatement policies greater than the costs of those policies.**[39]

Most analyses do not attempt to undertake cost and benefit analyses of greenhouse gas abatement policies. Most concentrate on potential costs. For example, John Weyant, director of Stanford's Energy Modeling Forum, summarized the short-to-intermediate run costs to the economy, and concluded that:

> "First, if the emissions target requires moving faster than the natural rate of capital stock turnover and technology development, significant additional adjustment costs are likely to be incurred...."[40]

More specifically, Weyant, argues:

> "The costs of stabilizing global carbon emissions appear likely to be in the range of about 4 percent of GDP per year by the year 2100."[41]

A recent study by the U.S. Office of Technology Assessment (OTA) connects the timing of abatement efforts and the availability of technology to reduce the growth in emissions. For example, the OTA study noted that:[42]

- "Large emission reductions are likely to be costly, but phasing emission controls in over a long period can reduce the cost substantially."
- "Delaying the implementation of emission controls for 10 to 20 years will have little effect on atmospheric concentrations."
- "Costs of controlling emissions are highly dependent on assumed rates and determinants of technology innovation, and this process is not adequately understood or modeled at present."

Dr. Alan S. Manne, Professor Emeritus of Operations Research at Stanford University, recently reached a similar conclusion:

> "Since global temperatures are not likely to rise significantly during the next several decades, an aggressive CO_2 abatement policy is unwarranted for the near term. Such policies, if implemented, could cost many hundreds of billions of dollars. Even after 2020, there would still be enough time to adapt the global economy to a sharp decline in carbon emissions if we learn that such action is warranted."[43]

Climate policymakers need to be aware of more than just costs and benefits. If climate change occurred, impact would likely be global. This suggests that **all** countries should bear some of the burden of reducing emissions. Currently this is not the case. Under the Framework Convention on Climate Change (FCCC), developed countries assume all the obligations for limiting carbon emissions. On the other hand, developing countries need only report their emissions—even though they account for more than half of the world's current carbon dioxide emissions.[44]

Moreover, developing countries are expected to be the overwhelming source of future growth in greenhouse gas emissions.[45] In other words, severe reductions in greenhouse gas emissions by the United States, or even all developed countries, would impose large costs on those countries but yield little in the way of benefits—even under drastic climate change scenarios.

A rational policy on climate change must seek to balance the present known costs of policies to control greenhouse gas emissions against the uncertain and distant future benefits of avoided climate change. Included in that calculation is a core question about sustainable development—namely, that funds used to promote the potential welfare of future generations cannot be used to promote the welfare of today's poor. Thomas Schelling framed this difficult choice confronting many developing economies this way: "[I]t would be hard to make the case that the countries we now perceive as vulnerable would be better off 50 to 75 years from now if 10 or 20 trillions of dollars had been invested in carbon abatement rather than in their economic development."[46]

The body of current scientific evidence does not indicate a need to make such a choice. Neither an apocalyptic crisis nor an inevitable Malthusian meltdown of society looms over the horizon. Rather, the issue of potential climate change is but one of many long-term issues that humanity has had to address, and will continue to address. These issues include the sustainability of food supplies, the exhaustibility of natural resources and the preservation of ecosystems. Climate change differs from most environmental and sustainable development issues, however, because if it does exist, no single country or individual can effectively address it.

Given the current state of knowledge, society must weigh the potential impact of energy use on the climate against the services that energy products provide. In reaching any decisions that would limit energy use, society must consider ways to minimize the costs of moving to lower energy consumption levels. Radical action by the United States alone or even by all the OECD countries to rapidly reduce energy use would be very costly and would have relatively little effect on long-term atmospheric concentrations of greenhouse gases. Moreover, most levels of emission reductions now under consideration lack sound analytical basis.

NOTES TO CHAPTER 5

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CONCLUSION

Making the right energy choices

The miraculous energy panacea that some environmental activists seem to be dreaming of doesn't exist. No fuels both ensure environmental protection and provide the energy needed for economic growth more cost-effectively than the fuel mix consumers choose through competitive markets. All fuels—oil, natural gas, ethanol, electricity, solar, coal and other energy sources—offer both advantages and disadvantages.

Making the right energy choices involves weighing those advantages and disadvantages and picking the best fuel for each job. The issue is: How will those choices be made, and by whom? Many environmentalists don't trust that Americans will make the right choices, so they advocate having government step in. Would that be wise?

Petroleum's advantages and disadvantages

Most Americans agree that currently oil is the right choice in the United States for many uses—especially transportation:

- The new generation of gasolines is the right fuel for driving in the most smog-prone cities.
- Unleaded gasoline is the right fuel for travel in the vast open spaces of this country, for it delivers the mileage and range other fuels can't match.
- Diesel is the powerhouse that carries food from farmland to cities and manufactured goods from factories to stores.
- Kerojet fuel allows airplanes to take us on vacation or business trips.
- Heating oil keeps many a New England homeowner warm during the cold winter nights.

Oil is in these instances—and many others—the right energy choice. No other fuel is as easy to transport and use, as powerful in small quantities or as abundant, affordable and clean. Because of these attributes, oil provides the energy for 97 percent of U.S. transportation needs—for both personal travel and commercial freight.

Admittedly, America's reliance on oil has some drawbacks. The United States imports half of what it uses and oil is by its very nature finite. Like other fossil fuels, oil is not entirely consumed in the process of providing energy. Though technological advances have lessened emissions significantly, some remain that add to local pollution concerns, while carbon dioxide emissions raise concerns about potential global climate change.

Facts show that concerns about oil use are overblown

To some people, these concerns are reason enough to force Americans to make different energy choices. They believe Americans should be forced to change their lifestyle in order to use less oil. They advocate forcing many Americans to use their cars less or buy new, more expensive ones that run on alternative fuels.

But as the preceding chapters show, the disadvantages of oil use aren't as serious as some would have us believe. Let's review the facts:

- **The world is not running out of oil.** Just because oil is an exhaustible resource doesn't mean that exhaustion is inevitable. Energy markets provide a mechanism—rising prices—that signal when a resource is becoming scarce and encourage the development of alternative energy sources. Despite repeated predictions of oil scarcity, crude prices remain low, and gasoline prices (after adjusting for inflation) are basically the same as they were 35 years ago. The neo-Malthusian forecasts that economic growth would prove unsustainable because of scarce resources are wrong.

  While U.S. oil production has peaked, in part due to restrictions that have prevented oil companies from exploring and producing in many promising areas, proved world reserves are higher now than ever before—nearly a trillion barrels. That's enough to sustain current production for 50 years, even if not another barrel is found. But this estimate is conservative, as proved reserves represent only the crude oil known beyond a reasonable doubt to be recoverable under current economic conditions with existing technology.

  When estimates of probable reserves—less certain but still likely reserves—are included, total world oil resources rise to between 1.4 trillion and 2.1 trillion barrels—enough to sustain current rates of world consumption for 63 to 95 years. As we know, the world doesn't stand still. Technological change will likely extend this even further—an extra three to four years for each 1 percent increase in the average recovery rate. Technological change is the key factor that the Malthusians haven't taken into account.

  As a well known energy economist put it: "The key dispute in energy is between those who believe that only human ingenuity limits economic development and those who feel that resource availability ultimately constrains material economic growth. The evidence clearly supports the proposition that human ingenuity has long prevailed over resource scarcity and suggests this situation will persist for at least the next half century."[1]

- **The need for imported oil is a manageable risk.** World resources are abundant. But the United States' reliance on so much imported oil has raised concerns about energy security and whether America can count on its sources of supply.

  U.S. energy and oil use will continue to grow over the coming decades, and unless U.S. policies toward access change, production will decline. As a result, the United States will depend more on foreign oil. But the world oil market has changed significantly since the 1980s, and there is no given level of oil imports that automatically endangers energy security.

  The United States, among others, has developed strategic petroleum reserves that it can tap to stabilize the market in the case of a supply disruption. The increasing economic interdependence of oil-producing and oil-importing countries creates a mutual and growing interest in economic stability. We're now discovering oil supplies in countries outside of the Persian Gulf, places where no one ever thought to look before.

For these reasons, among others, short-run supply disruptions of much-needed oil imports are less of a danger to the U.S. economy than they were in past years. They are a manageable risk.

- **Americans don't overconsume energy.** Facts show that Americans make the right energy choices. They use energy as efficiently as other countries considering the size of this country, the energy-intensive industries that have flourished here and the American lifestyle. Americans don't waste energy, and they have good reasons to need more energy than people in many other countries with smaller land masses and different industrial mixes.

  U.S. economic growth depends largely on the availability of low-cost energy to transport goods over long distances and to power American industries such as paper, plastics and aluminum. Our economic success in global competition reflects wise resource use, for the U.S. wouldn't be competitive if industry did not make the right energy choices.

  Energy markets are no different from most other markets. For example, Americans confront the substantial costs of driving, including the costs of less-polluting cars and cleaner gasoline, and still choose to drive because of the benefits of mobility.

  The claims that Americans overconsume a host of products, including energy, because of market "failure" are a smokescreen for efforts to force Americans to change the way they live. Some environmental extremists are of the mindset that consumers just can't be trusted to make smart choices because they've been "brainwashed" by a materialistic society. But this debate is really about suburbs, congestion, the decline of central cities, and whether forcing Americans to abandon their cars will bring about the reinvention of the places where Americans live and work on another model.

- **Environmental quality has gotten better—not worse.** American cities are far more smog-free than 25 years ago, by the U.S. government's own measures. The Clean Air Act has yielded most of America's documented environmental progress. Of the six prevalent "criteria" pollutants measured, levels of five have declined from 1970 to 1993: lead by 98 percent, particulates by 78 percent, sulfur dioxide by 30 percent, ozone by 24 percent and carbon monoxide by 24 percent. Only nitrogen oxide increased—by 14 percent.

  America's energy providers, including the oil companies, have contributed to this progress by making major modifications to meet today's environmental standards. By the year 2000, the petroleum industry could be making more than 10 percent of all U.S. expenditures on the environment—more than U.S. oil companies are expected to spend on drilling for new domestic oil supplies.

  Automakers have been making changes to produce cleaner cars, too. As a result of the changes that have been made to both cars and fuels, tailpipe emissions have dropped by 96 percent since the advent of pollution controls. Additional changes now being introduced will cut the remaining emissions in half—for a total reduction of 98 percent.

  Due to this progress, in many American cities automobiles and light trucks are no longer the primary or even secondary cause of summertime smog. In 1993, sources other than automobiles produced nearly three-quarters of the nation's hydrocarbon emissions—one of the big culprits in smog formation—

attributable to human activities.

With the advent of cleaner gasolines and new automotive technologies, the use of oil for the nation's energy needs can coexist with continued environmental progress. It isn't necessary to make Americans give up driving their cars in order to have a cleaner environment.

- **Alternative fuels are far from perfect substitutes for oil.** Reducing the amount of oil the nation uses only makes sense if we have another better source of energy to replace it. But that perfect substitute simply doesn't exist—at least not yet.

  All alternatives have advantages and disadvantages. None is pollution-free, and some burn no cleaner than the most advanced gasoline fuel/vehicle system. They generally cost more and have performance limitations compared with conventional technology. All lack an established distribution infrastructure.

  While alternatives may be able to marginally reduce air pollution compared with conventional gasoline-powered transportation, there are usually more affordable ways to achieve the same results. Because alternatives are generally more expensive, consumers will choose alternative fuels only when government either subsidizes or mandates their use. Federal subsidies already on the books total more than $1 billion annually, and by the year 2010 they will cost taxpayers almost $10 billion a year—or $40 per person. In sum, the benefits of alternatives simply aren't worth the costs.

  Wanting to develop a technologically superior form of transportation—and throwing money at the effort—isn't enough to make it happen. The history of innovation is one of serendipity, of the right idea at the right time, of a juxtaposition of time and events that catapults society into a new age unpredictably. Alternative, better fuels and vehicles will, without a doubt, be discovered, but trying to force the creation of new technologies by government fiat simply won't work.

- **The implications of fossil fuel use for the global climate are, at best, uncertain.** Little is known about why the climate changes over decades, over centuries—or even over millennia. Although considerable research is underway, the dimensions of the problem, much less the policy implications, are far from sure.

  The climate models that have forecast rising global temperatures as a result of greenhouse gas emissions, such as carbon dioxide from automobile exhaust, are still crude attempts to duplicate the enormous complexity of the earth's ecosystem. Ocean currents, winds, clouds, plants and animals all affect the global climate.

  Both our scientific knowledge in some key fields and our ability to represent these phenomena in an accurate model are at an early stage. Predictions depend on a detailed understanding of the interrelationship between clouds, oceans, wind, rain and sun. They also depend on the roles that plants, animals and people play in altering the physical environment.

  Because the models cannot accurately depict how our climate works, they aren't reliable enough to reproduce the temperature history for this century. So far the models predicted rising temperatures early in the 20th century—**prior** to the rise in greenhouse gas emissions. This contradicts the premise that fossil fuel emissions caused temperature increases in the latter half of this century.

  Given this scientific uncertainty, common sense dictates a conservative, "no regrets" policy. The voluntary adoption of technologies that reduce greenhouse gas emissions where practical makes sense. Much can be done—and is being done—without the significant economic risks of the more extreme policy proposals.

Clearly we need more information about climate change. Society needs to look for a balance between the potential environmental implications of climate change and the economic growth that fossil fuel use provides. We must weigh proposed climate policies—which may or may not provide benefits many years from now—against society's many immediate needs. Few of the policies now being proposed produce benefits that outweigh their costs. We need additional scientific research and the adoption of low-cost, high-benefit policies, but not an immediate, forced transition from oil.

There will not be a serious penalty for waiting until we know more. The U.S. Congress's Office of Technology Assessment concludes that "initial delays of 10 or 20 years in implementing emission stabilization will have little effect on ultimate atmospheric carbon concentrations."[2]

Facts don't support the contention that oil use must be curtailed. Americans are making the right energy choices now, based on the relative merits of the fuels available in the marketplace and the state of today's technology. Our current reliance on oil makes economic, environmental and common sense.

How do we know society will make the right choices?

How do we know that society will continue to make the right energy choices? Can we rely on consumers, businesses and producers to determine the fuel mix used by the United States without government policymakers taking the lead, pointing the way?

As we continue to reinvent energy to meet society's concerns about the environment and build an economy that will provide for future generations, the **right** energy choices will unfold in a way that we cannot accurately foresee.

Energy choices are not static; they evolve as both technology and lifestyles change. Making the right choices is an evolutionary process. Technological advances change the choices consumers make, as fuels become more or less cost-effective with advances in the design of the engines and appliances that use them.

Many environmentalists oppose aspects of the modern American lifestyle—single family suburban homes, reliance on cars for commuting and shopping centers instead of downtown urban areas. By faulting oil—and therefore gasoline—they hope to force Americans out of their cars and begin a restructuring of society on more utopian terms.

So the question is: "How should society make energy choices?"

Two paths lie ahead. Either Americans can continue to make their own choices as their needs and lifestyles evolve, or we can let government policymakers choose for us, regardless of the consequences.

The decentralized self-organization of the market system will lead Americans to make the right choices for the way they live now. A regime of central control would force different energy choices. As Michael Rothschild summarizes in *Bionomics*:

> "Throughout history, the forces of central control and decentralized self-organization have been locked in perpetual struggle. Since civilization began, societies have had to draw boundaries between state power and personal freedom, between politics and economics, between fixed rules and fluctuating prices. In the final analysis, despite its momentous con-

> sequences, the battle over the future of environmental policy is just another skirmish in a centuries-old war for the power to decide."[3]

The alternative to relying on market choices is to relinquish the freedom to make our own choices. It's clear that many environmental activists would prefer that government policymakers direct energy policy for the "good" of the environment.

On what grounds can they assert that government policymakers have the ability to make the right choices?

Government decision-making can't point to the same record of success that private economic evolution can. In *The March of Folly,* noted historian Barbara Tuchman begins by stating: "A phenomenon noticeable throughout history regardless of place or period is the pursuit by governments of policies contrary to their own interests. Mankind, it seems, makes a poorer performance of government than of almost any other human activity."[4]

The voters in all developed countries are clamoring for more effective government. But as Peter Drucker points out:

> "We do not have a theory of what government can do. No major political thinker—at least since Machiavelli, almost 500 years ago—has addressed this question. All political theory, from Locke on through The Federalist Papers and down to the articles published by today's liberals and conservatives, deals with the process of government: with constitutions, with power and its limitations, with methods and organizations. None deals with substance. None asks what the proper functions of government might be and could be. None asks what results government should be held accountable for."[5]

We know from experience that government does not make effective long-term economic decisions. Before the economic failure of Eastern European communism, many thought that a centrally planned economy could deliver economic resources more efficiently. But as F.A. Hayek wrote in *The Fatal Conceit*: "This notion appears eminently sensible at first glance. But it proves to overlook the facts ... that the totality of resources that one could employ in such a plan *is simply not knowable to anybody*, and therefore can hardly be centrally controlled."[6] By its very nature, an economy that is evolving—that is developing new technologies and new products, phasing out obsolete ones and relying on the market for signals in order to change—cannot be planned, and the entire rationale for centralized decision-making collapses.[7]

Some fear that our future will always be in some ways uncertain, unknowable. Former Secretary of Energy Jim Schlesinger reminds us that when it comes to long-range planning, a "Cook's Tour" approach—like a vacation where every step is laid out in advance—isn't the best way to go. A better paradigm is "Lewis and Clark" planning—named for the explorers. Lewis and Clark made decisions on which way to go at every fork. With uncertainty, you get where you want to go best by evaluating new information all the time and making decisions along the way. The future is uncertain, but you are adapting as new information comes to light.

Based on history, we can have confidence that Americans will make the right decisions through the free market system that has served our nation so well. The element of uncertainty is anathema to some. Yet, the essence of liberty is taking risks and embracing uncertainties.

NOTES TO CONCLUSION

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