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## EPIC Request for Comments: Modeling Tools RFC

*Additional submitted attachment is included below.*

**Lawrence Berkeley National Laboratory Comments responding to the CEC's "*Draft Solicitation on Modeling Tools to Evaluate Distributed Energy Resources (DERs) and Microgrids located behind the meter on California's Modern Distribution Systems*"**

June 21st, 2017

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Thank you for the opportunity to submit comments from Lawrence Berkeley National Laboratory (Berkeley Lab), Energy Technologies Area (ETA) in response to the "EPIC Request for Comments: *Draft Solicitation on Modeling Tools to Evaluate Distributed Energy Resources (DERs) and Microgrids located behind the meter on California's Modern Distribution Systems*.

We have been privileged to support the State of California in research, design, development and demonstration (RDD&D) of innovation technologies, program design and evaluation, code compliance strategies, water-energy dynamics, demand response and other research efforts that have, over the past 30 years, contributed nearly $484 billion in economic value to the US economy.

We respect California's RDD&D funding as unique in the world. As a fulcrum of numerous CEC applications we have perspectives based on our extensive experience applying for a wide variety of EPIC funding.

These comments are merely offered based on our extensive experience applying to and participating in EPIC-funded projects. We have organized our comments around the CECs format followed in the Request for Comments document questions/format:

CEC Questions and Responses:

1. **(For all groups) Are the proposed funding amounts identified in this Request for Comments (RFC) appropriate for the work requested? Please explain the rationale behind the recommendations, and if applicable, what the appropriate level of funding should be to develop the products identified in this draft solicitation?**

(General)
Berkeley Lab is leading the development of tools such as the Distributed Energy

Resources Customer Adoption Model (DER-CAM)[1], a state of the art decision support tool used extensively to address the problem of optimally sizing and scheduling distributed energy resources under multiple microgrid settings. Berkeley Lab over the years, has invested in developing DER-CAM, that is widely adopted by the industry in multiple large and small microgrid designs around the world. For such tools to be a statewide resource, the interfaces for design inputs need to be simple to use and the outputs should be visual. In addition, most microgrid tools today take into account the spot prices of the technology and do not integrate well into a forecasting model - both for the rates and possible monetization strategies as well as costs of the technology. In our experience, tools like DER-CAM which have the potential to be comprehensive, robust and a central resource, the amount of investment needed is approx $2M for the front end, $1M for the core optimization engine integration with other COTS modules such as rate engine, weather forecasting and $1M for robust testing framework.

**2. (For all groups) What are specific recommendations you can provide to improve the group descriptions of the solicitation outlined in this RFC that would result in a better evaluation of the impacts of high concentrations of DER? Please explain the rationale behind the recommendations.**

(General)

- We recommend that for the tools contemplated, it will be important that the tools incorporate a multi-node architecture with power flows or exchanges between nodes.
- Tool should be able to integrate with a library of standard DER modules.
- Most tools today take into account some average value cloud impact analysis. For much more robust analysis, we recommend exploring a more thorough cloud impact analysis especially for solar resources.
- Most tools today are standalone and do not have interfaces to the ISO and DSO interfaces. For the locational value, it will be important for the tools to have the ISO/DSO interfaces.
- Because Microgrids are more holistic, it is important that the tools model not only electric and thermal energy, but also effects of energy efficiency and demand response. Tools would integrate Volt/VAR support as well as modeling stochasticity and EV modeling and energy storage modeling with an acceptable runtime performance.
- Energy storage is key to microgrids - however the representation of storage is simplistic. Since storage is largely electrochemical, physics based representation of storage would be more accurate.
- In urban environments, since most of the DERs are combination of PV and storage, we recommend investigating methods to parameterize simple models of distribution feeder power consumption and PV generation using historical data that would be capable of estimating feeder-level PV production using real-time measurements. We recommend data-driven approach for estimating PV

[1] https://building-microgrid.lbl.gov/projects/der-cam

generation in real time on a per feeder basis, in partnership with the utilities, provided the availability of sufficient information in the form of SCADA, AMI, (potentially) distribution PMU, weather, and PV production measurements. This would benefit the developers from lucrative placement of DERs and utilities from accessing a real-time estimation of PV production on a per-feeder basis on second to sub-second timescales.

- Modeling tools today focus on steady state modeling with a clear focus on minimizing overall costs, which are usually sufficient for grid connected operation. However, for islanded operation we recommend validating battery sizing taking into account dynamic conditions (sudden changes in load, generation, etc). In our experience, it would be beneficial to be able to integrate this functionality.
- For monetization, the market models should be sophisticated enough to model different types of market participation opportunities. Monetization of microgrids depend on participation in capacity markets and other ancillary services market. On a territory by territory basis, or feeder by feeder basis, we should be able to rank order the ancillary services by monetary value as well as determine possible capacity of DERs that can be enabled.

(Regarding Group 2)

- Since the IOUs have distinct distribution service territories, the objective of having a translation tool among the distribution planning tools will benefit most from analysis with integration of the transmission-level grid. Therefore, the interoperability of the developed tool with transmission planning tools is essential.

**3. (For all groups) Are there existing efforts that complement the groups identified in this RFC? Are there specific changes to this proposed solicitation that you would suggest to better leverage these existing efforts? Please explain the rationale behind the recommendations and the expected value of your recommendations.**

(General)
Berkeley Lab is currently developing a software prototype to illustrate the potential for DER-CAM to be used as a tool to provide information on aspects related to the locational value of DER, as well as on grid impacts associated with high levels of DER penetration. Continuing on this effort, we would like to pursue additional research in collaboration with CA utilities to determine key issues including optimal microgrid siting, locational value of DER, and leveraging DER and microgrids to provide grid supportive services.

(Regarding Group 1)
CyDER[2] by Berkeley Lab includes a system planning tool that streamlines approval processes for DERs such as PVs, which can be extended to microgrids planning. Since

[2] https://energy.gov/eere/sunshot/project-profile-cyder-cyber-physical-co-simulation-platform-distributed-energy

CyDER is modular and interoperable with the existing commercial tools such as CYME, the framework is scalable to a large number and variety of DERs. This feature of CyDER can bring significant benefits to a project in Group 1 in assessing values of different types and use cases of microgrids.

(Regarding Group 2)
The purpose of this comment is to make the commission aware of research, development, and application activities related to open-source, cross-tool modeling frameworks for electric grids making use of FMI and Modelica-based tools. From the projects described below, an estimated $30 million has gone to support projects that use or develop FMI/Modelica-based tools with power system simulation applications. In addition, ABB manages 7% of the power in Germany by an FMI/Modelica-based toolchain[3].

In addition, the European Network of Transmission System Operators, ENTSO-E, which represents 42 electricity transmission system operators (TSOs) from 35 countries across Europe, has begun to embrace these type of standards, thanks to the results of the iTesla[4] and OpenCPS European project, which will be described further below. These results gave the necessary input to ENTSO-E in the development of a document[5] that explains how Modelica models can be linked to the Common Grid Model Exchange Standard (CGMES), which is now part of the CGMES v2.5 documentations (Annex F)[6]. The ability to couple the mathematical models defined in the Modelica language with CIM as now specified in the CGMES v2.5 standard implies that IOP tests must be carried out to assess conformance to the standard.

The ENTSO-E Common Information Model (CIM) interoperability tests facilitate the development of CIM standards for both ENTSO-E and International Electrotechnical Commission (IEC). IEC CIM standards are also used in North America. These IOP tests are tailored to ensure adequate representation of important business requirements for TSOs. The tests are also designed to allow vendors to verify the correctness of the interpretation of the CIM standards. The tests directly support ENTSO-E processes towards achieving the objectives of the EU Third Energy Package. ENTSO-E was established and given legal mandates by the EU's Third Legislative Package for the Internal Energy Market in 2009, which aims at further liberalizing the gas and electricity markets in the EU. The integration of renewable energy sources (RES), which is a major target of the EU's energy and climate policy objectives for 2020 and beyond, will affect existing electricity grid infrastructure, operations and the functioning of the electricity market itself. The integration of renewables into the power system requires for their intermittency to be balanced. This can be tackled by electricity grids operating

[3] https://liu.se/en/article/liu-software-regulates-german-electricity-production
[4] http://www.itesla-project.eu/
[5] ENTSO-E, "Use of Modelica in the Dynamics profile of the CGMES version 2.4," Version 2, January 31, 2016.
[6]https://www.entsoe.eu/Documents/CIM_documents/IOP/CGMES_2_5_TechnicalSpecification_61970-600_Part%201_Ed2.pdf

smartly and cost efficiently. To do this, a seamless and efficient information exchange is recommended at various stages, between an increasing number of companies – TSOs, DSOs, generators, etc., - that will need to perform modeling and simulation-based studies and to use models in operations, which is beyond their current operational practices.

The Functional Mockup Interface (FMI)[7] creates a tool-independent standard by which dynamic models can be exchanged or co-simulated among the different tools. The models are encapsulated in a zip file containing C code expressing the model, and solvers if necessary, and an xml file expressing model metadata. These zip files are called Functional Mockup Units (FMU). FMI is managed by the Modelica Association[8], developed by a nine-member steering committee (BOSCH, Dassault Systemes, dSPACE, ESI ITI, IFP EN, Maplesoft, Modelon, QTronic, Siemens PLM), and advised by a nine-member advisory committee (AVL, DLR, Fraunhofer, IBM, Open Modelica Consortium, Synopsys, TWT, University of Halle, Wolfram MathCore AB). There are 101 tools that currently do or plan to support the FMI standard. These tools span a number of sectors, including automotive, aerospace, manufacturing, and energy.

FMI is used extensively in the Cyber Physical Co-simulation Platform for Distributed Energy Resources project (CyDER)[9], which is focused on developing a modular and scalable tool for power system planning and operation. The project is funded by the U.S. Department of Energy as part of the Sunshot Initiative and is led by Lawrence Berkeley National Laboratory, with partners Lawrence Livermore National Laboratory, PG&E, and EATON. The tool is built on three pillars: quasi-static time series co-simulation and optimization, real-time data acquisition, and hardware-in-the-loop application. FMI is used to export models from the CYMDIST[10] distribution system analysis software and GridDyn[11] power transmission simulation software package for co-simulation of the distribution and transmission systems. Additionally, a PV forecasting tool developed as part of the project and an EV forecasting tool, V2G-Sim[12], are used to provide input data to the co-simulation.

Power system model validation is required by the WECC[13]. The policy for “Generating Unit Model Validation” has been in place since 2012, however, due to the lack of adequate standards in the power system field for model exchange, only a limited number of tools for conventional generation units have been developed[14]. The integration of renewable energy sources will require more alternatives to these efforts,

[7] http://fmi-standard.org/
[8] https://www.modelica.org/
[9] https://energy.gov/eere/sunshot/project-profile-cyder-cyber-physical-co-simulation-platform-distributed-energy
[10] http://www.cyme.com/software/cymdist/
[11] https://github.com/LLNL/GridDyn
[12] http://v2gsim.lbl.gov
[13] https://www.wecc.biz/Corporate/WECC%20Generating%20Unit%20Model%20Validation%20Policy%202012.pdf
[14] https://energy.gov/sites/prod/files/2014/09/f18/05-2014TR-PeerReview-Etingov.pdf

and the FMI standard would be a key enabler for their development. An example of this potential is the open-source software tool RaPId[15], which allows for the measurement-based calibration of any model within an FMU[16].

The value of FMI is starting to be recognized also by power system domain software vendors in North America. In particular, the EMTP-RV software (http://www.emtp-software.com/) now provides support for the FMI standard, allowing the tool to provide support for multi-time-step and multi-core simulations, which are necessary to speed up the performance and speed-up computations when analyzing fast dynamics of renewable energy sources such as wind parks[17]. However, the case of EMTP-RV is an exception, and not a rule in the power system domain.

Other open-source power system modeling efforts are occurring using Modelica, an open-source, equation-based modeling language for dynamic simulation of engineering systems that span multiple physical domains. Modelica is being used in the automotive, aerospace, manufacturing, and energy sectors, including power generation, power distribution, and building energy consumption. The IBPSA Project 1[18] is an international collaboration between 30 institutions to create Modelica and FMI-based component models and tools to simulate energy systems from the building to the district scales, including power systems. OPENCPS[19] is a European project focusing on cyber-physical system modeling tools and environment development, including interoperability of Modelica/UML/FMI, improved execution speed, co-simulation, and certified code generation. The iTesla project [http://www.itesla-project.eu/] created the iTesla Power System Library (iPSL) containing power system component models for phasor time domain simulations in Modelica. Development of this library has been continued in the OpenIPSL: Open-Instance Power System Library[20].

(Regarding Group 3)
For capacity planning a MIPs model may be employed for capacity analysis and related scenarios. Berkeley Lab is engaged in developing techniques for improving the runtime performance of the optimization engine used for designing and planning microgrids.

4. **(For groups 2, 3 and 4) Should it be required that all source code generated as a result of this solicitation be hosted on a public open-source developers site such as GitHub? If not, describe how to ensure distributed version control and source code management functionality while making the open-source code available to the open-source developers' community.**

(General)

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[15] http://www.sciencedirect.com/science/article/pii/S235271101630019X
[16] https://github.com/SmarTS-Lab/iTesla_RaPId
[17] http://www.emtp-software.com/page/fmi-options
[18] https://ibpsa.github.io/project1/
[19] https://www.opencps.eu
[20] https://github.com/SmarTS-Lab/OpenIPSL

- Linux Foundation partnership could help with source code control as well as access to a robust developer community to advance the tools contemplated.
- Another option to consider is providing a cloud based hosting resource for the tool with an ability to perform runtimes and scenarios by users in their own space. Berkeley Lab currently provides the service for thousands of DER-CAM users.

**5. (For all groups) Are there suggestions to better complement the needs associated with CPUC proceedings related to Modeling, distributed renewable generation, electric vehicles, the use of Smart Grid Technologies and Distribution Resource Planning? Please provide specific recommendations and rationale.**

(General)
Tools that are used for design and configuration for microgrids should play an important role in being able to transfer the design and monetization assumptions to the controller of the microgrids via a standardized software. The same could also be accomplished via developing a common information model that captures the specification of DERs and possible value streams of the DERs as well as their interaction with the storage modules for the purposes of design, configuration and control of microgrids and the underlying resources.

Should you need any clarification on the comments above we would be delighted to provide it.

Berkeley Lab looks forward to continuing to engage with the CEC and other key stakeholders in helping adoption of clean energy technologies. It has been our privilege to work with the State of California on critical issues affecting the State and our environment. As a representative member of our country's National Laboratory system, Berkeley Lab greatly values the opportunity to participate as a stakeholder in this process.

Respectfully,

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