School of Engineering and Computer Science

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Date: **June 7, 2010**

Subject: **Concept paper submitted for the US Department of Energy Photovoltaic (PV) Manufacturing Initiative Funding Opportunity: DE-FOA-0000237**

Topic Area: **University-Focused PV Manufacturing Initiative**

Title: **Michigan University PV Manufacturing Collaboration**

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Executive Summary

The Oakland University (OU) School of Engineering and Computer Science has assembled a collaboration of Michigan Universities and for-profit companies which are engaged in the manufacture of PV materials, cells, or panels, or are in the process of developing, demonstrating, and commercializing innovative PV manufacturing technologies.

The OU Clean Energy Research Center (CERC) would like to propose the following collaborative effort to support and enhance the great amount of PV manufacturing and innovation already underway in the State of Michigan.

The confluence of several events has created a unique opportunity to make this collaboration a timely and valuable asset to Michigan's technological redevelopment:

- Michigan's economy and manufacturing base is in a period of transition
- The manufacturing capacity of Michigan is second to none across the globe,
    - with our access to engineering and technical talent,
    - skilled workforce,
    - existing manufacturing facility base,
    - and an existing and robust supply chain infrastructure
- Numerous PV manufacturing ventures and PV supply chain suppliers already exist in Michigan or are planned for construction
- The market for and focus upon clean energy solutions in the United States continues to grow

Please review the following pages which broadly describe the structure of this proposed University-Focused PV manufacturing R&D collaboration. The basic concept is to create a structure wherein industry-expressed needs for solutions in the PV manufacturing sector will be funded as University R&D projects under a ten year plan.

This proposal will apply for a $2.5M annual grant from the Department of Energy for five years to fund a new Michigan university led PV manufacturing collaboration. The collaboration will consist of multiple universities, industry partners, and a panel of experts brought together to select and oversee multiple R&D projects aimed at solving technical challenges identified by the consortium's industry partners.

At its core, the collaboration will consist of a panel of industry and academic experts in the PV field. This panel will: 1) review R&D needs identified by industry partners, 2) select those of highest technical merit and industry-wide impact, 3) and then fund university projects aimed at addressing these R&D needs. Basic research will not be funded. Only R&D projects which directly support new manufacturing ventures, increased production capacity, or the resolution of technical challenges in existing PV manufacturing processes will be supported.

A ten year business model will is presented which will fund multiple R&D projects of a diverse technical nature. Approximately $380,000 per year will be used to create and administer the collaboration with staff, facility space, and operational expenses. This overhead equates to 20% of the total project funding and cost match. The remainder will fund R&D projects under partnering agreements. Successful projects that result in profitable PV operations will be asked to repay a portion of their R&D grant support over a multiple year time period. Additional State of Michigan tax credits and grants will be pursued to supplement and leverage the initial federal

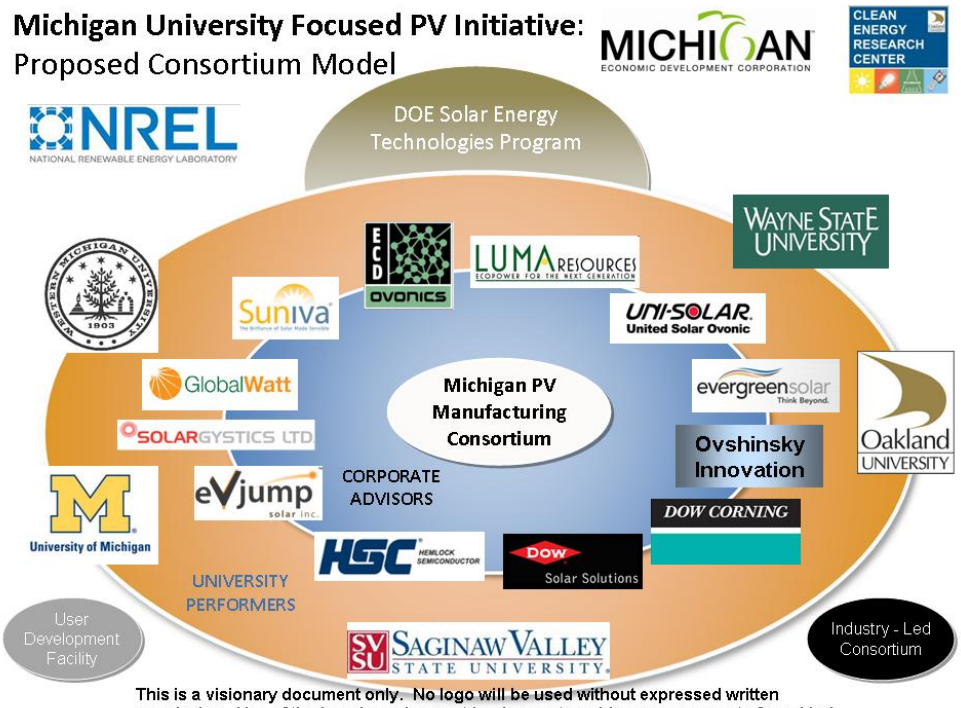
DOE funds in order to make this program self sustaining. A 20% cost share is required by the DOE, therefore both industry and university partners will be asked to limit overhead and/or offer some funding of "in-kind services" or other soft costs to help provide this DOE cost share. A tiered cost share system will be implemented for universities, innovative startups, small companies, and large companies.

Core Objectives

- Commercialization of new manufacturing techniques,
- Solving technical challenges of existing manufacturers to increase output or lower costs,
- Increase United States Market share of worldwide PV cell and module production,
- Increase gross MW output of US PV cell and module production,
- Address multiple technologies and manufacturing challenges,
- Will not focus all resources on one technical option, but on many,
- Commercialization of new and cutting edge technologies,

Research and development needs will be solicited from an advisory board composed of for-profit entities. These R&D needs are expected to include critical barriers to improved efficiency, reduced manufacturing costs, increased cell life, increased manufacturing uniformity and quality, and increased production throughput. These needs will be the focus of collaboration funded projects in the form of University R&D projects.

Proposed Collaboration Structure



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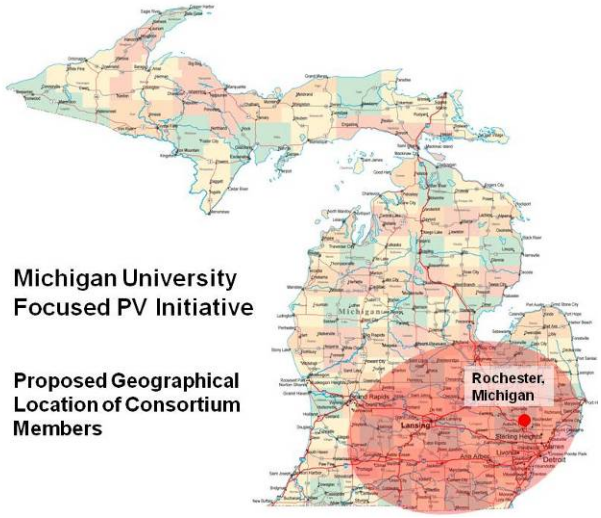
The collaboration will consist of southeast Michigan universities and industry partners as shown below. Most of the parties in the figure to the right have expressed an interest or have committed to joining the collaboration. The industry group consists of a number of market leaders in silicon production, thin film PV manufacturing, building integrated PV modules, and multiple technology innovators working on the next generation of lower cost, high reliability PV.

This collaboration will help support the work being done a Western Michigan University's Center for the Advancement of Printed Electronics. This Center is making a push into PV R&D with their proposal for a printed electronics Manufacturing Development Facility. The Michigan PV

collaboration can fund printed PV projects at just such a facility as well as work closely with any other industry led PV collaborations.

This is a visionary document only indicating a *proposed* set of team members and collaborative structure. No logo or formal endorsement will be used without expressed written permission. Use of the logo here does not imply a formal agreement or partnership at this stage of the proposal process. However, as of June 7, 2010, the majority of the parties shown above have expressed an interested in taking part in the collaboration.



Collaboration Members as of June 3, 2010

Affiliation	Name	Expertise/Focus	Interest Level
Dow Corning	Dr. Bonnie Ludwig	Silicon photovoltaics and related technologies	Interested Party
eVjump Solar	Michael Medvec	Process scale-up and commercialization support	Committed
LUMA Resources	Dr Richard Blieden	Scale up of BIPV roofing shingle manufacturing	Committed
MEDC, Centers of Energy Excellence	Deanna Richeson	Director of COEE grant program which brings businesses, universities and the state together to create jobs in the alternative and advanced energy industry.	Committed
Oakland University	Dr Louay Chamra	Dean of the School of Engineering and Computer Science	Committed
Oakland University	Dr T.C. Yih	Vice President of Grants, Contracts, and Research	Committed
Ovshinski Innovation LLC	David Strand	Next generatation commercialization of thin film PV technology	Interested Party
Saginaw Valley State Univ.	Christopher Schilling	Professor of Mechanical Engieering with a focus on Energy Engineering and Sciences	Committed
Solargystics Ltd.	Dr. Lin Higley	Refinement and scale-up of atmospheric plasma deposition process for PV	Committed
United Solar Ovonic	Dr. Subhendu Guha	Roll-to-roll processing enhancements for higher efficiency thin film PV	Interested Party
University of Michigan	Dr. Pravansu Mohanty	Additive Manufacturing, Thermal Spraying, Laser Materials Processing, Biomaterials, Nanostructured Materials, Functionally Designed Materials	Committed
University of Michigan	Dr. Max Shtein	Fundamental and applied challenges in physics and processing of organic and hybrid semiconductor materials and devices	Interested Party
University of Michigan	Dr. L. Jay Guo	Nanofabrication technology and applications, polymer photonic devices and microresonator biosensors, nanoelectronics, nano-biotechnology, surface plasmon-polariton based photonic	Committed
University of Michigan	Dr. Jamie Phillips	Optoelectronics; Materials for Solid State Electronic and Optoelectronic Devices; Solid-State Energy Conversion Technologies	Interested Party
Wayne State University	Dr. Hilary H. Ratner	Vice President of Research	Interested Party
Wayne State University	Dr James Woodyard	Working with eVjump Solar for the past year on fabrication of CIGS prototypes	Interested Party
Western Michigan University	Dr Margaret Joyce	Director of the Center for the Advancement of Printed Electronics (CAPE)	Interested Party

Additional contacts have been made with several other companies in the Michigan PV manufacturing industry: Suniva, Gobal Watt, Hemlock Semiconductor, and Evergreen Solar. It

is hoped that all of these companies will also find value in joining the collaboration prior to the submission of the full proposal this September.

Strategic Technical Objectives

At this early stage, this collaboration will specifically refrain from committing to any one particular PV technology. This collaboration will focus on the needs of the rapidly growing Michigan PV manufacturing industry, deficiencies in the module and sub-module manufacturing processes, challenges in the supply chain, and support for emerging technologies. One of the first steps of the collaboration will be to create a Michigan PV Manufacturing Roadmap.

At a minimum the roadmap will:

- Assess the current PV market and state of manufacturing capabilities.
- Assess roadblocks and technical challenges, both industry wide and technology specific.
- Identify tasks to provide incremental, evolutionary change based on proven, existing technologies and companies
- Identify potential investments in higher risk R&D to support innovation
- Determine common goals and a "destination", even if this is a mutually agreed upon "moving target".
- Provide a shared vision of how to get "there"

The collaboration will focus on technical barriers to areas that have the highest probability to have the highest impact on PV module cost, efficiency, reliability, as well as overall US photovoltaic manufacturing capacity.

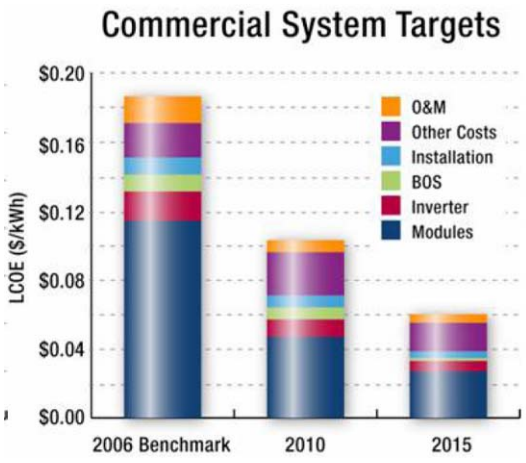
The chart shown here from the DOE Solar Energy Technologies Program illustrates these areas of focus.

TIOS		METRICS			
TIER 1 TIOs	TIER 2 TIOs	Performance Efficiency	Cost	O&M	Reliability
Modules	Module				
	Absorber				
	Cells and Contacts				
	Interconnections				
	Packaging				
	Manufacturing				
Inverter & BOS	Inverter				
	Inverter Software				
	Inverter Components/Design				
	Inverter Packaging/Manufacturing				
	Inverter Integration				
	Other BOS				
Systems Engineering & Integration	System Engineering & Integration				
	System Manufacturing/Assembly				
	Installation & Maintenance				

Note: Red Box = High Impact, Yellow Box = Moderate Impact and Grey Box = Little or No Impact

Michigan is perhaps the most advanced area in the United States involved in thin film PV manufacturing and Building Integrated PV (BIPV) systems. These areas will continue to be a central focus of project support and R&D.

The cost makeup of a typical PV installation is shown here. The PV module will continue to be the most significant cost element, requiring the largest investment in R&D funding. However, system



integration costs and issues are not insignificant in both cost and reliability. Multiple companies in this proposed collaboration are focusing on BIPV to solve some of these challenges.
Below are a few specific technical interests listed by some of the committed collaboration team members:

- Molded conductive polymer substrates for PV cell for direct deposition of absorber layer.
- Conductive transparent conductive film and encapsulation of cell.
- ZnMgO buffer layer and ability to avoid intrinsic-ZnO layer in CIGS stack.
- Alternative metal for traditional Mo back conductive contact layer.
- Method to make quick connect ohmic contacts on PV cell.
- Superstrate thin film PV cell on PC that is formed to a shape after solar layer deposition.
- Tandem PC Superstrate CIGS cell with 2nd absorber in series for enhanced efficiency.
- Rapid thermal process of deposited CIGS in seconds to 550 degrees C.
- Green CIGS solar cell with very low cost materials.
- Work on methods to increase efficiency of CIGS solar cell by texturing and or film layers.
- Process and Method to gain extremely low sheet resistance in back contact layer, i.e. Mo or alternative metal.
- Atmospheric deposition of improved efficiency a-Si, CdTe, and CIGS thin film PV
- New materials for increased spectral absorbsion in thin film a-Si PV

Items to be Resolved Prior to Full Proposal in August 2010

- Intellectual property issues
- Proprietary information issues
- Detailed structure of the collaboration and formal commitments of proposed team members
- Contractual structure for partial repayment of grant funds by successful projects
- Seek formal commitment from the Michigan Economic Development Corporation for a $5M contribution to the collaboration

Business Model

A five year grant from the DOE at $2.5M per year will create the collaboration and fund the start of the program. Oakland University's Clean Energy Research Center will administer the program for an estimated cost of $380,000 per year, with a 4% annual escalation. In order to create a successful funding model to maximize the delivered R&D projects as well as continue the program for a full ten program, several other funding sources are proposed.

Proposed Funding Mechanisms:

1. Department of Energy: $2.5M per year for five years
2. University partner cost match (10%)
3. Industry partner cost match (Large manufacturing company, 40%)
4. Industry partner cost match (Small manufacturing company, 20%)
5. Industry partner cost match (Early R&D/startup, 10%)
6. Collaboration member dues
7. Repayment of 50% of grant funds by commercially successful projects
8. A potential $5M in Michigan Economic Development Corporation funding (Subject to future funding by the State of Michigan and approvals by the COEE program)

To sustain the collaboration in years six through ten, R&D projects that have lead to successful commercialization ventures will be asked to repay the collaboration 50% of their initial R&D

project grant over a multi-year period. Details of this mechanism will be fully developed under the full proposal. An estimated 5% return of grant funds to the program is budgeted for years five through 10 in the following models.

Additional matching funds will be requested from the State of Michigan and/or the Michigan Economic Development Corporation (MEDC) under their existing Centers of Energy Excellence (COEE) program. Round 1 of the COEE program provided a 50/50 cost match for federally funded manufacturing R&D projects for clean energy technologies at a level of $45M. Round two is presently underway with an additional $30M. The COEE program only matches federal funds for product development ventures that will produce a manufactured product in three years. MEDC has a photovoltaic specialty.

On the following page, two preliminary budgets are shown. Budget 1 contains funding sources 1 – 7 to provide a total of $18.2M for project funding (63% grant funds and 37% partner cost match). Budget 2 contains funding sources 1 – 8 to provide a total of $29.2M for project funding (63% grant funds and 37% partner cost match). Both budgets also include $4.6M for overhead and administration over the 10 year program.

Information on the MEDC Centers of Energy Excellence Program – Solar Focus

Michigan Senate Bill 1380 / Public Act 175 established a Centers of Energy Excellence (COEE) Program to promote the development, acceleration and sustainability of energy excellence sectors in this state. In 2008, the Michigan Strategic Fund Board awarded $43M to six projects in the first phase of the program. The 2009 Michigan Public Act 144 allowed a second phase of the COEE program. Key provisions of the COEE Phase II program include an additional $30M.

Technology and resources converge in Michigan. As the automotive R&D capital of the world, Michigan has also given rise to a full complement of independent solar energy research, development and manufacturing entities focused on new solar power technologies, some of which are derived from the automotive industry. Michigan is a global leader in Manufacturing System Integration, including Supply Chain Integration and Simulation-Based Manufacturing. Within the broad spectrum of engineering capacities found in Michigan are heat transfer, power and control electronics, CAD/CAM and logistics. These abilities have stimulated the dynamic growth of Michigan's solar energy sector. Michigan's solar technology leaders have captured the attention of solar power industry watchers everywhere.

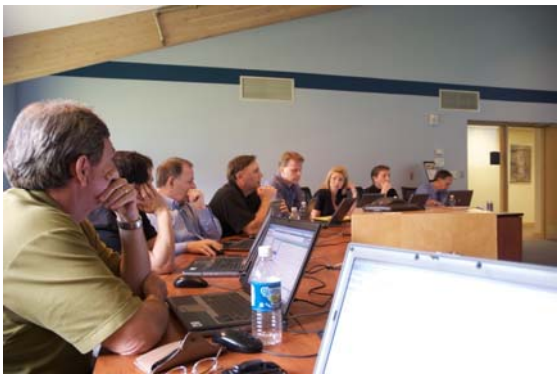
Michigan companies are taking the solar technology manufacturing lead. With Michigan's advanced manufacturing infrastructure, high-tech workforce and robust scientific community, we are a world leader in developing solar technologies to meet the needs of the exploding solar energy market. Drawn by this scientific boom and a highly educated community that includes over 65,000 engineers, global solar energy powerhouses have made their headquarters here. Below are a few examples of projects presently underway.

- **United Solar Ovonic** (Nasdaq: ENER) is the world leader in thin-film solar technology and the manufacturer of thin-film PV modules and laminates distributed globally under the Uni-Solar brand. The company has a Michigan-based manufacturing capacity of 178MW, with plans to expand to up to 720MW by FY2011.
- **Hemlock Semiconductor Corporation** is the world's leading producer of hyper-pure polycrystalline silicon for the semiconductor and solar power industries. Based in Saginaw

County, this subsidiary of Dow Corning has begun production at its new polysilicon facility that will nearly double its output of polycrystalline silicon (polysilicon). The new facility is part of a $1.5 billion expansion at its Hemlock site, bringing the company's annual capacity to approximately 19,000 metric tons by the end of 2008, making it the largest single polysilicon facility in the world.

- **Clairvoyant Energy Solar Panel Manufacturing Inc.** plans to invest $856 million (over four phases) at the former Ford Wixom Assembly Plant to manufacture solar panels. The project is expected to create over 750 direct jobs over the next five years in addition to nearly 4,600 indirect jobs.
- **Evergreen Solar** (Nasdaq: ESLR) has developed state-of-the-art manufacturing featuring their unique String Ribbon™ wafer technology. Today its solar panels are among the highest quality products in the industry. Because of the unique way they are made, they are also among the most environmentally friendly solar panels in the business. Marlborough, Massachusetts based Evergreen Solar is building a $55.2M plant in the Midland, Michigan Eastwick Industrial Park to create string for the company's proprietary, low-cost Sting Ribbon wafer technology.
- **Dow Solar Solutions** is a business unit of the Dow Chemical Company (NYSE:DOW) currently focused on developing BIPV solar arrays for residential and commercial markets. Leveraging a $20M DOE grant in 2007, the Dow Solar Solutions Application Center in Freeland, Michigan developed and recently launched the POWERHOUSE™ Solar Shingle, a revolutionary thin film CIGS photovoltaic that can be integrated into rooftops with standard asphalt shingle materials. The company will invest approximately $50 million in a production facility for this award-winning product, including a 7,500-square-foot addition and the installation of new machinery and equipment in Midland, Michigan.
- **Dow Corning Solar** is a business unit of the Dow Corning Corporation, a joint venture equally owned by The Dow Chemical Company and Corning, Inc. Located in Midland, Michigan, Dow Corning has been a global leader in silicones, silicon-based technology and innovation for more than 60 years, and is constantly improving its array of adhesives and encapsulants for the PV industry.

The Oakland University Collaboratory



The consortium will be virtually based at the Oakland University Collaboratory at the OU Business INCubator. This multimedia, virtual meeting space is an electronic decision support system environment that empowers group work teams to simultaneously brainstorm information and ideas in order to foster collaboration, categorization, prioritization and consensus building. Session participants will sit at computer stations set up in two large, half-circle conference tables or connect remotely via teleconference/webinar. A facilitator will guide the group through a list of activities, often including brainstorming and evaluation tools, which will allow participants to enter comments and votes directly into the system from their computer station. Collaboratory sessions are meant to encourage honesty and efficiency. All sessions have the option of running in "anonymous mode," meaning all feedback that is entered into the session (comments, votes, etc.) is completely anonymous, or "name tag mode," where all comments are tagged with the commenter's name. Oral discussion complements participation via computer station.

Proposed PV Manufacturing Initiative BUDGET 1 (dollars in millions)

			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	TOTALS
1	**Expenses and Subcontract R&D Funding from Collaboration**		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
2	Michigan PV Collaboration Administration		$0.38	$0.40	$0.41	$0.43	$0.44	$0.46	$0.48	$0.50	$0.52	$0.54	**$4.56**
3	Subcontract funding for large company manufacturing R&D projects		$1.00	$1.00	$1.00	$1.00	$1.00	$0.40	$0.40	$0.40	$0.40	$0.40	**$7.00**
4	Subcontract funding for small company manufacturing R&D projects		$0.50	$0.50	$0.50	$0.50	$0.50	$0.00	$0.00	$0.00	$0.00	$0.00	**$2.50**
5	Subcontract funding for technology R&D projects		$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.10	**$1.90**
6	**TOTAL EXPENDITURES**		**$2.08**	**$2.10**	**$2.11**	**$2.13**	**$2.14**	**$1.06**	**$1.08**	**$1.10**	**$1.12**	**$1.04**	**$15.96**
7													
8	**Funding Sources**												
9	Estimated Grant Fund Percentage Repayed to Collaboration		0%	0%	0%	0%	5%	5%	5%	5%	5%	5%	
10	Estimated Grant Funds Repayed (line 9 x sum of all previous years line 6)		$0.00	$0.00	$0.00	$0.00	$0.43	$0.46	$0.49	$0.52	$0.55	$0.57	**$3.00**
11	Previous Year End Balance		$0.00	$0.47	$0.92	$1.36	$1.79	$2.62	$2.06	$1.51	$0.98	$0.45	**$12.17**
12	DOE PV Manufacturing Initiative Funding		$2.50	$2.50	$2.50	$2.50	$2.50	$0.00	$0.00	$0.00	$0.00	$0.00	**$12.50**
13	Michigan Economic Development Corporation COEE		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.00**
14	Collaboration Member Dues		$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	**$0.50**
15	**TOTAL ANNUAL BUDGETS**		**$2.55**	**$3.02**	**$3.47**	**$3.91**	**$4.76**	**$3.12**	**$2.59**	**$2.08**	**$1.57**	**$1.07**	
16													
17	**Cost Match**												
18	University Partner Cost Match (% of lines 3+4+5)	10%	$0.19	$0.19	$0.19	$0.19	$0.19	$0.07	$0.07	$0.07	$0.07	$0.06	**$1.27**
19	Industry Partner Cost Match (% of line 3, large company)	40%	$0.67	$0.67	$0.67	$0.67	$0.67	$0.27	$0.27	$0.27	$0.27	$0.27	**$4.67**
20	Industry Partner Cost Match (% of line 4, small company)	20%	$0.13	$0.13	$0.13	$0.13	$0.13	$0.00	$0.00	$0.00	$0.00	$0.00	**$0.63**
21	Industry Partner Cost Match (% of line 5, technology R&D)	10%	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	$0.01	**$0.21**
22	**TOTAL COST MATCH**		**$1.00**	**$1.00**	**$1.00**	**$1.00**	**$1.00**	**$0.36**	**$0.36**	**$0.36**	**$0.36**	**$0.33**	**$6.77**
23													
24	**Total R&D Project Funding**												
25	Collaboration Subcontract Grants Issued (lines 3+4+5)		$1.70	$1.70	$1.70	$1.70	$1.70	$0.60	$0.60	$0.60	$0.60	$0.50	**$11.40**
26	Collaboration Subcontract Grants plus Cost Match (lines 22+25)		$2.70	$2.70	$2.70	$2.70	$2.70	$0.96	$0.96	$0.96	$0.96	$0.83	**$18.17**
27													
28	**YEAR END BALANCE (lines 15 - 6)**		**$0.47**	**$0.92**	**$1.36**	**$1.79**	**$2.62**	**$2.06**	**$1.51**	**$0.98**	**$0.45**	**$0.03**	

Proposed PV Manufacturing Initiative BUDGET 2 (dollars in millions)

This Budget Model includes an Additional $5M in Michigan Economic Develop Corporation Funds

			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	TOTALS
1	**Expenses and Subcontract R&D Funding from Collaboration**		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
2	Michigan PV Collaboration Administration		$0.38	$0.40	$0.41	$0.43	$0.44	$0.46	$0.48	$0.50	$0.52	$0.54	**$4.56**
3	Subcontract funding for large company manufacturing R&D projects		$1.50	$1.50	$1.50	$1.50	$1.50	$1.00	$0.75	$0.50	$0.50	$0.50	**$10.75**
4	Subcontract funding for small company manufacturing R&D projects		$1.00	$1.00	$1.00	$1.00	$1.00	$0.00	$0.00	$0.00	$0.00	$0.00	**$5.00**
5	Subcontract funding for technology R&D projects		$0.40	$0.40	$0.40	$0.40	$0.40	$0.15	$0.15	$0.15	$0.15	$0.10	**$2.70**
6	**TOTAL EXPENDITURES**		**$3.28**	**$3.30**	**$3.31**	**$3.33**	**$3.34**	**$1.61**	**$1.38**	**$1.15**	**$1.17**	**$1.14**	**$23.01**
7													
8	**Funding Sources**												
9	Estimated Grant Fund Percentage Repayed to Collaboration		0%	0%	0%	0%	5%	5%	5%	5%	5%	5%	
10	Estimated Grant Funds Repayed (line 9 x sum of all previous years line 6)		$0.00	$0.00	$0.00	$0.00	$0.73	$0.78	$0.83	$0.86	$0.89	$0.92	**$5.01**
11	Previous Year End Balance		$0.00	$0.27	$0.52	$0.76	$0.99	$1.92	$1.14	$0.63	$0.39	$0.17	**$6.79**
12	DOE PV Manufacturing Initiative Funding		$2.50	$2.50	$2.50	$2.50	$2.50	$0.00	$0.00	$0.00	$0.00	$0.00	**$12.50**
13	Michigan Economic Development Corporation COEE		$1.00	$1.00	$1.00	$1.00	$1.00	$0.00	$0.00	$0.00	$0.00	$0.00	**$5.00**
14	Collaboration Member Dues		$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	$0.05	**$0.50**
15	**TOTAL ANNUAL BUDGETS**		**$3.55**	**$3.82**	**$4.07**	**$4.31**	**$5.26**	**$2.75**	**$2.01**	**$1.54**	**$1.34**	**$1.14**	
16													
17	**Cost Match**												
18	University Partner Cost Match (% of lines 3+4+5)	10%	$0.32	$0.32	$0.32	$0.32	$0.32	$0.13	$0.10	$0.07	$0.07	$0.07	**$2.05**
19	Industry Partner Cost Match (% of line 3, large company)	40%	$1.00	$1.00	$1.00	$1.00	$1.00	$0.67	$0.50	$0.33	$0.33	$0.33	**$7.17**
20	Industry Partner Cost Match (% of line 4, small company)	20%	$0.25	$0.25	$0.25	$0.25	$0.25	$0.00	$0.00	$0.00	$0.00	$0.00	**$1.25**
21	Industry Partner Cost Match (% of line 5, technology R&D)	10%	$0.04	$0.04	$0.04	$0.04	$0.04	$0.02	$0.02	$0.02	$0.02	$0.01	**$0.30**
22	**TOTAL COST MATCH**		**$1.62**	**$1.62**	**$1.62**	**$1.62**	**$1.62**	**$0.81**	**$0.62**	**$0.42**	**$0.42**	**$0.41**	**$10.77**
23													
24	**Total R&D Project Funding**												
25	Collaboration Subcontract Grants Issued (lines 3+4+5)		$2.90	$2.90	$2.90	$2.90	$2.90	$1.15	$0.90	$0.65	$0.65	$0.60	**$18.45**
26	Collaboration Subcontract Grants plus Cost Match (lines 22+25)		$4.52	$4.52	$4.52	$4.52	$4.52	$1.96	$1.52	$1.07	$1.07	$1.01	**$29.22**
27													
28	**YEAR END BALANCE (lines 15 - 6)**		**$0.27**	**$0.52**	**$0.76**	**$0.99**	**$1.92**	**$1.14**	**$0.63**	**$0.39**	**$0.17**	**$0.00**	

Recommendations taken from "Lessons Learned from the PV Manufacturing Technology and PV Manuf. R&D and Thin-Film PV Partnership Projects" (NREL/TP-520-39780, Sept06)

The collaboration team has studied multiple past consortiums and collaborative efforts in both the PV field and other technical arenas. Past PV manufacturing and R&D collaborations have yielded some valuable lessons and guidance that the Michigan collaboration utilize as a foundation as we create our road map, business plan, and as we select and manage R&D projects. The NREL PV program reviewed these items: 1) Public-Private Cost Sharing, 2) Project Proposal Evaluation Panel Composition, 3) Intellectual Property and Collaboration, 4) Contracting Delays, 5) Scale of Contracts, 6) Company Maturity, Stage of Development, and Iterative Processes, 7) Addressing Common Problems across Companies, 8) Link between Applied R&D and Technology Development, 9) Limitations of Cost and Performance Projections, 10) The Difficulty of First-Time Manufacturing, 11) Module Reliability Problems during Introduction of Innovative Technologies, 12) Reluctance of Successful Companies to Adopt Innovative Approaches, and 13) Budget Adequacy.

Some of the specific areas which have been incorporated into this program include:

- **Institute a multi-tiered cost-share program.** Account for size & type of the entity, type of technology, and type of work. Less cost share for higher-risk activities.
- **Include national laboratories.** Expand this structure to include national labs.
- **Understand the trade-offs in choosing a selection panel:** Tech. specialists inside the industry vs. more objective and independent panelists outside the PV industry. Emerging technologies may require more expert panelists.
- **Place subcontracts quickly and Streamline processes.** Streamline selection and subcontracting. Address IP issues up front, instead of allowing them to become obstacles at the end of the process. The longer work takes to begin, the less valuable it is.
- **Select the best proposals every time.** Select only the highest-ranked proposals for each subcontract. Completely re-compete subcontracts each time they are up for renewal. Objectively compare the merits of proposals from past subcontractors and emerging companies.
- **Make awards based on risk/reward profiles.** For more mature companies/technologies, make awards to a small number of capable companies. For emerging companies/ technologies, spread funding around to decrease overall project risk and increase the potential for innovation. Too much money leads to waste, and too little money leads to substandard results. Award large-scale manufacturing subcontracts to companies with large-scale manufacturing capabilities; award applied R&D subcontracts to emerging companies performing applied research.
- **View highly optimistic claims with healthy skepticism & Evaluate past performance of previous awardees**
- **Address generic problems.** Solving generic PV problems boosts much of the industry.
- **Test early, Expect problems, and Be patient.**
- **Support aggressive and risk taking companies & Set aggressive goals.** Continue to seed and support aggressive PV companies, especially those that adopt innovative new.
- **Commit to building a knowledge base for the long term.** Recognize the importance of acquiring fundamental knowledge and make this effort a priority. Provide patient, consistent support to universities and national laboratories in performing the research.
- **Support work that aids the transition.** Parallel R&D at national labs and universities can help PV companies make the transition to first-time manufacturing.

Thank you for considering this Concept Paper. We look forward to feedback from the DOE and hope to be a strong contender for this opportunity to work with the Department of Energy.

Sincerely,

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