

ACTION RECOMMENDATIONS

FOR A PROJECT ON

EXPANDING MARKETS FOR PHOTOVOLTAICS

FACILITATED BY THE
RENEWABLE ENERGY POLICY PROJECT¹

SECTION ONE: PROJECT CONTEXT

I. THE PROBLEM:

PHOTOVOLTAIC (PV) TECHNOLOGY HAS ENORMOUS POTENTIAL TO MITIGATE POLLUTION, REDUCE ENERGY-RELATED EMISSIONS OF GREENHOUSE GASES, EXPAND ACCESS TO ELECTRICITY FOR RURAL POPULATIONS, AND ACCELERATE A WORLD-WIDE TRANSITION TO A CLEAN, DISTRIBUTED ENERGY SYSTEM BY FILLING NICHE MARKETS. UNFORTUNATELY, NOTWITHSTANDING TWO DECADES OF STEADY TECHNICAL PROGRESS AND PRICE REDUCTIONS, MARKETS FOR PHOTOVOLTAICS REMAIN SMALL AND SCATTERED.

IN PART, THE PREDICAMENT OF PHOTOVOLTAIC POWER REFLECTS ASTONISHING DECLINES IN THE PRICE OF FOSSIL FUELS. THE PAST TWO DECADES BROUGHT INCREASING MECHANIZATION OF THE AMERICAN COAL INDUSTRY, DEREGULATION OF THE NATURAL GAS INDUSTRY, AND THE INABILITY OF THE ORGANIZATION OF PETROLEUM EXPORTING COUNTRIES TO MAINTAIN ITS CARTEL INTACT AFTER THE MID-1980S. IN FACT, IN MARCH OF 1998 THE REAL PRICE OF OIL NEARED ITS ALL-TIME LOW. PHOTOVOLTAIC POWER, WHILE EVER CHEAPER, HAS BEEN UNABLE TO CATCH THE MOVING TARGETS SET BY COMPETING RESOURCES, WHICH IN ANY CASE BEGAN THE PRICE RACE FROM A POINT FAR OUT AHEAD. IN ADDITION, CONSUMERS WISHING TO INSTALL PHOTOVOLTAIC SYSTEMS FACE SUBSTANTIAL NON-PRICE BARRIERS. THESE INCLUDE LACK OF APPROPRIATE FINANCING AND ELECTRIC COMPANIES' DISINCLINATION TO BUY BACK EXCESS PV-GENERATED ELECTRICITY AT RETAIL RATHER THAN WHOLESALE RATES. FINALLY, OF COURSE, PHOTOVOLTAIC POWER WILL SEEMLESS ATTRACTIVE THAN ITS COMPETITORS AS LONG AS THE PRICE OF CONVENTIONAL ENERGY SOURCES IGNORES THE ENVIRONMENTAL AND GEOPOLITICAL COST OF USING ENERGY.

NUMEROUS PAST RESEARCH PROJECTS EXPLORED BARRIERS TO THE EXPANSION OF PHOTOVOLTAIC MARKETS. HOWEVER, ACCUMULATING CONCERN OVER ENVIRONMENTAL PROBLEMS (CHIEFLY CLIMATE CHANGE AND DIRTY AIR) AND THE POLITICAL ISSUES THEY ENGENDER BEGS THE QUESTION: HOW CAN

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WE BEST APPLY AVAILABLE RESOURCES TO INCREASE THE SIZE OF MARKETS FOR PHOTOVOLTAICS?

II. THE TECHNOLOGICAL PROMISE

~~OBSERVATION OF THE PHOTOVOLTAIC EFFECT DATES BACK SOME 150 YEARS.~~ SINCE INVENTION OF THE LIGHT-POWERED SILICON CELL AT BELL LABS IN 1954, STEADILY INTENSIFYING RESEARCH, COMMERCIALIZATION AND MANUFACTURE HAS PRODUCED A GLOBAL INDUSTRIAL CAPACITY OF 125.8 PEAK MEGAWATTS (MWP) SHIPPED IN 1997,ⁱ WHICH SUSTAINS A BUSINESS OF OVER ONE BILLION DOLLARS PER YEAR. ACCORDING TO THE ELECTRIC POWER RESEARCH INSTITUTE (EPRI) AND THE U.S. DEPARTMENT OF ENERGY (DOE), INCREASING VOLUMES OF PHOTOVOLTAIC PRODUCTION HAVE DRIVEN DOWN PRICES AT AN 82% PROGRESS RATIO, TYPICAL OF MANUFACTURED GOODS, WHOSE RATIOS GENERALLY FALL BETWEEN 70 AND 90%.ⁱⁱ THE PRESIDENT'S COUNCIL OF ADVISORS ON SCIENCE AND TECHNOLOGY NOTES THAT THE PRICE OF INSTALLED PV SYSTEMS HAS FALLEN FROM \$17 PER PEAK WATT (WP) IN 1984, TO \$9 IN 1992, TO \$6 IN 1996.ⁱⁱⁱ GIVEN ANNUAL MARKET GROWTH OF 20%, EPRI AND THE DOE PREDICT THAT THE COST OF A TYPICAL RESIDENTIAL SYSTEM WILL FALL FROM APPROXIMATELY \$18,100 IN 1997 TO \$4100 IN 2030, AS THE PRICE OF THE PV MODULES THEMSELVES FALLS FROM \$3.75 TO \$0.63/WP.^{iv} THE OFFICE OF TECHNOLOGY ASSESSMENT REPORTED IN 1995 ~~BEFORE ITS DEMISE~~ THAT THE COST OF ELECTRICITY FROM PHOTOVOLTAIC PANELS WAS PREDICTED TO DROP TO BETWEEN TEN AND TWENTY CENTS PER KILOWATT-HOUR (kWh) BY 2000, AND DECLINE RAPIDLY THEREAFTER, REACHING A PRICE OF BETWEEN EIGHT AND FOUR CENTS/kWh BY 2030.^v SINCE THEN, THE EXPERIENCE OF THE SACRAMENTO MUNICIPAL UTILITY DISTRICT (SMUD) SEEMS TO HAVE VALIDATED SUCH OPTIMISM, AND EVEN CAST IT AS CONSERVATIVE: SMUD REPORTS THAT THIRTY-YEAR LEVELIZED COSTS FOR PV ELECTRICITY HAVE FALLEN FROM 23 CENTS/kWh IN 1993 TO 16 CENTS/kWh TODAY, AND WILL REACH 8-9 CENTS/kWh IN 2002.^{vi} IN SUM, PHOTOVOLTAIC TECHNOLOGY HAS MADE IMPRESSIVE ENGINEERING AND ECONOMIC PROGRESS IN RECENT YEARS, AND ANALYSTS EXPECT THIS PROGRESS TO CONTINUE.

HOWEVER, THE COST OF ENERGY FROM PV REPRESENTS ONLY A ROUGH APPROXIMATION OF THE TECHNOLOGY'S VALUE. IN FACT, THE SPECIAL CHARACTERISTICS OF PV MAKE INAPPROPRIATE A SIMPLE COST-OF-ENERGY BASIS WITH CENTRAL-STATION GENERATION. BECAUSE PV GAINS LESS FROM ECONOMIES OF SCALE THAN DO FOSSIL-FUEL OR NUCLEAR PLANTS, USERS CAN DEPLOY IT IN QUITE SMALL SIZES. PERHAPS MORE IMPORTANT, PV PROVES ESPECIALLY VALUABLE WHERE TRANSMISSION GRIDS OPERATE AT FULL CAPACITY OR LIE FAR FROM WHERE CUSTOMERS NEED POWER. FOR EXAMPLE, CITING PAPERS PRESENTED TO THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, EPRI AND THE U.S. DOE NOTE THAT IN SOME PARTS OF THE U.S. IT CAN COST UP TO 40 CENTS/kWh TO SUPPLY ELECTRICITY ON SUMMER AFTERNOONS, MAKING DISTRIBUTED PV SYSTEMS AN ATTRACTIVE OPTION.^{vii} AND, CHALLENGING ASSUMPTIONS THAT PV SYSTEMS THRIVE ONLY IN ISOLATED, NEAR-DESERT CONDITIONS, THE UNION OF CONCERN SCIENTISTS SUGGESTS THAT DISTRIBUTED PHOTOVOLTAICS COULD SUPPLY A SUBSTANTIAL FRACTION OF THE BOSTON EDISON COMPANY'S POWER NEEDS, DUE IN PART TO THE URBAN UTILITY'S CONGESTED DELIVERY SYSTEM.^{viii} IN SHORT, EVEN AT TODAY'S PRICES, PV CAN PROVIDE VALUABLE SERVICE IN SEVERAL MARKETS.

NEVERTHELESS, THE COST OF ENERGY FROM PHOTOVOLTAICS REMAINS HIGHER THAN MOST ALTERNATIVES. TO CONTINUE THE PROGRESS MADE SO FAR BY SOLAR ENGINEERS AND ENTREPRENEURS, IT WILL BE NECESSARY TO DRIVE UP PRODUCTION AND EXPAND MARKETS STILL MORE THROUGH AGGRESSIVE MARKETING AND COMMERCIALIZATION. SOME ANALYSTS EXPRESS THE PROBLEM AS A “MOUNTAIN OF DEATH,” WHICH CHARACTERIZES THE HIGH COSTS OF PRODUCING FIRST-OF-A-KIND PRODUCTS. OTHERS REFER TO A “VALLEY OF DEATH,” IN WHICH COMPANIES SELLING NEW PRODUCTS SUFFER FROM NEGATIVE CASH FLOW AS THEY READY THEIR WARES FOR A MASS MARKET.^{ix} INCREASING PRODUCTION TO ACHIEVE ECONOMIES OF MASS MANUFACTURE, WHICH IN TURN MAY ENCOURAGE PURCHASERS TO PURSUE ECONOMIES OF LARGE-SCALE DEPLOYMENT, WILL COMPRISE PART OF THE SOLUTION. EQUALLY IMPORTANT WILL BE THE CONSTRUCTION OF A MARKET CHAIN INCLUDING THE PRODUCTION OF RAW MATERIALS, THE MANUFACTURE AND DISTRIBUTION OF PV MODULES, THE MANUFACTURE AND DISTRIBUTION OF OTHER SYSTEM COMPONENTS, THE PROVISION OF CONSUMER FINANCING, AND THE INSTALLATION AND MAINTENANCE OF COMPLETE PV SYSTEMS, IN WHICH EACH LINK HAS A FINANCIAL INCENTIVE IN EXPANDING THE PHOTOVOLTAIC MARKET.

III. THE ENVIRONMENTAL PROMISE

CONVENTIONAL ENERGY SOURCES LEVY SERIOUS AND WELL KNOWN ENVIRONMENTAL COSTS. MORE TO THE POINT, THEY DIRECTLY AND—THROUGH ECOSYSTEM DAMAGE—INDIRECTLY THREATEN HUMAN HEALTH. AS A CLEAN GENERATION TECHNOLOGY, PHOTOVOLTAICS HELP SOLVE ENERGY-RELATED ENVIRONMENTAL PROBLEMS.

- **DIRTY AIR:** THE ENVIRONMENTAL PROTECTION AGENCY (EPA) CLAIMS SUBSTANTIAL REDUCTIONS IN AIR POLLUTION SINCE 1970, A PERIOD IN WHICH GROSS DOMESTIC PRODUCT, POPULATION AND VEHICLE MILES HAVE BURGEONED. STILL, OUR PROGRESS TOWARD CLEAN AIR IS PARTIAL. THE EPA REPORTS THAT 90 MILLION CITIZENS (DOWN FROM 140 MILLION IN 1990) STILL BREATHE UNACCEPTABLY DIRTY AIR. THIRTY-THREE AREAS STILL EXCEED FEDERAL SMOG STANDARDS. AIR-BORNE PARTICULATE MATTER, MUCH OF IT EMITTED BY POWERPLANTS, KILLS AS MANY AS 50,000 AMERICANS PER YEAR.^x THE EPA DOES NOT EVEN REGULATE—YET—ELECTRIC UTILITIES’ EMISSIONS OF SOME AIR-BORNE TOXINS SUCH AS MERCURY, WHICH MANY SEE AS A GROWING PROBLEM.^{xi}
- **ECOSYSTEM DAMAGE:** ALTHOUGH THE CLEAN AIR ACT HAS GREATLY REDUCED SULFUR EMISSIONS FROM POWERPLANTS, THE FLOW OF NITROGEN COMPOUNDS REMAINS GRAVE, CONTRIBUTING ESPECIALLY TO GROUND-LEVEL SMOG FORMATION, INCIDENCE OF ACID RAIN IN THE APPALACHIAN MOUNTAINS AND OTHER AREAS, AND THE DISRUPTION OF MARINE AND ESTUARINE ECOSYSTEMS. MERCURY REPRESENTS AN ADDITIONAL THREAT TO THESE ECOSYSTEMS AND TO THE FOOD CHAIN. IN ADDITION, COAL MINING OFTEN RESULTS IN LAND SUBSIDENCE, DESTROYED LANDSCAPES AND POLLUTED WATER; TECHNIQUES SUCH AS MOUNTAINTOP REMOVAL PRODUCE EQUIVALENT MOUNTAINS OF SLAG AS WELL.
- **CLIMATE CHANGE:** THE PHENOMENON OF GLOBAL CLIMATE CHANGE MUST NOW BE ADDED TO THIS LITANY OF “CONVENTIONAL” EFFECTS. SCIENTISTS LARGELY AGREE THAT, IN THE WORDS OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, “THE BALANCE OF EVIDENCE . . . SUGGESTS A

DISCERNIBLE HUMAN INFLUENCE ON HUMAN CLIMATE” CHIEFLY THROUGH THE BURNING OF FOSSIL FUEL AND DEFORESTATION , ALTHOUGH EVIDENCE IS UNCLEAR ON WHEN, WHERE AND HOW MUCH CHANGE TO EXPECT.^{xii}

INCREASED DEPLOYMENT PHOTOVOLTAIC TECHNOLOGY AS A SUBSTITUTE FOR FOSSIL FUELS WILL HELP ALLEVIATE AND EVEN REVERSE THESE PROBLEMS.

IV. THE POLITICAL MOMENT

SEVERAL POLITICAL FACTORS MAKE THIS AN AP T MOMENT TO PROMOTE RENEWABLE ENERGY. AS DAN REICHER, ASSISTANT SECRETARY FOR ENERGY EFFICIENCY AND RENEWABLE ENERGY AT THE DEPARTMENT OF ENERGY SUGGESTS, THE CONFLUENCE OF CLIMATE POLICY, RESTRUCTURING OF THE ELECTRIC SECTOR AND TIGHTER CLEAN AIR STANDARDS “BODES WELL” FOR RENEWABLES.^{xiii} HOWEVER, THE UNIQUE OPPORTUNITY OFFERED BY THESE EVENTS MAY DISSIPATE IN YEARS OR EVEN MONTHS.

Comment: [R]

- **CLIMATE POLICY:** THE UNITED STATES’ INITIAL NEGOTIATING POSITION AT THE THIRD CONFERENCE OF THE PARTIES TO THE FRAMEWORK CONVENTION ON CLIMATE CHANGE, HELD IN KYOTO, JAPAN IN DECEMBER OF 1997, SUGGESTED THAT DEVELOPED NATIONS CUT GREENHOUSE EMISSIONS TO 1990 LEVELS BY ABOUT 2010. THIS SUBSTANTIAL CUT WOULD STILL HAVE BEEN ANEMIC COMPARED TO POLICIES SUPPORTED BY THE U.S. PRESIDENT AND VICE PRESIDENT AT THE RIO DE JANEIRO EARTH SUMMIT IN 1992—AND WELL BELOW CUTS PROPOSED IN KYOTO BY THE EUROPEAN UNION , JAPAN AND A COALITION OF SMALL ISLAND STATES. IN THE END, PRODDED BY VICE PRESIDENT GORE’S LAST-MINUTE EXHORTATION TO FIND A COMPROMISE, THE U.S. AGREED TO CUT EMISSIONS TO 7% BELOW 1990 LEVELS BY ABOUT 2010.

THE ADMINISTRATION MUST NOW CONVINCe SKEPTICS IN THE SENATE—RESPONSIBLE FOR RATIFYING INTERNATIONAL TREATIES—THAT THE NATION CAN ACHIEVE SUCH CUTS WITHOUT SLOWING ECONOMIC GROWTH. AT THE SAME TIME , THE ADMINISTRATION MUST RE-ESTABLISH ITS ENVIRONMENTAL CREDENTIALS WITH VOTERS AND ADVOCACY GROUPS DSMAYED BY ITS RESISTANCE TO A MORE ACTIVE CLIMATE POLICY. SO FAR, THE ADMINISTRATION HAS TOUTED NEW, CLEAN TECHNOLOGIES AS ABLE TO DELIVER ECONOMIC GROWTH AND CLIMATE PROTECTION SIMULTANEOUSLY. NOTABLE AMONG THESE ENDEAVORS, THE MILLION SOLAR ROOFS INITIATIVE AIMS TO “EXPAND THE DOMESTIC MARKET FOR SOLAR ENERGY IN THE UNITED STATES.” BY COMBINING GRANTS TO “BUY DOWN” PV SYSTEMS, LOW-COST FINANCING FOR ALL SOLAR ENERGY SYSTEMS , AND LARGE GOVERNMENT PURCHASES OF SOLAR TECHNOLOGY, THE PROGRAM HOPES TO PROMOTE THE INSTALLATION OF ONE MILLION SYSTEMS BY 2010.^{xiv} U.S. IS NOT AN ENVIRONMENTAL OGRE—HOWEVER, SUCH SUPPORT COULD CONCEIVABLY DWINDLE SHOULD THE ECONOMY SLOW, OR SHOULD AN “ANTI-ENVIRONMENTAL” CANDIDATE OF EITHER PARTY MAKE A STRONG SHOWING IN THE RUN-UP TO THE 2000 PRESIDENTIAL ELECTION.

- **RESTRUCTURING:** THE AMERICAN ELECTRIC SECTOR IS ABANDONING REGULATED RATES OF RETURN AND CENTRALIZED MONOPOLY STRUCTURE IN FAVOR OF MARKET-BASED PRINCIPLES AND ORGANIZATION . THESE CHANGES SHOULD BRING CHEAPER POWER, AS AGGREGATED AND

INDIVIDUAL CONSUMERS BEGIN TO NEGOTIATE FOR CHEAPER RATES, AND INEFFICIENT PLANTS ARE FORCED OFF LINE. THESE ONE-OFF SAVINGS CAN BE USED TO BRING CLEAN RENEWABLE POWER, WHICH INITIALLY WILL COST MORE THAN CONVENTIONAL ALTERNATIVES, INTO THE ENERGY SYSTEM. FOR EXAMPLE, THE CITY OF PORTLAND HAS RE-NEGOTIATED RATES ON BEHALF OF ITS CITIZENS, AND SPLIT THE SAVINGS BETWEEN LOWER RATES AND INVESTMENT IN A WIND FARM. YET THIS OPPORTUNITY, TOO, WILL BE GONE IN A FEW YEARS. AS PRICES RESUME THEIR INEVITABLE ASCENT, PEOPLE MAY BE LESS OPEN TO INVESTMENT IN RENEWABLES.

- **CLEAN AIR:** THE FEDERAL GOVERNMENT HAS INSTITUTED NEW RULES LIMITING CONCENTRATIONS OF FINE AIRBORNE PARTICULATE MATTER AND GROUND-LEVEL OZONE. THE EPA WILL IMPLEMENT THESE REGULATIONS IN COMING YEARS. OTHER RULES MAY SOON LIMIT EMISSIONS OF MERCURY, NITROGEN OXIDES AND, PERHAPS, CARBON DIOXIDE. ELECTRICITY GENERATORS, RESPONSIBLE FOR LARGE PROPORTIONS OF THESE POLLUTANTS, CURRENTLY PONDER THE LEAST COSTLY WAYS TO COMPLY WITH CLEAN AIR POLICIES, AND TO OFFSET THE RISK OF MORE RIGOROUS STANDARDS IN THE FUTURE. MANY MAY FAVOR END-OF-THE-STACK CONTROLS SUCH AS SCRUBBERS, COSTLY INVESTMENTS WHICH ARE DIFFICULT TO REVERSE. THE CURRENT MIXTURE OF CLEAN AIR POLICY AND BUSINESS DECISIONS THUS OFFERS A UNIQUE MOMENT OF OPPORTUNITY FOR RENEWABLES, PARTICULARLY IF POLICY MAKERS WILL ALLOW POLLUTERS TO USE DEPLOYMENT OF RENEWABLES TO COMPLY WITH THE INCREASINGLY STRINGENT STANDARDS.

TOGETHER, THESE FACTORS MAKE THIS AN IDEAL MOMENT TO PROMOTE THE USE OF RENEWABLES THROUGH MARKET EXPANSION AND APT POLICIES.

SECTION TWO: REPP'S PROGRESS TO DATE

IN THE SCOPING PAPER FOR THIS PROJECT, THE RENEWABLE ENERGY POLICY PROJECT (REPP) PROPOSED TO CONDUCT A SERIES OF INTERVIEWS WITH EXPERTS WITHIN, NEXT TO AND OUTSIDE THE PV FIELD, WITH THE PURPOSE OF GLEANING A "BASKET" OF POLICY, MARKET AND HYBRID MECHANISMS WHICH COULD RAPIDLY EXPAND PV MARKETS. TO DATE, WE HAVE SPOKEN WITH THE FOLLOWING THIRTY-SIX PEOPLE:

1. SAM BALDWIN, DIRECTOR OF INTERNATIONAL PROGRAMS FOR THE NATIONAL RENEWABLE ENERGY LABORATORY
2. LARRY CROWLEY OF IDAHO POWER RESOURCES CORP. AND ITS PARENT, THE IDAHO POWER COMPANY
3. BOB DIMATTEO OF CHARLES STARK DRAPER LABORATORY, AN INDEPENDENT, NON-PROFIT LABORATORY
4. PETER DREYFUS, COORDINATOR OF THE DEPARTMENT OF ENERGY'S "MILLION ROOFS" INITIATIVES
5. MICHAEL ECKHART, SENIOR CONSULTANT TO SHELL SOLAR AND DIRECTOR OF THE SOLAR BANK
6. BILL EDWARDS OF THE NATIONAL RURAL UTILITY COOPERATIVE FINANCE CORP.
7. DAWN ERLANDSON, EXECUTIVE DIRECTOR OF THE CENTER FOR A SUSTAINABLE ECONOMY
8. ANDREW HOERNER, TAX SPECIALIST AT THE CENTER FOR A SUSTAINABLE ECONOMY
9. MARK FARBER OF EVERGREEN SOLAR, A MANUFACTURER OF PV MODULES
10. HARVEY FOREST OF SOLAREX, A MANUFACTURER OF PV MODULES
11. CHRISTOPHER FLAVIN, VICE PRESIDENT AT THE WORLDWATCH INSTITUTE
12. ERIC INGERSOLL OF LUCID, INC.
13. LYNN IVEY, SENIOR INVESTMENT COUNSELOR AT STRINGFELLOW AND SCOTT, A SMALL INVESTMENT HOUSE
14. MICHAEL JANSKA, SENIOR ASSOCIATE AT GE CAPITAL

15. ROBERT KELLY, CHAIRMAN AND CEO OF ENRON RENEWABLE ENERGY CORP.
16. KEN LOCKLIN, MANAGING DIRECTOR OF THE RENEWABLE ENERGY AND EFFICIENCY FUND AT ENERGY INVESTORS FUNDS
17. MICHAEL MARVIN, DIRECTOR OF THE BUSINESS COUNCIL FOR SUSTAINABLE ENERGY
18. PAUL MAYCOCK, EDITOR OF *PV NEWS*
19. DANA MELLECKER AND STEVE HOGAN OF SPIRE CORP., MANUFACTURER OF PV-MANUFACTURING EQUIPMENT
20. ALAN MILLER, CLIMATE SPECIALIST AT THE WORLD BANK'S GLOBAL ENVIRONMENT FACILITY
21. MAC MOORE OF BP SOLAR
22. DON OSBORN, MANAGER OF THE SACRAMENTO MUNICIPAL UTILITY DISTRICT'S SUCCESSFUL PV PROGRAMS
23. MIKE PHILIPS, INTERNATIONAL ENERGY VENTURES, A CONSULTANCY FOR INTERNATIONAL RENEWABLE ENERGY FINANCE
24. JIM RANNELS, MANAGER OF SOLAR PROGRAMS AT THE U.S. DEPARTMENT OF ENERGY
25. VINCENT SCHWENT OF THE CALIFORNIA ENERGY COMMISSION
26. LARRY SHIRLEY, DIRECTOR OF THE NORTH CAROLINA SOLAR CENTER
27. SCOTT SKLAR, EXECUTIVE DIRECTOR OF THE SOLAR ENERGY INDUSTRIES ASSOCIATION
28. THOMAS STARRS, PRINCIPAL OF KELSO STARRS & ASSOC.
29. TOM STRAIT, PARTNER IN WASHINGTON UTILITY GROUP, CONSULTANTS TO PRIVATE AND COOPERATIVE ELECTRIC UTILITIES
30. JOEL STRONBERG, PRINCIPAL OF THE JBS GROUP
31. STEVEN STRONG, PRESIDENT OF SOLAR DESIGN ASSOCIATES, A SOLAR ARCHITECTURAL FIRM
32. GRIFFIN THOMPSON OF THE INTERNATIONAL INSTITUTE OF ENERGY CONSERVATION
33. JIM TROTTER OF SOLAR ELECTRIC SPECIALTIES, AN ASSEMBLER AND DISTRIBUTOR OF PV SYSTEMS
34. CARL WEINBERG, EXECUTIVE DIRECTOR OF THE RENEWABLE ENERGY POLICY PROJECT
35. JANE WEISSMAN, DIRECTOR OF THE INTERSTATE RENEWABLE ENERGY COUNCIL
36. HOWARD WENGER, PRINCIPAL OF PACIFIC ENERGY RESOURCES

REPP'S ADAM SERCHUK AND VIRINDER SINGH PERFORMED THESE INTERVIEWS IN PERSON OR OVER THE TELEPHONE. JOEL STRONBERG, WHO REPP HIRED AS A CONSULTANT FOR THIS PHASE OF THE PROJECT, ASSISTED. FROM THESE INTERVIEWS, WE HAVE IDENTIFIED SEVEN LINKED AREAS THAT MERIT FUTURE RESEARCH. WE DESCRIBE THESE IN SECTION THREE, BELOW.

PART THREE: ACTION RECOMMENDATIONS

OUR FIELD RESEARCH SUGGESTS THAT THE FOLLOWING BASKET OF TOPICS MERITS DEEPER EXAMINATION. IN ALL CASES, WE SUGGEST THAT THE EXAMINATIONS FOCUS ON THREE CHALLENGING QUESTIONS:

- **WHAT** IS THE IDEAL STATE OF AFFAIRS IN EACH AREA DEFINED?
- **WHO**—CURRENTLY OR POTENTIALLY—ARE THE MOST IMPORTANT INDIVIDUALS AND INSTITUTIONS ABLE TO EFFECT CHANGES?
- **HOW** CAN THOSE PEOPLE AND ORGANIZATIONS MOVE PV TOWARD THE IDEAL ENDPOINT?

IN SHORT, THE EXPLORATIONS DESCRIBED SHOULD STATE ***WHO HAS TO DO WHAT*** TO ENSURE THAT THE RECOMMENDED CHANGES OCCUR.

AS THE TOPICS WE IDENTIFY BELOW FREQUENTLY OVERLAP, REPP WILL ENSURE THAT THE AUTHORS

PERIODICALLY SHARE THEIR PERSPECTIVES AND PROGRESS THROUGHOUT THE PROCESS.

A. GOVERNMENT BUY-DOWNS FOR THE RESIDENTIAL MARKET :

AT ABOUT \$6/WP (INCLUDING INSTALLATION), ROOFTOP PV SYSTEMS CONTINUE TO COST MUCH MORE THAN GRID POWER. THE SOLAR INDUSTRY PROBABLY NEEDS TO HALVE THAT PRICE TO ESTABLISH ROOFTOP PV SYSTEMS IN THE RESIDENTIAL MARKET, IMPLYING A DROP IN MODULE PRICE FROM \$3.75/WP TODAY TO BETWEEN \$1.00 AND \$1.50/WP. SOME EXPERTS THEREFORE FAVOR A GOVERNMENT "BUY-DOWN" PROGRAM WHICH WOULD USE PUBLIC FUNDS TO MAKE UP THE DIFFERENCE BETWEEN THE PRICE OF PV SYSTEMS AND THE PRICE OF GRID POWER. FOR EXAMPLE, BOB WILLIAMS OF PRINCETON UNIVERSITY SUGGESTS THAT BUYING DOWN THE PRICE OF PV SYSTEMS TO \$3.00/WP MIGHT REQUIRE SUBSIDIZING 80 MWP WORLDWIDE AT A TOTAL COST OF ONLY \$60 MILLION.^{xv}

THE FEDERAL GOVERNMENT MIGHT STRUCTURE A BUY-DOWN PROGRAM IN VARIOUS WAYS. FOR EXAMPLE, IN LATE MARCH OF 1998 THE CALIFORNIA ENERGY COMMISSION OPENED A FOUR-YEAR PROGRAM THAT WILL SUBSIDIZE EMERGING RENEWABLE ENERGY TECHNOLOGIES (DEFINED AS FUEL CELLS, SMALL WIND TURBINES, SOLAR THERMAL ELECTRIC TECHNOLOGIES AND PV) WITH \$54 MILLION ALLOCATED FROM CHARGES LEVIED ON RATEPAYERS AS PART OF THE STATE'S COMPREHENSIVE ELECTRIC INDUSTRY RESTRUCTURING SETTLEMENT. THE STATE WILL PAY UP TO \$3.00/WP FOR INSTALLED RESIDENTIAL PV SYSTEMS DURING THE PROJECT'S FIRST PHASE, GRADUALLY REDUCING THE SUBSIDY TO \$1.00/WP.^{xvi} THE PROGRAM AIMS TO ENCOURAGE PV FIRMS TO BUILD ADDITIONAL MANUFACTURING PLANTS, THUS INCREASING THEIR ECONOMIES OF SCALE AND OF MASS PRODUCTION, AND LOWERING UNIT COSTS AND PRICES. CONTRARY TO WILLIAMS' OPTIMISTIC SUGGESTION DESCRIBED ABOVE, PROGRAM OFFICIALS DOUBT THAT THE MARKET PROVIDED BY THE CALIFORNIA PROGRAM WILL BY ITSELF ACHIEVE THE TARGET MODULE PRICE OF \$1.50, BUT HOPE THAT THE PROGRAM WILL SEND A POSITIVE SIGNAL TO THE INDUSTRY.^{xvii}

REPP RECOMMENDS AS THE FIRST RESEARCH TOPIC AN EXPLORATION OF THE SUITABILITY OF A NATIONAL PV BUY-DOWN PROGRAM. THE INVESTIGATION SHOULD EMPHASIZE A FRANK DISCUSSION OF THE FOLLOWING ISSUES, ASKING *WHO WOULD HAVE TO DO WHAT* TO MAKE A BUY-DOWN PROGRAM SUCCESSFUL :

- *MARKET SIGNALS*: SOME SOLAR BUSINESS LEADERS AND MANY POTENTIAL LENDERS REMAIN SKEPTICAL OF SUBSIDY-BASED MARKETS, FEARING THAT GOVERNMENTS WILL SUDDENLY WITHDRAW THE SUBSIDY, STRANDING MANUFACTURERS WITH IDLE CAPACITY, OUTSTANDING DEBT AND THE THREAT OF BANKRUPTCY. WHEREAS THE UNIQUE CIRCUMSTANCES OF THE CALIFORNIA RESTRUCTURING SETTLEMENT PROVIDES A KNOWN SUM OF FUNDING OVER FOUR YEARS, ONE OF OUR INTERVIEWEES TOLD US HALF-HUMOROUSLY THAT INVESTORS DISCOUNT APPROPRIATION-BASED FEDERAL COMMITMENTS TO 2%, AND TAX-FUNDED PROGRAMS TO 50%, NO MATTER HOW WELL INTENTIONED OR COMMITTED THE GOVERNMENT MAY BE IN ANNOUNCING THE PROGRAM INITIALLY.^{xviii} HOW, THEN, MIGHT THE FEDERAL GOVERNMENT STRUCTURE A PV BUY-DOWN PROGRAM SO AS TO GIVE MANUFACTURERS AND POTENTIAL INVESTORS THE CONFIDENCE THEY NEED TO EXPAND MANUFACTURING CAPACITY, RATHER THAN SIMPLY MAXIMIZING THE USE OF EXISTING CAPACITY AND RAISING PRICES? CAN POLICY MAKERS ENSURE THAT PRICES WILL INDEED DROP? ABOVE ALL, CAN THEY BE REASONABLY CERTAIN

THAT A BUY-DOWN PROGRAM WILL PROVE BENEFICIAL IN BOTH THE SHORT AND LONG TERMS?

- *PICKING WINNERS:* MANY THINK THAT THE FEDERAL GOVERNMENT HAS A POOR RECORD AT CREATING TECHNOLOGY WINNERS AND DEPLOYING THEM IN THE MARKET. A BUY-DOWN PROGRAM WOULD INDEED CREATE ARTIFICIAL DEMAND, AND IT NEED NOT (INDEED, SHOULD NOT) SPECIFY VARIETIES OF PV TECHNOLOGY. BUT SEVERAL OF OUR INFORMANTS NOTED THAT THE BUY-DOWN CONCEPT STILL RESTS ON POLICY-MAKERS' IDENTIFICATION OF ROOFTOP RESIDENTIAL SYSTEMS AS THE BEST USE OF PV, RATHER THAN THE JUDGMENT OF THE MARKET. IS THIS A VALID CONCERN?
- *FILLING IN THE VALUE CHAIN:* SOME OF THE EXPERTS WE INTERVIEWED SUGGESTED THAT THE PHOTOVOLTAIC INDUSTRY SUFFERS NOT ONLY FROM SMALL SIZE BUT FROM INAPPROPRIATE STRUCTURE. THAT IS, THE INDUSTRY LACKS SUFFICIENT MARKETERS, DISTRIBUTORS AND INSTALLERS, AND MOST MANUFACTURERS CONTINUE TO SELL PHOTOVOLTAIC MODULES AS A COMMODITY RATHER THAN ACTUAL CONSUMER-READY PRODUCTS. WILL A BUY-DOWN PROGRAM ENCOURAGE THE EMERGENCE OF A HEALTHY INDUSTRY STRUCTURE, ABLE TO EVOKE CONSUMER ENTHUSIASM IN THE ABSENCE OF SUBSIDIES?

RECOMMENDED AUTHORS ON BUY-DOWN PROGRAMS: TOM STARRS AND VINCENT SCHWENT

B: POLICIES TO SUPPORT A DISTRIBUTED ENERGY SYSTEM:

SEVERAL ENERGY ANALYSTS FIND THE ENVIRONMENTAL ATTRIBUTES OF PHOTOVOLTAICS ALMOST COINCIDENTAL. FOR THESE OBSERVERS, SOLAR WILL SUCCEED BECAUSE OF ITS AMENABILITY TO SMALL-SCALE, DISTRIBUTED INSTALLATION CLOSE TO WHERE CONSUMERS ACTUALLY NEED ENERGY. THEY ENVISION A SYSTEM INCORPORATING DIVERSE, MASS-PRODUCED, DISTRIBUTED RESOURCES, ALL OF WHICH FUNCTION WELL IN DECENTRALIZED SETTINGS AND ALL OF WHICH ARE FAIRLY CLEAN. THESE MIGHT INCLUDE ENERGY-EFFICIENCY RETROFITS, FUEL CELLS, ENERGY STORAGE MEASURES, COGENERATING GAS-FIRED MICRO-TURBINES AND THE LIKE, ALONGSIDE RENEWABLE ENERGY TECHNOLOGIES SUCH AS PV SYSTEMS. YET, FOR SUCH A SYSTEM TO EMERGE, CERTAIN OTHER ELEMENTS WILL ALSO HAVE TO BE IN PLACE.

WE RECOMMEND THAT A SECOND COMPONENT OF THE "EXPANDING PV MARKETS" PROJECT EXAMINE THE MECHANISMS THAT CAN FACILITATE THE INCORPORATION OF PV INTO THE EMERGING DISTRIBUTED ENERGY SYSTEM. THIS EXAMINATION SHOULD INCLUDE, AT LEAST, DISCUSSION OF THE FOLLOWING MEASURES, WITH A STRESS ON *WHO HAS TO DO WHAT* TO MAKE THE MEASURE A REALITY.

- **NET METERING:** WHERE ELECTRIC COMPANIES CONSENT TO PURCHASE HOMEOWNERS' EXCESS SOLAR-GENERATED ELECTRICITY, THEY PREFER TO DO SO AT (LOW) WHOLESALE, RATHER THAN (HIGHER) RETAIL, RATES. "NET METERING" POLICIES REQUIRE UTILITIES TO BUY BACK HOMEOWNERS' EXCESS POWER AT RETAIL RATES, IN EFFECT SPINNING THE METER BACKWARDS AS THE HOME SYSTEM FEEDS POWER INTO THE GRID. UTILITIES OFTEN OBJECT TO THE PRACTICE, POINTING OUT THAT MOST OF THE PRICE OF ELECTRICITY

REFLECTS THE COST OF TRANSMISSION AND DISTRIBUTION, AND THAT HOMEOWNERS SHOULD BE PAID ONLY FOR GENERATION. TWENTY-ONE STATES CURRENTLY OFFER NET METERING PROVISIONS. HOW CAN POLICY MAKERS MOST SATISFACTORILY AND FAIRLY DESIGN NET METERING PROGRAMS? SHOULD CONGRESS PASS A NATIONAL NET METERING STANDARD?

- **NATIONAL INTERCONNECTION STANDARD:** CURRENTLY, ELECTRIC COMPANIES DESIGN THEIR OWN INDIVIDUAL STANDARDS FOR PHYSICAL INTERCONNECTION WITH THE ELECTRIC GRID. THIS PREVENTS MANUFACTURERS OF SOLAR PROJECTS FROM DESIGNING PRODUCTS WITH NATIONAL APPEAL. SEVERAL GOVERNMENTAL AND NON-GOVERNMENTAL ORGANIZATIONS ARE NOW CONSIDERING A NATION INTERCONNECTION STANDARD. WHO NEEDS TO DO WHAT TO INSTITUTE SUCH A STANDARD? LIKEWISE, UTILITIES, WHICH MAY BE UNAWARE OF THE NEEDS OF SMALL-SCALE DECENTRALIZED GENERATION, OFTEN PLACE UNREASONABLE NON-TECHNICAL DEMANDS ON CUSTOMERS WISHING TO INSTALL THEIR OWN GENERATION, FOR EXAMPLE, EXORBITANT LIABILITY INSURANCE. IN OTHER CASES, LOCAL ZONING AND OTHER CODES HAMPER SOLAR INSTALLATION. HOW MIGHT UTILITIES AND OTHER RELEVANT ENTITIES INSTITUTE A REASONABLE NATIONAL PROTOCOL?
- **DISTRIBUTION RULES:** IN CERTAIN AREAS AND UNDER CERTAIN CONDITIONS, DISTRIBUTION UTILITIES (“DISCOS”) WILL FIND IT IN THEIR INTERESTS TO PROMOTE DISTRIBUTED PV. IN OTHERS THEY WILL NOT. WHAT MARKET RULES FOR THE OPERATION OF DISCOS WOULD BEST FOSTER DISTRIBUTED PV, WHILE NOT UNDULY PENALIZING THE DISCO ITSELF?
- **COVENANTS:** SEVERAL COMMUNITIES AND HOUSING DEVELOPMENTS HAVE ARTICULATED COVENANTS THAT PROHIBIT BUILDING OWNERS FROM MODIFYING THE EXTERNAL PROFILE OF THEIR STRUCTURES. SUCH AGREEMENTS IMPEDE INSTALLATION OF RESIDENTIAL PV SYSTEMS. HOW CAN THE SOLAR INDUSTRY BEST RESPOND TO THIS PROBLEM?

RECOMMENDED AUTHORS ON DISTRIBUTED ENERGY ISSUES: TOM STARRS AND HOWARD WENGER

C: UNSUBSIDIZED MARKETS

MUCH OF THE UNITED STATES’ PV MANUFACTURING CAPACITY SERVES SUBSIDIZED MARKETS (LARGELY IN JAPAN AND GERMANY).^{xix} THE PRESIDENT OF SIEMENS SOLAR RECENTLY DISMISSED TWO-THIRDS OF THE WORLD PV MARKET AS UNNATURAL, IN THAT NO NEED EXISTS FOR WHICH CUSTOMERS ARE WILLING TO PAY, AND HE WARNED AGAINST THE VOLATILITY OF SUBSIDY-DEPENDENT MARKETS.^{xx} SEVERAL PEOPLE WITH WHOM WE SPOKE SUGGESTED THAT THE PV INDUSTRY SHOULD INSTEAD CONCENTRATE ON THOSE MARKETS WHERE THEIR WARES CAN COMPETE TODAY. IN THE UNITED STATES, THESE INCLUDE, FOR EXAMPLE: TELECOMMUNICATIONS AND SIGNALS; SYSTEMS FOR FARMS, BOATS, CAMPERS AND ISOLATED HOME; PARKS AND FORESTS; CATHODIC PROTECTION; ETC. IN ADDITION, PV CAN PROVIDE ECONOMIC RESIDENTIAL POWER TODAY IN AREAS WHERE THE GRID HAS NOT YET REACHED.

SUCH A STRATEGY RAISES IMPORTANT QUESTIONS. WE RECOMMEND AN INVESTIGATION OF *WHO*

WOULD HAVE TO DO **WHAT** TO BUILD UNSUBSIDIZED MARKETS:

- **CURRENT AND POTENTIAL SIZE OF UNSUBSIDIZED MARKETS:** WHERE WILL FUTURE MARKETS THAT DO NOT REQUIRE SUBSIDIES FOR VIABILITY LIKELY EMERGE? ONE CLUE TO THEIR EXISTENCE MIGHT BE A LARGE BODY OF CAPITAL STOCK READY FOR TURNOVER, FOR EXAMPLE AGING, REMOTE IRRIGATION PUMPS. ANOTHER MIGHT BE INDUSTRIES UNDER PRESSURE TO REDUCE ENVIRONMENTAL IMPACT, FOR EXAMPLE NATURAL GAS PIPELINES, SOME OF WHICH NOW CONTEMPLATE INSTALLING ELECTRIC COMPRESSORS FOR ECONOMIC AND ENVIRONMENTAL REASONS.^{xxi} CAN ANALYSTS ARTICULATE GENERAL METRICS FOR IDENTIFYING SUCH OPPORTUNITIES? CAN WE GUESS THEIR SIZE?
- **ADEQUACY OF UNSUBSIDIZED MARKETS:** SOLAR FIRMS EXPLOITING EXISTING MARKETS CAN CERTAINLY OPERATE PROFITABLY. YET THE INTERESTS OF SOLAR FIRMS AND SUPPORTERS OF SOLAR ENERGY MAY NOT BE CONGRUENT. IF GIVEN A CHOICE, MANY SOLAR ENTHUSIASTS WOULD PREFER FIRMS TO SELL HIGH VOLUMES AT LOW MARGINS, RATHER THAN THE REVERSE, FOR ENVIRONMENTAL AND OTHER REASONS. MEANWHILE, SOME FIRMS MIGHT PREFER HIGHER PROFITS BROUGHT BY HIGH DEMAND AND MANUFACTURING PLANTS OPERATED AT HIGH CAPACITY. WILL NICHE MARKETS IN FACT OPEN BROADER MARKETS? AND IF NOT, WILL NICHE MARKETS PROVE ENVIRONMENTALLY SUFFICIENT?
- **INDUSTRY STRUCTURE:** TO EXPLOIT UNSUBSIDIZED MARKETS AGGRESSIVELY, THE PV INDUSTRY MAY REQUIRE A NEW STRUCTURE. A NUMBER OF OUR RESPONDENTS CONTENDED THAT TODAY'S PHOTOVOLTAIC INDUSTRY COMBINED LARGE, ENGINEERING-DRIVEN MANUFACTURING FIRMS THAT PRODUCE PV AS A COMMODITY WITH SMALL, MOM-AND-POP INSTALLERS AND WEAK DISTRIBUTORS. TO SUCCEED, SOME OF THESE CRITICS SUGGESTED, SOLAR FIRMS MUST PRODUCE CONSUMER-READY SOLAR PRODUCTS AND INTEGRATE INSTALLATION, MAINTENANCE AND PERHAPS FINANCING INTO THEIR OPERATIONS. OTHERS FELT THAT FIRMS WOULD NOT VERTICALLY INTEGRATE, BUT THAT DIFFERENT PLAYERS MUST EMERGE TO FILL ALL THE LINKS IN THE VALUE CHAIN. MOST AGREED, HOWEVER, THAT INSTALLATION AND SERVICING MUST GROW MORE SOPHISTICATED, AND THAT MANY SMALL SOLAR FIRMS IN BUSINESS TODAY WERE BARRIERS TO THE EVOLUTION OF THE MARKET. DOES ANY EVIDENCE—E.G., THE EXPERIENCE OF OTHER INDUSTRIES—SUGGEST THAT CERTAIN INDUSTRY FORMS CAN PROMOTE SUCCESSFUL EXPLOITATION OF UNSUBSIDIZED MARKETS? WHAT FORMS COULD THE PV INDUSTRY TAKE TO SUCCEED AS A PRODUCER OF UNSUBSIDIZED CONSUMER PRODUCTS?

RECOMMENDED AUTHOR ON CURRENT UNSUBSIDIZED MARKETS: ERIC INGERSOLL

D: CAPITAL FORMATION

THROUGHOUT THE INTERVIEW PROCESS, OUR RESPONDENTS RAISED AND CAME BACK REPEATEDLY TO THE QUESTION OF CAPITAL FORMATION: HOW CAN SOLAR ENDEAVORS ATTRACT SUFFICIENT FINANCIAL RESOURCES? A RESPONSE TO THIS CHALLENGE MIGHT INCLUDE THE FOLLOWING TOPICS, WITH A STRESS ON **WHO HAS TO DO WHAT** TO ACCELERATE CAPITAL FORMATION IN THE PV INDUSTRY:

- *WHERE IN THE VALUE CHAIN?* DIFFERENT RESPONDENTS REMARKED ON THE FINANCE NEEDS OF DIFFERENT ASPECTS OF THE SOLAR VALUE CHAIN , AND THE INAPPROPRIATE EMPHASIS ON “PROJECT” FINANCE MODELS TO THE EXCLUSION OF OTHER CAPITAL NEEDS. FOR INSTANCE , SOME TALKED ABOUT HOME CONSTRUCTION LOANS FOR BUILDERS WISHING TO INCORPORATE SOLAR INTO THEIR STRUCTURES, OTHERS MENTIONED THE FINANCIAL NEEDS OF SOLAR MANUFACTURERS, OTHERS DISCUSSED BUILDING A SOLAR COMPONENT INTO HOMEOWNER MORTGAGES, AND OTHERS SUGGESTED A FEDERAL “SUNNY MAE” PROGRAM TO AGGREGATE SOLAR MORTGAGES AND THUS REDUCE LENDER RISK. CAN ALL SUCH NEEDS BE ADDRESSED SIMULTANEOUSLY? IF NOT, WHICH NEEDS MERIT HIGHER PRIORITY?
- *LENDERS AND BORROWERS MEETING EACH OTHER’S NEEDS:* SEVERAL RESPONDENTS REPORTED THAT RENEWABLE ENERGY ENTREPRENEURS KNOW VERY LITTLE ABOUT THE DIFFERENT REQUIREMENTS OF DIFFERENT CLASSES OF LENDERS, FOR EXAMPLE INVESTMENT BANKS, BOUTIQUE FINANCIAL HOUSES, VENTURE CAPITALISTS AND CORPORATE FINANCIERS. HOW CAN RENEWABLE ENERGY BUSINESSES LEARN TO STRUCTURE DEALS MORE PALATABLY? EQUALLY IMPORTANT, MANY LENDERS KNOW VERY LITTLE ABOUT SOLAR. HOW CAN APPROPRIATE INFORMATION REACH THEM?
- *PACKAGING:* TO ATTRACT FINANCING TO SOLAR DEALS, IT MAY BE NECESSARY TO PACKAGE THEM SO AS TO REDUCE RISK. THIS COULD BE DONE BY AGGREGATING SOLAR LOANS NATIONALLY, AS IN THE “SUNNY MAE” IDEA MENTIONED ABOVE, SO AS TO REDUCE LENDER RISK. IT MIGHT ENTAIL PACKAGING SOLAR WITH OTHER ENERGY PRODUCTS, FOR EXAMPLE NATURAL GAS BACKUP. IT COULD EVEN ENCOMPASS NON-ENERGY PROJECTS THAT OFFER EITHER TECHNICAL SYNERGIES—E.G., TELECOMMUNICATIONS—OR THAT REQUIRE AN ENVIRONMENTAL COMPONENT—NEW CONSTRUCTION. WHAT IS THE BEST WAY TO PACKAGE SOLAR ENERGY FOR FINANCIERS?

PART D1)

RECOMMENDED AUTHOR ON DOMESTIC CAPITAL FORMATION: ERIC INGERSOLL AND BOB DIMATTEO

PART D2)

RECOMMENDED AUTHOR ON INTERNATIONAL PROJECT FINANCE: BROOKS BROWN

E: RURAL PV IN THE DEVELOPING WORLD

MANY OBSERVERS LOOK TO THE HUGE ENERGY GAP IN THE DEVELOPING WORLD TO SAVE—AND BE SAVED BY—PHOTOVOLTAIC TECHNOLOGY.^{xxii} FOR MANY POOR RURAL PEOPLE, GRID-EXTENSION REMAINS BEYOND HOPE. PV COULD PROVIDE THESE PEOPLE WITH BASIC LIGHT AND RADIO, RELIEVE RELIANCE ON EXPENSIVE AND DIRTY ALTERNATIVES SUCH AS KEROSENE, FACILITATE EDUCATION AND WOMEN'S SELF-EMPLOYMENT—THE LIST GOES ON. AND, IF A LARGE MULTILATERAL DEVELOPMENT FUND SUCH AS THE WORLD BANK WOULD SPEND A FRACTION OF ITS ENERGY BUDGET ON A MASSIVE PURCHASE OF PV, SUCH PEOPLE SUGGEST, THE PV INDUSTRY WOULD BE ABLE TO LOWER PRICES APPRECIABLY TO THE BENEFIT OF ALL.

WE ADVISE A FRANK EXAMINATION OF THE RELATIONSHIP AND POSSIBLE COMPLEMENTARITIES BETWEEN THE GOALS OF RURAL DEVELOPMENT AND THOSE OF EXPANDING PV MARKETS, WITH A FOCUS ON **WHO COULD DO WHAT** TO MAKE RURAL DEVELOPMENT AN EFFECTIVE PART OF THE PV INDUSTRY'S EXPANSION STRATEGY. IN PARTICULAR, THE FOLLOWING ISSUES SHOULD BE ADDRESSED:

- **ABSORPTION RATE:** WHILE MOST OBSERVERS REMAIN OPTIMISTIC ABOUT THE EVENTUAL EMERGENCE OF A RURAL PV MARKET IN THE DEVELOPING WORLD, MOST ALSO ACKNOWLEDGE THE HUGE VARIETY OF LOCAL CONDITIONS^{xxiii} AND THE UNIQUE VEXATIONS^{xxiv} OF CRAFTING A SUCCESSFUL TECHNOLOGY TRANSFER PROGRAM. BOB WILLIAMS, FOR EXAMPLE, SUGGESTS THAT GRID-CONNECTED, UTILITY-SCALE APPLICATIONS REMAIN THE ONLY WAY FOR DEVELOPING COUNTRY MARKETS TO ABSORB LARGE QUANTITIES OF PV QUICKLY.^{xxv} IT SEEMS CERTAIN THAT A WELL DESIGNED INTRODUCTION OF PV CAN MEET MANY DEVELOPMENT GOALS, BUT CAN THAT PROCESS HAPPEN FAST ENOUGH TO CONTRIBUTE TO THE VISIONS OF PV ENTHUSIASTS?
- **BUSINESS STRUCTURE:** MANY OF THE SUCCESSFUL PRIVATE-SECTOR PV VENTURES IN THE DEVELOPING WORLD DISPLAY A DIFFERENT BUSINESS STRUCTURE THAN THEIR COUSINS IN THE DEVELOPED WORLD. SPECIFICALLY, MOST ARE FRANCHISE-BASED, AND MOST LEASE OUT THE PV SYSTEMS THEMSELVES, RATHER THAN METERING AND SELLING THE ELECTRICITY. ARE PV TECHNOLOGY TRANSFER PROGRAMS TAKING SUFFICIENT NOTE OF THE DIFFERENT STRUCTURES APPROPRIATE TO DEVELOPING COUNTRY MARKETS?
- **LOCAL CONTENT:** INCREASINGLY, DEVELOPING COUNTRIES INSIST ON TRUE TECHNOLOGY TRANSFER RATHER THAN MERELY PURCHASING PRODUCTS MADE ELSEWHERE. SOME OF THOSE WE INTERVIEWED DOUBTED THAT PV FIRMS WOULD ACTUALLY BUILD FACTORIES IN-COUNTRY, AND COMMIT TO REMAIN THERE AS LONG-TERM PLAYERS. TO WHAT EXTENT IS SUCH A COMMITMENT A PRECONDITION FOR EXPANDING PV MARKETS IN THE DEVELOPING WORLD, AND TO WHAT EXTENT ARE PV FIRMS WILLING TO MAKE SUCH A COMMITMENT?

- *FINANCE VERSUS TECHNOLOGY:* SEVERAL PEOPLE WITH WHOM WE SPOKE IDENTIFIED THE AVAILABILITY AND COST OF CREDIT AS THE FACTOR CONSTRAINING THE PV MARKET IN THE DEVELOPING WORLD. THESE PEOPLE SUGGESTED THAT LOWERING THE PRICE OF THE TECHNOLOGY ITSELF MADE WOULD HAVE LESS EFFECT ON THE SIZE OF THE MARKET THAN MAKING AVAILABLE LONGER-TERM CREDIT WITH LOWER INTEREST RATES. HOW LARGE A ROLE DOES FINANCE PLAY COMPARED TO TECHNOLOGY, AND WHO MUST DO WHAT TO EXPAND ACCESS TO RURAL FINANCE FOR PV PURCHASES?

RECOMMENDED AUTHOR ON INTERNATIONAL MARKETS: MIKE PHILIPS

F: PUBLIC AND PROFESSIONAL EDUCATION

NEARLY ALL THE PEOPLE WITH WHOM WE SPOKE ACKNOWLEDGED THAT EXPANDING SOLAR MARKETS WILL REQUIRE A MASSIVE EDUCATION EFFORT. MANY DISCUSSED THE SYNERGIES AND DISTINCTIONS BETWEEN PUBLIC EDUCATION AND PRIVATE-SECTOR MARKETING; A FEW SUGGESTED THAT THESE TWO ENDEAVORS WILL SOONMERGE. ALTHOUGH MOST CONSUMERS EXPRESS SUPPORT FOR SOLAR ENERGY IN GENERAL, FEW HAVE THE INFORMATION THEY NEED TO LOCATE, SIZE, PURCHASE AND INSTALL A SOLAR SYSTEM THEMSELVES. EQUALLY IMPORTANT, FEW PROFESSIONALS—BUILDERS, BUILDING INSPECTORS, APPRAISERS, MORTGAGE OFFICERS, CODE WRITERS, ELECTRICIANS, REALTORS AND OTHERS—HAVE THE EXPERTISE NECESSARY TO DEAL WITH SOLAR ENERGY IN THE COURSE OF THEIR BUSINESSES. *WHO COULD DO WHAT* TO EDUCATE THE RELEVANT SEGMENTS OF AMERICA ON SOLAR ENERGY?

- *REACHING THE PUBLIC:* BUILDING SOLAR AWARENESS MIGHT REQUIRE ENVIRONMENTAL EDUCATION IN PUBLIC SCHOOLS FROM AN EARLY AGE. WHAT IS THE LIKELY COST AND BENEFIT OF SUCH A LONG-TERM ENDEAVOR, AND WHAT INSTITUTION(S) HAS A SUFFICIENTLY LONG HORIZON TO UNDERTAKE THEM? ALTERNATIVELY, SOLAR EDUCATION MIGHT BE MORE EFFECTIVELY UNDERTAKEN THROUGH REGIONAL OR EVEN NATIONAL SOLAR AWARENESS CAMPAIGNS, AIMED AT POTENTIAL CUSTOMERS AND TIED TO THE AVAILABILITY OF SOLAR PRODUCTS. EDUCATION MIGHT ALSO INCLUDE WORKSHOPS FOR POTENTIAL CUSTOMERS, PERHAPS TIED TO A “CARROT” OF FINANCING. WHAT COMBINATION OF MEASURES COULD BEST EFFECT SOLAR AWARENESS? EQUALLY IMPORTANT, WHAT COMBINATION OF FEDERAL, STATE, UNIVERSITY AND FOUNDATION FUNDS COULD BE USED FOR THIS PURPOSE?
- *PROFESSIONAL EDUCATION:* PROFESSIONALS IN THE BUILDING, FINANCIAL AND OTHER SECTORS NEED BETTER INFORMATION AND SKILLS IN ORDER TO INTEGRATE PV INTO THEIR ACTIVITIES. STATE AGRICULTURE AND EXTENSION OFFICES COULD ALSO PLAY AN IMPORTANT ROLE IN THIS, AS COULD UNIONS, LICENSING AND CONTINUING EDUCATION REQUIREMENTS, UNIVERSITY CURRICULA, AND PROFESSIONAL SOCIETIES. WHO ARE THE KEY PROFESSIONALS THAT MUST RECEIVE THIS TRAINING? HOW MIGHT IT BE FUNDED?

- *EDUCATION AND MARKETING:* TRADITIONAL PUBLIC INTEREST EDUCATION CAMPAIGNS CAN INTERACT WITH COMMERCIAL MARKETING IN INTERESTING WAYS . WHAT IS THE APPROPRIATE BALANCE OF TASKS BETWEEN THE TWO APPROACHES? HOW CAN MARKETING APPROACHES HELP IDENTIFY APPROPRIATE TARGETS FOR EDUCATION CAMPAIGNS SO THAT PUBLIC EDUCATION FUNDS RESULT IN THE GREATEST POSSIBLE INSTALLATION OF PV TECHNOLOGY?

RECOMMENDED AUTHOR ON PUBLIC AWARENESS: LARRY SHIRLEY

G: GOVERNMENT PROCUREMENT

THE FEDERAL GOVERNMENT REMAINS ONE OF THE LARGEST ENERGY CONSUMERS IN THE NATION ; STATE AND LOCAL GOVERNMENTS USE LARGE AMOUNTS OF ENERGY AS WELL. MUCH OF THIS ENERGY IS CONSUMED IN GOVERNMENT-OWNED BUILDINGS, WHICH RANGE FROM GIANT OFFICE COMPLEXES TO SCATTERED SUPPLY SHEDS. A DISPROPORTIONATE FRACTION OF GOVERNMENTS' ENERGY BILLS REFLECTS THE HIGH COST OF EXTENDING THE ELECTRIC GRID TO REACH ISOLATED RANGER STATIONS, EMERGENCY CALL BOXES ALONG HIGHWAYS, STREETLIGHTS, AND OTHER REMOTE SITES. BY MASS PURCHASES OF BUILDING-INTEGRATED PV SYSTEMS AND STAND-ALONE PV SYSTEMS FOR REMOTE USES, GOVERNMENTS COULD HELP PROVIDE A MARKET FOR THIS EMERGING TECHNOLOGY.

REPP RECOMMENDS A DEEPER LOOK INTO THE USE OF GOVERNMENT PROCUREMENT AS A DRIVER FOR PV MARKETS, INCLUDING A DISCUSSION OF THE FOLLOWING TOPICS, ASKING *WHO HAS TO DO WHAT* TO USE GOVERNMENT PROCUREMENT TO BUILD LONG-TERM PV MARKETS:

- *PAST EXPERIENCE:* GOVERNMENT PROCUREMENT HAS HELPED ESTABLISH MARKETS FOR SEVERAL ENVIRONMENTAL PRODUCTS, FOR EXAMPLE RECYCLED PAPER. HOW COULD GOVERNMENTS BUILD ON SUCH SUCCESS STORIES TO DRIVE PV MARKETS?
- *PROCUREMENT AS A MARKET SIGNAL:* IN ADDITION TO PROVIDING A MARKET FOR PV MANUFACTURERS, GOVERNMENT PROCUREMENT SHOULD ALSO ENCOURAGE MANUFACTURERS TO EXPAND PRODUCTION AND LOWER PRICES. EQUALLY IMPORTANT, IT SHOULD MAKE THE PV INDUSTRY ATTRACTIVE TO THE FINANCIAL COMMUNITY. HOW MIGHT GOVERNMENTS STRUCTURE THEIR PROCUREMENT PROGRAMS SO THAT MANUFACTURERS AND FINANCERS RESPOND IN THE DESIRED MANNER?
- *PROCUREMENT AND MARKET STRUCTURE:* AS NOTED ABOVE , SEVERAL OF OUR RESPONDENTS IDENTIFIED THE CURRENT STRUCTURE OF THE PV INDUSTRY AS A GREAT WEAKNESS. GOVERNMENT PROCUREMENT COULD CONCEIVABLE REINFORCE THAT WEAK STRUCTURE BY FURTHER INSULATING MANUFACTURERS FROM END-USE CONSUMERS, ON WHOM THE FATE OF THE INDUSTRY ULTIMATELY DEPENDS. CAN GOVERNMENTS DEVISE PROCUREMENT PLANS THAT FUNCTION AS A BRIDGE TO A ROBUST , MARKET-DRIVEN INDUSTRY WHICH PRODUCES AND MARKETS PRODUCTS THAT PEOPLE WANT TO BUY, RATHER THAN LOCKING IN A WEAK INDUSTRY STRUCTURE?

APPENDIX ONE: WORK PLAN

JANUARY: FORM ADVISORY COMMITTEE TO GUIDE OUR PROGRESS, REPP HAS CREATED A TECHNICAL ADVISORY COMMITTEE CONSISTING OF:

- MICHAEL JANSÁ, GE CAPITAL
- PAUL JEFFERISS, UNION OF CONCERNED SCIENTISTS
- RENZ JENNINGS, ARIZONA CORPORATION COMMISSION
- ALAN MILLER, GLOBAL ENVIRONMENT FACILITY
- KARL RÁBAGO, PLANERGY
- JOEL STRONBERG, THE JBS GROUP
- CARL WEINBERG, WEINBERG ASSOC.
- JANE WEISSMAN, INTERSTATE RENEWABLE ENERGY COUNCIL

THROUGHOUT THIS PROJECT WE HAVE CONSULTED THESE ADVISORS INDIVIDUALLY AND AS A GROUP, AND WE WILL CONTINUE TO DO SO.

JANUARY TO MARCH: SCOPING THE RENEWABLE ENERGY POLICY PROJECT (REPP) WILL INTERVIEW SEVERAL DOZEN EXPERTS FROM THE PHOTOVOLTAIC AND RELATED FIELDS TO IDENTIFY PUBLIC, PRIVATE AND HYBRID MECHANISMS ABLE TO EXPAND PV MARKETS. RATHER THAN SEEKING TO APPORTION PRAISE OR BLAME FOR PAST EFFORTS TO EXPAND PV MARKETS, REPP WILL FOCUS ON MECHANISMS THAT SEEM ABLE TO SUCCEED AMIDST THE CURRENT AND EMERGING CONFLUENCE OF BUSINESS, POLITICS AND PUBLIC OPINION.

APRIL: IDENTIFICATION OF SEVEN MECHANISMS WITH THE APPROVAL OF ITS INFORMAL ADVISORY COMMITTEE, REPP WILL IDENTIFY MECHANISMS AND ANALYSTS CAPABLE OF EXPLORING EACH ONE. (REPP MAY PROPOSE TO UNDERTAKE SOME OF THESE ANALYSES IN-HOUSE.) REPP WILL DELIVER THIS LIST OF *ACTION RECOMMENDATIONS* TO THE ENERGY FOUNDATION. AFTER REVIEWING REPP'S RECOMMENDATIONS, THE ENERGY FOUNDATION MAY REQUEST THAT REPP PURSUE FURTHER RESEARCH ON ELEMENTS THEY BELIEVE: 1) CAN FUNCTION TOGETHER AS AN INTEGRATED WHOLE, AND; 2) REQUIRE PLAUSIBLE COMMITMENT OF PUBLIC, PRIVATE, NON-PROFIT, ACADEMIC OR CHARITABLE RESOURCES.

MID-APRIL: SECURING AUTHORS UPON RECEIVING THE ENERGY FOUNDATION'S APPROVAL, REPP WILL NEGOTIATE WITH ITS PROPOSED AUTHORS.

MAY TO AUGUST, TRACK A: WRITING REPP WILL SUPERVISE THE COMPLETION OF THE STUDIES. DURING THIS TIME, REPP WILL ENSURE THAT THE AUTHORS OF THE DIFFERENT PIECES INTERACT, SHARE LEADS AND PRODUCE COMPLEMENTARY WORK BY ARRANGING CONFERENCE CALLS AND, IF POSSIBLE, OTHER MEETINGS. WORKING WITH ITS INFORMAL ADVISORS, REPP WILL PRODUCE A BRIEFING BOOK INCLUDING A COHERENT SET OF RECOMMENDATIONS.

MAY TO AUGUST, TRACK B: PREPARATION FOR IMPLEMENTATION AS REPP PURSUES THE RESEARCH DESCRIBED ABOVE, THE ENERGY FOUNDATION WILL CONSIDER HOW BEST TO MAKE USE OF THE ENVISIONED RESEARCH PRODUCT. THROUGHOUT THIS PERIOD, ENERGY FOUNDATION AND REPP WILL ADVISE EACH OTHER REGULARLY OF THE PROGRESS THEY ARE MAKING ON THESE TWO

TASKS.

SEPTEMBER: PROFESSIONAL REVIEW REPP WILL DISTRIBUTE THE BRIEFING BOOK TO AN INTERNALLY DEVELOPED LIST OF EXPERTS FOR REVIEW. THIS LIST MAY RESEMBLE THE ORIGINAL LIST OF INTERVIEW SUBJECTS NOTED ABOVE. REPP STAFF WILL THEN ASSEMBLE THE REVIEW COMMENTS, AND MAKE APPROPRIATE CHANGES TO ITS DOCUMENT.

EARLY OCTOBER: DELIVERY OF RECOMMENDATIONS REPP WILL MEET WITH THE ENERGY FOUNDATION AND PRESENT ITS WORK. AFTER REVIEWING REPP'S FINDINGS, THE ENERGY FOUNDATION WILL FORMULATE AN ACTION PLAN FOR DISSEMINATION AND IMPLEMENTATION.

NOVEMBER: PRESENTATION OF RESULTS REPP AND THE ENERGY FOUNDATION WILL PRESENT THE FINAL RECOMMENDATIONS AT THE FOURTH CONFERENCE OF THE PARTIES TO THE FRAMEWORK CONVENTION ON CLIMATE CHANGE IN BUENOS AIRES, ARGENTINA.

RESPONSIBILITIES: REPP WILL CONTRIBUTE STAFF TIME, OVERHEAD AND PROJECT OVERSIGHT TO THIS INITIATIVE. THE ENERGY FOUNDATION WILL REIMBURSE REPP FOR DOCUMENT PRODUCTION, PRINTING AND MAILING EXPENSES, TRAVEL EXPENSES, THE COST OF HIRING AUTHORS FOR THE MECHANISMS STUDIES AND, IF NECESSARY, FOR THE COST OF HIRING A CONSULTANT TO ASSIST WITH THE INTERVIEWS.

ENDNOTES

ⁱ "Changes to 1997 Market," *PV News* 17 (March 1998), p. 1. Amends earlier *PV News* figures.

ⁱⁱ Electric Power Research Institute and U.S. Department of Energy, "Overview of Photovoltaic Technology," *Renewable Energy Technology Characterizations*, EPRI TR-109496 (Palo Alto, CA: EPRI, 1997), p. 4-2. Progress ratios express the percent of cost remaining after each cumulative doubling in production volume.

ⁱⁱⁱ President's Committee of Advisors on Science and Technology, *Federal Energy Research and Development for the Challenges of the Twenty-First Century* (November 1997), p. 6-15.

^{iv} EPRI and U.S. DOE, "Residential Photovoltaics," p. 4-8. The baseline (i.e., 1997) figures reflect costs reported for the Sacramento Public Utilities District's "PV Pioneer" program, which serves scattered households. The report notes that it would cost substantially less to provide PV service to clusters of houses.

^v U.S. Congress, Office of Technology Assessment, *Renewing Our Energy Future*, OTA-ETI-614 (Washington, DC: U.S. Government Printing Office, 1995), p. 168.

^{vi} "Price for Turnkey Rooftop PV System to Continue to Fall to <\$2.60/Wp: SMUD," *The Solar Letter* 8 (10 April 1998), p. 144.

^{vii} EPRI and U.S. DOE, "Residential Photovoltaics," p. 4-6.

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^{viii} Michael Tennis, Alan Noguee, Paul Jefferiss and Ben Paulos, *Renewing Our Neighborhoods: Opportunities for Distributed Renewable Energy Technologies in the Boston Edison Service Area* (Cambridge, MA: Union of Concerned Scientists, 1995).

^{ix} See, for example, PCAST, *Federal Energy R&D*, figure 7.5 and page 7-14.

^x See, for example, Curtis Moore, *Dying Needlessly: Sickness and Death Due to Energy-Related Air Pollution* (College Park, MD: Renewable Energy Policy Project, 1997). See <http://www.repp.org/>.

^{xi} For background, see Irving Mintzer, Alan Miller and Adam Serchuk, *The Environmental Imperative: A Driving Force in the Development and Deployment of Renewable Energy Technologies* (College Park, MD: Renewable Energy Policy Project, 1996). See <http://www.repp.org/>.

^{xii} IPCC Working Group I, "1995 Summary for Policy Makers," Geneva (1995). See <http://www.unep.ch/ipcc/ipcc-0.html>.

^{xiii} "EERE Office Has Done Well, But Can Do Better; Opportunities Seen: Reicher," *The Solar Letter* 7 (21 November 1997), p. 443.

^{xiv} Solar Energy Industries Association, "Million Solar Roofs Implementation Plan," <http://www/seia.org/milroofs/msr.htm>, accessed 12 December 1997.

^{xv} Robert Williams, "Proposed Grand Bargain for Commercializing Renewable Electric Technologies in China," Center for Energy and Environmental Studies, Princeton University, unpublished manuscript (27 February 1998).

^{xvi} California Energy Commission, "Emerging Renewables Buydown Program Overview," <http://www.energy.ca.gov/greengrid/index.html>, accessed 20 March 1998. The Emerging Renewable Resources Account will fund purchase of grid-connected fuel cells, small wind turbines and photovoltaic systems through 31 March 2001.

^{xvii} Telephone interview by Adam Serchuk of Vince Schwent, California Energy Commission (13 March 1998).

^{xviii} Interview by Adam Serchuk and Virinder Singh of Ken Locklin, Energy Investors Fund (5 February 1998).

^{xix} See, e.g., Molly O'Meara, "Solar Cell Shipments Keep Rising" in Lester Brown et al. (eds.), *Vital Signs 1997* (New York: W.W. Norton & Co., 1997), p. 54; and Paul Maycock, "Boomer's Corner," *PV News* 17 (February 1998), p. 1. Maycock admonishes that "while the subsidized market is valuable for the PV industry, [I am] concerned that the new capacity must have lower manufacturing costs so that when the subsidies decrease, manufactured output is fully economic for grid-connected applications."

^{xx} "Siemens Warns of Premature Celebration," *The Solar Letter* (21 November 1997), p. 446.

^{xxi} Taylor Moore, "Powering the Pipeline," *The EPRI Journal* 22 (July/August 1997), pp. 26-32.

^{xxii} See, generally, *Rural Energy Development: Improving Energy Supplies for Two Billion People* (Washington, DC: The World Bank, 1996).

^{xxiii} Anil Cabraal, Mac Cosgrove-Davies and Loretta Schaeffer, "Best Practices for Photovoltaic Household Electrification Programs: Lessons from Experience on Selected Countries," World Bank Technical Paper #324.

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^{xxiv} Richard Acker and Daniel Kammen, “The Quiet (Energy) Revolution: Analyzing the Dissemination of Photovoltaic Power Systems in Kenya,” Princeton University Center for Energy and Environmental Studies, Report No. 287 (December 1944).

^{xxv} Williams, “Proposed Grand Bargain,” p. 8. Williams notes that “rural stand-alone markets are relatively modest in size and difficult to access and thus are not especially favorable theaters for establishing large installed generating capacities quickly, as is illustrated by the example of PV technology for rural applications.”