

DR. SOCOLOW: I STAND BETWEEN YOU AND  
6 DINNER, AND I'M HOPING I CAN PULL THE DIFFERENT PARTS  
7 OF THE DAY TOGETHER; ALSO, WITH THE LIGHTNING AND IF  
8 THERE'S POWER IN THE ROOM -- YOU CAN IMAGINE ABOUT  
9 TWO HOURS AGO I WAS SAYING, WHAT IF I HAVE TO TALK  
10 WITHOUT SLIDES -- IT IS INTERESTING. SO I WANT TO  
11 PULL IT TOGETHER.

12 I WILL START WITH A QUOTE FROM DAVE  
13 KEELING. OKAY. LET'S READ IT, AND THEN I WILL TELL  
14 YOU WHERE IT COMES FROM.

15 "A SAFE APPROACH IS JUST TO REMAIN AN  
16 INTERESTED OBSERVER OF THE UNFOLDING SCIENTIFIC  
17 EVIDENCE OF MAN-MADE GLOBAL CLIMATE CHANGE AND ITS  
18 POSSIBLE SIGNIFICANCE TO HUMAN WELFARE. WITHOUT RISK  
19 ONE CAN COMMENT DISPASSIONATELY . . . I BELIEVE,  
20 HOWEVER, THAT A MORE PRUDENT ATTITUDE WOULD BE TO  
21 HEED THE RISE IN ATMOSPHERIC CO2 CONCENTRATION AS  
22 SERIOUS UNLESS PROVEN TO BE BENIGN."

23 I THINK THAT IS A DAMN GOOD QUOTE, AND IT  
24 COMES FROM THE AUTOBIOGRAPHY MENTIONED A NUMBER OF  
25 TIMES. JUST I CAN'T RESIST ASSOCIATING MYSELF IN

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1 THIS PARTICULAR WAY; THAT I WAS THE EDITOR OF THE  
2 JOURNAL "ANNUAL REVIEW OF ENERGY AND THE ENVIRONMENT"  
3 THAT COMMISSIONED THIS AUTOBIOGRAPHY FROM DAVID  
4 KEELING, AND JOHN HART, WHO WAS ON THE EDITORIAL  
5 BOARD WITH ME, WORKED WITH DAVE TO GET THIS DONE, AND  
6 HIS WIFE WAS A MAJOR FACTOR IN HIS DECIDING TO DO IT,  
7 AND WE'RE VERY GLAD THAT SHE PREVAILED ON HIM TO PUT  
8 ALL THIS WORK INTO IT. IT'S A VERY INTERESTING  
9 AUTOBIOGRAPHY.

10 NOW, I WANT TO IDENTIFY THAT YOU HAVE  
11 FIGURED OUT THERE ARE THREE THREADS CORRESPONDING TO  
12 THE THREE PARTS OF THE IPCC -- SCIENCE, IMPACTS,  
13 MITIGATION -- RUNNING THROUGH THIS MEETING LIKE  
14 BRAIDS; AND THE THREAD OF MITIGATION IS REPRESENTED  
15 BY THE TALKS YOU JUST HEARD, BY MY TALK, TOMORROW  
16 AFTERNOON BY SUSAN SOLOMON'S TALK, WHICH DRAWS THE  
17 ANALOGIES, THE FASCINATING ANALOGIES,  
18 COMPARE-AND-CONTRAST EXERCISE BETWEEN THE OZONE STORY  
19 AND THE ONE WE'RE FACING NOW. AND THEN A GOOD PART  
20 OF FRIDAY IS THE MITIGATION THEME, STARTING WITH TWO  
21 TALKS, ONE FROM CHUCK KUTSCHER, WHO YOU HEARD FROM  
22 JUST A MOMENT AGO JUST NOW, ON RENEWABLES; AND THEN A  
23 VERY SERIOUS LOOK BY ONE OF THE LEADERS IN THIS  
24 FIELD, JULIO FRIEDMANN, ON CARBON CAPTURE AND STORAGE  
25 AND ITS MANY RAMIFICATIONS. IT'S GOING TO BE AN

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1 AUTHORITATIVE DISCUSSION.

2 FOLLOWING THOSE TWO TALKS, WE WILL HAVE TWO  
3 TALKS ON GEOENGINEERING. I WILL EXPLAIN WHY WE HAVE  
4 PUT GEOENGINEERING ON THE PROGRAM IN A FEW MINUTES.  
5 BUT ALBEDO MODIFICATION IS THE SUBJECT OF DAVID  
6 KEITH'S TALK; AND DAVID KARL ON MODIFICATION OF THE  
7 OCEAN SINK. THESE ARE SCARY THINGS; AND JUST IN ONE  
8 SENTENCE, YOU'RE GOING TO BE THE ONES WHO ARE THE  
9 ARBITERS OF WHICH ONES OF THESE THINGS GO FORWARD.

10 BY "YOU," I MEAN THE CLIMATE SCIENCE COMMUNITY.  
11 YOU'RE GOING TO BE MUCH NEEDED IN THIS ENDEAVOR.

12 THEN WE'LL HAVE THREE DISCUSSIONS REPORTING  
13 ON THE REGIONAL INITIATIVES, WHAT THE U.S. IS DOING  
14 WHILE TREADING WATER IN THE ABSENCE OF A NATIONAL  
15 PROGRAM, AND FINALLY, A TALK FROM MIKE WALSH,  
16 CO-CONVENER OF THIS MEETING, ON SOME OF THE CARBON  
17 MARKETS THAT ARE UNDERWAY. SO THAT'S THE MITIGATION  
18 THREAD THROUGH THIS MEETING. SO DON'T START GOING  
19 OUT THERE AND PLAYING GOLF.

20 (LAUGHTER)

21 THE OUTLINE OF THIS TALK IS THAT I WANT TO  
22 DESCRIBE, FIRST OF ALL, THE CONNECTION BETWEEN THE  
23 TWO PARTS OF THE MEETING THIS MORNING, STABILIZATION  
24 TARGETS AND TECHNOLOGY RESPONSES, WITH THE HELP OF A  
25 SIMPLE MODEL THAT HAS GOTTEN US AMAZING ATTENTION;

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1 THEN DISCUSSING SOME SPECIFIC WEDGES, EXPLAINING WHAT  
2 THOSE ARE; AND THEN RATHER BRIEFLY DISCUSSING THIS  
3 NEW ROLE FOR ENVIRONMENTAL SCIENTISTS AS BEING  
4 ARBITERS OF THE EFFICACY AND LEGITIMACY OF SOLUTIONS;  
5 AND THEN FINALLY A OR BID OF AN "AU REVOIR" FOR THOSE  
6 HEADING FOR BALI, IF THERE ARE ANY IN THE GROUP.

7 SO HERE IS HOW I PRESENT THE CARBON  
8 PROBLEM, AND I'M A SCIENCE TEACHER AT HEART, AND I  
9 TRY TO KEEP FINDING WAYS TO SIMPLIFY ASPECTS OF THIS  
10 STORY. SO I NOW SAY THE ATMOSPHERE IS A BATHTUB.  
11 THERE IS A CERTAIN AMOUNT OF CARBON DIOXIDE IN IT.  
12 WHAT DAVE KEELING WAS DOING WAS WEIGHING THE CO2 IN  
13 THE ATMOSPHERE. WHEN HE STARTED WORK -- A NUMBER NOT  
14 ON THERE -- THERE WERE ABOUT 2,600 BILLION TONS OF CO2  
15 IN THE ATMOSPHERE. THE PRE-INDUSTRIAL NUMBER WAS  
16 2,200. WE NOW HAVE IN THIS ATMOSPHERE TODAY ABOUT  
17 3,000 BILLION TONS OF CO2, A NUMBER THAT NOT MANY OF  
18 YOU WAKING IN THE MIDDLE OF THE NIGHT COULD COME OUT  
19 WITH, BUT YOU CAN ALL CALCULATE IT. THE  
20 PRE-INDUSTRIAL NUMBER 2,200, THE DEPTH OF THE ICE AGE  
21 IS MAYBE 1,500, AND SOMEWHERE AROUND 4,400, TWICE THE  
22 PRE-INDUSTRIAL QUANTITY, IS WHERE THE WARNING LIGHTS  
23 ARE.

24 ARE WE GOING TO TRY TO STAY BELOW THAT?

25 ARE WE GOING TO TRY TO STAY BELOW SOMETHING LOWER

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1 THAN THAT? ARE WE GOING TO GIVE UP AND SETTLE FOR  
2 SOMETHING ABOVE THAT? AND WE CALL THAT ROOM WHERE WE  
3 ARE, 3,000 AND SAY 4,400, THE HEAD ROOM THAT WE HAVE  
4 LEFT IN THE WAY OF EMISSIONS TO DIVIDE AMONG THE  
5 PARTS OF THE WORLD TODAY AND THE PRESENT AND THE  
6 FUTURE. THAT'S THE STRUCTURE OF THE PROBLEM.

7 NOW, OVER THERE I OBSERVE THAT THERE ARE  
8 THREE UNITS FOR DESCRIBING EXACTLY THE SAME THING,  
9 AND THERE IS A NEED AMONG ALL OF US TO EMPOWER  
10 PEOPLE. THERE IS THE TONS OF CO2. I HAVE DECIDED FOR  
11 THIS TALK TO KEEP TONS OF CO2 AS MY UNIT RUNNING  
12 THROUGH THE ENTIRE TALK BECAUSE BY THE END OF THE  
13 TALK, WE'RE TALKING ABOUT CARBON MARKETS, WHICH HAVE,  
14 FOR BETTER OR WORSE, CHOSEN TO TALK ABOUT COSTS IN

15 DOLLARS PER TON OF CO2 OR EUROS PER TON OF CO2, SO  
16 LET'S GET WITH IT. TONS OF CARBON MAKES LOTS OF  
17 SENSE AS AN ALTERNATE UNIT BECAUSE THAT'S THE  
18 CONSERVED QUANTITY. A TON OF CARBON COMES OUT OF THE  
19 GROUND, IT'S EITHER LEFT ON THE GROUND OR BURNED; IF  
20 IT'S IN THE ATMOSPHERE, IT'S THE CARBON IN THE CO2  
21 MOLECULE. THAT'S MY FAVORITE UNIT, BUT NOBODY IS  
22 USING IT EXCEPT A FEW OF US.

23 AND THE THIRD UNIT IS THE KEELING UNIT, THE  
24 UNIT OF THE ATMOSPHERIC COMMUNITY, THE FRACTION OF  
25 THE MOLECULES, 380 OUT OF A MILLION RIGHT NOW THAT

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1 YOU BREATHED A MOMENT AGO. BUT THEY'RE ALL  
2 PROPORTIONAL. 7.7 BILLION TONS OF CO2 AS A PPM.  
3 LET'S UNDERSTAND THAT, LET'S HELP OTHERS UNDERSTAND  
4 THAT, AND LET'S TRY TO MAKE THE STORY AS SIMPLE AS  
5 POSSIBLE, BECAUSE ONCE YOU DO THAT, YOUR FLOWS AND  
6 YOUR STOCKS ARE IN THE SAME UNITS.

7 WE ARE TODAY TAKING ABOUT -- WE ARE PUTTING  
8 ABOUT 30 BILLION TONS OF CO2 INTO THE ATMOSPHERE, ONE  
9 PER YEAR, ONE PERCENT OF THE STOCK PER YEAR. ABOUT  
10 HALF OF THAT, 15 BILLION TONS OF CO2, ARE BUILDING UP.  
11 THE OTHER 15 IS DIVIDED IN A WAY THAT I'VE DECIDED  
12 TODAY I DO NOT KNOW WHAT THOSE RIGHT NUMBERS ARE,  
13 MAYBE 7 AND 8, MAYBE 2 AND 12, BUT WE DO NEED TO GET  
14 A LITTLE BETTER FIX ON THIS. AND IT IS GOING TO  
15 REQUIRE PEOPLE USING ALL THE DIFFERENT TECHNIQUES  
16 COMING TOGETHER AND HAMMERING OUT A BEST ESTIMATE.  
17 I'M A LITTLE SURPRISED THAT I CAN'T DO A BETTER JOB,  
18 BUT IT MAY BE MY OWN INATTENTION.

19 THE MAIN POINT IS, OKAY, NOW WE'RE TALKING  
20 ABOUT 30 BILLION TONS OF CO2 GOING INTO THE  
21 ATMOSPHERE. AND FROM HERE ON, I'M BASICALLY GOING TO  
22 DECONSTRUCT THE 30 BILLION TONS OF CO2 GOING INTO THE  
23 ATMOSPHERE, AND THAT'S GOING TO BE MY PART OF THE  
24 DISCUSSION TODAY.

25 FROM THE KEELING STOCKS COMES AN INTEREST

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1 IN THE EMISSIONS; AND THE EMISSIONS THAT I'M FOCUSING  
2 ON ARE THE EMISSIONS FROM THE INDUSTRIAL SYSTEM.  
3 THERE IS ANOTHER SET OF EMISSIONS RELATED TO LAND USE  
4 CHANGE. AND SO LET'S LOOK AT THESE EMISSIONS.  
5 30 BILLION TONS OF CO2 PER YEAR TODAY. LET'S LOOK  
6 BACK; AND 57 YEARS AGO, ABOUT WHEN REVELLE AND SEUSS  
7 WERE THINKING ABOUT ALL OF THIS, IT WAS ONE-FIFTH AS  
8 MUCH. IT WAS 6 BILLION TONS OF CO2 PER YEAR GOING  
9 INTO THE ATMOSPHERE, AND IT WAS LESS WORRISOME.

10 AS I UNDERSTAND IT, REVELLE WROTE A PAPER  
11 WHERE HE EXTRAPOLATED HOW MUCH THE CO2 WOULD RISE  
12 ASSUMING 6 BILLION TONS OF CO2 PER YEAR WOULD STAY  
13 CONSTANT. APPARENTLY, RENIUS ALSO HAD THE IDEA THAT  
14 HE COULD EXTRAPOLATE THE CURRENT CO2 EMISSIONS OF THE  
15 DAY INTO THE FUTURE AND LEARN SOMETHING USEFUL.

16 ALL OF THAT CURVE LEAVES LOTS OF SPACE ON  
17 THE RIGHT-HAND SIDE SO THAT I CAN POSE TWO QUESTIONS  
18 FOR YOU, AND YOU WILL SEE WHERE THIS GOES. THE FIRST  
19 QUESTION IS: IF WE DO NOTHING, IF WE JUST DECIDE NOT

20 TO PAY ATTENTION TO CARBON, IT'S JUST TOO HARD, WE  
21 CAN'T GET OUR ACT TOGETHER, WHAT WILL BE THE CARBON  
22 EMISSIONS IN 50 YEARS? THERE IS A VERY LARGE  
23 LITERATURE ON THIS. A LARGE PART OF WORKING GROUP  
24 III, THE THIRD ASSESSMENT REPORT DEALT WITH THIS. I  
25 WANT TO MAKE ONE CORRECTION TO SOMETHING SAID DURING  
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1 THE DAY TODAY: THE RANGE OF EMISSIONS YOU SAW  
2 BETWEEN B2 AND A1 AND THINGS LIKE THAT WERE ALL MEANT  
3 TO BE IN THE ABSENCE OF AN INTEREST IN CARBON POLICY.  
4 THERE WAS NO CARBON MITIGATION IN ANY OF THAT. AND  
5 THE OBVIOUS MESSAGE WAS WE CAN HAVE ALMOST ANY ANSWER  
6 WITHOUT CARBON ATTENTION BECAUSE WE DON'T KNOW THE  
7 GROWTH RATES, WE DON'T KNOW THE PENETRATION RATES OF  
8 RENEWABLES AND NUCLEAR POWER AND SO FORTH; AND  
9 VARIOUS ANSWERS ARE PLAUSIBLE. SO THERE IS A SEA OF  
10 ANSWERS, 1,000 PAPERS AT LEAST, SOME OF THEM  
11 DELIBERATELY TRYING TO EXPLAIN THAT IT IS  
12 WELL-DEFINED.

13 THE OTHER QUESTION YOU CAN ASK IS: IF WE  
14 REALLY CARE ABOUT THE CARBON AND WANT TO BE  
15 RESPONSIBLE ON THIS PLANET AND DO OUR SHARE OF THE  
16 JOB THAT IS GOING TO EXTEND INTO THE FUTURE, THEN  
17 50 YEARS FROM TODAY WHAT SHOULD WE WANT TO HAVE  
18 ACCOMPLISHED? WHAT SHOULD WE BE PLEASED AT HAVING  
19 DONE? AND, AGAIN, THOUSANDS OF PAPERS, A DIFFERENT  
20 COMMUNITY, IMPACTS COMMUNITY, FOR THE MOST PART, AND  
21 A LOT OF DIFFERENT ANSWERS.

22 WHAT STEVE PACALA AND I DID WAS SAY WE GOT  
23 TO MAKE THIS SIMPLER, AND SO WE DREW THIS PAIR OF  
24 LINES, DOUBLE THE EMISSIONS IN 50 YEARS IF YOU DON'T  
25 TAKE THE CARBON PROBLEM SERIOUSLY, LEVEL EMISSIONS.

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1 YOU SHOULD BE VERY PROUD OF YOURSELVES. AND THAT WAS  
2 OUR PAPER IN 2004, AND WE ASSOCIATED THOSE WITH  
3 CONCENTRATIONS BY GOING BEYOND 2054, AND SAY SUPPOSE  
4 THE EMISSIONS -- I'VE UPDATED THIS NOW, SO YOU HAVE  
5 30 BILLION TONS OF CO2. WE HAVE UPDATED THIS TO 2007  
6 BUT KEPT THE SAME IDEA, FLAT LINE AND DOUBLE, BECAUSE  
7 IT HASN'T CHANGED THAT MUCH. WE HAVE, OF COURSE,  
8 LOST THREE YEARS AND, ACTUALLY, ALSO LOST ABOUT  
9 25 PPM, IF I CAN CHANGE UNITS, BETWEEN THIS PICTURE  
10 AND THE ONE WE HAD THREE YEARS AGO. PRETTY SOBERING.

11 SO DOUBLE THE EMISSIONS IN 50 YEARS. THEN  
12 STAY FLAT FOR 50 MORE YEARS. THEN GO DOWN TO  
13 STABILIZATION LEVELS IN THE FOLLOWING 50 YEARS. BY  
14 2157, YOU HAVE STABILIZATION. THAT WILL BE ABOUT  
15 TRIPLE, 800-AND-SOMETHING PARTS PER MILLION,  
16 REASONABLE ESTIMATES ABOUT SINKS; BUT OF COURSE,  
17 THAT'S WHERE THE UNCERTAINTY IS.

18 TAKE THE FLAT LINE AND GO TO STABILIZATION  
19 50 YEARS LATER. THAT'S ABOUT BEATING DOUBLING BUT  
20 NOT BY MUCH. OKAY. SO YOU'RE GOING TO HAVE  
21 SOMETHING LIKE 4,300, 4,200, OR SOME PLUS OR MINUS A  
22 LOT OF TONS OF CO2 IN THE ATMOSPHERE BY THE END OF  
23 THAT, BILLIONS OF TONS OF CO2 BY THE END OF THAT TIME  
24 PERIOD. SO WE PROPOSED A BINARY CHOICE, WHICH WAS

25 ESSENTIALLY THE WASHINGTON, D.C. BINARY CHOICE

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1 DISCUSSION IMPLICIT IN AROUND 2004: OH, THIS IS TOO  
2 HARD, WE'LL TAKE CARE OF IT IN THE SECOND HALF OF THE  
3 CENTURY, TRIPLE; OH, LET'S GET SERIOUS, DOUBLE.

4 AND LET ME TAKE ONE MINUTE WITH A BIT OF  
5 LONG DIVISION. 30 BILLION TONS OF CO2, 8 BILLION  
6 PEOPLE IN 2050 -- MAYBE 9 -- IS 4 TONS OF CO2 PER  
7 CAPITA PER YEAR. THAT'S OUR SHARE. I'M GOING TO  
8 COME BACK TO THAT NUMBER. MAYBE IT IS 5 NOW, GOING  
9 DOWN TO 4 TONS OF CO2 PER CAPITA PER YEAR. OKAY.

10 SO I'VE ADDED A RED LINE. I HOPE YOU CAN  
11 SEE IT. BECAUSE THE DISCUSSION THE LAST THREE YEARS  
12 HAS GOTTEN MORE COMPLICATED. ESSENTIALLY, PACALA AND  
13 I HAVE BEEN OUTFLANKED FROM THE LEFT. IF YOU REALLY  
14 TAKE 2 DEGREES C SERIOUSLY, THAT IS NOT THE TARGET WE  
15 WERE DRAWING. IT WOULD SAY YOU SHOULD NOT BE PLEASED  
16 WITH YOURSELF IF ALL YOU'VE ACCOMPLISHED IS THAT THE  
17 GLOBAL EMISSIONS ARE THE SAME 50 YEARS FROM NOW AS  
18 TODAY. YOU HAVE TO DO MUCH BETTER THAN THAT, AND  
19 MORE OR LESS SAYS THAT 3 DEGREES C IS THE LINE WE  
20 ORIGINALLY DREW.

21 SO NOW THERE IS THIS SECOND BIFURCATION  
22 BETWEEN THE 2 DEGREES AND THE 3 DEGREES WORLDS, WHERE  
23 WE DESPERATELY NEED THE HELP OF THE RESEARCH SCIENCE.  
24 WE, AS THE PUBLIC, NEED THE HELP OF THE RESEARCH  
25 SCIENCE COMMUNITY TO SAY DO WE REALLY THINK IT IS

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1 2 DEGREES C. IT'S A LOT HARDER AT 3 DEGREES C. IF I  
2 CAN TRANSLATE THAT INTO 450 VERSUS 550 PPM OR 3,600  
3 VERSUS -- 3,700 OR 3,800 VERSUS 4,400 BILLION TONS OF  
4 CO2. HOW MUCH DO WE REALLY NEED TO MAKE THAT EXTRA  
5 EFFORT?

6 THE BALI ENVIRONMENT IS GOING TO BE FULL OF  
7 PEOPLE WHO HAVE NO IDEA WHAT THE EFFORT MEANS WHO ARE  
8 GOING TO SAY WE MUST ACHIEVE 2 TO 3 DEGREES C OR  
9 DISASTER WILL ENSUE. AND WHAT I HOPE TO COMMUNICATE  
10 TODAY IS IF WE ARE GOING TO AIM FOR EVEN 3 DEGREES C  
11 OR 550 PPM OR 4,400 BILLION TONS OF CO2, WE ARE GOING  
12 TO HAVE TO WORK VERY HARD ALREADY.

13 SO I MENTIONED, JUST TO GET YOU GROUNDED A  
14 LITTLE BIT, THESE ARE THE KINDS OF BILLS, ELECTRIC  
15 UTILITY BILLS THAT I WANT TO SEE US START TO HAVE.  
16 THEY AREN'T THERE YET. IF 4 TONS OF CO2 PER CAPITA  
17 PER YEAR IS OUR SHARE, WE USE IT UP DRIVING A CAR  
18 10,000 MILES AT 30 MILES PER GALLON IN A YEAR. THAT  
19 WOULD BE OUR FULL QUOTA. COMPARE THAT TO WHAT YOU'RE  
20 DOING WITH YOUR CAR; AND IF YOU REALLY DO HAVE ONE  
21 CAR SHARED BY TWO ADULTS, WHICH I CAN DOUBT FOR MOST  
22 OF YOU, BUT IF YOU DO, YOU CAN SHARE IT IN YOUR  
23 QUOTA. FLYING A MILE AND DRIVING A MILE IN A  
24 30-MILE-PER-GALLON CAR ARE ABOUT THE SAME IN THEIR  
25 CARBON CONSEQUENCES, WITH NORMAL AVIATION, COMMERCIAL

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1 AVIATION. SO, IN MY CASE -- AND I'M AFRAID IN MANY  
2 OF YOURS, TOO -- YOUR CARBON BUDGET IS COMPLETELY  
3 DOMINATED BY YOUR FLYING. LET'S JUST ADMIT IT AND

4 THEN START THINKING WHAT WE CAN DO ABOUT IT.  
5 MY HOME IN NEW JERSEY, AN AVERAGE U.S.  
6 CLIMATE, AVERAGE SIZE, NATURAL GAS FURNACE, WHICH  
7 INDEED WAS MORE EFFICIENT THAN USUAL, SO I COULD  
8 RAISE MY HAND WHEN I BOUGHT THAT ONE, USES ABOUT THE  
9 SAME UNIT OF 4 TONS CO2 PER CAPITA. THAT ONE I DIVIDE  
10 WITH MY WIFE. AND ELECTRICITY, WHICH IS THE VERY  
11 IMPORTANT COMPONENT, NO ONE I SUSPECT KNOWS THIS  
12 NUMBER IN THE ROOM -- IT WOULD BE NICE IF SOME OF YOU  
13 DID -- 300 KILOWATT HOURS A MONTH IS 4 TONS OF CO2 PER  
14 YEAR IF IT IS AN ALL-COAL ELECTRIC SOURCE. IF IT IS  
15 NEW JERSEY, WHICH HAS GOT NUCLEAR AND GAS AND COAL,  
16 IT'S ABOUT HALF AS CARBON-INTENSIVE AS A PURE-COAL  
17 STATE.

18 I DON'T KNOW WHAT HAWAII IS. I SORT OF  
19 FEEL THAT WE SHOULD HAVE BEEN REQUIRED TO LEARN THAT  
20 ON THE WAY IN, AND WE DIDN'T. THIS IS SORT OF THE  
21 CONSCIOUSNESS RAISING THAT WAS PART OF MR. BISHOP'S  
22 QUESTION, TRANSLATES INTO, AND SO FORTH.

23 SO THE MAIN MESSAGE, OBVIOUSLY, IS WE ARE  
24 USING A LOT MORE THAN OUR SHARE. THE U.S. AVERAGE IS  
25 5 TIMES THE GLOBAL AVERAGE TODAY, AND I SUSPECT IN

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1 THIS ROOM, IF WE WORKED IT OUT, OUR SHARES WOULD BE  
2 AT LEAST ANOTHER TIMES 2, THE AVERAGE AMERICAN.

3 THEN STEVE PACALA AND I ADDED ONE MORE  
4 IDEA, AND THAT'S THE WEDGE. THIS TRIANGLE CRIED OUT  
5 FOR SUBDIVISION. AND WE BROKE IT INITIALLY INTO  
6 SEVEN PIECES. I BREAK IT HERE INTO EIGHT PIECES.  
7 AND WE GAVE THEM A NAME, A "WEDGE," AND SO I WILL  
8 TELL YOU TODAY THAT A WEDGE IS A CAMPAIGN STRATEGY  
9 DRIVEN BY A CONCERN FOR CARBON WHICH OVER 50 YEARS  
10 LEADS TO 4 BILLION TONS OF CO2 PER YEAR NOT EMITTED  
11 INTO THE ATMOSPHERE, OKAY, 4 BILLION TONS OF CO2.  
12 ORIGINALLY, WE TALKED ABOUT 1 BILLION TONS OF CARBON.

13 I CAN'T TELL YOU HOW MANY PEOPLE IN THE  
14 GENERAL PUBLIC GETS COMPLETELY STUCK ON THE IDEA THAT  
15 THE CARBON ATOM CARRIES 2 OXYGEN ATOMS, AND SO THERE  
16 IS A FACTOR OF 3.7. IT IS NOT EASY FOR MOST OF THE  
17 PEOPLE WE'RE TRYING TO TALK TO TO UNDERSTAND THAT  
18 IDEA. LET'S JUST ACCEPT THAT AND PUSH ON.

19 SO I HAVE TRIED TO MAKE THIS ALL NOW IN  
20 TERMS OF TONS PER CO2. ALSO, IF SOME OF YOU CARE, WE  
21 WERE WRITING WITH 7 BILLION TONS OF CARBON EMITTED IN  
22 2004, AND THE BETTER NUMBER FOR 2007 IS 8 BILLION  
23 TONS OF CARBON PER YEAR. WE HAVE GONE UP BY  
24 15 PERCENT IN THE THREE YEARS SINCE WE WROTE THE  
25 PAPER, IN THE EMISSIONS RATE, AND IN FACT, NEARLY

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1 THAT NUMBER, 9/10, I THINK, THERE IS A TWO-YEAR LAG.  
2 I DON'T WANT TO GET INTO ALL OF THAT.

3 SO WHAT'S A WEDGE? WE ALSO INSISTED THAT  
4 THE TECHNOLOGIES WE WOULD CONSIDER ARE EITHER  
5 AVAILABLE OR ONE CAN UNDERSTAND HOW TO GET THEM  
6 DEPLOYED IN A BIG WAY OVER THE NEXT 50 YEARS, AND  
7 THERE IS COMMERCIALIZATION OF THE TECHNOLOGY  
8 SOMEWHERE. THAT WAS AN INTERESTING CRITERIA. WE

9 INCLUDED PV BECAUSE CLEARLY WE'RE USING IT EVEN  
10 THOUGH IT'S THE ONE THAT IS THE MOST PRICE  
11 NONCOMPETITIVE AT THE PRESENT TIME. WE INCLUDED A  
12 NUMBER OF OTHER ISSUES. WE HAD 15 EXAMPLES. I HAVE  
13 BEEN DELUGED WITH QUESTIONS ABOUT WHETHER SOMETHING  
14 OR SOMETHING ELSE IS A WEDGE OR NOT. THE POINT IS  
15 THERE ARE A LOT OF WAYS OF GETTING A WEDGE. AND IF  
16 IT IS A STRAIGHT LINE, IT IS 100 BILLION TONS OF CO2.

17 NOW, I WANT YOU TO HAVE A PRICE IN YOUR  
18 HEAD, BECAUSE IF YOU HAVE A PRICE IN YOUR HEAD, YOU  
19 NOW CAN TALK IMMEDIATELY ABOUT ANYTIME CO2, A TON IS  
20 MOVING, IT'S A CERTAIN NUMBER OF DOLLARS MOVING. SO  
21 HAVE IN YOUR HEAD \$30 A TON OF CO2.

22 THE NUMBER THAT WE SAW A FEW MINUTES AGO AT  
23 THE TOP OF AN ARROW, A VERTICAL ARROW, WAS 40 TONS.  
24 AND IT WASN'T EVEN WRITTEN DOWN, BUT IT WAS \$40 PER  
25 TON OF CO2 AS THE INCREMENTAL COST THAT WOULD BE

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1 NEEDED TO BE MET BY SOME POLICY IN ORDER FOR  
2 SOMETHING TO ACTUALLY HAPPEN, IN THE JUDGMENT OF ONE  
3 OF OUR SPEAKERS JUST A FEW MINUTES AGO. SO A  
4 \$30-A-TON WEDGE IS \$3 TRILLION. THAT'S THE SCALE OF  
5 WHAT WE NEED TO DO. IN THIS CASE, LET'S SAY EIGHT OF  
6 THEM WOULD GET THE JOB DONE FOR THE FIRST HALF  
7 CENTURY AT 3 TRILLION A PIECE. OKAY.

8 AND SO WE LOOK FOR WEDGES. AND IN FACT, SO  
9 WE NEED TO GET A SENSE OF -- NOW, I SAID DECONSTRUCT  
10 THE EMISSIONS. THIS HAPPENS TO BE IN TONS OF CARBON,  
11 AND I DON'T KNOW -- I COULD REDRAW IT, I HAVEN'T  
12 GOTTEN AROUND TO IT. IN 2000 WE WERE EMITTING  
13 23 BILLION TONS OF CO2 OR A LITTLE OVER 6 BILLION TONS  
14 OF CARBON. THE MAIN POINT IS YOU CAN LOOK AT HOW IT  
15 IS DISAGGREGATED INTO NINE PARTS BY COAL, OIL, AND  
16 GAS, ON THE ONE HAND, AND YOU HAVE ELECTRICITY,  
17 VEHICLES, AND STATIONARY USES THAT ARE NON-ELECTRIC.  
18 AND YOU SEE THAT THE TOP TWO, AS YOU WOULD EXPECT, I  
19 THINK -- THIS IS GLOBAL, ALL OF THIS -- IS COAL TO  
20 ELECTRICITY AND PETROLEUM TO VEHICLE. BUT BETWEEN  
21 THEM, THEY ONLY ADD UP TO HALF, AND THEY'RE ROUGHLY  
22 EQUAL. ALL OF THIS IS USEFUL TO SORT OF GET YOUR  
23 ARMS AROUND, WELL, HOW ARE WE GOING TO GET THESE  
24 KINDS OF MAJOR EMISSIONS. WE'VE GOT TO DO A LOT OF  
25 THINGS AT ONCE. THE HEATING SECTOR WOULD HAVE COAL

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1 FOR STEEL, IT WOULD HAVE CLUMPS OF COAL FOR HEATING  
2 IN A CHINESE VILLAGE, IT WOULD HAVE THE GAS AND OIL  
3 FURNACES OF THE UNITED STATES.

4 SO WE HAVE SOME IDEA OF WHERE TO LOOK. AND  
5 IN TRYING TO GIVE SOME STRUCTURE TO THIS, I HAVE  
6 FOUND IT USEFUL -- I'M GOING TO GO BACK AND MAKE ONE  
7 COMMENT. SORRY. THE ONE NUMBER I WANTED TO PICK OUT  
8 HERE IS 40 PERCENT OF ALL THE CO2 EMISSIONS INTO THE  
9 ATMOSPHERE ARE GOING TO THE ATMOSPHERE AT POWER  
10 PLANTS, AND 60 PERCENT NOT, GLOBALLY. THE U.S.  
11 NUMBER IS A LITTLE LOWER THAN 40 BECAUSE OUR  
12 TRANSPORTATION NUMBER IS HIGHER. BUT THAT MEANS  
13 40 PERCENT IS NEITHER SMALL NOR LARGE. IT MEANS YOU

14 CAN'T FORGET POWER NOR CAN YOU FOCUS EXCLUSIVELY ON  
15 POWER, AND THAT'S JUST THE IMPORTANT MESSAGE.

16 SO HERE IS A DISAGGREGATION INTO LARGE  
17 PLACES TO LOOK, LARGE AGENDAS, IF YOU LIKE, FOR  
18 FINDING WAYS TO SAVE CARBON IN THE GLOBAL EMISSIONS.  
19 AND THE FIRST IS ENERGY EFFICIENCY. I WILL TALK A  
20 LITTLE BIT MORE ABOUT THAT. WE CAN'T QUITE SAY  
21 ENOUGH ABOUT IT, AND WE ALSO HAVE TO BE VERY HUMBLE  
22 ABOUT THE CHALLENGE OF WHAT IS REQUIRED TO GET THAT  
23 DONE. DECARBONIZING ELECTRICITY IS AN EXTREMELY  
24 INTERESTING, IT IS AN EXCITING TOPIC, IT IS A  
25 TECHNOLOGY-RICH TOPIC. WE HAVE SEEN THAT YOU CAN'T

0284

1 GET THE WHOLE JOB DONE IF THAT IS ALL YOU THINK  
2 ABOUT. SO YOU GO TO THE USE OF FUELS; AND YOU SAY  
3 HOW DO WE DECARBONIZE THOSE, THE FURNACES AND THE  
4 CARS AND WHATNOT AT 4:00; AND AT 6:00 YOU ADMIT IT IS  
5 GOING TO BE EASIER TO DECARBONIZE ELECTRICITY THAN  
6 DECENTRALIZE USES OF CARBON. IF YOU THINK ABOUT  
7 TAKING THE CARBON OUT OF THE AUTOMOBILE EXHAUST, IT'S  
8 A PRETTY DAUNTING IDEA. AND SO YOU SHOULD EXPECT, WE  
9 SHOULD EXPECT THAT IN THE COURSE OF TAKING CARBON  
10 SERIOUSLY, WE WILL SHIFT SOME OF WHAT ARE TODAY USES  
11 OF CARBON IN DECENTRALIZED WAYS BY USES OF CARBON IN  
12 CENTRALIZED WAYS, LIKE THE PLUG-IN HYBRID ELECTRIC  
13 VEHICLES, PHEV, BEING EXAMPLE ONE AND PERHAPS THE  
14 HEAT PUMP FOR SPACE HEATING, ELECTRIC HEAT PUMP FOR  
15 SPACE HEATING BEING EXAMPLE NUMBER TWO, AND THERE  
16 WILL BE MANY OTHER EXAMPLES AT 6:00.

17 AT 8:00, I REMIND MYSELF THAT THE BIOSPHERE  
18 IS ITSELF AMENABLE TO MANIPULATION TO HAVE ADDITIONAL  
19 STANDING CARBON, THAT IS TO SAY, PLANTING TREES,  
20 CHANGING PLOWING METHODS, PERHAPS SOMETHING THAT  
21 BUILDS UP THE CARBON CONTENT OF THE BIOSPHERE IN THE  
22 OCEAN. IT IS HARD TO GET MORE THAN A WEDGE OR SO OUT  
23 OF THERE, BUT YOU CAN CERTAINLY TRY TO AND YOU CAN  
24 CERTAINLY DO SOMETHING, AND SOME OF THE OFFSET WORK  
25 WE'RE HEARING ABOUT IS IN THAT CATEGORY.

0285

1 AND THEN AT 10:00, IT IS NOT JUST CO2. I  
2 WISH WE UNDERSTOOD THE METHANE CYCLE THE WAY WE  
3 UNDERSTAND THE CO2 CYCLE, INADEQUATELY AS WE  
4 UNDERSTAND THE CO2 CYCLE, BECAUSE THEN WE WOULD BE  
5 MOVING ON TO TALKING MUCH MORE SERIOUSLY ABOUT  
6 GAINING ON THIS CLIMATE PROBLEM BY ATTENTION TO THE  
7 GASSES OTHER THAN CO2, NOTABLY METHANE. OF COURSE,  
8 WE'RE ATTENDING TO THEM HERE AND THERE, NITROUS OXIDE  
9 IN PARTICULAR IN INDUSTRIAL APPLICATIONS.

10 SO WHAT IS THIS WEDGE MODEL THAT YOU JUST  
11 SAW? WELL, I LOVE THE QUOTE FROM DAVID HAWKINS:  
12 "THE WEDGE MODEL IS THE IPOD OF CLIMATE CHANGE. YOU  
13 FILL IT WITH YOUR FAVORITE THINGS." BUT THEN HIS  
14 COROLLARY IS: "THEREFORE, PREPARE TO NEGOTIATE WITH  
15 OTHERS, WHO HAVE DIFFERENT FAVORITE THINGS."

16 SO IMPLICIT IN THE WHOLE WAY WE PRESENTED  
17 THIS MATERIAL THREE YEARS AGO WAS THE CONCEPT OF  
18 ALLIANCES AND OF NEGOTIATION, OF LETTING UNDER THE

19 SAME TENT, SOMEBODY WHO YOU ACTUALLY DISLIKE. I  
20 MEAN, THERE IS NO QUESTION SOME OF THESE RIVALRIES  
21 WITHIN THE ENERGY SYSTEMS INVOLVE SERIOUS DISLIKE,  
22 NOT JUST LACK OF INTEREST IN EACH OTHER. AND SO IT  
23 IS THAT KIND OF A GAME.

24 DAVID HAWKINS AND HIS COLLEAGUE, DAN  
25 LASHOF, ACTUALLY PREPARED A U.S. WEDGES DRAWING,

0286

1 CONSISTENT WITH OUR INITIAL DRAWING, WITH SIX  
2 STRATEGIES, OR CALL THEM A PRISM, IT WOULD BE FINE  
3 WITH ME, FOUR OF WHICH ARE EFFICIENCY, ONE OF WHICH  
4 IS RENEWABLES AND ONE OF WHICH IS CARBON CAPTURE AND  
5 STORAGE. THEY DO NOT INCLUDE NUCLEAR IN THEIR IPOD.  
6 THAT'S JUST HOW IT IS.

7 I WANT TO MAKE SURE THAT EVERYBODY IN THIS  
8 ROOM CAN ANSWER THE FOLLOWING QUESTION: WHAT IS  
9 DIFFERENT BETWEEN THIS IMAGE AND THE IMAGE I SHOWED  
10 OF THE WEDGES BEFORE, IN AN IMPORTANT WAY? THEY'RE  
11 MEANT TO BE CONSISTENT IN THE SAME SENSE THAT IT'S A  
12 DESCRIPTION OF THE SAME WORLD.

13 THIS HAS A DESCENDING BOTTOM, AND THE WORLD  
14 TOTAL HAD A FLAT BOTTOM, ON THE ASSUMPTION THAT WE  
15 WILL NOT HAVE THE SAME SHARE OF THE GLOBAL EMISSIONS,  
16 WE WILL HAVE A SMALLER SHARE OF GLOBAL EMISSIONS IN  
17 50 YEARS IF THE TOTAL IS THE SAME. SO THEY'RE MEANT  
18 TO BE CONSISTENT. AND OF COURSE, IF THE TOTAL GOES  
19 DOWN, THE U.S. EMISSIONS WOULD HAVE TO GO FURTHER  
20 DOWN. I MUST SAY THIS HAS NEVER BEEN CONTROVERSIAL.  
21 THERE ISN'T A SINGLE CONGRESSIONAL BILL THAT SAYS,  
22 WELL, WE STAY CONSTANT, I'M SORRY, THAT'S JUST TOO  
23 BAD, WE'RE BIG SHOTS, AND THAT'S WHAT WE'RE GOING TO  
24 DO. THEY ALL SEEM TO RECOGNIZE THE UNDERLYING TRUTH  
25 THAT THE DEVELOPED WORLD HAS TO GO DOWN IN EMISSIONS

0287

1 IN THE SPIRIT OF TONY BLAIR . . . AND WHAT IS  
2 IMPLICIT IN THIS CURVE, WHICH BY THE WAY IS THE ONE  
3 THAT IS IN AL GORE'S "INCONVENIENT TRUTH." HE CITED  
4 THE WEDGES, BUT HE SHOWED AND DIDN'T CLEARLY IDENTIFY  
5 THE HARD WORK BEHIND THIS GRAPH AT NRDC.

6 SO I'M GOING TO BRIEFLY NOW DISCUSS SOME OF  
7 THE WEDGES AS WE GO ON. THIS IS THE PART OF THE TALK  
8 THAT I CAN EXPAND TO HOURS OR MINUTES. I'LL TRY TO  
9 GO FAIRLY QUICKLY THROUGH EFFICIENCY WEDGES AND  
10 WEDGES THAT DISPLACE CONVENTIONAL COAL POWER.

11 SO FOR EFFICIENCY WEDGES, LET'S GO BACK TO  
12 THAT NUMBER, A TON OF CARBON, 4 TONS OF CO2 PER YEAR  
13 EMITTED BY A CAR THAT GOES 30 MILES A GALLON AND  
14 10,000 MILES AND LEARN THAT THE AUTO INDUSTRY  
15 BELIEVES THERE WILL BE 2 BILLION VEHICLES ON THE  
16 PLANET IN 2055 OR SO, THREE TIMES ROUGHLY WHAT WE  
17 HAVE TODAY. IF THEY ARE THE VEHICLE I AM JUST  
18 DESCRIBING, 8 BILLION TONS OF CO2 WILL GO INTO THE  
19 ATMOSPHERE. IF THEY GET 60 MILES PER GALLON ON  
20 AVERAGE, 4. WELL, THAT'S A WEDGE. IF THEY GET  
21 30 MILES A GALLON BUT WE HAVE CHANGED THE  
22 ORGANIZATION OF OUR CITIES AND PEOPLE DRIVE THEIR  
23 CARS HALF AS MUCH, BECAUSE 10,000 MILES A YEAR IS A

24 TYPICAL NUMBER TODAY, THAT WILL ALSO BE A WEDGE. AND  
25 IF YOU DO BOTH, YOU'LL HAVE A WEDGE AND A HALF.

0288

1 THE IMAGES THERE ARE A PRIUS, PUBLIC  
2 TRANSPORT, AND TELECOMMUTING. I VERY MUCH WANT TO  
3 EMPHASIZE THAT TRULY ONE OF THE THINGS THAT WE SHOULD  
4 BE TRYING TO DO IN CARBON MANAGEMENT IS REMOVE  
5 UNWANTED TRAVEL. UNWANTED TRAVEL IS WHEN YOU REALLY  
6 WOULD RATHER STAY HOME. AND IF YOU'RE NOT STAYING  
7 HOME, IT'S PROBABLY BECAUSE OF A FAILURE IN THE  
8 COMMUNICATIONS INDUSTRY, WHICH CAN BE REMOVED WITH  
9 ADDITIONAL TECHNOLOGY AND INVESTMENT AND CLEVERNESS.  
10 AND, OF COURSE, THIS CAN, ALSO, DEAL WITH YOUR  
11 AIRPLANE TRAVEL. WE COULDN'T HAVE HAD THIS MEETING  
12 EXCEPT FACE-TO-FACE, I THINK; BUT AN AWFUL LOT OF  
13 CONVERSATIONS CAN HAPPEN BECAUSE WE MET EACH OTHER  
14 HERE WITH THE HELP OF INFORMATION TECHNOLOGY. AND SO  
15 INVESTING IN CITIES AND REMOVING, REDUCING SPRAWL IS  
16 ANOTHER CLEARLY CARBON-IMPORTANT APPROACH, STRATEGY  
17 ALONG THE WAY TOWARDS REALIZING THESE SORTS OF CARBON  
18 EMISSIONS.

19 WHEN IT COMES TO EFFICIENCY IN ELECTRICITY,  
20 IT GOT MENTIONED SEVERAL TIMES IN THE PREVIOUS  
21 SESSION, BUT IT WASN'T SAID THAT 70 PERCENT OF THE  
22 ELECTRONS THAT LEAVE A POWER PLANT IN THE UNITED  
23 STATES END UP IN A BUILDING. BUILDINGS AND POWER  
24 PLANTS ARE THE SAME. IN THE POST-INDUSTRIAL WORLD,  
25 MORE AND MORE OF OUR FUEL IS IN PERSONAL TRANSPORT.

0289

1 MORE AND MORE OF OUR ELECTRICITY IS IN COMMERCIAL AND  
2 RESIDENTIAL BUILDINGS. THE POST-INDUSTRIAL WORLD IS  
3 A HEDONISTIC WORLD OF A LOT OF APPLICATIONS WHICH ARE  
4 THE PURE CONSUMPTION OF WELL-TO-DO PEOPLE. SO  
5 IMPROVING THE CARBON EMISSIONS, DEALING WITH THE  
6 CARBON EMISSIONS OF ELECTRIC POWER IS, FIRST OF ALL,  
7 FIGURING OUT HOW TO GET THE SAME BENEFITS WITH LESS  
8 ELECTRICITY USE. AND AT THIS POINT, I ALWAYS LOOK UP  
9 AT THE CEILING, AND I DID TODAY A LITTLE EARLIER, AND  
10 WE DO NOT HAVE FLUORESCENTS IN THIS PARTICULAR ROOF,  
11 AND I DARE SAY ONE OF THE THINGS WE COULD DO IS TO  
12 CASE, THIS GROUP AND OTHERS COULD CASE THE HOTELS  
13 BEFORE WE DECIDE TO USE THEM IF THERE'S REALLY ANY  
14 CHOICE AND MAKE SOME JUDGMENTS OR MAKE SOME  
15 CONDITIONS OF OUR GIVING THEM OUR BUSINESS THAT THEY  
16 ARE DOING SOMETHING IN THE WAY OF INVESTMENTS WHEN  
17 THEY TAKE AWAY TENS OF THOUSANDS OF DOLLARS FROM US  
18 BY THE END OF THE MEETING. WE HAVE TO START THINKING  
19 THAT WAY.

20 SO, QUICKLY, THROUGH ELECTRICITY -- I WANT  
21 TO SAY A LOT, OF COURSE, AND I ONLY HAVE A LITTLE  
22 TIME -- AND PART OF IT IS TO ADVERTISE FRIDAY  
23 MORNING. BUT A NUMBER THAT CAN ANCHOR THIS  
24 DISCUSSION IS THAT 700 1-GIGAWATT ELECTRIC POWER  
25 PLANTS WILL PUT 4 BILLION TONS OF CO<sub>2</sub>, A WEDGE, INTO

0290

1 THE AIR PER YEAR. THERE IS AN ASSUMPTION THERE ABOUT  
2 CAPACITY FACTOR. THERE IS AN ASSUMPTION THERE ABOUT

3 EFFICIENCY. BUT 6 MILLION TONS OF CO2 PER  
4 1,000-MEGAWATT PLANT PER YEAR IS AN EQUIVALENT  
5 NUMBER. SO IF WE -- AND WE CAN GET A WEDGE BY NOT  
6 BUILDING 700 CONVENTIONAL COAL POWER PLANTS OF  
7 1,000-MEGAWATT SIZE. SO YOU CAN DO THAT WITH  
8 EFFICIENCY, AND YOU CAN DO THAT A LOT OF OTHER WAYS.  
9 AND LET ME MAKE SURE YOU KNOW IT IS MULTIPLES OF  
10 700 OF THOSE PLANTS WHICH ARE SLATED FOR CONSTRUCTION  
11 OVER THE NEXT 50 YEARS. IN FACT, THE NUMBER IS 1,800  
12 BY 2030, WITH CHINA IN FIRST PLACE, I THINK U.S. AND  
13 INDIA ARE SECOND AND THIRD IN THAT PLAN. SO TARGET  
14 NUMBER ONE AND TARGET NUMBER TWO IN MY MIND,  
15 EFFICIENCY AND NOT BUILDING CONVENTIONAL COAL PLANTS  
16 WHEN YOU TAKE THIS PROBLEM SERIOUSLY.

17 WELL, CARBON CAPTURE AND STORAGE, WHICH  
18 JULIO FRIEDMANN WILL TALK ABOUT FRIDAY MORNING, IS  
19 REPRESENTED BY THIS PAIR OF IMAGES. THE POWER PLANT  
20 IS A DEMONSTRATION, IGCC PLANT BUILT IN INDIANA DOES  
21 NOT CAPTURE CARBON, BUT IT DOES GASIFY COAL, BUILT IN  
22 THE LATE 1990S AND IS STILL RUNNING. IN THE  
23 RIGHT-HAND IMAGE IS THE INJECTION OF CO2 INTO A POROUS  
24 SANDSTONE AQUIFER OFFSHORE IN NORWAY, WHICH HAS BEEN  
25 PUTTING A MILLION TONS OF CO2 INTO THE ATMOSPHERE

0291

1 SINCE 1996. AND SO YOU HAVE COMMERCIAL TECHNOLOGY  
2 READY TO ROLL OUT, AND THERE IS NO EXCUSE FOR NOT  
3 BUILDING FULL-SCALE PROJECTS FOR CARBON CAPTURE AND  
4 STORAGE. THIS IS A SITUATION WHERE A GENERAL HEARS A  
5 CAPTAIN SAY, "WELL, I'M NOT SURE WE'RE READY FOR THIS  
6 BATTLE," AND HE SAYS, "WELL, JUST GET READY." YOU  
7 KNOW, I MEAN, THERE IS NO REASON TO POSTPONE THIS;  
8 AND THERE IS A VERY NASTY PRESENTATION FROM SOME  
9 PLACES THAT WE NEED A COUPLE OF DECADES BEFORE WE CAN  
10 TAKE THIS ON. THIS IS, IN MY VIEW, DISINFORMATION.  
11 WE'VE GOT TO GET GOING. WE'LL DEVELOP THE POLICY AND  
12 THE TECHNOLOGY SIDE BY SIDE IN SEVERAL FULL-SCALE  
13 PROGRAMS AROUND THE WORLD. FUTUREGEN, FOR EXAMPLE,  
14 IS NOT ON THE CRITICAL PATH AT ALL. THE DIRECTOR  
15 HIMSELF SAYS THIS. IT WAS TO DEVELOP THE TECHNOLOGY  
16 THAT WILL BE USED IN THE SECOND GENERATION OF CARBON  
17 CAPTURE AND STORAGE PROGRAMS THAT MIGHT COME ON A  
18 DECADE LATER.

19 I FEEL VERY STRONGLY THAT WE NOT GET THIS  
20 WRONG. WE ARE READY TO BUILD FULL-SCALE COAL WITH  
21 CAPTURE AND STORAGE AT THIS TIME. OF COURSE, IT  
22 COSTS MORE, AND THAT REQUIRES POLICIES THAT MAKE THE  
23 COMPANIES WANT TO GO AND DO IT.

24 JUST TO MAKE SURE YOU KNOW SOMETHING ABOUT  
25 THE READINESS OF THE CARBON CAPTURE AND STORAGE

0292

1 REGIME, THIS IS AN 800-KILOMETER, 500-MILE CO2  
2 PIPELINE, THE LONGEST IN THE WORLD, BUILT IN THE  
3 MID-EIGHTIES TO TAKE CO2 AND ENHANCE OUR RECOVERY IN  
4 WEST TEXAS IN THE PERMIAN BASIN, AND IT WAS BUILT  
5 BECAUSE THERE WAS A SUBSIDY ON ENHANCED OIL RECOVERY.  
6 IT ACTUALLY ACCESSES IN NORTH AND SOUTHWESTERN  
7 COLORADO A NATURAL FORMATION THAT IS NEARLY PURE CO2

8 AND IMMENSE. IT IS A NATURAL WONDER OF THE WORLD.  
9 SO THANKS TO THAT POLICY, WE'RE PULLING CO2 OUT OF THE  
10 GROUND THAT WOULD NEVER HAVE COME TO THE SURFACE  
11 WITHOUT THAT POLICY.

12 CLEARLY, WE HAVE TO HAVE A DIFFERENTIATION  
13 BETWEEN THE VARIOUS OBJECTIVES THAT WE HAVE AHEAD OF  
14 US, FOR EXAMPLE, NOT TO HAVE A CO2 POLICY, NOT TO HAVE  
15 AN OIL POLICY THAT ENDS UP ENCOURAGING MORE OF THIS  
16 BECAUSE WE HAVE TO PLAN OUR CCS WORLD AND OUR ENERGY  
17 SECURITY WORLD IN SOME COHERENT FASHION. ANOTHER OF  
18 THE PROJECTS, QUITE A BIT LIKE THE ONE IN NORWAY IS  
19 ACTUALLY IN AN OPEC STATE, IN AN ARAB STATE, IN  
20 ALGERIA, IN THE DESERT, WHERE ANOTHER MILLION TONS OF  
21 CO2 PER YEAR ARE BEING INJECTED, THREE OIL COMPANIES  
22 PARTICIPATING IN THIS PROGRAM BECAUSE THEY WANTED TO  
23 GET FIRST-MOVER ADVANTAGE.

24 WHEN IT COMES TO RENEWABLES, WHICH CHUCK  
25 KUTSCHER WILL TALK ABOUT, THE NUMBERS -- THE ONE

0293

1 CONSEQUENCE OF OUR "WEDGES" PAPER WAS TO STARTLE  
2 PEOPLE AS TO HOW MUCH RENEWABLE ENERGY WAS REALLY  
3 INVOLVED IN A WEDGE. ROUGHLY A MILLION 2-MEGAWATT  
4 WINDMILLS WOULD BE REQUIRED IF THEY OFFSET COAL TO  
5 ACHIEVE ONE WEDGE. NOW, THAT, WE ARE 4 PERCENT OF  
6 THE WAY TO THAT. WIND IS GROWING 30 PERCENT A YEAR.  
7 A FULL WEDGE IS NOT THE SLIGHTEST BIT INCONCEIVABLE,  
8 BUT IT IS A LOT OF WIND. BY THE WAY, THOSE OF YOU  
9 LOOKING CLOSELY ARE SAYING, I THOUGHT IT WAS 700,000  
10 MEGAWATTS; WHY IS IT SUDDENLY 200,000 MEGAWATTS, AND  
11 THE ANSWER IS THAT FACTOR OF 3 IS MY SHORTCUT FOR  
12 INTERMITTENCY BECAUSE THE NAMEPLATE POWER ON WINDMILL  
13 IS ONE INTERRUPTION IN . . . HOURS, AND WIND IS  
14 VARIABLE. AND THAT FACTOR OF 3 IS APPROXIMATELY  
15 RIGHT FOR BOTH PV AND FOR WIND. QUICK AND DIRTY, GET  
16 THE NUMBERS APPROXIMATELY RIGHT, GIVE PEOPLE THE  
17 POWER TO THINK ABOUT THIS THEMSELVES. THAT'S BEEN MY  
18 DRIVING INTEREST FOR SOME TIME, AND THIS IS AN  
19 EXAMPLE.

20 PHOTOVOLTAICS, AGAIN, I THINK CHUCK WILL  
21 SAY MUCH MORE ABOUT IT. IT COMES IN BOTH DISTRIBUTED  
22 AND CENTRALIZED FORM. WE ARE QUITE A BIT FURTHER  
23 BEHIND IN TOTAL DEPLOYED PV, BUT 30 PERCENT OF GROWTH  
24 RATES FOR A DECADE CHARACTERIZE PV, AS WELL AS WIND,  
25 LOOKING BACK THE PAST TEN YEARS.

0294

1 CONCENTRATING SOLAR POWER, LESS KNOWN BY  
2 MANY PEOPLE, VERY SIMPLE. CONCENTRATE THE SUNLIGHT,  
3 RAISE THE TEMPERATURE OF THE FLUID . . . THAT'S AT  
4 THE FOCUS, ENOUGH TO BE ABLE TO RUN AN ENGINE. YOU  
5 CAN USE EITHER 1-DIMENSIONAL FOCUSING, AS SHOWN HERE,  
6 OR A PARABOLIC DISH AND ADD 2-DIMENSIONAL FOCUSING  
7 AND HIGHER TEMPERATURE. CAPITAL COSTS ARE VERY  
8 INTERESTING, AND PROMISING TECHNOLOGIES, TUNE IN  
9 FRIDAY MORNING.

10 WHEN WE GET TO NUCLEAR, THE NUMBER TO HAVE  
11 IN MIND IS THAT WE HAVE 350,000 MEGAWATTS OF NUCLEAR  
12 POWER TODAY, WHICH ROUGHLY ARE ONE FOR ONE,

13 SUBSTITUTABLE WITH COAL. SO IF WE PHASE OUT NUCLEAR  
14 POWER IN THIS COUNTRY, THAT WILL BE MINUS ONE-HALF  
15 WEDGE. AND IF WE TRIM THE CURRENT NUCLEAR STOCK BY  
16 2050, THAT WILL BE PLUS ONE WEDGE, AND THAT IS AN  
17 INTERESTING STORY.

18 NOW, I HAVE JUST TWO SLIDES ON NUCLEAR.  
19 ONE IS THIS IMAGE, WHICH IS ONE OF THE DOMINION POWER  
20 PLANTS IN VIRGINIA NEAR THE CHESAPEAKE, AND IT SHOWS  
21 YOU IN THE FOREGROUND SOMETHING WHICH IS ATTACHED TO  
22 ABOUT HALF OF OUR NUCLEAR POWER PLANTS TODAY, BUT WE  
23 REALLY HAVEN'T LEARNED MUCH ABOUT IT. THERE HASN'T  
24 BEEN AN INTEREST IN EITHER THE INDUSTRY OR IN ITS  
25 CRITICS TO TELL YOU THAT THE SHORT-TERM STORAGE

0295

1 PROBLEM HAS BEEN SOLVED. THOSE ARE THE DRY CASKS IN  
2 THE FOREGROUND, ABOUT THREE OR FOUR MAIN  
3 COMPUTERS . . . AS I UNDERSTAND IT. MAYBE MS. HOWES  
4 CAN FIX IT FOR ME. BUT IT IS ON THAT SCALE. AND SO  
5 THEY HAVE BEEN THERE FOR QUITE A WHILE NOW, PILING  
6 UP, AND THEY HOLD THE CO2 -- THEY HOLD THE CO2 -- THEY  
7 HOLD THE SPENT FUEL THAT CAME OUT OF THE POWER PLANT  
8 AFTER IT HAS SPENT SEVERAL YEARS IN THIS FAMOUS  
9 SWIMMING POOL. WE WERE FACING A CRISIS THAT THE  
10 SWIMMING POOLS WERE FILLING UP. WE HAD TO GET TO  
11 YUCCA MOUNTAIN IN A HURRY. SOME GROUPS OF  
12 TECHNOLOGISTS WHO HAVE NOT BEEN CELEBRATED GOT IN THE  
13 ACT AND SAID, WE CAN FIND ANOTHER WAY. SO OUT OF THE  
14 SWIMMING POOL, INTO THE DRY CASK STORAGE. AND AS  
15 MS. HOWES SAID, UP TO A 100-YEAR SOLUTION IS AT LEAST  
16 IMPLICIT THERE. THAT MEANS NEGOTIATING A NEW  
17 CONTRACT ABOUT WASTE DISPOSAL BETWEEN THE NUCLEAR  
18 INDUSTRY, THE NUCLEAR COMMUNITY, AND SOCIETY. WE  
19 SAID 50 YEARS AGO TECHNOLOGISTS WILL BE ABLE TO PUT  
20 IT AWAY FOREVER. WE NOW KNOW WE CAN'T. WE HAVE TO  
21 HAVE A NEW CONTRACT, WE WILL SAY WE WILL HAVE TO BE A  
22 BURDEN ON THE NEXT GENERATION OR THREE GENERATIONS  
23 OUT THAT WILL HAVE TO DO SOMETHING WITH THIS, AND  
24 WE'RE SORRY, BUT THAT'S PART OF WHAT GOES WITH  
25 NUCLEAR ENERGY, AND LET'S GO EITHER WE'RE GOING TO

0296

1 LIVE WITH THAT OR WE'RE NOT GOING TO HAVE IT, AND  
2 LIVING WITH THAT SEEMS TO ME CONSISTENT WITH THE WAY  
3 WE BURDENED THE FUTURE GENERATIONS WITH LOTS OF  
4 OTHERS PROBLEMS BY OUR OWN CONSUMPTION.  
5 AND NOT MUCH WAS SAID TODAY, BUT IF NUCLEAR  
6 POWER IS GOING TO CONTRIBUTE TO THE GREENHOUSE  
7 PROBLEM AS OPPOSED TO VARIOUS DOMESTIC ENERGY  
8 SECURITY PROBLEMS, IT HAS GOT TO BE GLOBAL; AND THOSE  
9 700 GIGAWATTS OF NUCLEAR-DISPLACING COAL ARE NOT  
10 GOING TO BE IN THE U.S., FOR THE MOST PART; A SOME  
11 SMALL FRACTION WILL BE. SO WE HAVE TO HAVE AN  
12 INTERNATIONAL REGIME TO MANAGE NUCLEAR POWER THAT  
13 WE'RE ALL COMFORTABLE WITH. THE GAS CENTRIFUGE SHOWN  
14 THERE IS A WAY OF ENRICHING URANIUM TO DEAL WITH  
15 TODAY'S LIGHT . . . ENRICHED URANIUM PLANTS. IRAN IS  
16 BUILDING SOMETHING OF THIS SORT. WE ARE NOT  
17 COMFORTABLE. SO WE HAVEN'T GOTTEN THE INTERNATIONAL

18 REGIME RIGHT. WE COULD FIX IT. WE HAVE TO BE  
19 WILLING TO GIVE UP SOME SOVEREIGNTY, I THINK, IN  
20 ORDER TO FIX IT. BUT THIS ISN'T HAPPENING. AND SO I  
21 DON'T THINK WE'RE READY FOR A NUCLEAR WEDGE UNTIL WE  
22 DEAL WITH THE INTERNATIONAL MANAGEMENT OF NUCLEAR  
23 POWER.

24 SO, IN THAT GENERAL FRAME, I WANT TO  
25 CONCLUDE THIS "WEDGES" DISCUSSION WITH THE

0297

1 OBSERVATION -- IT IS HARD TO READ IT -- "EVERY WEDGE  
2 STRATEGY CAN BE IMPLEMENTED WELL OR POORLY." AND I  
3 THINK THAT'S CRITICAL. I HAVE NO FAVORITE WEDGES.  
4 PEOPLE LIKE TO ASK ME THAT QUESTION. EVERYTHING CAN  
5 BE DONE WELL OR POORLY. CONSERVATION CAN CERTAINLY  
6 BE DONE IN SUCH A WAY THAT WE ALL FEEL IT TO BE  
7 REGIMENTATION. THE AUTO INDUSTRY TALKS ABOUT FORCING  
8 PEOPLE INTO SMALL CARS. IT HAS MANY DIMENSIONS, THIS  
9 REGIMENTATION ISSUE. RENEWABLES ARE OFTEN COMPETING  
10 WITH LAND. AS WE KNOW FROM THE EXPERIENCE NOW WITH  
11 BIOFUELS, NUCLEAR POWER HAS THIS COUPLING TO NUCLEAR  
12 WAR I JUST MENTIONED. AND CLEAN COAL REALLY REQUIRES  
13 IT TO BE CLEAN UPSTREAM, TOO, WHEN IT COMES TO THE  
14 MINER'S SAFETY AND THE MANAGEMENT OF THE COAL MINES  
15 THEMSELVES.

16 AND WE ARE ALL GOING TO BE IN THE BUSINESS  
17 OF SOLUTION SCIENCE, ADDRESSING THE QUALITY OF THE  
18 SOLUTIONS FROM A SCIENCE PERSPECTIVE, ENVIRONMENTAL  
19 PERSPECTIVE. IT IS NOT JUST GETTING A LIST OF  
20 SOLUTIONS BUT MAKING SURE WE'RE DOING THEM WELL.

21 AND SO THAT THIS NEW ROLE I'M IDENTIFYING  
22 FOR THE PEOPLE IN THIS ROOM AND THEIR LABORATORIES --  
23 RALPH CICERONE TOLD ME HE HAS BEEN SAYING THIS FOR  
24 15 YEARS, HE HAS BEEN SAYING IT IN MANY MORE  
25 PROMINENT PLACES THAN I HAVE, I HAVE BEEN SAYING IT

0298

1 AS LONG -- THAT THERE IS GOING TO BE A JOB. I HAVE  
2 GFND IN MY BACKYARD, SO I SAY IT OVER THERE; THAT  
3 THERE IS A JOB FOR MANAGING AND DISCIPLINING THE  
4 PROPOSALS FOR WHAT TO DO WITH MANAGING THE CARBON  
5 PROBLEM, IN PARTICULAR, MORE AGGRESSIVE SOLUTIONS,  
6 AND SO THAT FRIDAY MORNING WE WILL HAVE TWO TALKS ON  
7 GEOENGINEERING.

8 PARTING THOUGHTS FOR BALI: I WANT TO JUST  
9 SHOW A COUPLE OF IMAGES OF SOME NEW WORK THAT WE'RE  
10 DOING. ONE IS ANOTHER PARTITION OF THIS 30 BILLION  
11 TONS OF CO2, AGAIN I THINK WE HAVE CHANGED UNITS HERE.  
12 THE DEVELOPING WORLD HAS PASSED THE OECD IN THE LAST  
13 COUPLE OF YEARS IN EMITTING 50 PERCENT OF THE  
14 CO2 . . . AND ONE COULD ASK THE QUESTION: KNOWING  
15 THAT THEY ARE ROUGHLY 50/50 TODAY, IF YOU WERE TO  
16 ALLOW CO2 TO DOUBLE, HOW WOULD YOU PARTITION THE CO2  
17 EMISSIONS BETWEEN THE DEVELOPING AND DEVELOPED WORLD?  
18 THERE IS 2.4 AND 1.6 GROWTH RATES. IF YOU INSIST ON  
19 CONSTANT, MAYBE IT WOULD BE 1.6 AND .4 MULTIPLES OF  
20 TODAY FOR THE TOTAL TO BE THE SAME. AND SO YOU SEE  
21 THE INDUSTRIALIZED WORLD DOWN BY A FACTOR OF 4 AND  
22 THE DEVELOPING WORLD BY A FACTOR OF A THIRD IN ONE

23 ARBITRARY BUT MEANT TO BE AN IMAGE OF THE JOB OF  
24 DEALING WITH CONSTANT EMISSIONS IN 50 YEARS, STARTING  
25 FROM 50 PERCENT EMISSIONS FROM THE OECD TO ONLY

0299

1 TODAY.

2 AND THIS IS ANOTHER, A NEW IDEA, MY FINAL  
3 NUMERICAL SLIDE: SUPPOSE WE COULD TAKE THIS  
4 30 BILLION TONS OF CO2 PER YEAR AND ACTUALLY ALLOCATE  
5 IT TO EVERY HUMAN BEING ON THE PLANET, RICHEST TO  
6 POOREST. BY A COUPLE OF TRICKS, PACALA AND I AND  
7 WONDERFUL CO-WORKERS ARE COMING UP WITH THIS GRAPH  
8 RIGHT NOW, WHICH WILL BE MODIFIED, AND WE ORDER THEM  
9 FROM THE LARGEST EMITTERS TO THE SMALLEST EMITTERS,  
10 AND PAYING NO ATTENTION WHATSOEVER TO WHAT COUNTRY  
11 THEY COME FROM. OKAY? BUT WE USE INCOME AND  
12 EQUALITY DATA FROM THE WORLD BANK TO GET THIS GOING.  
13 AND THEN WE SAY SUPPOSE WE HAVE A TARGET OF A CERTAIN  
14 MAXIMUM NUMBER OF EMISSIONS AND WE DECIDE TO DO IT  
15 ONLY USING THE RICHEST PEOPLE, HOW MANY PEOPLE WOULD  
16 HAVE TO PARTICIPATE IN GETTING THEIR LEVELS DOWN TO  
17 SOME FLOOR, ESSENTIALLY IT IS THE SAME. WE'RE GOING  
18 TO HAVE A 100 PERCENT TAX RATE ABOVE A CERTAIN VALUE,  
19 AND WE WILL COLLECT THE INCOME THAT WAY. SO IT ENDS  
20 UP FOR -- THIS IS THE EIA DATA FOR 2030, 43 BILLION  
21 TONS OF CO2 EMITTED. SUPPOSE WE CAN GET DOWN TO 30.  
22 ONE BILLION PEOPLE WOULD HAVE TO PARTICIPATE. THEIR  
23 EMISSIONS WOULD HAVE TO GO DOWN TO 11 TONS OF CARBON  
24 DIOXIDE A YEAR, THREE TIMES THE AVERAGE. THAT WOULD  
25 BE A WAY OF GETTING THE JOB DONE.

0300

1 AND THEN, ON THE RIGHT-HAND, WE ALSO SAY  
2 SUPPOSE WE ADD THE POVERTY AGENDA AND GET EVERYBODY  
3 LOWER THAN 1 TON OF CO2 PER CAPITA PER YEAR. YOU  
4 WOULD HAVE A LITTLE BIT MORE PEOPLE INVOLVED. THEN,  
5 IN THAT SLIDE, WHERE DO THESE PEOPLE LIVE? IT TURNS  
6 OUT ROUGHLY ONE-QUARTER OF THOSE BILLION ARE IN  
7 CHINA, ONE-QUARTER IN THE UNITED STATES, ONE-QUARTER  
8 ARE IN THE REST OF THE OECD, AND ONE-QUARTER IS  
9 WHAT'S LEFT IN THE WORLD. FOUR ROUGHLY EQUAL  
10 PORTIONS, A QUARTER OF A BILLION PEOPLE EACH  
11 PARTICIPATING IN CARBON MITIGATION.

12 THERE ARE A NUMBER OF MESSAGES TUCKED IN  
13 HERE WHICH YOU CAN NOW ANTICIPATE AND UNDERSTAND. IT  
14 IS A PROPOSAL ON HOW TO UNLOCK THE BALI DILEMMA. I  
15 SAY THIS IS A WAY OF COUNTING PEOPLE BY COUNTING ONLY  
16 RICH PEOPLE AND REALIZING THAT WHEN THE OECD HAS THE  
17 SAME EMISSIONS AS THE DEVELOPING WORLD BUT ONE-FIFTH  
18 AS MANY PEOPLE, THEN YOU HAVE A PER CAPITA DIFFERENCE  
19 OF 5, BUT JUST AS MANY PEOPLE INVOLVED WHO ARE  
20 WELL-TO-DO, OR NEARLY AS MANY. SO WE HAVE TO DEAL  
21 WITH THE WELL-TO-DO TOGETHER WHEREVER THEY ARE, DEAL  
22 WITH THE CARBON PROBLEM THE SAME WAY. THAT'S THE  
23 KIND OF UNIVERSAL PRINCIPLE.

24 I'M GOING TO SKIP THAT ONE AND ASK YOU, IN  
25 THE FINAL SLIDE, TO THINK ABOUT THIS, BECAUSE THIS IS

0301

1 HOW I THINK ABOUT YOU: NEVER IN HISTORY HAS THE WORK

2 OF SO FEW LED TO SO MUCH BEING ASKED OF SO MANY. YOU  
3 ARE A FEW THOUSAND PEOPLE. YOU ARE ABOUT TO TURN THE  
4 WORLD INSIDE OUT WITH YOUR REQUIREMENTS FOR REDUCING  
5 THE CO2 EMISSIONS. YOU ARE NOT ASKING SOMETHING EASY.

6 THIS IS SOMETHING I WANT TO MAKE SURE COMES  
7 THROUGH FROM THIS MEETING. THIS IS WHERE THE SUBJECT  
8 GETS COMBINED THAT WE HAVE BEEN TALKING ABOUT ALL  
9 DAY.

10 THE WARNINGS ABOUT GLOBAL CLIMATE CHANGE  
11 FROM THE CLIMATE SCIENTISTS HAVE LAUNCHED A DEEP  
12 RE-EXAMINATION OF THE ENERGY SYSTEM AND OTHER  
13 RESOURCE-INTENSIVE ASPECTS OF ORDINARY LIVING. IT IS  
14 CRUCIAL THAT THESE SCIENTISTS CONVEY AS CAREFULLY AS  
15 POSSIBLE WHAT THEY KNOW AND HOW WELL OR POORLY THEY  
16 KNOW IT.

17 AND YOU HAVE BEEN DOING A VERY GOOD JOB,  
18 BUT THE STAKES ARE RISING.

19 AND FINALLY, I WANT TO CLOSE WITH A FINAL  
20 DAVID KEELING QUOTE, BECAUSE HE'S A VERY LOVABLE MAN  
21 WHO, UNFORTUNATELY, I NEVER MET. I ONLY SPOKE TO HIM  
22 OVER THE TELEPHONE.

23 "PERHAPS MY SUCCESS IN SUSTAINING TIME  
24 SERIES MEASUREMENTS WILL EVENTUALLY RAISE THE GENERAL  
25 SCIENTIFIC REGARD FOR MAKING REPETITIVE BUT IMPORTANT

0302

1 ENVIRONMENTAL MEASUREMENTS. ALSO, I HOPE THAT THERE  
2 WILL ALWAYS BE OPPORTUNITY FOR INDIVIDUAL SCIENTISTS  
3 TO PURSUE SCIENTIFIC LEADS NOT ANTICIPATED BY  
4 COMMITTEES OR AGENCIES. THERE IS A PLACE FOR THE  
5 INDIVIDUAL BEING A CURMUDGEON, BEING DETERMINED, AND  
6 CHANGING THE WORLD."

7 THANK YOU VERY MUCH.

8