Xcel Energy's
Renewable Development Fund (RDF)

Biennium Report to the Minnesota State Legislature and the Minnesota Public Utilities Commission

January 1, 2017 – December 31, 2018

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Xcel Energy provides the energy that powers millions of homes and businesses across eight Western and Midwestern states. Headquartered in Minneapolis, the Company is an industry leader in responsibly reducing carbon emissions and producing and delivering clean energy solutions from a variety of renewable sources at competitive prices. Northern States Power Company – Minnesota, an Xcel Energy Company, provides electricity to approximately 1.3 million customers and natural gas to more than 450,000 customers in Minnesota.

The Renewable Development Fund (RDF) is a program mandated by the Minnesota State Legislature with oversight by the Minnesota Public Utilities Commission. The RDF's mission is to increase renewable energy market penetration, assist renewable energy projects and companies, and support emerging renewable energy technology.

I. EXECUTIVE SUMMARY

This 2017 – 2018 Renewable Development Fund (RDF) Biennium Report documents Xcel Energy's efforts to administer grants and programs mandated by the Minnesota legislature to support the development of emerging renewable electric energy technology.

During this biennium, the 29.7 MW of renewable energy generation capacity operational through RDF funding has generated more than 150 megawatt hours (MWh) of electricity. A complete list of RDF projects that were active during the biennium is included in Appendix A of this report.

Six new projects were started during the 2017 – 2018 biennium. These projects were from the RDF's fourth grant funding cycle approved by the Minnesota Public Utilities Commission (MPUC or Commission) in 2014 and included three energy production projects and three research and development projects.

II. RDF PROGRAM BACKGROUND

The RDF program was mandated by the Minnesota Legislature in 1994 in conjunction with legislation regarding the Prairie Island nuclear generating plant in Red Wing, Minnesota. As a condition of storing spent nuclear fuel in dry casks at Prairie Island, Minn. Stat. § 116C.779 initially required NSP-Minnesota, as the public utility owner of the plant, to transfer $500,000 for each dry cask containing spent fuel to a renewable energy fund after January 1, 1999, amounting to $9 million annually. In 2003, this statute was amended to authorize additional nuclear-waste storage at Xcel Energy's Prairie Island plant and increased the amount Xcel Energy must pay to $16 million annually, of which $10.9 million annually shall be used to fund renewable small-wind, hydro and biogas incentives via the renewable energy production incentive (REPI) program administrated by the Department of Commerce. (See Section V for further discussion of REPI.)

In 2007, the statute was further amended to add an additional assessment of $350,000 for each dry cask stored at Xcel Energy's Monticello nuclear generating plant. The annual amount set aside for RDF funding has increased throughout the years as the Company has placed in service more dry cask storage at its Prairie Island and Monticello nuclear generating plants. A cumulative total of $301.35 million has been set-aside for the RDF since inception.

Photovoltaic array atop the roof of the McCarthy Gymnasium at the University of St. Thomas in St. Paul, which is part of a micro-grid that the University of St. Thomas is installing through a RDF funded project.

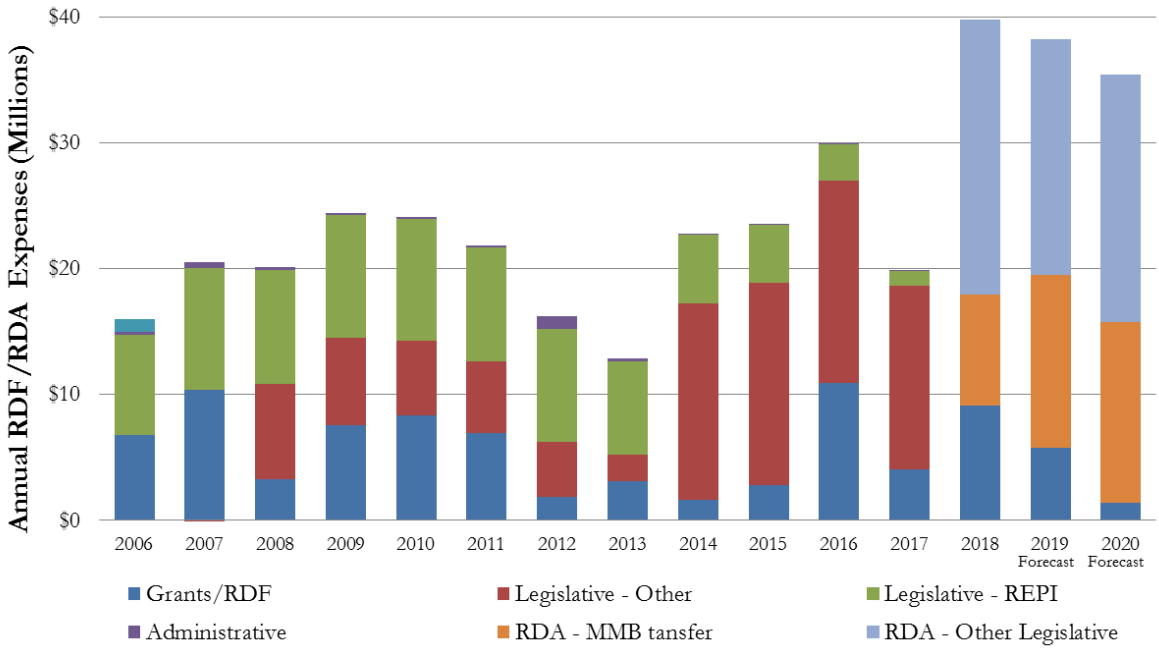
In 2012, the Minnesota Legislature amended the RDF Statute affecting administration of the RDF program. The 2012 amendments provided more flexibility for the Commission to disapprove or modify proposed RDF expenditures that it finds to be non-compliant with prior orders or otherwise not in the public interest. Modifications included adding language to focus funding only for development of renewable energy sources and to give preference to projects located within Minnesota. The amended RDF Statute also defined the consulting role that an advisory group provides and clarified that Xcel Energy has full and sole authority to determine which expenditures shall be submitted to the Commission for approval. Several RDF administrative requirements that were in effect due to Commission orders were incorporated into the RDF Statute. For example, reports written by grantees must include sufficient detail for technical readers as well as a clearly written summary for non-technical readers, reports must be posted online on a public web site, and reports must acknowledge that the project was made possible in whole or part by Xcel Energy's Minnesota electric ratepayers.

In the 2017 legislative session, there were numerous changes to the manner in which the RDF is administered. First, the legislation replaced the Renewable Development Fund with a Renewable Development Account (RDA) administered by the MMB. The 2017 legislative changes had two separate provisions for transferring money to the MMB—one for a transfer in 2017 and another provision for transfer in 2018 and beyond.

Beginning January 15, 2018, and continuing each January 15 thereafter, the legislation requires the Company to transfer the annual obligation for the storage of dry casks located at the Prairie Island power plant and the Monticello nuclear power plant less the amount necessary to pay its obligations for legislative payments. In prior years, costs were not charged to customers until the project met certain known and measurable criteria, so the annual cask fees were carried forward as an encumberment or deferred grant payment. Under the 2017 law, the cask payments are charged to customers in the year they accrue. Thus, starting in 2018 the payments to the MMB will increase the costs

of the RDF and RDA program for our customers. Figure 1 below demonstrates the overall RDF cost recovery trends.

Figure 1: Annual RDF/RDA Costs for Recovery



While the amount of the RDF annual costs recovered from customers fluctuates over time depending upon the cost of legislative programs and grant awards, during the next few years we anticipate an additional short-term increase in the amount our customers annually pay for the RDF and RDA as deferred grant payments are recovered on top of the transfer of funds to the MMB. We note that the projections for 2019 and 2020 in Figure 1 may increase if ongoing RDF grant projects meet known and measurable criteria, which will then allow the Company to recover those costs from its customers.

The cost of Commission-approved program expenses allocated to Minnesota is recovered through an adjustable surcharge on Xcel Energy's customer bill statements as part of their monthly charges for electricity. This surcharge mechanism is known as a "rate rider". Each year, on October 1, Xcel Energy submits an RDF summary report to the Commission. This summary report contains a proposed RDF rate rider charge for the upcoming year and an annual financial report which summarizes the RDF program's past expenses and a two-year expense forecast. In 2017, the RDF charge was $0.001034 per kWh. In 2018, the RDF charge was $0.001318 per kWh.

The 2017 legislation also revised the purposes for which RDA funds could be expended and made a number of changes to the administration of the RDA, the composition of the RDA advisory group, and how projects will be awarded funding from the RDA into the future. However, the 2017 legislation does not provide clarity on who is on the RDA advisory group and who appoints the members, whether Xcel Energy continues to administer the RDA, how administrative costs for the advisory group's independent

evaluator are paid, and whether the Company and advisory group should continue to use the procedural steps for funding cycles laid out in the Commission's previous orders.

The grant award process contemplated under newly enacted Minn. Stat. § 116C.779 subdivision 1(l), (m), and (n) culminates with the Commission presenting "its recommended appropriations from the account to the Senate and House of Representatives committees with jurisdiction over energy policy and finance annually by February 15." Given the relatively recent passage of the 2017 legislation and lack of detail in the statute, the Company has not yet provided any recommendation of projects for funding to the Commission.

Essentially, the 2017 legislation created two types of programs under the statute—the legacy RDF legislative mandates and grants (which continue to be referred to as the RDF) and the new RDA, which is funded by the annual transfer to the MMB.

A. Legacy RDF Program

The legacy RDF program is administered by Xcel Energy program staff, who have responsibility for the day-to-day administration of the RDF grant contracts and resources.

A RDF advisory group was established by Xcel Energy, and serves as an independent entity to assist Xcel Energy in evaluating and overseeing grant projects. Xcel Energy uses technical and professional consulting resources, as needed, to carry out its duties on the RDF. The advisory group has seven members consisting of representatives from the following organizations:

- Environmental interests (two)
- Prairie Island Indian Community (one)
- Residential customers (one)
- Commercial and Industrial customers (one)
- Xcel Energy (two)

The RDF advisory group is further detailed in Appendix B.

B. Newly Created RDA Program

The 2017 legislation struck a provision that referenced the Company's management of the program. Under the newly enacted statute, there is no entity that "manages" the RDA, but the MMB does "administer" the RDA.

The 2017 legislation seems to contemplate a new RDA advisory group, potentially with different composition that the legacy RDF advisory group, with more responsibility for preparing the requests for proposals and making funding recommendations to the Company. The statute does not say who appoints the advisory group, and the legislature has not yet provided clarification, so no appointments have been made.

Dragonfly Solar in Lakeville, Minnesota. The project installed solar facilities near an existing windfarm

III. LEGACY RDF PROGRAM MISSION AND PERFORMANCE METRIC EVALUATION

The legacy RDF's mission was established in October 2006 through a Commission Order as an operational guideline for the fund. The 2012 amendments to the RDF Statute, Minnesota Statute section 116C.779, further clarified and supported the mission.

> *The overall purpose (mission) of the fund is to increase the market penetration within the state of renewable electric energy resources at reasonable costs, promote the start-up, expansion, and attraction of renewable electric energy projects and companies within the state, stimulate research and development within the state into renewable electric energy technologies, and develop near-commercial and demonstration scale renewable electric projects or near-commercial and demonstration scale electric infrastructure delivery projects if those delivery projects enhance the delivery of renewable electric energy.*

For priorities identified by the Commission, the legacy RDF program has established the following performance metrics for evaluating program effectiveness:

A. Expansion of knowledge base
B. Environmental benefits
C. Economic benefits

These performance metrics, detailed below, are revisited after the completion of each project to determine whether the project:

- remained on course with its stated goals,
- furthered RDF program objectives; and
- was a prudent and beneficial grant award on behalf of the Company's customers.

A. Expansion of Knowledge Base. Project milestone reports and final reports submitted by grant recipients provide a public venue for the disclosure of new research breakthroughs that can stimulate the further development of new renewable technologies. These reports are available on the RDF web page at https://www.xcelenergy.com/energy_ortfolio/renewable_energy/renewable_development_fund. During this biennium, the RDF webpages received 6,669 inquiries. Of these inquiries, 1,416 were obtaining information about a specific RDF project. (See Table 1).

Table 1 - RDF Website Activity (2017 - 2018)

Project Type	2017		2018	
	Inquiries	Projects	Inquiries	Projects
Biomass	n/a	79	n/a	61
Hydro	na/	26	n/a	32
Solar	n/a	224	n/a	248
Wind	n/a	289	n/a	172
Higher Education	n/a	180	n/a	105
Other Inquiries	2,999	n/a	2,254	n/a
Total	2,999	798	2,254	618

In addition, the publication of project results provides another avenue to expand the academic and practical knowledge base of renewable energy technologies. During this biennium, numerous articles and papers were published in scientific journals and project outcomes were described in technical papers and presented at various conferences and expositions throughout the United States and the world. One patent was awarded and another patent was filed with the U.S. Patent and Trademark Office. Please see Appendix C for a comprehensive list of the various items listed above. These publications and venues provide a critical scientific peer review of project research findings and are a basis for additional research activities or commercial efforts.

B. Environmental Benefits. The RDF's environmental contribution is the avoidance of both air pollutant and greenhouse gas emissions when compared with alternative methods of generating electricity. Installed RDF energy production projects generated 124,416 MWh of electricity during the 2017-2018 biennium. Overall, RDF projects have generated a total of 631,330 MWh of electricity produced from a renewable energy resource. (See Table 2) Since solar electricity is mostly generated during peak daytime periods, it can also help meet demand energy requirements.

Table 2 – Electrical Generation (MWh)			
Type	**Prior Bienniums (prior to 2017)**	**Current Biennium (2017-2018)**	**Total Generation**
Biomass	2,583	285	2,870
Hydro	198,133	79,713	277,846
Solar	39,295	22,078	61,301
Wind	252,449	36,794	289,248
Total	492,460	138,870	631,325

From 2005 to 2017, Xcel Energy has significantly reduced emissions from the power plants we own: sulfur dioxide (SO_2) by 72 percent and nitrogen oxides (NO_X) by 76 percent. Xcel Energy plans to do more through our clean energy strategy and transition to cleaner energy sources by installing advanced emissions controls on our generating plants.

Hydro, solar and wind resources create no air emissions. When compared to electrical energy produced by coal, hydro, solar and wind generation has provided environmental benefits through reductions in several primary air emission categories. Hydro, solar and wind-sourced electrical generation offsets the release of emissions resulting from conventional electrical power generation and helps Xcel Energy meet a goal to reduce carbon dioxide (CO_2) emissions 60 percent from 2005 levels by 2030. From 2005 to 2017, Xcel Energy has reduced CO_2 emissions by 35 percent.

RDF projects have also generated Renewable Energy Credits (RECs) which are tradable, non-tangible energy commodities. These credits represent the environmental attributes of the power produced from renewable energy projects. RDF projects have generated 560,287 RECs which can be used to meet Xcel Energy's renewable energy goals and requirements to the benefit of its electric customers. (See Table 4)

Table 4– Renewable Energy Credits (REC's)			
Type	**Prior Bienniums (prior to 2017)**	**Current Biennium (2017-2018)**	**Total Generation**
kWh	492,460	138,870	631,325
Credits	463,820	129,595	593,415

C. *Economic Benefits.* RDF grants for renewable energy research and energy production initiatives generate economic benefits by promoting and expanding economic activity on both a local and regional scale through the purchase of goods and services, expansion of employment opportunities, and in some cases, fostering new or expanded business opportunities. In cases where permanent energy production facilities are constructed, RDF investments can also expand the property tax base for a

community through land improvements. RDF grant funds support economic growth by providing an incentive that produces goods and services.

D. Leveraged Funds: RDF grant awards have leveraged other funds to expand and/or enhance project activity. Since program inception, RDF grant awards have stimulated the investment of more than $200 million in renewable energy. This includes more than $139 million in construction activity, goods and services as a result of the start-up, expansion and attraction of renewable energy projects and companies in the Minnesota service territory and more than $61 million in research.

Energy production projects that have been active during this biennium have leveraged more than $8.7 million in other than RDF funds.

Table 5 – Energy Production Funds Leveraged (Active Projects in 2017 - 2018 Biennium)

Technology	Grant	Cost Share	Total Costs	Leverage
Hydro	$1,538,591	$2,612,647	$4,151,238	170%
Solar	$2,619,741	$3,990,487	$6,610,228	152%
Wind	$0	$2.085,145	$2,085,145	-
Total	$4,158,332	$8,688,279	$12,846,611	209%

An additional $4.2 million has been leveraged during this biennium for research and development, including $3.9 million in Minnesota. Research and development projects typically do not have the extensive leverage capacity as compared to energy production because the funding is predominately applied to personnel rather than construction and material costs. (See Table 6) Other qualitative benefits may exist.

Table 6 - Research and Development Funds Leveraged (Active Projects in 2017 - 2018 Biennium)

Technology	Minnesota			Outstate			Total Leverage
	RDF Grant	Cost Share	Leverage	RDF Grant	Cost Share	Leverage	
Biomass	$1,411,141	$3,743,213	2.65%	$850,000	$274,511	32%	34.65%
Solar	$328,198	$109,407	33%	$410,345	$0	0%	33%%
Wind	$1,828,969	$109,407	.06%	$0	$0	0%	0.06%
Multiple	$7,557,215	$0	0%	$0	$0	0%	0%
Total	$11,125,523	$3,962,028	35.71%	$1,260,345	$274,511	32%	67.71%

Minneapolis Park and Recreation canopy mounted solar array in Minneapolis, Minnesota, A RDF-funded project

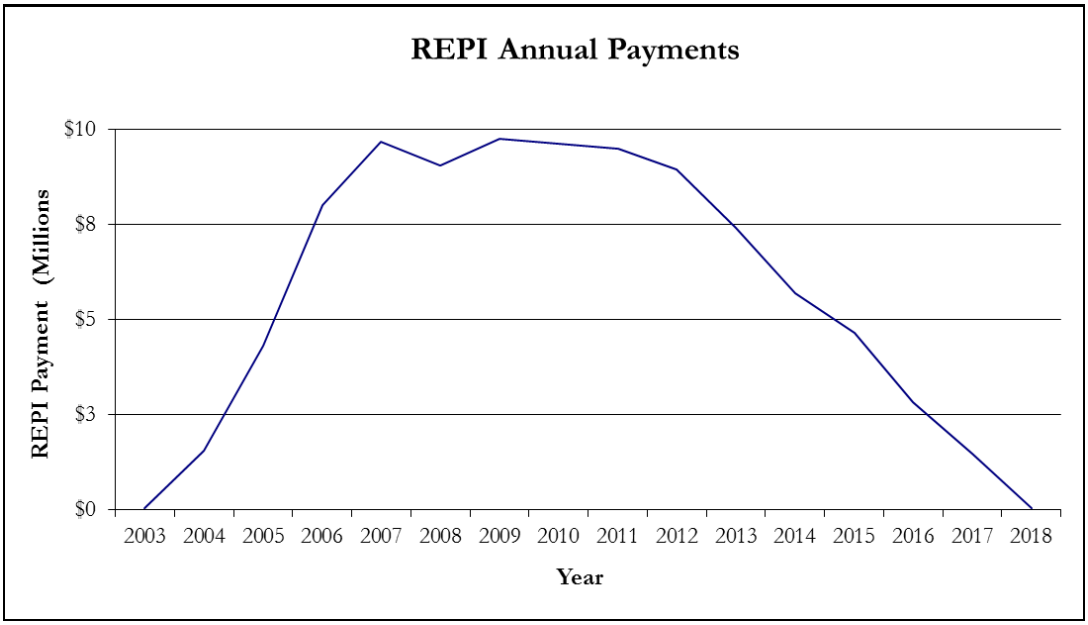
IV. LEGACY RDF FUNDING ACTIVITY

Since 2001, the RDF program has provided over $300 million for renewable energy initiatives, including $86.4 for RDF grant payments, $92.6 million for REPI payments, $128.5 million for legislatively mandated projects and programs, and $2.4 million for general program support. These mandated programs include the appropriation of $25 million to the University of Minnesota for the Initiative for Renewable Energy and Environment (IREE). The RDF grant payments of $86.4 million have been awarded over four grant cycles to 90 projects.

V. LEGACY LEGISLATIVE MANDATES

a. Renewable Energy Production Incentives (REPI)

As specified by Minn. Stat. §116C.779, Subd. 2., the RDF program provides REPI payments up to $10.9 million for qualifying facilities including up to $9.4 million annually for electricity generated by wind energy conversion systems and up to $1.5 million annually for on-farm biogas recovery facilities and hydroelectric facilities. Minnesota Statute §216C.41 authorizes an incentive payment of 1.5 cents per kWh for qualified wind projects through 2018 and hydro projects through 2021. Approximately 225 MW of small wind facilities are subscribed in the program. REPI payments since program inception have totaled approximately $92.6 million.

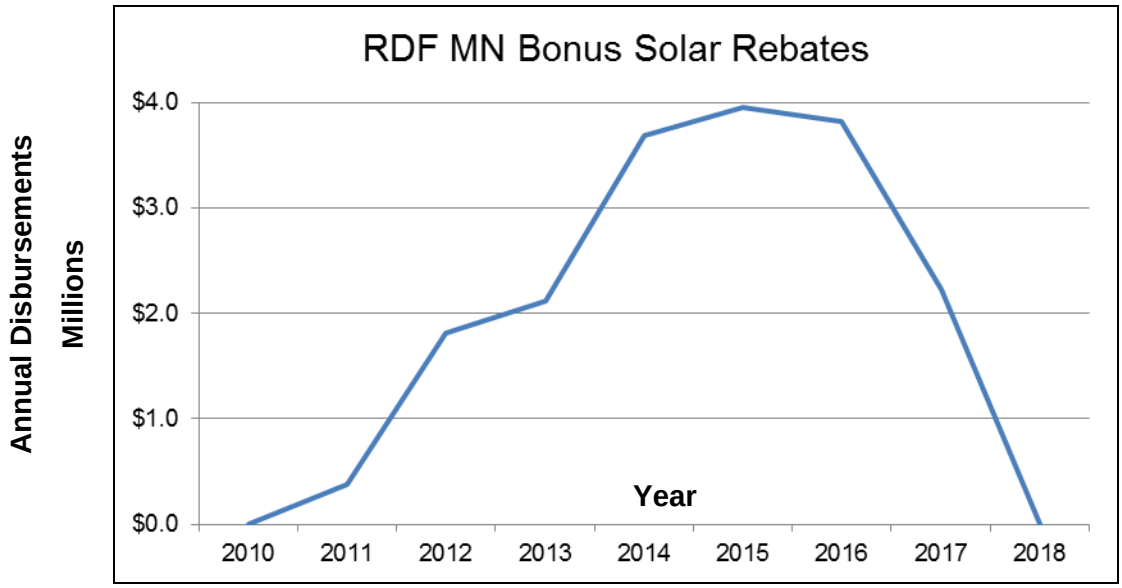


b. RDF Solar Rebates (Minnesota Bonus)

In 2010, the Minnesota Legislature approved a measure to utilize $21 million from the RDF program for solar rebates called Minnesota Bonus. This program was available to customers for incentives awarded from 2011 to 2013. After this time, the Made in Minnesota program was created by new legislation sunsetting the original legislation described below.

By statute the Minnesota Bonus program provided funding over a five year period ($2 million in state fiscal year 2011, $4 million in state fiscal year 2012, and $5 million per year in state fiscal years 2013 – 2015). The legislation specifies that Xcel Energy would administer the RDF rebates for solar photovoltaic (PV) systems less than 40 kW installed by customers in the Company's Minnesota service territory. The RDF solar rebates were only available for systems that use solar modules manufactured or assembled in Minnesota. The amount of the RDF solar rebate was the difference between the sum of all RDF rebates awarded to the applicant and $5 per watt of installed generating capacity. In addition, the amount of all rebates or other forms of financial assistance awarded to an applicant by a utility and the state, including the RDF solar rebate were not to exceed 60 percent of the total installed cost of the solar PV installation net of federal income taxes at the highest applicable income tax rates.

These incentives were provided as $/kW rebates to customers paid over a five year period. Due to naturally occurring gaps from the time of award until the project installation, most of these five-year payments will be completed by 2019, though some projects encountered additional installation delays that will prolong their payment cycles.



Minnesota Bonus rebates were first disbursed in 2011. No additional capacity was awarded since the program closed in 2014. Most of the projects were installed during 2014 and 2015, however a very small number of additional projects continued to be completed. Payments for the five-year payments have continued for a total reimbursement of over $19 million for the program thus far. The Minnesota Bonus provided roughly 3.8 MW of installed capacity from 138 projects.

c. Made in Minnesota (MiM) Solar Incentive Account

Minnesota legislation, Minn. Stat. §216C.417, established a "Made in Minnesota" solar energy production incentive account as a separate account in the special revenue fund in the state treasury in 2013. Beginning Jan. 1, 2014 and each Jan. 1 thereafter, through 2023, for a total of ten years each electric public utility subject to Conservation Improvement Program (CIP) requirements must annually pay to the Commissioner of Commerce five percent of the minimum amount it is required to spend on CIP. Affected utilities are Xcel Energy, Minnesota Power and Ottertail Power. Funds from the RDF, when added to the total amount paid to by the three affected utilities, totals a combined annual payment of $15.0 million. In 2017, Minn. Stat. §216C.417 was repealed and all applications for the MiM program were to be approved by May 1, 2017, and installed by Oct. 31, 2018. Since program inception, $36.1 million has been disbursed. In this biennium the RDF payment to the MIM Solar Incentive Account was $24.1 million.

The Made in Minnesota program led to an installation of roughly 17.4 MW of solar capacity from more than 1,300 projects.

d. Solar*Rewards

In 2013, Minn. Stat. §116C.7792 was enacted to establish a solar energy incentive program to be operated for five consecutive calendar years beginning in 2014 with no specifications around where panels are manufactured. This legislation directed that $5,000,000 shall be allocated for each of the five years from the RDF. With the commission of the system, a qualifying system would be paid a production incentive over the course of 10 years. In October of 2013 Xcel Energy filed a program proposal with the Department of Commerce seeking approval of the Company's Solar*Rewards program which was approved on March 28, 2014. Solar*Rewards incentives cannot be combined with incentives from other state and utility programs, including Made in Minnesota. .

In 2017 the legislature amended Minn. Stat. §116C.7792 to extend the program through 2021. In this extension, $5,000,000 was allocated in each of the first four years (2014-2017), $15,000,000 in the fifth year (2018), $10,000,000 in each of the sixth and seventh (2019-2020) years and $5,000,000 in the eighth year (2021) from funds withheld from transfer to the Renewable Development Account (RDA). In 2018, the statute was further revised to increase the allowable name plate capacity from 20 kWdc to 40 kWdc . This revision also allows for more than one solar system per premise to be eligible for this incentive program, subject to an aggregate cap of no more than 40 kWdc. Further, the solar system eligible for incentive must be sized to less than 120 percent of the customer's on-site annual energy consumption when combined with other distributed generation resources.

Since this program's inception using RDF/RDA funding in 2014, 14.4 MW of solar have been installed (roughly 1,500 systems). Approximately, $600,000 has been disbursed in the form of customer production incentives. In this biennium the RDF payments to the Solar Energy Incentive Program was $551,886. Prior to 2014, a similar program was available using Conservation Improvement Fund resources.

VI. OVERALL LEGACY RDF PROJECT STATUS

In order to maintain program transparency, the RDF administration files quarterly progress reports with the Commission (available at www.puc.state.mn.us) summarizing legacy RDF project activity. RDF grant recipients submit project milestone reports to the Company, providing a description of activities and findings. Milestone reports are posted on the RDF web page at https://www.xcelenergy.com/energy_portfolio/renewable_energy/renewable_development_fund . In addition, RDF grant recipients provide a final project report to the RDF advisory group.

VII. CURRENT CONTRACTS UNDER THE LEGACY RDF

As stated above, six legacy RDF projects executed contracts and started project activity in the 2017 – 2018 biennium and one RDF grant contract was terminated.

At the end of the 2017 – 2018 biennium, there were nineteen legacy RDF projects under contract. One was awarded a grant in the third funding cycle, approved by the Commission in 2008. The remaining eighteen projects were awarded grants in the fourth funding cycle, approved by the Commission in 2014.

Of the eighteen projects awarded grants in the fourth funding cycle, six were renewable energy production projects that, once completed, are expected to install an additional 4 MW of solar generation capacity and 500 kW of wind generation capacity in the state and nine projects were research and development projects. The remaining three projects awarded grants in the fourth funding cycle were higher education block grants with the University of Minnesota (U of M), Minnesota State Colleges and Universities (MNSCU), and the University of St. Thomas (UST). The fourth funding cycle was the only RDF funding cycle to date to allow higher education block grants like those awarded to U of M, MNSCU, and UST.

VIII. REIMBURSEMENT OF LEGACY RDF PROJECT COSTS

Grant funds are disbursed on a reimbursement basis according to project progress and milestones stipulated in each RDF grant contract. More than $12 million was dispersed in the biennium to reimburse project costs. (See Table 11) Some projects were completed under budget and over $4 million in savings was credited to the RDF program.

Table 11 - Use of Funds Under RDF Contract (1/1/2017 – 12/31/2018)

Cycle	Contracted RDF Funds	RDF Funds Dispersed			Funds not utilized
		Prior to 12/31/2017	1/1/2017 - 12/31/2018	Balance after 1/1/2019	
Cycle 1	$15,550,401	$11,671,876	$0	$0	$3,878,525
Cycle 2	$29,440,996	$27,369,559	$0	$0	$2,071,437
Cycle 3	$22,510,293	$22,063,889	$0	$0	$446,404
Cycle 4	$38,249,648	$12,989,538	$12,259,340	$8,080,085	$4,920,685
Total	$105,751,338	$74,094,862	$12,259,340	$8,080,085	$11,317,051

XI. BENEFITS OF LEGACY RDF PROJECTS TO NSP-MINNESOTA CUSTOMERS

The majority of legacy RDF projects are based in Minnesota. As a result, most of the RDF dollars are also spent in Minnesota. Part of the selection criteria for RDF grant projects relates to the benefits a project will bring to the Company's Minnesota

customers. Therefore, research activity conducted by an entity that is not located in Minnesota needs to be applicable and transferable to the state. This is often accomplished through the use of a Minnesota site serving as a host for the development and demonstration of an RDF project. (See Table 12)

Table 12 – Minnesota Hosts Activities (1/1/2017 – 12/31/2018)

Project	Grantee	Minnesota Host	Host Location	Host Activity
RD3-77	Coaltec Energy USA	P & K Farms	Northfield, Minn.	Pilot demonstration of gasifier
EP4-24	Bergey Windpower	Xcel Energy customers	Central and S.W. Minnesota	Install 10kW wind turbines
EP4-48	Oak Leaf Energy	Met Council	Shakopee, Minn.	Install 970 kW photovoltaic array
RD4-5	University of Florida	West Central Turkey; Northern Contours; SunOpta Grains; Denco II LLC's	Pelican Rapids Fergus Falls Alexandria, MN Morris, MN	Conduct a three-year research project to demonstrate biogasification of organic wastes

Appendix D details the Minnesota Congressional districts that have either hosted project activity or have had a project sponsor located within their boundaries.

X. NEWLY CREATED RENEWABLE DEVELOPMENT ACCOUNT (RDA)

Under the 2017 legislation, RDA funds may be expended only for any of the following purposes:

(1) to stimulate research and development of renewable electric energy technologies;

(2) to encourage grid modernization, including, but not limited to, projects that implement electricity storage, load control, and smart meter technology; and

(3) to stimulate other innovative energy projects that reduce demand and increase system efficiency and flexibility.

According to the MMB, who administers the RDA account, the actual balance of the RDA in 2018 was $48,027,000. In the 2017-18 biennium, no funds were expended from the RDA.

XI. CONCLUSION

The legacy RDF program continues to fund the remaining grants made for renewable electric energy research, development and demonstration projects in Minnesota. Throughout the past twelve years and four grant award cycles, the legacy RDF program has supported projects of state, regional and national significance. Yet, not all projects

work out as planned, and it often takes years for research projects to be successful. There have been many lessons learned in conjunction with legacy RDF projects and this experience is often applied to future efforts.

As described in this biennial report, there is a lack of clarity on the newly created RDA. The company looks forward to working with the Minnesota Legislature and other stakeholders on clarifications to the 2017 RDA statute. We remain committed to making certain the legacy RDF Program and the newly created RDA program provide maximum benefits for those individuals who most directly make it possible – the Company's customers.

APPENDIX A – RDF Projects-Biennium (1/1/2017 – 12/31/2018)

Active RDF Projects During Past Year (1/1/2017 - 12/31/2018)

	Contract	Project Name	Grant	Type	Cycle	Category	Status	Project End Date
1	AH-01	Crown Hydro	$5,100,000	EP	1	Hydro	terminated	10/22/2018
2	RD3-77	Coaltec Energy USA	$1,000,000	RD	3	Biomass	current	4/22/2018
3	EP4-3	Minneapolis Public Schools	$917,250	EP	4	Solar	current	1/10/2019
4	EP4-11	Innovative Power Systems	$1,850,000	EP	4	Solar	complete	4/12/2018
5	EP4-15	Minnesota Renwable Energy Society	$2,661,320	EP	4	Solar	current	7/17/2019
6	EP4-20	Target Corporation	$583,513	EP	4	Solar	complete	10/1/2017
7	EP4-22	Minneapolis Park & Rec. Board	$969,741	EP	4	Solar	current	12/28/2017
8	EP4-24	Bergey Windpower	$1,106,600	EP	4	Solar	current	11/24/2017
9	EP4-29	Dragonfly Solar	$1,650,000	EP	4	Solar	current	5/8/2018
10	EP4-34	City of St. Paul	$555,750	EP	4	Solar	complete	6/9/2017
11	EP4-42	Aurora St. Anthony Falls	$239,994	EP	4	Solar	current	1/30/2019
12	EP4-44	Region 5	$1,993,659	EP	4	Solar	current	3/8/2020
13	RD4-1	University of Minnesota (Gasification)	$999,999	RD	4	Biomass	current	1/4/2020
14	RD4-2	University of Minnesota (Dairy)	$982,408	RD	4	Solar/Wind	current	1/31/2020
15	RD4-7	InterPhases Solar	$1,000,000	RD	4	Solar	current	1/12/2020
16	RD4-8	City of Red Wing	$1,999,500	RD	4	Biomass	current	2/6/2021
17	RD4-11	University of Minnesota (Torrefaction)	$1,899,449	RD	4	Biomass	current	10/3/2019
18	RD4-12	University of Minnesota (Noise)	$625,102	RD	4	Wind	current	9/2/2018
19	RD4-13	University of Minnesota (VWS)	$1,391,684	RD	4	Wind	current	6/2/2020
20	RD4-14	Barr Engineering	$161,081	RD	4	Wind	current	11/16/2018
21	HE4-1	MnSCU	$5,500,000	HE	4	various	current	5/31/2020
22	HE4-2	University of St. Thomas	$2,157,215	HE	4	various	current	12/12/2019
23	HE4-3	University of Minnesota (REMF)	$3,000,000	HE	4	various	current	2/20/2020
24	RD4-5	University of Florida	$1,109,538	RD	4	Biofuel	current	3/23/2021
		Total RDF Projects	**$39,453,803**					

*Project end date dependent upon anticipated completion of project activity

APPENDIX B - RDF Advisory Group

- Joe Sullivan, Manager Legislative and External Affairs
  Center for Energy and Environment
  Representing the Environmental Community

- Jessica Tritsch, Senior Campaign Representative
  Sierra Club North Star Chapter
  Representing the Environmental Community

- Lise Trudeau, Engineer
  Minnesota Department of Commerce, Division of Energy Resources
  Representing residential customers

- Sam Harper, Regional Energy Manager
  Gerdeau Ameristeel
  Representing commercial and industrial customers

- Heather Westra
  Representing Prairie Island Indian Community

- Kevin Schwain, Manager Emerging Customer Program
  Xcel Energy
  Representing Xcel Energy-Minnesota

- Tami Gunderzik, Senior Manager Product Portfolio
  Xcel Energy
  Representing Xcel Energy-Minnesota

RDF Administration

- Bria Shea, Director, Regulatory and Strategic Analysis
  Xcel Energy

- Pamela Gibbs, Grant Administrator, RDF
  Xcel Energy

APPENDIX C - Scientific Articles and Presentations

Scientific Articles						
Date	Grant #	Grantee	Author	Article Title	Journal	Published
Apr. 2017	HE4-3	U of M	M. Prakash., S. Talukdar, S. Attree, V. Yadav, and M. Salapaka	Distributed Finite Time Termination of Ratio Consensus for Averaging in the presence of Delays	*Cornell University Library*	Yes
Apr. 2017	HE4-3	U of M	Mangal Prakash Saurav Talukdar Sandeep Attree Vikas Yadav Murti V. Salapaka	Distributed Finite Time Termination of Consensus in the presence of Delays	*ArXiv (Cornell University).*	Yes
May 2017	HE4-3	U of M	A. K. Sahoo N. Mohan	Modulation and Control of a Single-Stage HVDC/AC Solid State Transformer Using Modular Multilevel Converter	*IEEE Applied Power Electronics Conference and Exposition (APEC) 2017*	Yes
May 2017	HE4-3	U of M	A. K. Sahoo N. Mohan	Analysis and experimental validation of a modular multilevel converter with 3-level T-type submodules	*IEEE Applied Power Electronics Conference and Exposition (APEC) 2017*	Yes
June 2017	HE4-3	U of M	Zhang, Li, Walter, O'Brien, Manno, Voigt, Mork, Baryshev, Kakalios, Aydil, Leighton	Potential Resolution of the Doping Puzzle in Iron Pyrite: Carrier Type Determination by Hall Effect and Thermopower	*Nature Communications*	Yes
Aug. 2017	HE4-3	U of M	P. Lyu W. Chen H. Li L. Shen	On the interaction of turbine wake and offshore wind-wave field in offshore wind farm: large-eddy simulation with actuator models	*Proceedings of the 3rd North American Wind Energy Symposium*	Yes
Sept. 2017	HE4-3	U of M	P. Lyu W. Chen H. Li L. Shen	On the interaction of turbine wake and offshore wind-wave field in offshore wind farm: large-eddy simulation with actuator models	*Proceedings of the 3rd North American Wind Energy Symposium*	Yes

Oct. 2017	HE4-3	U of M	Sourav Patel, Sandeep Attree, Saurav Talukdar, Mangal Prakash and Murti V. Salapaka	Distributed Apportioning in a Network of Energy Resources for providing Ancillary Services	*International Conference on Smart Grid Communications (IEEE Smart Grid Comm), Germany, Oct 23-26, 2017, IEEE.*	Yes
Nov. 2017	HE4-3	U of M	Tianqi Wang, Laxman Raju Thoutam, Abhinav Prakash, William Nunn, Greg Haugstad and Bharat Jalan	Defect-driven Localization Crossovers in MBE-Grown La-doped SrSnO3 films	Physical Review Materials (rapid communications)	Yes
Nov. 2017	HE4-3	U of M	Santhosh Krishnamoorthi , Saurabh Tewari, Siddharth Raju, Dan Opila, Abhijit Kshirsagar and Ned Mohan	A Ride-Through Method Using Input-Filter Capacitors for Three-Level Indirect Matrix Converter based Open-End Winding Drive	*IEEE-ECCE-2017 conference*	Yes
Nov. 2017	HE4-3	U of M	K. V. Iyer M. Cai D. Murthy-Bellur B. Palmer N. Mohan	A half-turn winding for compact, high-current, high-turns-ratio, low-leakage-inductance transformer	*ECCE 2017*	Yes
Nov. 2017	HE4-3	U of M	G. Hanline L. Bumke C. Chluba E. Quandt R.D. James	Phase Engineering and Supercompatibility of Shape Memory Alloys	Materials Today	Yes

Papers/Presentations

Date	Grant #	Grantee	Author	Paper Title	Conference	Location
Jan. 2017	HE4-3	U of M	Richard James	*Phase transformations and soft magnetism*	NSF DMREF Kick-off on Soft Magnetism	Golden, CO
Jan. 2017	HE4-3	U of M	Richard James	*Atomistically inspired origami*	Department Seminar	Atlanta, GA
Jan. 2017	HE4-3	U of M	Bharat Jalan	*Chemistry, Growth kinetics and Epitaxial Stabilization of Sn2+ in Sn-doped SrTiO3 using (CH3)6Sn2 tin precursor*	Electronic Materials and Application Conference,	Orlando, FL

					Invited talk	
Jan. 2017	HE4-3	U of M	Richard James	*Phase transformations and soft magnetism*	NSF DMREF Kick-off on Soft Magnetism	Denver, CO
Feb. 2017	HE4-2	UST	Greg Mowry	*An Introduction to Microgrids*	North Central Electrical League Inc.	St. Paul, MN
Feb. 2017	HE4-2	UST	Greg Mowry	*An Introduction to Microgrids*	12th Annual Excel Engineering Technical Conference	Shoreview, MN
Feb. 2017	HE4-3	U of M	Ned Mohan	*Is energy storage the game changer we've been looking for?*	IonE Panel Discussion, University of Minnesota	Minneapolis, MN
Feb. 2017	HE4-3	U of M	Bharat Jalan	*MBE Growth and Stoichiometry Control of Complex Oxides*	UMN Energy Conversion Workshop	Minneapolis, MN
Feb. 2017	HE4-3	U of M	Richard James	*Twisted X-rays, orbital angular momentum and the determination of atomic structure*	Applied Mathematics Seminar	Berkeley, CA
Feb. 2017	HE4-3	U of M	Ned Mohan	*Is energy storage the game changer we've been looking for?*	IonE Panel Discussion	Minneapolis, MN
Feb. 2018	HE4-3	U of M	Ned Mohan	Is energy storage the game changer we've been looking for?	IonE Frontiers on the Enviromnment	Minneapolis, MN
Mar. 2017	HE4-3	U of M	Richard James	Atomistically inspired origami	Colloquium	Houston, TX.
Mar. 2017	HE4-2	UST	Greg Mowry	*Exploring the Advancement of the Microgrid Controller as a Means of Enhancing Microgrid Research and Development to Improve Energy Reliability and Distribution*	7th Microgrids and Distributed Generation for Public and Private Sectors	Boston, MA
Mar. 2017	HE4-3	U of M	Ashish Sahoo Ned Mohan	*Analysis and Experimental Validation of a Modular Multilevel Converter with 3-Level T-Type submodules*	Institute of Electrical and Electronics Engineers - Applied Power Electronics Conference	Tampa, FL
Mar. 2017	HE4-3	U of M	Ashish Sahoo Ned Mohan	*Modulation and Control of a Single-Stage HVDC/AC Solid State Transformer Using Modular Multilevel Converter*	Institute of Electrical and Electronics Engineers - Applied Power	Tampa, FL

					Electronics Conference	
Mar. 2017	HE4-3	U of M	James and Jalan	*The Direct Conversion of Heat to Electricity using Ferroelectric Oxides*	UMN Sustainability & Energy Expo	Minneapolis, MN
Mar. 2017	HE4-3	U of M	Bharat Jalan	*Structure, Defects and Electronic Transport in High-Mobility BaSnO3 Films and Heterostrostructrues*	APS March Meeting	New Orleans, LA
Mar. 2017	HE4-3	U of M	Bharat Jalan	*Hybrid Molecular Beam Epitaxy for Functional Oxide Thin Films and Heterostructures*	AEM Department Seminar	Minnneapolis, MN
Apr. 2017	HE4-3	U of M	Zhang, Li, Walter, O'Brien, Manno, Voigt, Mork, Baryshev, Kakalios, Aydil and Leighton	*Potential resolution to the doping puzzle in iron pyrite: carrier type determination by Hall effect and thermopower*	Materials Research Society Spring Meeting	Phoenix, AZ
May 2017	RD4-12	U of M	C. Feist W. Herb	*Human Response to Wind Turbine Noise: Infrasound and Amplitude Modulation*	7th International Conference on Wind Turbine Noise	Rotterdam, Netherlands
May 2017	HE4-3	U of M	Voigt, Walter, Ray, Gagliardi, Aydil and Leighton	*Understanding and controlling doping in pyrite FeS2, a potential earth abundant, non-toxic, low cost photovoltaic*	IPRIME Annual Meeting	Minneapolis, MN
May 2017	HE4-3	U of M	P. Singh P. Seiler	*Controlling A Meandering Wake: Insights From Full-Information Control*	American Control Conference	Seattle, WA
May 2017	HE4-3	U of M	Richard James	*Design of supercompatible shape memory alloys (Plenary Lecture)*	Shape Memory and Superelastic Technologies	Galway, Ireland
May 2017	HE4-3	U of M	Richard James	*New concepts for the direct conversion of heat to electricity*	Golden Medallion Lecture of the College of Science and Engineering	Minneapolis, MN
May 2017	HE4-3	U of M	Richard James	*Compatibility, hysteresis and the direct conversion of heat to electricity*	Colloquium	San Diego, CA
June 2017	RD4-7	InterPhases	Shalini Menezes	*Flexible CISe Thin Film Solar Cells*	IEEE Photovoltaic Specialist Conference	Washington, DC
June 2017	HE4-3	U of M	Ned Mohan	*Power-Related CUSP™ Curriculum*	NSF-Workshop	Minneapolis, MN

July 2017	HE4-2	UST	Greg Mowry	*An Introduction to Microgrids and University of St. Thomas Renewable Energy Facility*	2017 National Society of Professional Engineers Conference	Atlanta, GA
June 2017	HE4-3	U of M	M. Guala	*Experimental Observation of sand and snow dynamics*	Seminar at Politecnico di Torino	Turin, Italy
June 2017	HE4-3	U of M	M. Guala	*Extracting Energy from wind an dwater:Influence and control of complex boundary conditions*	Seminar at ETH Zurich	Zurich, Switzerland
Aug. 2017	HE4-3	U of M	Bharat Jalan	*Novel Radical-based Molecular Beam Epitaxy Approach for Metal Oxide Films Containing Elements of Low Oxidation Potential*	21st American Conference on Crystal Growth and Epitaxy	Santa Fe, NM
Aug. 2017	HE4-3	U of M	Bharat Jalan	*Band-Engineered Complex Oxide Interfaces: Role of Defects and Growth Approaches*	21st American Conference on Crystal Growth and Epitaxy	Santa Fe, NM
Aug. 2017	HE4-3	U of M	Bharat Jalan	*Novel Radical-based Molecular Beam Epitaxy Approach for Metal Oxide Films Containing Elements of Low Oxidation Potential*	XXVI International Materials Research Congress	Cancun, Mexico
Aug. 2017	HE4-3	U of M	Ned Mohan	*Understanding power electronic converters to interface wind, PVs, EVs, etc. with the Grid*	UMCEE Sponsored Workshop	Minneapolis, MN
Aug. 2017	HE4-3	U of M	M. Guala	*Wall turbulence structure in the atmospheric surface layer. Scaling and implications on wind turbine siting*	Seminar at University of Southern California	Los Angeles, CA
Sept. 2017	HE4-3	U of M	Bharat Jalan	*"Novel Molecular Beam Epitaxy Approaxh for High Quality Perovskite Thin Films"*	Department Colloquium, Institute for Materials Science	Kiel, Germany
Sept. 2017	HE4-3	U of M	Bharat Jalan	*Charge Transfer at Complex Oxide Interfaces*	Department Seminar	Lyngby, Denmark
Sept. 2017	HE4-3	U of M	Ned Mohan	*Back-to-back MMC interface with virtual DC link for interfacing renewables to the grid*	North American Power Symposium (NAPS)	Morgantown, WV
Sept. 2017	HE4-3	U of M	P. Lyu W. Chen H. Li L. Shen	*On the interaction of turbine wake and offshore wind-wave field in offshore wind farm: large-eddy simulation with acutuator models*	3rd North American Wind Energy Symposium	Ames, IA

Oct. 2017	RD4-7	InterPhase	Shalini Menezes	*New Technology for Flexible Thin-Film Photovoltaic Devices*	6th International Conference on Materials Science and Engineering	Beijing, China
Oct. 2017	HE4-3	U of M	Richard James	*Supercompatibility and the Direct Conversion of Heat to Electricity*	Timoshenko Lecture	Stanford, CA
Oct. 2017	RD4-1	U of M	Nan Zhou	*Coating on SiC foam support as a composite catalyst for fast microwave-assisted pyrolysis of biomass*	2017 AICHE Annual Meeting	Minneapolis, MN
Oct. 2017	RD4-1	U of M	Shiyu Liu	*Bio-fuel production from sequential two-step catalytic fast microwave-assisted biomass pyrolysis.*	2017 AICHE Annual Meeting	Minneapolis, MN
Oct. 2017	RD4-1	U of M	Roger Ruan	*Microwave-assisted catalytic pyrolysis and gasification for solid wastes conversion and utilization.*	2017 AICHE Annual Meeting	Minneapolis, MN
Oct. 2017	HE4-3	U of M	Richard James	*Twisted X-rays, orbital angular momentum and the determination of atomic structure*	Hong Kong University of Science and Technology	Hong Kong
Oct. 2017	HE4-3	U of M	Richard James	*Theory-based discovery of highly reversible phase-transforming materials*	IAS Distinguished Lecture	Hong Kong
Oct. 2017	HE4-3	U of M	Ned Mohan	*A Ride-Through Method Using Input-Filter Capacitors for Three-Level Indirect Matrix Converter based Open-End Winding Drive*	ECCE 2017	Cincinati, OH
Oct. 2017	HE4-3	U of M	Ned Mohan	*A High-Frequency AC-Link Single-Stage Asymmetrical Multilevel Converter for Grid Integration of Renewable Energy Systems*	ECCE 2017	Cincinati, OH
Oct. 2017	HE4-3	U of M	Bharat Jalan	*Invited Seminar on Direct Conversion of Heat to Electricity Project*	Department Seminar	Centre County, PA
Oct. 2017	HE4-3	U of M	Richard James	*Soft is hard and hard is easy: some recent developments linking LCEs and martensite*	International Liquid Crystal Elastomer	Houston, TX.
Nov. 2017	HE4-3	U of M	Voigt, Moore, Manno, Walter, Aydil, and Leighton	*Evidence for sulfur avacancies as the origin of n-type doping in pyrite FeS2*	Materials Research Society Fall Meeting	Boston, MA
Nov. 2017	HE4-3	U of M	P. Lyu, W. Chen, H. Li, and L. Shen	*Numerical investigation of interactions between marine atmospheric boundary layer and offshore wind farm*	70th Annual Meeting of the American Physical Society Division of Fluid	Denver, CO

					Dynamics	
Dec. 2017	RD4-12	U of M	Peggy Nelson	*Human Postural Sway Results in Response to Audible and Infrasound Emissions from Wind Turbines*	Acoustical Society of America Conference	New Orleans, LA
Sept. 2018	HE4-3	U of M	Dr. Ananya Renuka Balakrishna and team	*Energy Conversion In the Small Temperature Difference Regime*	The Annual Review of Materials	
Sept. 2018	HE4-3	U of M	Grid Interface for Renewables, Storage and Green Micro-grid group	*Virtual Inertia Scheme Implementation*	2018 Energy Conversion Congress and Expo	Portland, OR
Sept. 2018	HE4-3	U of M	Modulation Team	*Pulse Width Modulation (PWM)*	8th International Conference on Power Electronics, Drives and Energy Systems	
Patents						
Apr. 2018	HE4-3	U of M		The Direct Conversion of Heat to Electricity Using Phase Transformations in Ferroelectric Oxides	Filed with USPTO	
June 2018	HE4-3	U of M		Operation of a Modular Multilevel Converter Based Topology	Patent Awarded	

APPENDIX D – Location of RDF Projects by Congressional District

RDF Congressional Districts (1/1/2017 - 12/31/2018)									
					Renewable	Host Site		Project Sponsor	
	RDF Contract	Grant	Type	Cycle	Category	District	Location	District	Organization
District 1									
	EP4-24	$1,106,600	EP	4	Solar	MN06	Lincoln, Lyon, P	OK	Bergey Windpower, Norman
	EP4-29	$1,650,000	EP	4	Solar	MN01	Dodge City	MN03	Dragonfly Solar, Lakeville
	HE4-1	$5,500,000	HE	4	various	MN01	Minnesota State,	MN04	U of M, St. Paul
	RD4-14	$161,081	RD	4	Wind	MN01	Grand Meadows	MN05	Barr Engineering, Minneapolis
District 2									
	RD3-77	$1,000,000	RD	3	Biomass	MN02	P & J Farms, N	IL	Coaltec Energy USA, Carterville
	EP4-15	$2,661,320	EP	4	Solar	MN02	Northfield	MN05	MRES, Minneapolis
	EP4-29	$1,650,000	EP	4	Solar	MN01	Dodge City	MN03	Dragonfly Solar, Lakeville
	RD4-2	$982,408	RD	4	Solar/Wind	MN02	WCROTC, Morr	MN05	U of M, Minneapolis
	RD4-8	$1,999,500	RD	4	Biomass	MN02	MSW Campus, R	MN05	City of Red Wing
District 4									
	EP4-11	$1,850,000	EP	4	Solar	MN04	EIC, St. Paul	MN05	IPS, Minneapolis
	EP4-20	$583,513	EP	4	Solar	MN04	Midway Superst	MN05	Target, Minneapolis
	EP4-34	$555,750	EP	4	Solar	MN04	CHS Field, St. P	MN04	City of St. Paul
	HE4-1	$5,500,000	HE	4	All	MN05	Century College,	MN04	U of M, St. Paul
	HE4-2	$2,157,215	HE	4	All	MN05	UST, St. Paul	MN05	UST, St. Paul
	HE4-3	$3,000,000	HE	4	All	MN05	U of M, Minnear	MN04	U of M, St. Paul
District 5									
	AH-01	$5,100,000	EP	1	Hydro	MN05	Crown Hydro, M	MN05	Crown Hydro, Minneapolis
	EP4-11	$1,850,000	EP	4	Solar	MN04	EIC, St. Paul	MN05	IPS, Minneapolis
	EP4-15	$2,661,320	EP	4	Solar	MN05	North Minneapo	MN05	MRES, Minneapolis
	EP4-20	$583,513	EP	4	Solar	MN04	Midway Superst	MN05	Target, Minneapolis
	EP4-22	$969,741	EP	4	Solar	MN05	MPRB, Minneac	MN05	MPRB, Minneapolis
	RD4-1	$999,999	RD	4	Biomass	MN05	U of M, Minnear	MN05	U of M, Minneapolis
	RD4-2	$982,408	RD	4	Solar/Wind	MN02	WCROTC, Morr	MN05	U of M, Minneapolis
	RD4-7	$1,000,000	RD	4	Solar	CA/MN05	InterPhases/U o	CA	InterPhases Solar, Moorpark
	RD4-11	$1,899,449	RD	4	Biomass	MN08	NRRI, Coleraine	MN05	U of M, Minneapolis
	RD4-12	$625,102	RD	4	Wind	MN05	U of M, Minnear	MN05	U of M, Minneapolis
	RD4-13	$1,391,684	RD	4	Wind	MN05	U of M, Minnear	MN05	U of M, Minneapolis
	RD4-14	$161,081	RD	4	Wind	MN01	Grand Meadows	MN05	Barr Engineering, Minneapolis
	HE4-3	$3,000,000	HE	4	All	MN05	U of M, Minnear	MN04	U of M, St. Paul
District 6									
	EP4-24	$1,106,600	EP	4	Solar	MN06	Stearns, Sherbur	OK	Bergey Windpower, Norman
	HE4-1	$5,500,000	HE	4	All	MN05	St. Cloud State,	MN04	U of M, St. Paul
District 8									
	RD4-11	$1,899,449	RD	4	Biomass	MN08	NRRI, Coleraine	MN05	U of M, Minneapolis