From:	Clifton Below
To:	PUC: Executive.Director; allison@44northlaw.com; amfarid@dartmouth.edu; Bart.Fromuth@felpower.com; Buckley, Brian; brian.rice@eversource.com; charliespencevt@gmail.com; Shute, Christa; christine.hastings@eversource.com; devin@utilityapi.com; Kreis, Donald; dpatch@orr-reno.com; eisfeller@unitil.com; epler@unitil.com; erica.menard@eversource.com; ethan.goldman@gmail.com; golding@communitychoicepartners.com; heather.tebbetts@libertyutilities.com; henry@cleanenergynh.org; Brennan, James J; Morse, Jason; jessica.chiavara@eversource.com; jmarks@acadiacenter.org; Julia Griffin; Cramton, Karen; karen.sinville@libertyutilities.com; kat.mcghee@leg.state.nh.us; katherine.peters@eversource.com; katherine.provencher@eversource.com; kelly@cleanenergynh.org; Demmer, Kurt; madeleine@cleanenergynh.org; marc.lemenager@eversource.com; matthew.fossum@eversource.com; maureen.karpf@libertyutilities.com; mdean@mdeanlaw.net; Melissa.Samenfeld@libertyutilities.com; michael.sheehan@libertyutilities.com; michael@missiondata.io; nikhil@greentelgroup.com; PUC - OCA Litigation; paul@packetizedenergy.com; pmartin2894@yahoo.com; Shaun Mulholland; simpsonc@unitil.com; Eckberg, Stephen; Frink, Stephen; Tad Montgomery; Greg Ames; Frantz, Tom
Subject:	RE: Docket No. 19-197 Development of a Statewide Multi-Use Online Energy Data Platform - Staff Rebuttal Testimony
Date:	Friday, October 23, 2020 4:37:22 PM
Attachments:	19-197 LGC Rebuttal Testimony of A Salas.pdf 19-197 LGC Rebuttal Testimony of A Farid.pdf

And witnesses Farid, Salas, a

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From: Clifton Below
Sent: Friday, October 23, 2020 4:28 PM
To: PUC: Executive.Director <Executive.Director@puc.nh.gov>; allison@44northlaw.com; amfarid@dartmouth.edu; Bart.Fromuth@felpower.com; Buckley, Brian <Brian.D.Buckley@puc.nh.gov>; brian.rice@eversource.com; charliespencevt@gmail.com; Shute, Christa <Christa.B.Shute@oca.nh.gov>; christine.hastings@eversource.com; devin@utilityapi.com; Kreis, Donald <Donald.M.Kreis@oca.nh.gov>; dpatch@orr-reno.com; eisfeller@unitil.com; epler@unitil.com; erica.menard@eversource.com; ethan.goldman@gmail.com; golding@communitychoicepartners.com; heather.tebbetts@libertyutilities.com; henry@cleanenergynh.org; Brennan, James J <James.J.Brennan@oca.nh.gov>; Morse, Jason <Jason.J.Morse@puc.nh.gov>; jessica.chiavara@eversource.com; jmarks@acadiacenter.org; Julia Griffin <julia.griffin@hanovernh.org>; Cramton, Karen <Karen.P.Cramton@puc.nh.gov>; karen.sinville@libertyutilities.com; kat.mcghee@leg.state.nh.us; katherine.peters@eversource.com; katherine.provencher@eversource.com; kelly@cleanenergynh.org; Demmer, Kurt <Kurt.F.Demmer@puc.nh.gov>; madeleine@cleanenergynh.org; marc.lemenager@eversource.com; matthew.fossum@eversource.com; maureen.karpf@libertyutilities.com; mdean@mdeanlaw.net; Melissa.Samenfeld@libertyutilities.com; Clifton Below <Clifton.Below@lebanonnh.gov>; michael.sheehan@libertyutilities.com; michael@missiondata.io; nikhil@greentelgroup.com; PUC - OCA Litigation <OCALitigation@oca.nh.gov>; paul@packetizedenergy.com; pmartin2894@yahoo.com; Shaun Mulholland <Shaun.Mulholland@lebanonnh.gov>; simpsonc@unitil.com; Eckberg, Stephen <Stephen.R.Eckberg@puc.nh.gov>; Frink, Stephen

<Stephen.P.Frink@puc.nh.gov>; Tad Montgomery <Tad.Montgomery@lebanonnh.gov>; Greg Ames <tga@tga3.com>; Frantz, Tom <Thomas.C.Frantz@puc.nh.gov>
Subject: RE: Docket No. 19-197 Development of a Statewide Multi-Use Online Energy Data Platform - Staff Rebuttal Testimony

Attached please find the rebuttal testimony of the LGC witness Golding. Hard copies will not follow pursuant to the PUC's pandemic procedures.

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STATE OF NEW HAMPSHIRE

BEFORE THE

PUBLIC UTILITIES COMMISSION

Docket No. DE 19-197

Electric and Natural Gas Utilities

Development of a Statewide, Multi-use Online Energy Data Platform

REBUTTAL TESTIMONY OF

APRIL SALAS

October 23, 2020

On behalf of

The Town of Hanover

& the Local Government Coalition

Q. Please identify yourself and previous involvement in this docket.

A. I am April Salas, Sustainability Director, Town of Hanover, 41 South Main Street, Hanover, NH 03755. I filed Direct Testimony on behalf of the Town of Hanover and Local Government Coalition. I've also attended and participated in a number technical sessions including those before the filing of testimony and collaborated in written commentaries during that process which are referenced in Dr. Farid's and Clifton Below's testimony.

Q. What is your rebuttal testimony?

A. Eversource and Unitil (EU) asked me 3 discovery questions that clarified several points in my direct testimony. I am submitting my responses to their discovery requests as my rebuttal testimony. The standard discovery response formatting has been removed, except for the request number line. A few minor (non-substantive) typos have been fixed.

Request No. EU to LGC 1-019 Witness & Respondent: April Salas

Page 16, line 9: Please cite the regulatory authority mentioned that allows for a data request once per year.

RESPONSE: See "Original Page 29" of Liberty Utilities Tariff and subsequent terms: https://newhampshire.libertyutilities.com/uploads/Rates%20and%20Tariffs/Electric%202020/2020-08-01%20GSE%20Tariff%20No.%2021.pdf under § 49:

"iv. Services Provided – One per Calendar Year with No Fee

1. Usage and Billing kW Data"

Request No. EU to LGC 1-020 Witness & Respondent: April Salas

Page 16, line 11-13: Please explain why the authorization process to receive large customer data was delayed if the customers had consented to sharing their data.

RESPONSE: This question should be directed to Liberty Utilities. Explicit approval was required and obtained, which took upwards of six months, and then for reasons unknown to the Town of Hanover, we experienced delays in receiving the requested/approved information.

Request No. EU to LGC 1-021 Witness & Respondent: April Salas

Page 17, line 6-10: Please describe in detail the structure and format of the data received, the inaccuracies present in the data, how the data "immediately began to degrade with time", and why no simple process exists to replicate this data acquisition effort.

RESPONSE: Data requested included 15-minute interval data, recorder/location ID, date, KW and KVA. We requested this information for only the six largest electric customers in the town of Hanover.

What was received just for the six largest users was a mix of Excel files with inconsistently formatted rows and columns, as well as hourly data for some accounts and 15-min interval data for others. When reviewing location/recorder ID numbers, we found overlapping dates/times with differing KW and KVA data. Additionally, we had to undertake the tedious task of combing through thousands of lines of data to parcel through recorder ID numbers and attach them to 'rate classes' to derive meaningful information related to our community's electric load. For example, it should not be surprising that some entities have meters that fall within more than one rate class, such as residential, small, medium, and large commercial: G3, G2, and G1, so this data needs to be sorted. Moreover, the data that was received took nearly 6 months to receive, about a month more to 'process', and it was all instantly out of date due to the fact that it is a historical snapshot in time.

There is no system in place to automate the customer permissions (or revocation if it is to be ongoing open-ended permission) and/or to provide updated data to the town on a continuing and regular basis, much less to assure the consistent formatting and quality of the data or provide permission-free aggregated data. The utilities need to ask themselves the question "why no simple process exists to replicate this data acquisition effort?"

Q. Does this conclude your rebuttal testimony?

A. Yes, it does.

THE STATE OF NEW HAMPSHIRE

BEFORE THE

PUBLIC UTILITIES COMMISSION

DE 19-197

Electric and Natural Gas Utilities

Development of a Statewide, Multi-use Online Energy Data Platform

Rebuttal Testimony of Dr. Amro M. Farid

On behalf of
City of Lebanon, NH &
Local Government Coalition

October 23, 2020

Q. Please identify yourself and previous involvement in this docket.

A. I am Dr. Amro M. Farid, an Associate Professor of Engineering at the Thayer School of Engineering at Dartmouth and an Adjunct Associate Professor of Computer Science at the Department Science at Dartmouth College, which is located at 14 Engineering Drive, Hanover, NH. I am also the Chief Executive Officer of Engineering Systems Analytics (ESA) LLC, which is located at 89 Washburn Hill Road, Lyme NH. I previously filed direct testimony in this proceeding on behalf of the City of Lebanon as part of the Local Government Coalition. Prior to that I participated in most of the technical sessions and provided commentary in my areas of expertise. Most recently I responded to a set of discovery/data requests from Eversource and Unitil.

Q. What is your rebuttal testimony?

A. Eversource and Unitil (EU) asked 19 discovery questions of me. Some elicited additional background and clarification of my direct testimony, while others were, perhaps, more adversarial in contrasting their positions with my own. Since all my responses elucidate my testimony in contrast to their positions, especially where we differ, I am submitting my responses to their discovery requests and questions as my rebuttal testimony. The standard discovery response formatting has been removed, except for the request number line. A few responses have had minor (non-substantive) typos fixed. My response to Request No. EU to LGC 1-070 on pages 6-12 below, concerning TVR, was prepared in collaboration with witness Clifton Below and should be considered the joint testimony of both of us.

Request No. EU to LGC 1-067 Witness & Respondent: Dr. Amro M. Farid

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Page 132, line 3: Please provide the syllabus for the course referenced and provide details on how long you've been teaching this course.

RESPONSE: Please see Attachment EU to LGC 1-067 for the ENGG 199: Model Based Systems Engineering, Analysis and Simulation course. I've taught some variation of this course since 2011.

Request No. EU to LGC 1-068 Witness & Respondent: Dr. Amro M. Farid

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Page 132, line 8: Does EPECS perform active management of transmission system configuration or voltage or frequency management? Give examples of services or reports provided.

RESPONSE: Yes, it does. Please see the following peer-review publications for details.

1. A. M. Farid and A. Muzhikyan, "The Need for Holistic Assessment Methods for the Future Electricity Grid (Best Applied Research Paper Award)," in GCC CIGRE Power 2013, (Abu Dhabi, UAE), pp. 1–12, 2013.
2. A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, "Variable Energy Resource Induced Power System Im- balances: A Generalized Assessment Approach," in IEEE Conference on Technologies for Sustainability, (Portland, Oregon), pp. 1–8, 2013.
3. A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, "Variable Energy Resource Induced Power System Imbalances: Mitigation by Increased System Flexibility, Spinning Reserves and Regulation," in IEEE Conference on Technologies for Sustainability, (Portland, Oregon), pp. 1–7, 2013.
4. A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, "A Power Grid Enterprise Control Method for Energy Storage System Integration," in IEEE Innovative Smart Grid Technologies Conference Europe, (Istanbul, Turkey), pp. 1–6, 2014.
5. A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, "An Enhanced Method for the Determination of Load Following Reserves," in American Control Conference, 2014, (Portland, Oregon), pp. 1–8, 2014.
6. A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, "An Enhanced Method for Determination of the Ramping Reserves," in IEEE American Control Conference, (Los Angeles, CA, USA), pp. 1–8, 2015.
7. A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, "An Enhanced Method for Determination of the Regulation Reserves," in IEEE American Control Conference, (Los Angeles, CA, USA), pp. 1–8, 2015.
8. A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, "An Enterprise Control Assessment Method for Variable Energy Resource Induced Power System Imbalances Part 1: Methodology," IEEE Transactions on Industrial Electronics, vol. 62, no. 4, pp. 2448–2458, 2015.

9. A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, “An Enterprise Control Assessment Method for Variable Energy Resource Induced Power System Imbalances Part 2: Results,” IEEE Transactions on Industrial Electronics, vol. 62, no. 4, pp. 2459 – 2467, 2015.
10. B. Jiang, A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, “Impacts of industrial baseline errors in demand side management enabled enterprise control,” in IECON 2015 – 41st Annual Conference of the IEEE Industrial Electronics Society, (Yokohama, Japan), pp. 1–6, 2015.
11. A. M. Farid, B. Jiang, A. Muzhikyan, and K. Youcef-Toumi, “The Need for Holistic Enterprise Control Assessment Methods for the Future Electricity Grid,” Renewable & Sustainable Energy Reviews, vol. 56, no. 1, pp. 669–685, 2015.
12. A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, “An A Priori Analytical Method for Determination of Operating Reserves Requirements,” International Journal of Energy and Power Systems, vol. 86, no. 3, pp. 1–11, 2016.
13. A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, “Relative Merits of Load Following Reserves and En- ergy Storage Market Integration Towards Power System Imbalances,” International Journal of Electrical Power and Energy Systems, vol. 74, no. 1, pp. 222–229, 2016.
14. A. Muzhikyan, A. M. Farid, and T. Mezher, “The Impact of Wind Power Geographical Smoothing on Operating Reserve Requirements,” in IEEE American Control Conference, (Boston, MA, USA), pp. 1–6, 2016.
15. B. Jiang, A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, “Demand Side Management in Power Grid Enterprise Control – A Comparison of Industrial and Social Welfare Approaches,” Applied Energy, vol. 187, no. 1, pp. 833–846, 2017.
16. S. O. Muhanji, A. Muzhikyan, and A. M. Farid, “Long-term challenges for future electricity markets with distributed energy resources,” in Smart Grid Control: An Overview and Research Opportunities (J. Stoustrup, A. M. Annaswamy, A. Chakrabortty, and Z. Qu, eds.), pp. 59–81, Berlin, Heidelberg: Springer, 2017.
17. S. O. Muhanji, A. Muzhikyan, and A. M. Farid, “Distributed Control for Distributed Energy Resources: Long-Term Challenges & Lessons Learned,” IEEE Access, vol. 6, no. 1, pp. 32737 – 32753, 2018.
18. A. Muzhikyan, T. Mezher, and A. M. Farid, “Power System Enterprise Control with Inertial Response Procurement,” IEEE Transactions on Power Systems, vol. 33, no. 4, pp. 3735 – 3744, 2018.
19. S. O. Muhanji, A. Muzhikyan, G. Moynihan, D. Thompson, Z. Berzolla, and A. M. Farid, “2017 ISO New England System Operational Analysis and Renewable Energy Integration Study,” in IEEE Systems of Systems Conference, (Anchorage, AK,USA), pp. 1–6, 2019.

20. A. Muzhikyan, S. Muhanji, G. Moynihan, D. Thompson, Z. Berzolla, and A. M. Farid, "The 2017 ISO New England System Operational Analysis and Renewable Energy Integration Study," Energy Reports, vol. 5, pp. 747–792, July 2019.
21. S. O. Muhanji and A. M. Farid, "An Enterprise Control Methodology for the Techno-Economic Assess- ment of the Energy Water Nexus," Applied Energy, vol. 1, no. 1, p. 25, 2019.
22. S. O. Muhanji, W. C. Schoonenberg, and A. M. Farid, "Transforming the Grid's Architecture – Enterprise Control - the Energy Internet of Things and Heterofunctional Graph Theory," IEEE Power and Energy Magazine, vol. 17, no. 5, pp. 71–81, 2019.
23. S. O. Muhanji, C. Barrows, J. Macknick, and A. M. Farid, "An Enterprise Control Assessment Case Study of the Energy-Water Nexus for the ISO New England System," Renewable and Sustainable Energy Reports, vol. 1, no. 1, p. 31, 2020.

Request No. EU to LGC 1-069 Witness & Respondent: Dr. Amro M. Farid

Page 136, lines 20-22:

A. Please elaborate on the definition of "wire's asset".
B. Please explain what communications architecture would be utilized to communicate with customer devices when controlling or indirectly controlling customer devices for the distribution benefit mentioned.
C. Who is responsible for owning and maintaining this communications architecture?
D. Please explain what recourse the utility has for loss of customer communications when relying on immediate demand reduction from customer equipment.
E. Would you expect the customer devices to have local override controls to ensure operation for grid conditions?
F. If the platform does not operate as needed for grid operations, what happens to the grid?
G. Please compare the overall reliability of a customer-controlled device versus a "wire's asset"?
H. How do you expect the customer to be compensated for operation of their devices or penalized for mis-operation?

RESPONSE: The entirety of the second paragraph on Page 136 including lines 20-22 is a direct quote from Electric Power Research Institute website and its peer reviewed EPRI journal. As the leading research and development organization of the electric power sector in the United States, it maintains a membership model for electric utilities. If EU are not already members, I would

encourage them to join where they will have greater access to EPRI research on the Shared Integrated Grid and more specific answers to all of these questions.

Request No. EU to LGC 1-070 Witness: Dr. Amro M. Farid

Respondents: Dr. Farid & Clifton Below

Page 140, lines 4-5: Time varying rates are already available to customers in NH. Please explain "meaningful choices of time-varying rates" in the context of existing rates.

RESPONSE: The quotation is not in specific reference to New Hampshire. The quoted language is part of a one sentence paraphrase of his recent article submitted as "ATTACHMENT D to Testimony of A Farid for LGC" from Bates page 253-259 The full sentence cited in the request is as follows:

"The distinguished energy economist Dr. Ahmad Faruqui[1] in his recent article in the journal Regulation entitled "Refocusing on the Consumer: Utilities regulation needs to prepare for the "prosumer" revolution" recounts the more than 50-year saga of trying to advance a basic building block of grid modernization: customer access to meaningful choices of time-varying rates. [Faruqui 2020][2]. He summarizes this saga and the current state [of] grid modernization in this way: . . ."

The reader is referred to that attachment to understand what Dr. Faruqui might consider meaningful choice of TVR as well as the wealth of articles and presentations he has made on this topic over many years, available through his website hyperlinked to in footnote 1. This EU data request calls for additional research and analysis to consider in the context of NH rates, which is beyond the purpose of a data request, but in this case we won't object as it is a useful exercise to undertake and report thus.

Among Dr. Faruqui's recent writings on rate design we found his co-authored article on "Expanding Customer Choices in a Renewable Energy Future" that includes a section on

[1] https://www.brattle.com/experts/ahmad-faruqui

[2] Attachment D, also found at https://www.cato.org/sites/cato.org/files/2020-03/regv43n1-6.pdf.

"**Principles for Meaningful Rate Options and Signals.**"[3] This article is appended as Attachment EU to LGC 1-070 for easy reference..

Here is what we understand to exist for choices of time-varying rates in existing rates for NH investor-owned electric distribution utilities:

- Unitil apparently does not currently offer any choice of time-varying rates.[4]
- Eversource offers two choices of optional time-varying rates that they call "Time-Of-Use." These are both very simple 2-part rates with a very broad definition of "on-peak"- from 7 am to 8 pm all weekdays, except holidays, with limited differentiation of overall per kWh rates. There is one rate option for residential customers, R-OTOD, and one for small commercial customers under 100kW demand, G-OTOP. While some rate components for larger C&I customers have time varying elements, others do not, and none are optional choices.
- Liberty offers two TVR options, however the choice is limited in both cases to residential customers. Most residential customers can choose the Rate D-10 option. It has a broad on-peak period of 8 am to 9 pm weekdays except holidays. It only applies TOU rates to distribution charges, though it does so with a broad differential. The other TVR option is rate D-11, the 3-part TOU rate developed for Liberty's battery pilot, in part by LGC witness Clifton Below.[5] The Regulatory Assistance Project characterized it this way in their recent publication "Rate Designs for Modern Grid"[6]: ***"[t]he Liberty storage pilot rate design accepted by the New Hampshire PUC is the most advanced modern rate design in New England, and closest to the Maryland rate designs" that they characterize as one of the most well designed TOU rates.*** The battery storage pilot at this stage is limited to only 100 customers and we understand that it is fully subscribed with a waiting list, so unless someone drops out and you are at the top of the waiting list, this rate is not currently a choice for anyone. An identical 3-period TOU rate has recently been made available to residential customers for charging plug-in electric vehicles as Rate EV. However, there is an additional monthly customer charge for the separate meter and it isn't

[3] "Expanding Customer Choices in a Renewable Energy Future," Ahmad Faruqui, Principal, and Mariko Geronimo Aydin, Senior Associate, The Brattle Group, in *Leadership in Rate Design, A Compendium of Rates Essays, Supplement to Public Power Magazine*, May-June, 2019. Available here: https://www.publicpower.org/system/files/documents/Leadership-in-Rate-Design.pdf

[4] https://unitil.com/energy-for-businesses/electric-information/tariffs

[5] See https://www.puc.nh.gov/Regulatory/Docketbk/2017/17-189/LETTERS-MEMOS-TARIFFS/17-189_2018-11-19_GSEC_TECH_STATEMENT_TOU.PDF

[6] See pages 10-11, "Rate Designs That Work for a Modern, Customer-Oriented Grid" by David Littell and Joni Sliger, Regulatory Assistance Project, 2/20, https://www.raponline.org/wp-content/uploads/2020/02/rap-littell-sliger-rate-designs-modern-customer-oriented-grid-2020-february.pdf

supposed to be used for purposes other than charging EVs. The customer also has to commit to the rate for a minimum of 2 years and they would need to invest in an additional meter socket, load panel, and circuit to power a dedicated vehicle charger if they don't already have such.

In terms of how meaningful these options are, with the exception of Liberty's 3-part TOU rate which is only available to a very limited portion of all customers for limited purposes, the 3 other options all are conventional 2-part rates with a 13 hour on-peak period on all work week days, that is too broad to get much price response from shifting load or storage. It is not clear whether Eversource's R-OTOD and G-OTOD rates are revenue (or customer cost) neutral compared with Rates R and G for a customer with class average load shape particularly because they have fixed customer charges that are about twice that of the standard non-TOU Rates R and G.

The meaningfulness of these limited offerings can be judged, in part, by the portion of customers that find them meaningful enough to choose these options. The Grid Modernization Working Group Final Report[7] included this snapshot of how many customers choose these TVR rates:

Table B.7 Number of Customers for Each Rate Offering

	Eversource			Unitil			Liberty		
	Residential	Gen. Service	Outdoor lighting	Residential	Gen. Service	Outdoor lighting	Residential	Gen. Service	Outdoor lighting
Flat energy rates	426,576	-	953	-	724	-	-	7,239	
Inclining block rates	-	-	-	65,237	-	-	35,435	-	-
Declining block rates	-	75,517	-	-	-	-	-	-	-
Seasonal Rate	-	-	-	-	-	-	-	-	-
Time-of-use rates	38	159	-	-	-	-	1,420		-
Critical peak pricing	-	-	-	-	-	-	-	-	-
Peak-time rebates	-	-	-	-	-	-	-	-	-
Total no. of customers:	426,614	75,676	953	65,237	11,181	1,706	35,877	6,436	685

For Eversource TOU rates attracted a mere 4/100 of 1% of customers, while Liberty's 2-part TOU rate, with the same customer charge as Rate D, did about 100 times better, but still only a mere 3% of all customers found this TOU rate to be meaningful enough to choose. In contrast, Dr. Faruqui reports much higher levels of participation in more meaningful TVR rate programs[8]:

[7] At p. 39, https://www.puc.nh.gov/Regulatory/Docketbk/2015/15-296/LETTERS-MEMOS-TARIFFS/15-296_2017-03-20_NH_GRID_MOD_GRP_APP_FINAL_RPT.PDF

[8] "Moving Ahead with Time-Varying Rates (TVR): US and Global Perspectives, 4/620, Ahmad Faruqui Presented to NARUC Staff Subcommittee on Rate Design, Slide 2: https://brattlefiles.blob.core.windows.net/files/18500_moving_ahead_with_time-varying_rates_tvr_-_us_and_global_perspectives.pdf

TVRs are deployed to residential customers around the world

	Type of Rate	Applicability	Participating Customers
Oklahoma *(OGE)*	Variable Peak Pricing (VPP)	Opt-in	20% (130,000)
Maryland *(BGE, Pepco, Delmarva)*	Peak Time Rebate (PTR)	Default	80%
Ontario, Canada	Time-of-Use (TOU)	Default	90% (3.6 million)
Great Britain	Time-of-Use (TOU)	Opt-in	13% (3.5 million)
Hong Kong *(CLP Power Limited)*	Peak Time Rebate (PTR)	Opt-in	27,000
Arizona *(APS, SRP)*	Time-of-Use (TOU)	Opt-in	APS: 57%, SRP: 36%
California *(PG&E, SCE, SDG&E)*	Time-of-Use (TOU)	Default (2020)	TBD – 75-90%*
California *(SMUD)*	Time-of-Use (TOU)	Default	75-90%*
Colorado *(Fort Collins)*	Time-of-Use (TOU)	Mandatory	100%
Illinois *(ComEd, Ameren IL)*	Real Time Pricing (RTP)	Opt-in	50,000
Michigan *(Consumers Energy)*	Time-of-Use (TOU)	Default (2020)	TBD – 75-90%*
France	Time-of-Use (TOU)	Opt-in	50%
Spain	Real Time Pricing (RTP)	Default	40%
Italy	Time-of-Use (TOU)	Default	75-90%*

*Estimated participation based on historical trends

Next, we consider the legal and regulatory history in New Hampshire to consider what might be a meaningful choice of TVR rates and consider some historical touchstones:

- For 24 years NH's electric utility restructuring statute has called for the development of a competitive retail market for electricity supply and other related services, and specifically stated:

  Competitive markets should provide electricity suppliers with incentives to operate efficiently and cleanly, open markets for new and improved technologies, ***provide electricity buyers and sellers with appropriate price signals,*** *and improve public confidence in the electric utility industry. [*And that:*] Customers should be able to choose among options such as . . . real time pricing.*[9]

- 22 years ago the original implementation of the EDI in New Hampshire was designed to accommodate 3 period time-of-use rates that could be differentiated by day of week and seasonally and that could be offered by competitive suppliers. The periods were characterized as on-peak,

[9] RSA 374-F:1 and RSA 374-F:3, II.

shoulder, and off-peak, with data fields for kWh usage, kW, and kVA in each period. [10] At that time the anticipated business relationships, like Data Platform Use Cases, to be supported by the EDI included the following:

> "Competitive Service Providers:
>
> "(i) Offer large customers or their authorized agents competitive metering products or services.
>
> (ii) Notify Distribution Company of agreements to provide metering products and services to large customers.
>
> (iii) Install telemetering equipment at customer locations for the purpose of replacing estimated usage data with measured usage data.
>
> (iv) Notify Distribution Company when telemetering installations have been completed and whenever the equipment malfunctions.
>
> (v) Allow Distribution Companies to access the meter for usage determination or provide usage data to Distribution Companies in electronic format in a timely manner.
>
> (vi) Fulfill applicable registration requirements prior to doing business in New Hampshire.
>
> (vii) Abide by applicable rules and/or orders issued by the Commission.
>
> (viii) Nominate business and technical contact persons to facilitate inter-business communications."[11]

- 13 years ago, the Commission took note of the fact:

> . . . that ISO-New England has recommended that the conventional peak/off-peak time-of-use rate structure be modified to provide customers a reasonable opportunity to shift load from peak period. Specifically, ISO-New England recommended a structure that includes a minimum of three periods: peak, shoulder and off-peak. The peak period would be shorter than the peak period in conventional time-of-use rates, which for some utilities extends from 7:00 a.m. until 8:00 p.m., Monday through Friday.[FN omitted] Reducing the number of hours in the peak period and adding a shoulder period would,

[10] See the totality of the documents at https://www.puc.nh.gov/Electric/edi.htm and the definitions in the Glossary of Terms on pages 49-50 of the "Consensus Plan for the Transmission of Electronic Data in New Hampshire's Retail Electric Market," April 2, 1998, DR 96-150, https://www.puc.nh.gov/Electric/EDI/edirev53.pdf.
[11] Id at 11.

according to ISO-New England, provide customers a much greater incentive for customers to shift load out of the peak period because the shorter peak period produces a higher cost-based peak rate, while the shoulder period provides a convenient home for the load shifted out of the peak period.[12]

- Last month, in its "Order Determining the Appropriateness of Rate Design Standards for Electric Vehicle Charging Stations Pursuant to SB 575" while discussing Staff's recommendation for consistent seasonal 3-period TOU rates to apply to all 3 major rate components for residential electric vehicle charging, the Commission noted Eversource's assertion that its existing two-period TOU rates "are an appropriate starting point for serving customers with EVs"[13] The Commission observed and concluded:

> Based on December 2019 registration data, New Hampshire is home to approximately 4,200 electric vehicles. Tr. at 91. Only approximately 40 of Eversource's more than 400,000 residential customers take service under the residential time of use rate. Staff Memo at 3. The lack of interest in Eversource's existing two-part rate structure suggests that it may be inadequate for purposes of electric vehicle charging. We also take administrative notice of Eversource's filing in DE 19-057 to note Eversource's recent petition for a rate increase declined to revise its residential time of use rate despite advice from its own cost of service consultant to the contrary.
>
> The guidelines proposed by the Commission Staff regarding a consistent framework for separately metered residential electric vehicle charging rate designs are appropriate, subject to three clarifications. First, we agree with the City of Lebanon that the five-hour peak duration is more appropriate than the four-hour peak duration. Second, the 3:1 peak to off-peak ratio should represent an average ratio during a given year, not during any one season. Third, we note that these guidelines serve as a useful starting point and are generally consistent with the rate designed and approved for the purposes of Liberty's Battery storage pilot, and later adopted for Liberty's separately-metered EV

[12] NHPUC Order # 24,763, 6/22/07, p. 24, https://www.puc.nh.gov/Regulatory/CaseFile/2006/06-061/ORDERS/Order%20No.%2024,763%20%20Regarding%20the%20Adoption%20of%20Standards%20for%20Time-Based%20Metering%20and%20Interconnection%20-6-22-07.pdf
[13] NHPUC Order # 26,394, 8/18/20, p. 16, https://www.puc.nh.gov/Regulatory/Docketbk/2020/20-004/ORDERS/20-004_2020-08-18_ORDER_26394.PDF.

TOU Rate. Liberty Utilities (Granite State Electric) Corp., Order No. 26,376 at 9. (June 30, 2020).[14]

Request No. EU to LGC 1-071 Witness & Respondent: Dr. Amro M. Farid

Page 144, line 5: Please explain how the PUC would determine the reasonableness of costs before implementing the platform, if the regulatory process excludes these requirements.

RESPONSE: My testimony on Page 144, line 5 and indeed the entirety of Q5.2 does not make any mention "reasonableness of costs". The EU have posed a question that does not concern my testimony.

Request No. EU to LGC 1-072 Witness & Respondent: Dr. Amro M. Farid

Page 146, lines 4-7: If the utilities are stakeholders, users of the data, and solely knowledgeable of back end systems, why should the utilities not be involved in the functional design of the platform?

RESPONSE: The question seemingly misconstrues my testimony. My testimony does not state: "the utilities should not be involved in the functional design of the platform" as written in the question above. My testimony states: *"I do not interpret RSA 378:52,I to mean that the utilities shall exclusively conduct all technical activity related to the data platform.*" It is clear that RSA 378:52, I states: "*the utilities shall design and operate the energy data platform*" which is a statement of the necessity of the utilities' design role. However, the law does not explicitly state that this design and operation role belongs exclusively to the utilities. Therefore, there is no explicitly stated reason for me to conclude that the utilities are sufficient to design and operate the energy data platform. Furthermore, and as my testimony states, "*I do not believe it to be in the best interest of the New Hampshire public to do so*". Necessity is not equivalent to sufficiency.

Request No. EU to LGC 1-073 Witness & Respondent: Dr. Amro M. Farid

Page 146, lines 14-16: Please provide representative examples of where niche engineering consultancies are less expensive.

[14] Id at pp. 16-17.

RESPONSE: mPrest, Kevala, and Engineering Systems Analytics provide engineering services at rates that are "often less expensive" than more "well-known" engineering organizations with expertise in requirements engineering.

Request No. EU to LGC 1-074 Witness & Respondent: Dr. Amro M. Farid

Page 150, lines 9: Please explain extensibility of the platform with examples.

RESPONSE: Page 150, line 9 is the third of five requirements that are summarized from the LGC scoping comments. The scoping comments at tab 27 of the Docket Book in this proceeding explains what extensibility is and how to best achieve it.

Request No. EU to LGC 1-075 Witness & Respondent: Dr. Amro M. Farid

Page 150, line 16: Please provide a list of commercially-neutral grid stakeholders.

RESPONSE: It's impossible to provide an exhaustive list for the simple reason that the implementation of the data platform may require a commercially-neutral non-for-profit entity to be formed as a new entity. Beyond this possibility, some commercial-neutral grid stakeholders are non-for-profit organizations. These include an Independent System Operator (e.g. ISO New England), academia (e.g. Dartmouth College or UNH), a non-for-profit customer-owned utility (e.g. New Hampshire Electric Co-Op), or a government entity such as the Public Utility Commission, Office of the Consumer Advocate, or municipality. For-profit supply-side grid stakeholders such as investor-owned utilities and demand-side consumers are not commercially-neutral.

Request No. EU to LGC 1-076 Witness & Respondent: Dr. Amro M. Farid

Page 153, line 5: Please explain how the platform can make the same data available to all participants at the same time, if the customer may only approve access to data for a limited number of market participants.

RESPONSE: The question seemingly misconstrues my testimony. My testimony does not state that: "*the same data available to all participants at the same time*" as the question states. My testimony states: "*First, the data housed and shared by the data platform must, by design, make sure that competing electric grid market participants have access to the same data at the same*

time". The statement is clear in its reference to competing electric grid market participants. For example, electric distribution utilities and community power aggregators are effectively competing electric grid market participants because a given electricity consumer can opt for electricity service from one or the other.

To elaborate and clarify my testimony, the electric distribution utility, by virtue of its present monopoly over distribution system assets and metering infrastructure, has access to data that other competing electric grid market participants and specifically community power aggregators do not have. Consequently, if the electric distribution utility, in this monopoly role, were to withhold data and information then it could undermine competing electric grid market participants including specifically community power aggregators from developing highly competitive electric rates and services. Furthermore, it is important to note that the relevant customer here need not even be a costumer of the distribution utility. Rather, the customer could receive electricity service from a community power aggregator. Such a situation could lead to the highly undesirable market situation where the electricity distribution utility either inadvertently, knowingly, or intentionally sabotages the community power aggregator's competitive service to its own customers by withholding data information about the community power aggregators own customer for the simple reason that the electric distribution utility has a present monopoly over distribution assets and metering infrastructure. My testimony emphasizes that the data platform enables a level-playing field for a retail electricity market.

Request No. EU to LGC 1-077 Witness & Respondent: Dr. Amro M. Farid

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Page 153, line 7: Please explain why the department of the utility that controls the operation of the platform must be isolated and provide any applicable legal requirements.

RESPONSE: My testimony states: "Second, the department of the utility that operates the data platform itself must be isolated in their communication from the departments responsible for the purchase and sale of electricity to grid stakeholders". Let Team A be the department of the utility that operates the data platform itself. Let Team B be the department of the utility responsible for the purchase and sale of electricity to grid stakeholders. Let Team C be a competing market participant outside the utility. In order to further the for-profit mission of the utility, Team A and Team B are incentivized to collaborate and facilitate each other's respective jobs. It is possible

and likely, for Team A to make data and information available to Team B without necessarily making that same data information available to Team C. Consequently, Team B would have disproportionate market power over Team C.

Request No. EU to LGC 1-078 Witness & Respondent: Dr. Amro M. Farid

Page 154, line 18: Is the API based platform proposed by the utilities substantially different from the ISO example noted? If so, please elaborate.

RESPONSE: Yes. Allow me to highlight several obvious differences. First, each Independent System Operator in the country is a non-for-profit entity tasked with ensuring an equitable marketplace for wholesale electricity transactions. Although, they have access to system data through SCADA systems, they are not transmission owners.

In the meantime, each of the distribution utilities is a for-profit entity and have no obligation to provide a level-playing field for all competing electric grid market participants. Although, they are distribution owners, they have yet to describe a solution that shares system data through their SCADA systems.

Simply having an "API" is not enough to equate the two.

Even if the technical design were identical, and they are far from it, it would be entirely careless to expect that a data platform would have a similar socio-technical market function if the entity that designs and operates works under fundamentally different laws, regulations, and governance structures.

Request No. EU to LGC 1-079 Witness & Respondent: Dr. Amro M. Farid

Page 155, line 20: RSA 378 specifically states that the data platform be certified by the Green Button Alliance. Given your testimony that "this flow of data is not sufficient to achieve the legislative objectives of RSA 378", how do you propose we meet the obligation of Green Button Certification for the platform?

RESPONSE: The question seemingly misconstrues my testimony. The question seems to suggest that because my testimony states "this flow of data is not sufficient to achieve the legislative objectives of RSA 378" then the testimony is somehow advocating that we dispose with the Green

Button Standard. This is categorically false. Please see my testimony in response to Q6.10 on pages 162-163. It makes it clear that the data platform should adhere to the IEC standards commonly referred to as the "Common Information Model (CIM)". It states clearly: "The Green Button Standard is simply a subset of the CIM".

In short, and again, necessity is not equivalent to sufficiency. The Green Button Standard is necessary but not sufficient, whereas the Common Information Model is the most sufficient group of standards available today. Implementing the CIM in no way jeopardizes the implementation of the Green Button Standard.

Request No. EU to LGC 1-080 Witness & Respondent: Dr. Amro M. Farid

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Page 156, line 17: Please provide your definition of "smart interval meters".

RESPONSE: In the context of this testimony, we are using the term "smart interval meters" as a layman equivalent for Advanced Metering Infrastructure or more commonly AMI.

Request No. EU to LGC 1-081 Witness & Respondent: Dr. Amro M. Farid

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Page 156, line 17: Please provide your definition of "market" and "financial data" with a list of expected data fields.

RESPONSE: My testimony specifically states that although the term "market/financial data" is not technically precise, nor does it have a well-accepted definition in the literature, it has been used extensively in the docket's technical sessions. Its use in testimony comes out of a desire to find commonality of language. A more technical precision definition would refer to the data fields in IEC 62325 (part of the Common Information Model). The interested reader is encouraged to read this widely accepted standard for "market/financial data" fields. It is the responsibility of the distribution utilities to design the data platform and select the specific fields from these standards in accordance with the stakeholder requirements identified by this docket.

Request No. EU to LGC 1-082 Witness & Respondent: Dr. Amro M. Farid

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Page 156, line 18: Please provide a list of expected data fields for "system" data.

RESPONSE: My testimony specifically states that although the term "system data" is not technically precise, nor does it have a well-accepted definition in the literature, it has been used extensively in the docket's technical sessions. Its use in testimony comes out of a desire to find commonality of language. A more technical precision definition would refer to the data fields in IEC 61970 and 61968 (part of the Common Information Model). The interested reader is encouraged to read these widely accepted standards for "system data" fields. It is the responsibility of the distribution utilities to design the data platform and select the specific fields from these standards in accordance with the stakeholder requirements identified by this docket.

Request No. EU to LGC 1-083 Witness & Respondent: Dr. Amro M. Farid

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Page 161, line 1: Is a circuit map the extent of system data being requested? If not, please provide detail.

RESPONSE: The testimony on Page 161 Line 1 shows that system data is readily available in neighboring states. To my knowledge, the distribution utilities have yet to commit to the same here in NH.

To answer the question more specifically: No, a circuit map is not sufficient system data for the simple reason that a circuit map is not sufficient system data to enable the community power aggregation use cases that we have previously submitted as part of this docket. With regard to the specific data fields necessary to implement these use cases, the LGC objects to this question as overly broad as it effectively asks the witness to undertake additional analysis, develop new information as part of the data request which is not an appropriate use of discovery. It is the responsibility of the distribution utilities to design the data platform and select the specific fields from established international standards in accordance with the stakeholder requirements identified by this docket.

Request No. EU to LGC 1-084 Witness & Respondent: Dr. Amro M. Farid

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Page 165, line 14: Does the estimated capitalized cost of the proposed third-party platforms include integration with and mapping of the utility's legacy data sources? How do these solutions handle vendor and customer authorization workflows as defined by the Green Button Connect My Data standards?

RESPONSE: Neither Attachment E nor F in my testimony mentions "integration with and mapping of the utility's legacy data sources". Nor do they speak to "Green Button Connect My Data Standards". Consequently, the question is outside the scope of my testimony and I do not wish to speculate. Rather my testimony does explicitly state: "*While this solution would have to be matched to the functional requirements discussed above and likely customized to New Hampshire's needs, its current implementation as described in the attached slides is an excellent starting point from which to discuss practical avenues*". This remains my testimony.

Consequently, the question asks the witness to undertake additional analysis and develop new information as part of the data request which is not an appropriate use of discovery.

Request No. EU to LGC 1-085 Witness & Respondent: Dr. Amro M. Farid

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Page 165, lines 4-12: Please explain who would operate the systems referenced and act as the data platform operator. Please explain how these systems would share data with other stakeholders with specific reference to the Green Button Connect standard.

RESPONSE: RSA 378:52 states: "the utilities shall design and operate the energy data platform". This language leaves open the possibility for the distribution utilities to design, build and operate the energy data platform themselves or outsource this technical activity to a vendor. The mention of mPrest and Kevala in my testimony serves to suggest investigation of the latter possibility.

In reference to the part of the question pertaining to the Green Button Connect standard, please see my response to data request # EU to LGC 1-084.

Q. Does this conclude your rebuttal testimony?

A. Yes, it does.

Lesson 1 – Course Syllabus: Setting off on the Path of Engineering Complex Systems

ENGG 199: Model-Based Systems Engineering, Analysis & Simulation

Course Introduction

Prof. Amro M. Farid

Delivered: Tuesday, January 7, 2020

Last Modified: January 7, 2020

Syllabus Outline

Objective 1

To explain how we will learn to engineer complex systems . . .

- Course Logistics
- Instructional Team
- Course Rationale
- Course Components
- The Learning Environment
- Expectations
- Lecture Summary

Conclusion 1

Students will have a clear understanding how ENGG 199-MBSE will proceed this term.

Lecture Logistics

Course Title & Number: ENGG 199 Model-Based Systems Engineering

Term & Year: Winter 2019

Lecture Hall: Cummings Hall. Room 202.

Class Time: 2A-Block – TR 2:25 - 4:15

X-Hours: 2AX-Block – Wed 4:35-5:25. Note: Many X-Hours will be used this term.

Instructional Team

Lead Instructor

Lead Instructor: Prof. Amro M. Farid

Office Location: Maclean. Room 215.

Office Phone: (603) 646-1524

Email: amfarid@dartmouth.edu

Office Hours: Before Class. TR 1:25-2:25

Teaching Assistant

Teaching Assistant: Dakota Thompson

Email: dakota.j.thompson.th@dartmouth.edu

Course Rationale

Course Prerequisites

ENGG 199-MBSE, like other introductory graduate-level systems engineering courses at other universities, is meant to be taken after the student has well-established their undergraduate engineering program.

The prerequisites are:

- ENGS 20, 21, and 22
- At least 1 from ENGS 25 or 26 or 27 or 52
- Preferred 1 from ENGS 65 or 66 or 75 or 89.
- Equivalent courses allowed by permission.

Prerequisite Knowledge

1. **Scientific Computing**. Comfort in computer programs (in MATLAB or Python) that compute numerical values of several logically organized functions (ENGS 20)
2. **Introductory Design Skills**. Comfort in designing and implementing a small-scale engineered system in a small team environment *(ENGS 21)*
3. **Introductory Systems Analysis**. Comfort in analyzing analytically as well as numerically lumped parameter linear dynamic systems *(ENGS 22)*
4. **Intermediate Systems Analysis**. Comfort in analyzing analytically as well as numerically more complex systems (e.g. thermodynamic, controls-based, stochastic, or supply chains). *(ENGS 25, 26, 27, 52)*
5. **Intermediate Design Skills**. Comfort in designing and implementing a medium-scale engineering system in a medium-sized team environment. *(ENGS 65, 66, 75, or 89)*

Model-Based Systems Engineering sits upon a solid foundation of design-synthesis and mathematical analysis skills.

Without this foundation, MBSE is largely untenable in a 10-week term.

Course Description

This course is designed to introduce students to the world of model-based systems engineering. Systems Engineering is an interdisciplinary field of engineering and engineering management that enables the realization of successful complex systems over their life-cycles. Systems Engineering integrates multiple disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation to obsolescence. Systems Engineering considers the technical, social, and business needs of all stakeholders with the goal of realizing a successful system. At its core, systems engineering utilizes systems thinking principles to organize this body of knowledge.

This course will prepare students to engineer, analyze, and simulate complex systems. Such systems are characterized by a high level of heterogeneity and a large number of components. They will appreciate the physical, informatic, social and economic aspects of such systems. They will use systems thinking concepts and abstractions to manage complexity. They will learn to use model-based systems engineering techniques to model a system's form, function, and concept. They will analyze the structure of these systems using graph-theoretic approaches. Finally, they will learn to simulate social, technical, and economic systems with continuous-time and discrete-event dynamics. The systems engineering skills developed over the course are applicable to a broad range of disciplinary applications.

Course Components

Course Goal

To prepare students with the skills to engineer complex engineering systems through systematic steps of modeling, analysis and simulation.

Motivating Examples:

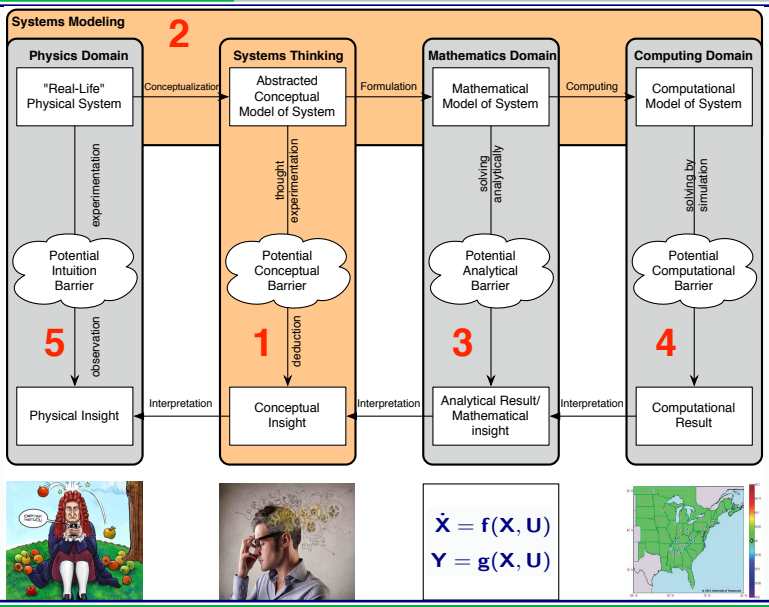
- Roving Mars 2006
- Curiosity Rover 2011
- 3 Epic Fails
- Why it is so hard?

Central Topics I

1. **Systems Thinking**: The ability to think about a question, circumstance, or problem explicitly as a system – a set of interrelated entities. *Whole Course.*
2. **Model Based Systems Engineering**: The process of translating the structure, behavior, and concept of a "real-life" system into a graphical, analytical, or computational model or representation. *Weeks 1-5*
3. **Graph Theory**: The ability to analyze the structure of systems in terms of interconnected elements. *Weeks 6-7*
4. **Systems Simulation**: "Solving by Simulation". The ability to develop simulations of system models so as to conduct computational experiments that mimic the physical behavior of "real-life" system in the time domain. *Weeks 8-9*

But Why These Central Topics???

Why These Five Central Topics?



Learning Objectives

Upon completing this course, students will be able to:

1. Use "systems-thinking" concepts and abstractions to manage complexity in systems.
2. Use model-based systems engineering techniques to model system's form, function, and concept.
3. Analyze the structure of systems using graph-theoretic foundations.
4. Simulate systems with continuous-time and discrete-event dynamics.
5. Exercise these skills with an engineering team.
6. Present models, analyses, and simulations in written and oral form in a professional manner.

This course is about how to think not what to think about systems!

MBSE is both an art and a science. The course will require you to exercise and develop your engineering judgement.

Course Schedule Part I

Topic	Week	Date	Associated Reading	Homework Assigned	Homework/Lab Due
☑ 1 Course Introduction: Model-Based Systems Engineering, Analysis & Simulation	Week 1	Tuesday January 7		Progress Check 1: The System Scope & Boundary	
☑ 2 Introduction to Model Based Systems Engineering	Week 1	Wednesday January 8	CCS Chapters 1-3		CRQs
☑ 2.1 Q&A Session: Systems Thinking I					
☑ 3 Introduction to SysML & System Form	Week 1	ThursdayJanuary 9	FMS Chapter 4 & CCS Chapter 4		CRQs
☑ 3.1 Q&A Session: Systems Thinking					
☑ 3.2 Practical Session: Systems Thinking of a Complex Engineering System					
☑ 4 Practical Session: Block Diagram for the Formula Hybrid	Week 2	Tuesday, January 14	FMS Chapter 7 & MATLAB OOP Tutorial	Progress Check 2: The System Form	Progress Check 1: The System Scope & Boundary & CRQs
☑ 4.1 Q&A Session: Systems Form					
☑ 4.2 Practical Session: Modeling System Form in SysML & MATLAB					
☑ 5 Introduction to System Function I	Week 2	Wednesday, January 15	CCS Chapter 5		CRQs
☑ 5.1 Q&A Session: System Function					
☑ 6 Introduction System Function II	Week 2	Thursday, January 16	FMS Chapter 9		CRQs
☑ 6.1 Q&A Session: Modeling Flow Based Behavior w/ SysML					
☑ 6.2 Practical Session: Modeling System Function in SysML & MATLAB					
☐ 7 Activity, Sequence & State Machine SysML Diagrams	Week 3	Tuesday, January 21	FMS Chapter 10&11	Progress Check 3: The System Function	Progress Check 2: The System Form
☐ 7.1 Q&A Session: Modeling Message & Event Based Behavior w/ SysML					
☐ 7.2 Practical Session: Modeling System Function in SysML & MATLAB					
☐ 8 Introduction to System Concept	Week 3	Wednesday, January 22	CCS Chapter 6		CRQs
☐ 8.1 Q&A Session: System Concept					
☐ 9 Introduction to System Architecture	Week 3	Thursday, January 23	CCS Chapter 7&8		CRQs
☐ 9.1 Q&A Session: Introduction to System Concept & Architecture					
☐ 9.2 Practical Session: Modeling System Architecture in SysML & MATLAB					
☐ 10 **Class Cancelled**	Week 4	Tuesday January 28		**MBSE Report & Presentation**	Progress 3: The System Function
☐ 11 Introduction to the Allocated Architecture	Week 4	Wednesday, January 29	FMS Chapter 13		CRQs
☐ 11.1 Q&A Session: Modeling the Allocated Architecture w/ SysML					
☐ 12 The Mathematics of Networks	Week 4	Thursday, January 30	Newman Chapter 6		
☐ 12.1 Q&A Session: The Mathematics of Networks					CRQs
☐ 12.2 Practical Session: Modeling System Form as a Graph					

Course Schedule Part II

Topic	Week	Date	Associated Reading	Homework Assigned	Homework/Lab Due
13 Graph Measures & Metrics	Week 5	Tuesday February 4	Newman Chapter 7	Progress Check 4: Network Measures & Metrics	MBSE Report & Presentation
13.1 Q&A Session: Graph Measures & Metrics					
13.2 Student Presentations					
14 The Need for Hetero-functional Graph Theory	Week 5	Wednesday, February 5	SKF Chapters 1-3		CRQs
14.1 Q&A Session: Need for Hetero-functional Graph Theory					
15 HFGT: System Concept	Week 5	Thursday February 6	SKF Chapter 4-4.1, 5-5.3.		CRQs
15.1 Q&A Session: HFGT System Concept					
15.2 Practical Session: Modeling System Architecture as a Knowledge Base					
16 HFGT: Physical System	Week 6	Thursday, February 11	SKF Chapter 4.2, 5.4	Progress Check 5: Hetero-functional Adjacency Matrix	Progress Check 4: Network Measures & Metrics
16.1 Q&A Session: HFGT Hetero-functional Adjacency Matrix					
16.2 Practical Session: Modeling System Architecture as a Hetero-functional Graph					
17 HFGT Controllers & Decision-makers	Week 6	Tuesday, February 12	SKF Chapter 4.3-4.4, 5.5-5.6		CRQs
17.1 Q&A Session: HFGT Controllers & Decision-makers					
18 Introduction to Discrete-Event Dynamics	Week 6	Wednesday, February 13	Petri-Net Tutorial		CRQs
18.1 Q&A Session: Discrete-Event Dynamics					
18.2 Practical Session: Modeling Decision-Making Structure in HFGT					
19 HFGT Operands	Week 7	Tuesday, February 18	SKF Chapters 4.5-4.6, 5.7-5.8	Network Analysis Report & Presentation	Progress Check 5: Hetero-functional Adjacency Matrix
19.1 Q&A Session: HFGT Operands					
19.2 Practical Session: Modeling HFGT Operand Behavior					
20 HFGT System Adjacency Matrix	Week 7	Wednesday, February 19	SKF Chapters 4&5		CRQs
20.1 Q&A Session: HFGT System Adjacency Matrix					
21 Introduction to Continuous-Time Dynamics — Simscape	Week 7	Thursday, February 20	Simscape Tutorial		CRQs
21.1 Practical Session: Modeling HFGT System Structure					
21.2 Practical Session on Simscape					
22 Practical Session on Simulation Development	Week 8	Tuesday, February 26		Progress Check 7: Dynamic Simulation	
23 Student HFGT Presentations	Week 8	Wednesday, February 20			Network Analysis Report & Presentation
24 Practical Session on Simulation Development	Week 8	Thursday, Febraury 28			
25 Practical Session on Simulation Development	Week 9	Tuesday March 3		Final MBSE Report	Progress Check 7: Dynamic Simulation
26 Course Conclusion	Week 9	Thursday March 5			
27 Final MBSE Report	Finals	Friday, March 13			Final MBSE Report

Course Schedule Rationale: Why does this course exist at Thayer?

The motivation for this course comes from three immediate needs:

1. The MEM program is seeking to expand its "product development" track. This course specifically seeks to address product development of large complex systems where the tools of systems engineering are required to actively manage the complexity of the engineering development.
2. The Graduate Energy Program – as it is currently taught – exposes students to a wide variety of energy systems applications domains and then analyzes these energy systems with a wide variety of systems engineering tools. This is too much to do without prerequisite preparation. This ENGG 199 provides the underlying foundation for studying energy systems.
3. We currently do not have a graduate level systems engineering course for students in application domains other than energy.

Ultimately, 21st century engineers are facing a slew of engineering systems challenges, and MBSE sits at the heart of the solution.

The Learning Environment

Learning Environment: Overview of Learning Flow

- Independent Reading & Reflection
- In Class Q&A Sessions
- In Class Practical Sessions: Collaborative Modeling, Analysis & Simulation Time
- Independent Modeling, Analysis & Simulation Time

The practice of MBSE is ultimately conceptual & cognitive. Independent time for reflection is the key to developing these skills.

Nevertheless, the practice of MBSE is always implemented in collaborative teams. Class time will be used for interactive Q&A and collaborative modeling, analysis, and simulation exercises.

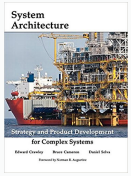
In order to ground our learning of MBSE, we will be using a complex engineering system throughout the course. (Groups of 2-3)

Independent Reading & Reflection

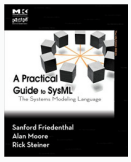
- The study of systems ultimately requires organizing the mind with **abstract** interconnected concepts.
- The books provide deeper explanations & examples of these concepts than a single in-class oral presentation.
- Reading abstract concepts requires the reader to engage more with the material than a lecture format.

In order to support Independent Reading, please prepare 5 Critical Reflection Questions on the reading for the start of every class.

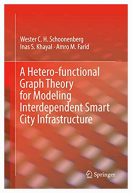
Independent Study: Required & Suggested Text Books



- **Required Text**: Crawley et. al. 2015.[1] *(purchase)*
- A new practical text focusing on learning the abstract principles of systems-thinking.
- Will be used extenstively in Weeks 1-5.



- **Required Text**: Friedenthal et. al. 2011 [2] *(handout)*.
- A new practical reference text on SysML and its syntax.
- Will be used extensively in Week 1-5 and then later as a reference.



- **Required Text**: Schoonenberg 2018[3]. *(purchase)*
- A comprehensive text on hetero-functional graph theory.
- Will be used extensively in Weeks 6-7.

In Class Q&A Sessions

- In addition to independent reflection, the systems thinking mind must be exercised in **engaged** collaborative discussion.
- This is a precursor to many discussions on complex engineering projects.
- We will have a structured Q&A discussion on the pre-assigned reading.
- There will be no use of lecture or powerpoint.
- Be ready to make these in-class discussions your own.

Engaged discussion requires engaged preparation prior to class.

In Class Practical Sessions

- In addition to engaged collaborative discussion, MBSE is best learned by **doing**.
- We will use class-time to initiate exercises in the MBSE of a complex engineering system of your choosing.
- Depending on class enrollment, we will break up into groups of 2-3.
- While this activity will be mostly independent, I'll be in class to steer you away from big modeling mistakes.
- These sessions will primarily focus on systems thinking skills rather than the syntax of MBSE.

Dive right in! Don't be afraid to make mistakes. Modeling is an iterative process.

Independent Modeling, Analysis & Simulation Time

- This is your chance to get it right.
- The rough draft modeling completed in class can be refined into computer-based modeling programs.
- While you will have to coordinate your efforts with others in class, ultimately much of the modeling, analysis and simulation time must be done independently.
- This will support accurate conclusions about architecture of the complex engineering system in your written reports and oral presentations.

This is where you see the large complex engineering system represented virtually.

Specific Student Needs

Religious Observances:

Some students may wish to take part in religious observances that occur during this academic term. If you have a religious observance that conflicts with your participation in the course, please meet with me before the end of the second week of the term to discuss appropriate accommodations.

Disabilities:

Students with disabilities enrolled in this course and who may need disability-related classroom accommodations are encouraged to make an appointment to see me before the end of the second week of the term. All discussions remain confidential, although the Student Accessibility Services office may be consulted to discuss appropriate implementation of any accommodation requested.

Expectations

Assessment

The course assessment is meant to support students in their learning of MBSE; breaking a very complex task of modeling a complex engineering system into manageable chunks.

- 22% Class Participation including submission of 5 critical reflection questions before class.
- 18% (6) Weekly Modeling Progress Checks
- 20% Model-Based Systems Engineering Report & Presentation
- 20% Network Analysis Report & Presentation
- 20% Final Simulation Report & Presentation

Dartmouth College Grade Descriptions

A Grade: Excellent mastery of course material. Student performance indicates a very high degree of originality, creativity, or both. Excellent performance in analysis, synthesis, and critical expression, oral or written. Student works independently with unusual effectiveness.

B Grade: Good mastery of course material. Student performance demonstrates a high degree of originality, creativity, or both. Good performance in analysis, synthesis, and critical expression, oral or written. Student works well independently.

C Grade: Acceptable mastery of course material Student demonstrates some degree of originality, creativity, or both Acceptable performance in analysis, synthesis, and critical expression, oral or written Student works independently at an acceptable level

D & E grades can be discussed on a case by case basis.

Conclusion 2

Every student will have the opportunity to **earn** an A grade.

Class Participation

The class discussion grade emphasizes the importance of independent reading, reflection and engaged in-class discussion.

- Complete the reading.
- Prepare at least 5 reflective questions noting the page(s) that inspired the question.
- Pose your questions in the class discussion
- Submit your questions to Canvas so that they can be collated into the MBSE Book of Questions.

Weekly Modeling Progress Checks

The weekly modeling progress checks are meant to give students milestones in completing the course's three reports and presentations.

- The Tortoise vs. the Hare. Steady consistent effort wins the race.
- The focus is on producing the figures, equations, and graphs that will anchor the reading of the report.
- Topic sentences and important conclusions can be bulleted.
- These checks will help you to flesh out the report and presentation straightforwardly in advance of the deadlines.

Model-Based Systems Engineering Report & Presentation

The report and presentation focuses on the MBSE of a complex engineering system using SysML as a modeling language. It must discuss:

- System boundary, context, and scope
- System Form
- System Function
- System Concept & Architecture
- The report need not be lengthy but it must comprehensively and clearly discuss the above points.
- The presentation emphasizes clarity of content and delivery.

Network Analysis Report & Presentation

The report and presentation focuses on the network analysis of a complex engineering system. It must discuss:

- Relevant Incidence Matrices
- Relevant Adjacency Matrices
- Decomposition to an "Appropriate" level.
- The report need not be lengthy but it must be comprehensively and clearly discuss the above points.
- The presentation emphasizes clarity of content and delivery.

Final Simulation Report Report & Presentation

The report and presentation focuses on the simulated behavior of the chosen engineering system. It's content will be approved in advance. It depends on the scope of your subsystem.

Academic Honor Principle Summary

The practice of MBSE is a collaborative endeavor. You are integrating a large amount of information from a wide variety of sources.

Some advice:

- Work with your peers.
- Cite early.
- Cite often.
- Give credit where credit is due.
- Ask me if you have doubts.

Syllabus Summary

Syllabus Outline

Objective 2

To explain how we will learn to engineer complex systems . . .

- Course Logistics
- Instructional Team
- Course Rationale
- Course Components
- The Learning Environment
- Expectations
- Lecture Summary

Conclusion 3

Students will have a clear understanding how ENGG 199-MBSE will proceed this term.

References I

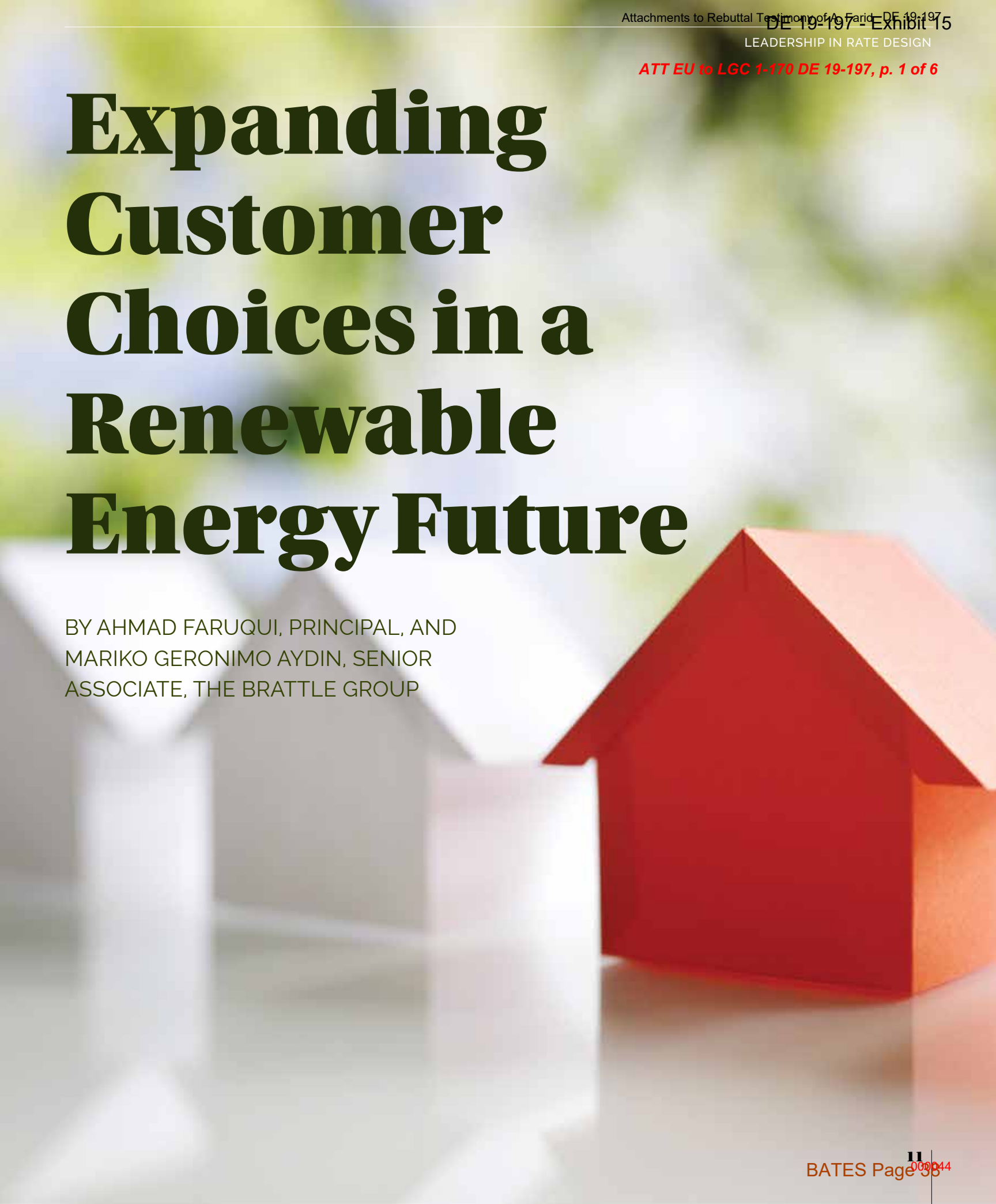
[1] E. Crawley, B. Cameron, and D. Selva, *System Architecture: Strategy and Product Development for Complex Systems*. Upper Saddle River, N.J.: Prentice Hall Press, 2015.

[2] S. Friedenthal, A. Moore, and R. Steiner, *A Practical Guide to SysML: The Systems Modeling Language*, 2nd ed. Burlington, MA: Morgan Kaufmann, 2011.

[3] W. C. Schoonenberg, I. S. Khayal, and A. M. Farid, *A Hetero-functional Graph Theory for Modeling Interdependent Smart City Infrastructure*. Berlin, Heidelberg: Springer, 2018. [Online]. Available: http://dx.doi.org/10.1007/978-3-319-99301-0

Expanding Customer Choices in a Renewable Energy Future

BY AHMAD FARUQUI, PRINCIPAL, AND MARIKO GERONIMO AYDIN, SENIOR ASSOCIATE, THE BRATTLE GROUP



For three years, Hawaii stood alone among other states in its commitment to reaching 100% renewable energy. In 2018 and early 2019, several large jurisdictions followed suit: California passed into law a policy of 100% clean energy by 2045; Washington, D.C.'s city council passed a standard for 100% renewables by 2032; New Mexico passed a 100% zero carbon requirement by 2045; and Puerto Rico adopted a policy for 100% renewable energy by 2050.[i] Many other states are considering and moving forward with similar policies and laws. Meanwhile, the number of cities and counties committed to 100% clean energy is growing dramatically.[ii] The 100% clean electricity supply that seemed impossible 10 years ago has now become a tangible and feasible future.

Figure 1 shows the end goal of state-level (plus Washington, D.C. and Puerto Rico) clean energy standards in terms of percent renewables or clean energy. [iii] Five more states are not far behind, with clean energy goals of 50% or more. With these policies, decarbonization of electricity is making great strides, with more to come as momentum builds.

The Value of Customer Flexibility in a High-Renewables World

In the first steps toward electricity decarbonization, going green is as straightforward as adding a solar or wind plant to the resource mix. In addition to forecasting peak demand as they have always done, resource planners and policymakers must determine when and where to build renewable resources and at what size these resources will be cost-effective.

With higher renewables penetration, planning for greener electricity becomes less about building individual resources and more about building a resource portfolio and system that — as a whole — is tuned to take advantage of clean power when it is available. One key challenge is what to do about the hour-to-hour and minute-to-minute mismatch between renewables output and electricity consumption. At times, electricity supply from renewables may be higher than consumption. At other times, supply may be lower than consumption. System operators must have the resources and tools they need to match supply and demand exactly.

In this context, customer flexibility becomes increasingly valuable. Any consumption that can be reasonably shifted to

Figure 1: End Goal of Clean Energy Standards by Jurisdiction

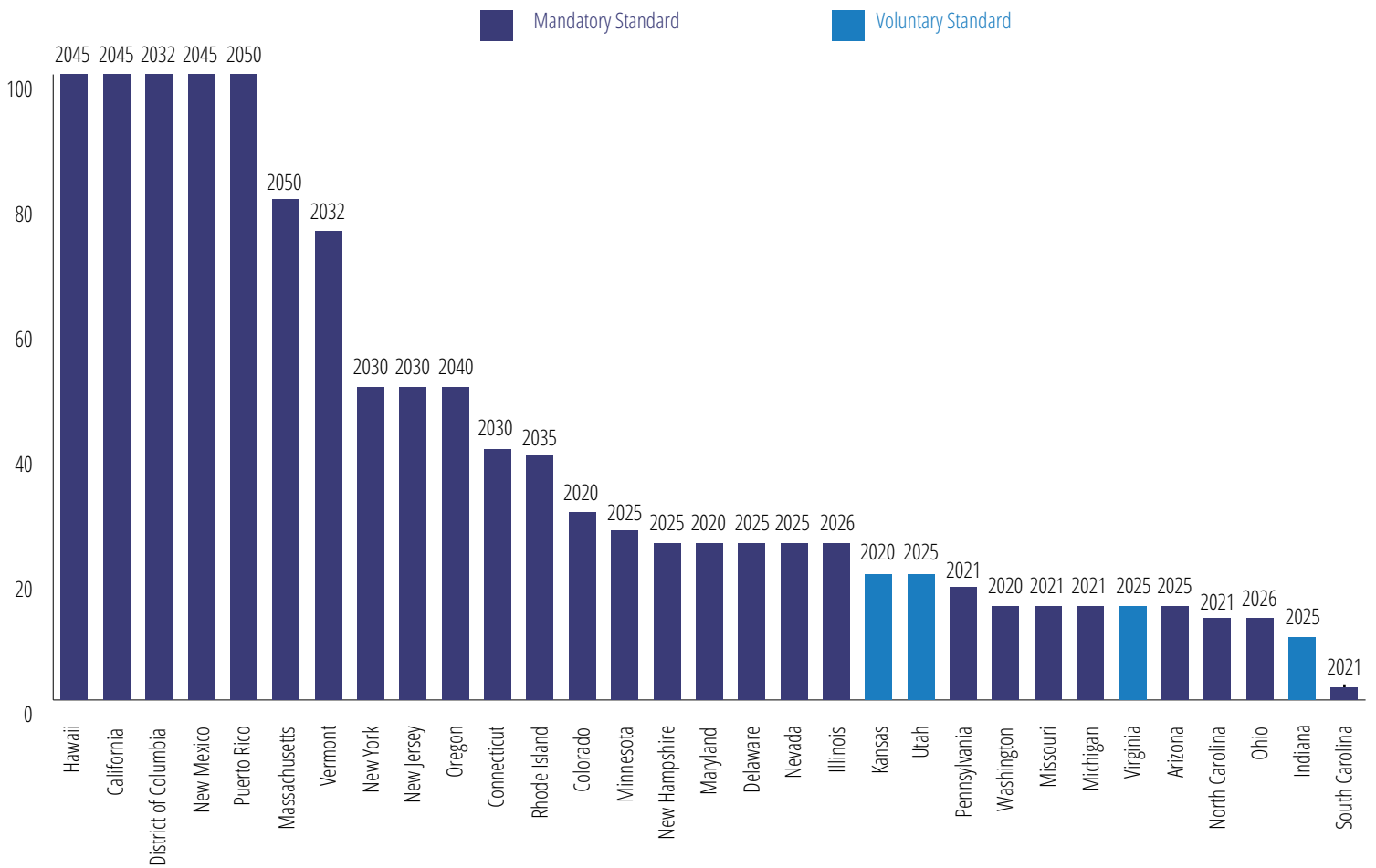
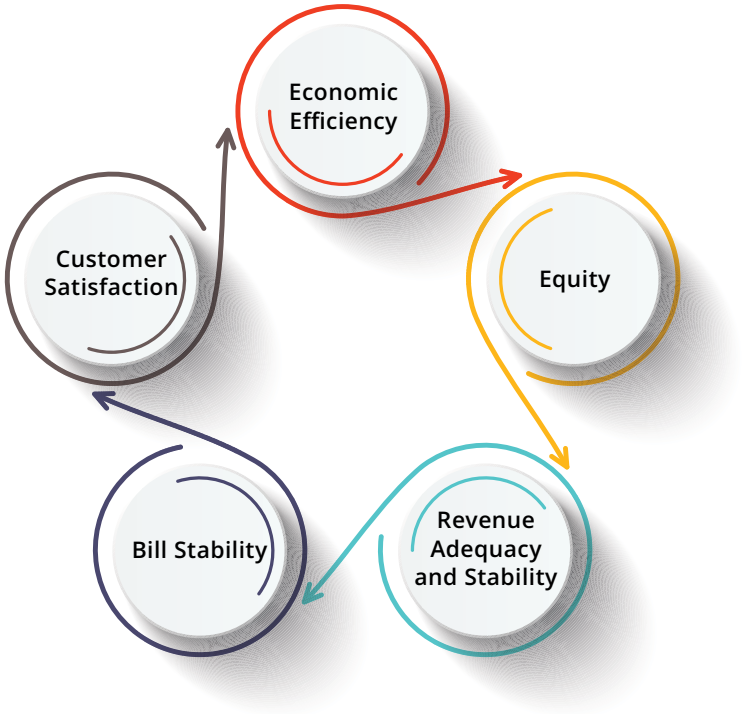


Figure 2: Objectives for Effective Retail Rates



times when renewables-based supply is high will prevent loss or curtailment of renewables output when it is available. In doing so, customers also shift consumption away from times when renewables-based supply is lower, which can avoid the cost of power supplied by battery storage or even fossil fuel-based generation. This concept is expanding our traditional thinking about customer flexibility: from traditional "demand response" focused on moving consumption *away* from peak periods, to something more dynamic and including "load shift" *toward* low-cost periods.[iv]

Future studies and evaluations of demand response will need to broaden the definition of demand response and the scope of benefits it can provide.[v] Using customer flexibility as a resource in any and all hours is critical to getting the most out of a high-renewables system.

Principles for Meaningful Rate Options and Signals

Electricity is delivered (and sometimes produced) by a regulated natural monopoly, and customers pay for electricity through regulated retail rates. Given that framework, the principles of effective regulated rates hold true regardless of a high-renewables future. Effective rates should address and balance the regulator's high-level objectives for economic efficiency, equity, revenue adequacy and stability, bill stability, and customer satisfaction, as shown in Figure 2.[vi]

The objectives for retail rates are interrelated, and some can represent tangible tradeoffs for customers. One customer, for example, might want to see how power supply costs vary within a day, to moderate their air conditioner on the hottest days when costs are high and save money overall. Another customer might not have the same flexibility to cut air conditioning on the hottest days, might not want to feel penalized for that flexibility, and might prefer more bill stability and costs smoothed over time.

Using customer flexibility as a resource in any and all hours is critical to getting the most out of a high-renewables system.

An in-between rate option with moderate cost variability over time — such as the traditional volumetric rates that dominate the industry today — might be meaningless to both customers. The first customer may feel that the cost variability they see is not a strong enough signal (or concentrated enough) to respond to. And the second customer may feel that the cost variability by month or season is not equitable nor helpful given that they can't respond to it. In either case, customers pay the total cost of service. How well rates are tailored to customers' preferences and their ability to respond can impact how effective the rates are in incentivizing customers to save money when they can reasonably do so, while increasing customers' satisfaction and sense of equity.

For customers of today and tomorrow, rate objectives need to be defined and addressed at a more granular level that is tailored to the diversity of customers and their preferences, possibly even at a customer-specific level. We now have better information technology and tools to understand customers' behaviors and preferences, and to help them receive and respond to signals so they can shape their consumption in a meaningful way.

An hourly real-time price signal... can help show customers exactly what hours contribute most (and least) to the cost to serve them.

The Diversity of Efficient Rate Options

How do customers weigh opportunities to reduce cost versus bill stability? Regulators and utilities have experimented with a wide range of rate options and signals, as demonstrated in Figure 3. Traditional volumetric rates (standard tariff) yield relatively low bill volatility. However, the potential for bill savings is limited — a customer is only empowered to reduce costs through bulk conservation (i.e., a customer reducing total kWh consumed over a month).

For even less bill volatility, utilities can offer a fixed monthly bill (e.g., budget billing plan), shown as the leftmost point in Figure 3. Under this approach, the utility estimates total seasonal or annual bills, then divides the total by the number of months, similar to a payment plan. For example, Ohio's regulated electric and natural gas distribution utilities offer annual budget billing.[vii] Customers may like this type of bill because it is easier to financially plan for. But they must accept the tradeoff of having no signal to consume power when it is economical to do so, which theoretically will yield higher costs to customers overall.

Customers might be willing to risk more bill volatility if they have the flexibility to move consumption away from high-priced periods. An hourly real-time price signal, shown as the rightmost point in Figure 3, can help show customers exactly what hours contribute most (and least) to the cost to serve them. To date, the U.S. has relatively little experience applying real-time prices to residential customers, but experience in other parts of the world may provide some insights.

For example, in early 2017, about 12 million small customers in Spain, or about half of those eligible, were enrolled in a real-time price-based electricity rate, as part of a regulatory redesign to incentivize more efficient customer behavior and lower costs.[viii,ix]

In a high renewables system in the U.S., a real-time price signal can also be simplified to indicate when fossil fuel is being burned to serve customers (relatively high cents per kilowatt-hour), versus when renewables output is plentiful (low or even negative ¢/kWh). Translating a real-time price signal into an emissions signal may be more meaningful for some customers.

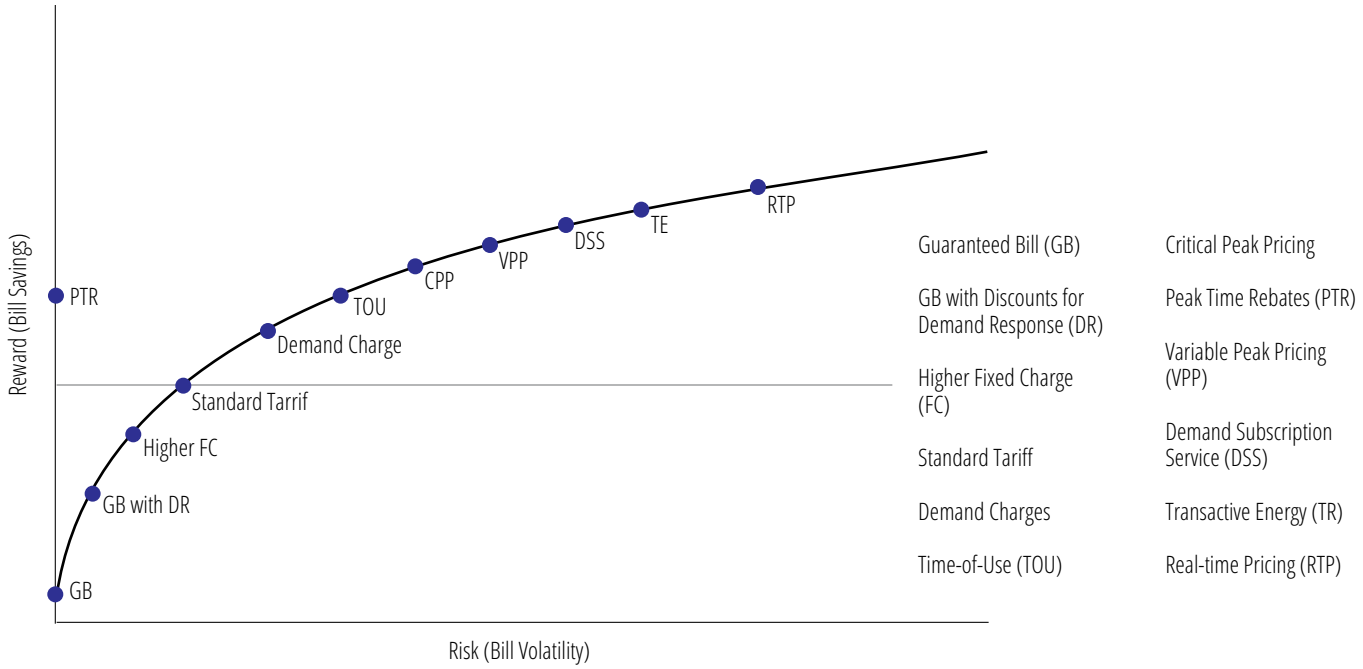
The tradeoff of higher bill volatility, however, can't completely be eliminated by the customer avoiding high-priced hours and consuming more in low-priced hours. There will always be the risk that prices are sometimes high when the customer can't or doesn't want to respond. More moderate time-varying price signals, like time-of-use rates and critical peak pricing, can also be quite effective if they are designed properly.[x]

Enabling Customer Flexibility through Tailored Retail Rates and Services

At its heart, traditional demand response is about giving better information to customers and letting them decide how to adjust (or not adjust) their consumption patterns. Studies on how electricity customers in the U.S. respond to cost signals — via retail rates and bills — have a history dating back to the late 1970s.[xi] Those studies affirm that customers care about cost and that they are willing and able to adjust their consumption away from high-cost periods.

Through subsequent decades of studies and experimentation, another thing is clear — customers have diverse preferences for types of cost signals they are willing to respond to. Preferences range from a flat guaranteed bill (low granularity cost signal) to retail rates that vary by hour in real time (high granularity cost signal), and many variations in between.

Figure 3: The Efficient Rate Frontier



Customers have shown that they will only respond to cost signals that are meaningful to them, and so customer options must be tailored carefully. To date, utilities and regulators have experimented with offering a handful of electricity rate options defined across broad customer classes. However, in other aspects of their lives, customers are getting used to having a world of options at their fingertips.

Today's customers have two important attributes that can affect their consumption patterns and must be considered along with retail rate design. First, customers have a heightened awareness of the electricity supply mix, and they may have stronger preferences for green attributes and where the power comes from (such as local or onsite power) than customers of yesterday. So, beyond cost signal options, customers might want options to choose a supply mix that better suits their preferences and values. There is growing evidence that customers want more control and options to tailor their power supply mix to their preferences.

Furthermore, customers are more comfortable with using technology and tools to make informed spending decisions. They use apps, search engines, web services and other tools on a daily basis to process and simplify an enormous amount of information to make even the simplest spending decisions. Advanced equipment like smart meters can improve the quality of cost, consumption, and supply mix data available to the customer. Tools and services including apps, price and consumption reports, and smart appliances can help the customer absorb that information quickly and adjust consumption patterns with more automation. Experiments with enabling technologies such as in-home displays and smart thermostats have already shown that customers can be more flexible if they are given better resources to do so.[xii]

The Path Forward

Electric utilities are well-poised to play a major role in providing tailored electricity services to customers in a new world where digital technologies and the internet of things are likely to be ubiquitous. To do so, utilities must continuously seek improved customer data to offer meaningful rate options and signals tailored to customer preferences. Utilities must also push forward with technology and tools that can help customers understand it all and respond with minimal effort.

The path to developing meaningful new rate structures and options for customers in a renewable energy future begins with better understanding how customer needs are changing. This can be done through focus groups and surveys that not only seek to understand preferences on cost versus bill stability, but also seek to understand preferences on power supply mix, environmental goals, and willingness to provide flexibility at different times of the day.

With customer preferences better understood, utilities can draw from the wealth of experience they already have in order to identify and test the effectiveness of differ-

ent rate options. This includes field testing new rate designs, determining their acceptance and comprehension by customers, and evaluating the impact of the new rates on energy consumption and load shapes. Experience has shown that it would be best to carry out the tests using randomized control trials or similar methods to make sure the results are statistically valid and can be generalized to the population of interest. Tests should include considerations of technologies that enable customers to easily understand their rates and any price or environmental signals they are receiving, set preferences for responding to those signals, and respond automatically in a way that does not disturb customers' quality of life.

Utilities and regulators will then need to develop an implementation plan for new rates. They must determine if the new rates should be offered on an opt-in, opt-out, or mandatory basis and how that may change over time. There are many different approaches to this and each has its pros and cons. There may be useful lessons learned from other utilities that have already rolled out similar rates.

To quell fears of unexpected impacts, it will be useful to compute the bill changes that the new rates will bring about and find ways to mitigate any adverse impacts.

Finally, continuous customer education and outreach is crucial for customers to understand the array of rate options they have, and for them to make the best use of the rate they choose. In a sense, this effort both begins and ends with a conversation with customers. Through those conversations, electric utilities and regulators can help customers make great strides in realizing the benefits of their renewable energy future.

About the Authors

Ahmad Faruqui *is an internationally recognized energy economist. He has analyzed the efficacy of a variety of tariff structures and carried out a meta-analysis of experimental results. His areas of expertise include demand response, energy efficiency, distributed energy resources, advanced metering infrastructure, plug-in electric vehicles, energy storage, inter-fuel substitution, combined heat and power, microgrids, and demand forecasting. He has worked for nearly 150 clients on five continents and testified before commissions in several states and provinces.*

Mariko Geronimo Aydin *is an economist with almost fifteen years of experience in analyzing the policies and economics of electricity system planning, regulation and de-regulation of electricity supply, and wholesale electricity markets across the U.S. Mariko specializes in helping clients meet their potential in a changing industry, by evolving utility business models and by developing customer choice, resource planning, and wholesale market refinements that can make the best use of clean, distributed, and customer-driven power supply resources in synergy with more traditional resources.*

i These policies and laws refer to the following legislative bills: HB 623 (Hawaii), SB 100 (California), B22-0904 (Washington, D.C.), SB 489 (New Mexico), and PS 1121 (Puerto Rico).

ii Note that 130 cities and counties have also committed to 100% clean energy. Sierra Club, "100% Commitments in Cities, Counties, & States," https://www.sierraclub.org/ready-for-100/commitments, Accessed April 2019.

iii DSIRE, "Detailed Summary Maps: Renewable Portfolio Standards (October 2018)," http://www.dsireusa.org/resources/detailed-summary-maps/, Accessed April 2019. Supplemented with research by The Brattle Group. Texas also has a voluntary target of 10,000 MW by 2025 for retail entities.

Massachusetts' goal of 80% by 2050 is based on its Clean Energy Standard. Massachusetts also has a separate Renewable Portfolio Standard with an implied target of 35% by 2030, and the Class I requirement growing by 1% per year thereafter.

iv Note that although the idea of flexible load shapes is gaining attention in the industry today, it is a concept that has been around for some time. See, for example, Gellings, Clark W., Pradep C. Gupta, and Ahmad Faruqui, "Strategic Implications of Demand-Side Planning," Chapter 8 in Plummer, James L., Eugene N. Oatman, and Pradeep C. Gupta (eds), Strategic Management and Planning for Electric Utilities, Prentice-Hall, Englewood Cliffs, 1985, pp. 137–150. See also, Schweppe, Fred C., Richard D. Tabors, and James L. Kirtley, "Homeostatic Control: The Utility/Customer Marketplace for Electric Power," MIT Energy Laboratory Report MIT-EL 81-033, September 1981.

v Faruqui, Ahmad, and Ryan Hledik, "Reinventing Demand Response for the Age of Renewable Energy," December 14, 2018, http://files.brattle.com/files/15059_reinventing_demand_response_for_the_age_of_renewable_energy_12-12-2018.pdf. Accessed April 2019.

vi Bonbright, James C., Albert L. Danielsen, and David R. Kamerschen, "Principles of Public Utility Rates," Arlington, Va: Public Utility Reports, 1988.

vii See The Public Utilities Commission of Ohio, "Budget Billing for Natural Gas and Electric Service," https://www.puco.ohio.gov/be-informed/consumer-topics/budget-billing-for-natural-gas-and-electric-service/, Accessed April 2019.

viii The rate is called the Voluntary Price for Small Consumers, or VPSC.

ix EURELECTRIC, "Dynamic Pricing in Electricity Supply," position paper, page 6, http://www.eemg-mediators.eu/downloads/dynamic_pricing_in_electricity_supply-2017-2520-0003-01-e.pdf. Accessed April 2019.

x Faruqui, Ahmad, Sanem Sergici, and Cody Warner, "Arcturus 2.0: A Meta-Analysis of Time-Varying Rates for Electricity," The Electricity Journal, Volume 30, Issue 10, December 2017.

xi Faruqui, Ahmad, and Mariko Geronimo Aydin, "Moving Forward with Electricity Tariff Reform," Regulation, Fall 2017, pp. 42–48.

xii Faruqui, Ahmad, Sanem Sergici, and Cody Warner, "Arcturus 2.0: A Meta-Analysis of Time-Varying Rates for Electricity," The Electricity Journal, Volume 30, Issue 10, December 2017.

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Subject:	RE: Docket No. 19-197 Development of a Statewide Multi-Use Online Energy Data Platform - Staff Rebuttal Testimony
Date:	Friday, October 23, 2020 4:44:56 PM
Attachments:	19-197 LGC Rebuttal Testimony of C Below.pdf 19-197 LGC RebuttalTestimony of K McGhee.pdf

And McGhee and Below

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Subject: RE: Docket No. 19-197 Development of a Statewide Multi-Use Online Energy Data Platform - Staff Rebuttal Testimony

Attached please find the rebuttal testimony of the LGC witness Golding. Hard copies will not follow pursuant to the PUC's pandemic procedures.

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THE STATE OF NEW HAMPSHIRE

BEFORE THE

PUBLIC UTILITIES COMMISISON

DE 19-197

Electric and Natural Gas Utilities

Development of a Statewide, Multi-use Online Energy Data Platform

Rebuttal Testimony of Clifton C. Below

On behalf of
City of Lebanon, NH &
Local Government Coalition ("LGC")

October 23, 2020

Table of Contents

I. Introduction

Q. Please identify yourself and your involvement in this proceeding.

A. I am Clifton C. Below, testifying on behalf of the City of Lebanon where I serve as Assistant Mayor. My personal office address is 1 Court Street, Suite 300, Lebanon, NH 03766. I previously filed direct testimony and have participated in most if not all technical sessions, contributing to written commentary with the Local Government Coalition earlier in the proceeding. I've helped coordinate the LGC testimony and discovery responses.

Q. What is the nature of your rebuttal testimony?

A. I have responded to 18 discovery/data requests from Eversource and Unitil directed to me that I am entering as part of my rebuttal testimony as they further explain and support some of my direct testimony, particularly in areas that contrast with utility positions. These responses to data requests have been reformatted to better fit testimony format and some minor typos have been fixed. The page numbers at the start of each request refer to the original Bates stamp page numbers in the LGC testimony filed on 8/17/20 and found at tab 63 of the docket book and also refiled the next day on 8/19 at tab 65with some improved Bates pagination and indexing, but the same content. I also collaborated with LGC witness Samuel Golding in the response to Request No. EU to LGC 1-058 concerning FERC jurisdictional issues around whether a transactive energy platform at the distribution system level that might be supported by the data platform contemplated in this proceed would be subject to FERC jurisdiction. And I collaborated with LGC witness Amro Farid on the response to Request No. EU to LGC 1-070 concerning TVR. Both responses are files with the other witnesses' testimony, but they should be considered ti be joint testimony with myself.

Q. Are there any general rebuttal remarks you would like to make?

A. Yes. I would like to call the attention of Commission and the parties to a virtual program that was sponsored over the course of this past summer on the "Digital Grid" by the Electric Power Research Institute and the Bits & Watts program of the Precourt Institute for Energy at Stanford University that supports the broad vision and potential for a NH data platform in contrast to the narrow vision of Eversource and Unitil. The vision is that the Digital Grid is the next frontier of electric grid modernization that "requires *an enabling data platform that standardizes how data from customer technologies and resources interfaces with grid."* This is a core element of the shared integrated grid as characterized in Dr. Amro Farid's direct testimony. He was among the presenters in one of many panels and his presentation was attached to his testimony as Attachment C, p. 189.

I have attached a few of slides from the presentations. All of them are available at: https://www.epri.com/research/sectors/technology/events/6182D0F6-9731-4819-83FD-3A126EEEF613. I'd like to call attention to one presenter, LF Energy[1] that was part of the Open Standards Data Platform panel. They are "an open source foundation focused on the power systems sector, hosted within The Linux Foundation. LF Energy provides a neutral, collaborative community to build the shared digital investments that will transform the world's relationship to energy."[2] They could be a tremendous resource as we work to develop a statewide multi-use, online energy data platform.

II. Discussion of whether a Cost/Benefit analysis is required

Request No. EU to LGC 1-001 Witness & Respondent: Clifton Below

REQUEST: Page 7, line 6: Please explain how you reconcile the statement that a cost/benefit analysis does not need to be undertaken with the language in the law that directs to Commission to "defer the implementation of the statewide, multi-use, online energy data platform... if it

[1] https://www.lfenergy.org/
[2] https://www.lfenergy.org/why-lfenergy/

determines that the cost of such platform to be recovered from customers is unreasonable and not in the public interest"? How should public interest be determined in the absence of a cost/benefit analysis? Please be as specific as possible with your criteria.

RESPONSE: I reconcile my assertion that neither the Commission nor other parties to this proceeding are required to undertake a benefit/cost analysis to determine if development and implementation of the multiuse, statewide data platform is in the public interest with RSA 378:51 by reading the plain language of the statute, as is standard practice in statutory interpretation. The first section of SB 284, which was enacted as Chapter 286, NH Laws of 2019, presents a number of findings by the NH General Court that together constitute a strong finding or presumption that it is in public interest to develop and implement a multi-use online data platform, by the body that has the highest authority to make such findings or determinations.

The NH Constitution provides that "all just power possessed by the state is [] granted to the general court to enact laws . . . to control and regulate the acts of [monopoly] corporations" including to provide "for the supervision of government thereof" as well as to limit and regulate the "size and functions of all [such monopoly] corporations. (Part II, Art. 83, Constitution of New Hampshire.) Over the years the General Court has enacted laws to create and delegate much of this authority to the Commission, however the General Court does regularly provide policy and regulatory direction to the Commission through legislative findings and enactments.

In this case the General Court finds, in part,[3] that:

> ***In order to accomplish the purposes of electric utility restructuring under RSA 374-F, to implement fully the state energy policy under RSA 378:37,*** *and to make the state's energy systems more distributed, responsive, dynamic, and consumer-focused,* ***it is necessary*** *to provide consumers and stakeholders with safe, secure access to information about their energy usage.* ***Access to granular energy data is a foundational element for moving New Hampshire's electric and natural gas systems to a more efficient paradigm***

[3] with emphasis added in this and subsequent quotations.

in which empowering consumers is a critical element. (Chapter 286:1, NH Laws of 2010)

The primary purpose of RSA 374-F to restructure the electric utility industry and guide its regulation going forward is stated in the first sentence of the purpose clause – to harness "the power of competitive markets" to reduce costs for consumers of electricity. It expressly identifies as "**key** elements in a restructured industry" "[i]ncreased customer choice and the development of **competitive** wholesale and **retail electricity services."** The work "key" in this context means "to be essential to, play the most important part in.[4]

The plain meaning of "necessary" in the context of the data platform statutory findings is "absolutely needed, required."[5] The plain meaning of "foundational" in this context is "of, relating to, or forming or serving as a base or foundation."[6] A foundation is a base or platform on which other structures, principles, or policies are supported. The plain meaning of "critical" in this context is "indispensable, vital."[7]

Another way to read or paraphrase the General Court's findings, at least in part, is that they have found, as a matter of law, that in order to realize the public policy goals of RSA 374-F and RSA 378:37 [by law deemed to be in the public interest] including to achieve the ***essential*** goal of developing an open and competitive market for retail electricity services and customer choice it is ***absolutely needed – required*** – to develop a robust data platform for a multiplicity of uses related to energy data and that the development and implementation this platform provides ***a base – a foundation*** – for moving the whole natural gas and electric systems forward to a more efficient paradigm or structure in which it is ***vital – indispensable –*** to empower consumers

[4] https://www.merriam-webster.com/dictionary/key
[5] https://www.merriam-webster.com/dictionary/necessary
[6] https://www.merriam-webster.com/dictionary/foundational
[7] https://www.merriam-webster.com/dictionary/critical

through development of the data platform. Hence, the General Court has established a rather clear presumption that development of the data platform is in the public interest.

The implementing language of the statute reinforces this presumption that development of the data platform is in the public interest. RSA 378:51 opens by creating an unequivocal mandate in the first instance:

> "The commission ***shall require*** electric and natural gas utilities to establish and jointly operate a statewide, multi-use, online energy data platform. The platform ***shall*** . . ." [and the statute goes on to specify a number of features (a)-(g) that the platform is required to have].

In the next section RSA 378:51, II requires an adjudicative proceeding to determine a number of features of the data platform grouped in subsections (a)-(c). There is nothing in this list that specifies that Commission or any party, including the utilities, are required to undertake a benefit-cost test, or even consider benefits or costs, much less make a positive determination that development and implementation of the platform is in the public interest or for the public good. If the legislature had wanted to require the Commission make an affirmative public interest determination on any basis, including evaluation of costs and benefits, they could have easily incorporated such languages into the list of determinations that the Commission is required to undertake as part of the adjudicated proceeding, but they did not. The legislature has required that the Commission make an affirmative finding that an action is in the public interest or for the public goods many times before[8], so they know how to write such a requirement. But they wrote no such requirement for an affirmative public interest determination and evaluation of costs and benefits as part of this adjudicative proceeding.

[8] Just as one example, RSA 374-G:5, II requires the Commission to make a positive public interest determination in order to authorize utility investments and cost recovery in certain distributed energy resources and includes as criteria for making such a determination evaluation of 9 factors, 3 of which expressly reference costs and benefits and 4 others reference costs, benefits, or benefits and liabilities.

Instead, as a separate requirement, apart from the adjudicative proceeding requirements, the General Court wrote at RSA 378:51, III that the "[c]ommission shall defer the implementation of the . . . platform pursuant to paragraph I if it determines that the cost of such platform to be recovered from customers is unreasonable and not in the public interest." Presumably implementation would be deferred until such time as the costs to be recovered from customers are no longer deemed to be unreasonable and not in the public interest, or perhaps until the General Court provides further direction. The language or RSA 378:51, III allows for a party, or perhaps the Commission, sua sponte, to make such a negative determination, if the Commission has the evidence to support a finding that the cost to be recovered from customers is unreasonable and not in the public interest. Nowhere in law is the opposite required, that the commission make a positive determination that the costs, relative to the benefits, are reasonable and in the public interest, even though that is frequently done in regulatory statutes, hence I conclude that the statute creates a rebuttable presumption that development of the data platform is in the public interest and that the burden of proof would be on the party asserting that the costs to be recovered from customers are unreasonable and not in the public interest to support a finding by the Commission that such is the case and that would only serve to defer implementation of the platform, not to eliminate the requirement.. However, at this point in the process, as Eversource and Unitil acknowledge at page 53 of their Joint Testimony, it is not possible "to provide specific cost estimates". It is worth noting, that even without a findings or purpose statement laws are presumptively enacted for the public good and in the public interest.

As an aside, looking beyond the plain meaning of the words and sentences in Chapter 264, NH Laws of 2019, it is possible to see the enactment of SB 264 as a way for the General Court to express frustration with the lack of progress by the Commission and utilities in realizing the purposes and potential of RSA 374-F, full implementation of RSA 378:37, and progress in advancing the objectives of Grid Modernization, alternative net metering tariffs, and the energy efficiency resource

standard, so taking matters more directly into their own authority, they have interceded to try to accelerate progress by mandating the development of this platform, while allowing for deferment in time if the costs charged to ratepayers to implement, presumably following a fair bit of design and specification to better determine costs, are shown to be unreasonable and not in the public interest. I do hope that this proceeding enables development of the fullest range and depth of possible functionality and benefits, now and into the foreseeable future, at a reasonable cost, without further intervention by the General Court.

Request No. EU to LGC 1-002 Witness & Respondent: Clifton Below

REQUEST: Page 7, line 18: Do you believe a cost/benefit analysis relative to overall platform development and specific platform functionality/functionalities would be reasonable and in the public interest?

RESPONSE: No. As explained in my response to EU 1-1, the law does not call for an overall cost/benefit analysis to determine public interest, because the General Court has created a rebuttable presumption that development of a statewide multi-use data platform is in the public interest and it is unproductive and perhaps contrary to law to try to second guess the General Court. To the extent costs and benefits are assessed it should be done holistically after the universe of use cases or user stories is established and agreed upon as stated repeatedly in response to utility questions about LGC proposed use cases found at tab 47 in the docket book for this case and incorporated by reference into the testimony of Dr. Amro Farid. For example, at p. 3 the LGC notes that the costs and benefits "from an individual use case should never be assessed individually. A given use case often accrues significant costs for "generic groundwork' that can be shared across multiple use cases … The total benefits of a given use case are usually not realized until other use cases have been implemented as well." These observations were made as part of the original scoping comments of the City of Lebanon, Town of Hanover, and Samuel Golding that can be

found at tab 27 in the docket book and incorporated by reference into the testimony of Dr. Amro Farid. See, in particular, the elaboration on this very point at page 9, which I incorporate into my response. This issue was further explained in the attached PDF entitled "ATT EU to LGC 1-2 DE 19-197 LGC on Use Case Reconciliation" that was provided to the entire service list in this docket on 5/28/20. For additional response to this request see the discussion that starts on the 2nd page of that document on the way forward regarding "use case prioritization" that continues on to the 3rd page.

For convenient reference I restate a portion of that discussion here:

> *Furthermore, it is important to distinguish between prioritization of engineering implementation and prioritization of scope. In the former, the engineering scope is held fixed and engineering and financial constraints determine which parts of the scope will be built first. In the latter, the engineering scope is entirely open for discussion creating the potential for stakeholder winners and losers. We believe strongly that "use case prioritization," without seeing how they might all fit together and share data sources and platform technical requirements, will destine this DE 19-197 docket to a highly contentious proceeding; one that most stakeholders wish to avoid as much as possible.*
>
> *Part of the reason that "use case prioritization" has been proposed is the unsupported belief that more stakeholder use cases will lead to impractical costs. First, this belief, until now, is not founded in any documented evidence. Second, it is extremely common that stakeholder use cases are overlapping. They could 1) be identical use cases but stated differently, 2) have overlapping elements, or 3) be a more specific or general version of each other. Furthermore, the data fields necessary for two entirely different use cases could be entirely the same. In all of these situations, additional use cases do not necessarily increase costs.*
>
> *Moreover, additional use cases and requirements could lower costs because they add greater precision and certainty for the engineering contractor and less engineering analysis is required to determine how to fulfill the use cases. Finally, it is well known within the field of systems engineering that uses cases and requirements do NOT drive costs. Rather, it is engineering artifacts that do. Speaking of costs before the data platform has been designed is an engineering non-sequitur. Returning to the example of the road, one wouldn't ask for the project cost before specifying the road's length, width, thickness, material and grade. Similarly, a cost-based discussion should only occur after*

the data fields associated with use cases have been determined. In contrast, use cases and requirements do drive valuable benefits.

III. Discussion around providing "raw" meter data through platform

Request No. EU to LGC 1-003 Witness & Respondent: Clifton Below

REQUEST: Page 7, line 22: Please specify what you believe the costs and security measures in place would need to be in order to provide "access to raw meter data on near real-time basis"?

RESPONSE: The LGC objects to this question as overly broad as it seeks information that the witness does not have and asks the witness to undertake additional research and analysis to develop new information as part of a data request, which is not an appropriate use of discovery. Notwithstanding the objection, the witness provides the following response:

A basic security measure would be to make the raw data available as "read-only" so that it could not be changed or deleted in the database where it resides by unauthorized users. The cost to provide it might depend on what kind of database it is stored in (e.g. cloud based AMI data vs. legacy MDMS internal database), but seems like it might be incrementally small if similar access is provided to validated data. It is just another similar database to connect to the platform as verified meter data. The cost to store it would depend on how long it is stored for and how much space it takes such as due to the granularity of the data and the data collection interval.

If a customer (or their proxy, such as through "connect my data") can stream such raw data in near real-time when it is collected, then storage costs for the utility shouldn't need to be any more than what they are now, which is to say, once the raw data has been verified, then the raw data may no longer need to be retained and the verified data can take its place. For example, the EKM metering system referenced in footnote #2 on page 8 of my testimony only stores the most recent 1,000 reads (regardless of frequency or interval of data collection) before the data is compiled or pruned into 15-minute intervals for permanent storage. Purchase of the $110 Push

device that handles all communication from the meter to the cloud based storage (without need for an intermediate computer) includes lifetime storage of 15 minute interval data for up to 50 meters per Push device, including for 3 phase meters that provides separate data for each phase as well as aggregated or total load data, at no additional or recurring cost. Data includes forward and reverse kWh, watts, volts, power factor, VARs, frequency, TOU period forward and reverse kWh for up to 4 periods, pulse counts, total KVARh, resettable kWh forward and reverse, and maximum demand (by choice of interval). So, from at least one vendor the cost of long-term meter data storage at a fairly high granularity appears to be minimal as the hardware with integral software may account for most of the one-time cost.

Request No. EU to LGC 1-004 Witness & Respondent: Clifton Below

REQUEST: Page 8, line 3: Please identify the "limitations and inaccuracies that might be inherent in raw or non-revenue grade data."

RESPONSE: This would appear to be a question that the utilities themselves would be in the best position to answer. Having worked with a few raw meter data sets, that have collected data at intervals of once per hour (on the top of the hour), once per minute, and once per every few seconds (mostly every 3 seconds), the primary limitation that I'm familiar with is missing data reads, i.e. meter reads at the specified interval that aren't there for whatever reason, or where the time stamp is off from what is desired. If one wants to "fill in the gaps" some kind of extrapolation or estimating algorithm needs to be applied. Another possible limitation or source of inaccuracy might arise from when the metering device is exchanged and the register reports have a disruption in numerical sequence that has to be corrected for. Some meters may have a multiplier or ratio that is applied to basic units to get the reporting units, so that could be misunderstood from raw data. The raw data may also need custom software to unencrypt or translate the data into meaningful units and descriptors. Non-revenue grade data could also be inaccurate and

inappropriate for revenue purposes because the underlying device has not been designed or verified to produce data within revenue grade tolerances for accuracy.

IV. Discussion around FERC jurisdictional issues

Request No. EU to LGC 1-005 Witness & Respondent: Clifton Below

REQUEST: Page 8, line 5: Please identify the FERC standards "that apply to utility operations under federal jurisdiction."

RESPONSE: Presumably all FERC standards apply to utility operations under federal jurisdiction as a jurisdictional matter. I am not acquainted with all of the details of FERC standards, but I would imagine that some FERC standards aren't applicable to particular operations because they only pertain to certain operations and not others.

Request No. EU to LGC 1-006 Witness & Respondent: Clifton Below

REQUEST: Page 8; line 7: Why would the referenced FERC standards relative to retail metering and distribution utility operations not be applicable to this data platform? Why would these standards not be applicable to third-party sources of data that "might be available through the platform"?

RESPONSE: First and foremost because this data platform is being developed pursuant to state law and is under state jurisdiction and not federal jurisdiction, so FERC standards are simply not applicable, except to the extent FERC jurisdictional data from the interstate transmission grid or interstate wholesale sale of electricity might be made some part of the platform.

I'm wondering why this is even a question as I presume electric utility lawyers are aware there is a fairly bright line between state and federal jurisdiction created explicitly by the Federal Power Act and confirmed by a series of US Supreme Court decisions. Simply put, retail meters and the data produced by them, as well as distribution utility operations and DERs generally including

distributed generation and storage that is less than 5 MW in capacity, not a FERC jurisdictional interstate wholesale market participant, and connected to the distribution grid are all under exclusive state jurisdiction and not under FERC jurisdiction. The General Court and the Commission in some circumstances might want apply FERC standards, such as the uniform system of accounts, to state jurisdictional matters, but they are not required to do so, as the still standing precedent of *Connecticut Light & Power Co. v. FPC*, 324 U.S. 515 (1945) makes clear, even for a non-lawyer. For readers that may not be familiar with how clearly the jurisdictional boundary has been drawn, the following excerpts from the US Supreme Court and FERC legal analysis provides a useful summary (with emphasis added)[9]:

From US Supreme Court FERC v. EPSA, 577 U. S. ____ (2016)[10]:

> . . . this Court held in *Public Util. Comm'n of R. I.* v. *Attleboro Steam & Elec. Co.*, 273 U. S. 83, 89–90 (1927), that the Commerce Clause bars the States from regulating certain interstate electricity transactions, including wholesale sales (*i.e.*, sales for resale) across state lines. That ruling created what became known as the "*Attleboro* gap"—a regulatory void which, the Court pointedly noted, only Congress could fill. [p. 3]
>
> . . . Congress responded to that invitation by passing the FPA in 1935. The Act charged FERC's predecessor agency with undertaking "effective federal regulation of the expanding business of transmitting and selling electric power in interstate commerce." *New York* v. *FERC*, 535 U. S. 1, 6 (2002) (quoting *Gulf States Util. Co.* v. *FPC*, 411 U. S. 747, 758 (1973)). Under the statute, the Commission has authority to regulate "the transmission of electric energy in interstate commerce" and "the sale of electric energy at wholesale in interstate commerce." 16 U. S. C. §824(b)(1).
>
> . . . the Act also limits FERC's regulatory reach, and thereby maintains **a zone of exclusive state jurisdiction.** As pertinent here, §824(b)(1)—the same provision that gives FERC authority over wholesale sales—states that "this subchapter," including its delegation to FERC, "shall not

[9] For additional legal analysis please see the protest of NARUC (which the NHPUC is a member of) in the petition of New England Ratepayers Association, FERC Case No. EL20-42, pp. 34 to 45 in particular, available at: https://pubs.naruc.org/pub/4204BA38-155D-0A36-31CE-8A05CD0AC660.

[10] https://www.supremecourt.gov/opinions/15pdf/14-840-%20new_o75q.pdf

apply to any other sale of electric energy." Accordingly, **the Commission may not regulate either within-state wholesales sales** or, more pertinent here, retail sales of electricity (*i.e.*, sales directly to users). See *New York*, 535 U. S., at 17, 23. State utility commissions continue to oversee those transactions.

. . . as earlier described, [FPA] §824(b) limit[s] FERC's sale jurisdiction to that at wholesale," **reserving regulatory authority over retail sales (as well as intrastate wholesale sales) to the States.** *New York*, 535 U. S., at 17 (emphasis deleted); see 16 U. S. C. §824(b); *supra*, at 3. **FERC cannot take an action transgressing that limit** no matter its impact on wholesale rates. [p. 17] . . . The Act makes federal and state powers "complementary" and "comprehensive," [p.27]

Excerpts from a "Legal Analysis of Commission Jurisdiction over the Rates, Terms and Conditions of Unbundled Retail Transmission in Interstate Commerce" that FERC attached as Appendix G to its Order No. 888 (https://www.ferc.gov/legal/maj-ord-reg/land-docs/order888.asp):

1. Relevant Federal Power Act Provisions Section 201(b)(1) of the FPA provides: The provisions of this Part shall apply to the transmission of electric energy in interstate commerce and to the sale of electric energy at wholesale in interstate commerce . . . . **The Commission shall have jurisdiction over all facilities for such transmission or sale of electric energy, but shall not have jurisdiction . . . . over facilities used in local distribution or only for the transmission of electric energy in intrastate commerce, or over facilities for the transmission of electric energy consumed wholly by the transmitter.** 16 U.S.C. 824(b)(1) (emphasis added). Thus, the statute on its face limits Commission jurisdiction over sales of energy to sales at wholesale, but does not limit jurisdiction over transmission to transmission used only for wholesale sales. Sections 201(c) and (d) define the meaning of "the transmission of electric energy in interstate commerce" and "sale of electric energy at wholesale in interstate commerce." Section 201(c) provides: For the purpose of this Part, electric energy shall be held to be transmitted in interstate commerce if transmitted from a State and consumed at any point

outside thereof: but only insofar as such transmission takes place within the United States. . . .

In *Connecticut Light & Power Co. v. FPC*, 324 U.S. 515 (1945)(CL&P), the Court reviewed the Commission's finding that a Connecticut utility was jurisdictional because it owned transmission facilities that were used in interstate commerce. The Court generally embraced the Jersey Central standard for determining whether facilities are used to transmit electric energy in interstate commerce. The Court emphasized that whether certain facilities transmit electric energy in interstate commerce is more a technical than a legal question. The Court stated:

> Federal jurisdiction was to follow the flow of electric energy, an engineering and scientific, rather than a legalistic or governmental, test. [p. 6] . . .

CL&P, which was decided two years after Jersey Central, is the leading case interpreting the section 201(b) local distribution provision. In CL&P, the Commission sought to regulate the accounting practices of Connecticut Light & Power Company [p. 18] At issue was whether CL&P was a "public utility" under the FPA. The utility's system encompassed an area solely within a single state (Connecticut) 36/ and did not interconnect with any other company that operated out of state. "Its purchases and sales, its receipts and deliveries of power, [were] all within the state." However, CL&P did purchase energy from companies that had, in turn, purchased energy from Massachusetts. The company also sold energy to a municipality that exported a portion of that energy to Fishers Island, located off the coast of Connecticut but "territory of New York." The Commission based its jurisdiction on these few transactions. The Court of Appeals affirmed the Commission, holding that the Commission's jurisdiction extended to "electric distribution systems which normally would operate as interstate businesses." The Court of Appeals found that: whether or not the facilities by which petitioner distributes energy from Massachusetts should be classified as 'local' is not relevant to this case. The sole test of jurisdiction of the Commission over accounts is whether these facilities, 'local' or otherwise, are used for the transmission of electric energy from a point in one state to a point in another. The Supreme Court reversed. It held that the statutory

language in section 201(b) of the FPA providing that the Commission "shall not have jurisdiction . . . over **facilities used in local distribution" is a limitation upon Commission jurisdiction that "the Commission must observe and the courts must enforce."** In analyzing the statute, the Court stated: It has never been questioned that technologically generation, transmission, distribution and consumption are so fused and interdependent that the whole enterprise is within the reach of the commerce power of Congress, either on the basis that it is, or that it affects, interstate commerce, if at any point it crosses a state line. . . .

But whatever reason or combination of reasons led Congress to put the provision in the Act, we think it meant what it said by the words "but shall not have jurisdiction over facilities used in local distribution." Congress by these terms plainly was trying to reconcile the claims of federal and local authorities and to apportion federal and state jurisdiction over the industry.

The Court decided that **this limitation on jurisdiction was "a legal standard that must be given effect** in this case in addition [p. 20] to the technological transmission test." . . .

The Court stated that whether or not local distribution facilities carried out-of-state electric energy was irrelevant. Whatever the origin of the electric energy they carried, so long as the utility used the lines for local distribution, they were exempt from federal jurisdiction. In fact, the Court stated that local distribution facilities "may carry no energy except extra-state energy and still be exempt under the Act."

The Court concluded that the Commission's order: must stand or fall on whether this company owned facilities that were used in transmission of interstate power **and** which **were not facilities used in local distribution.**

V. Issues when a customer gives 3rd party access to their data

Request No. EU to LGC 1-007 Witness & Respondent: Clifton Below

REQUEST: Page 8, lines 9-10: Other than "informed customer choice" in the competitive third-party market, what other data accuracy, timeliness, privacy, and security concerns

should be required for competitive third-party entities? What qualifications should potential users of the platform have to meet in order to be granted access to the platform?

RESPONSE: **T**he LGC objects to this question as overly broad as it seeks information that the witness does not have and asks the witness to undertake additional research and analysis to develop new information as part of a data request, which is not an appropriate use of discovery. Notwithstanding the objection, the witness provides the following response:

The statement referenced was specifically regarding standards for data retention. The context of the quoted text was with regard to "informed customer consent" helping to drive (or shape, if you will) requirements on third parties, so as to indicate that if a customer wants to release their data publicly, or some subset of it, or they want a vendor to retain it indefinitely, those should be options that an informed customer should be able to authorize. This would be in contrast to a policy that would require all third parties to destroy customer data within set periods of time, which would be impossible if was released publicly.

Request No. EU to LGC 1-008 Witness & Respondent: Clifton Below

REQUEST: Page 8, line 11: Please specify what the data storage cost and security issues would be "If a customer wants their individual customer data to be warehoused by a vendor indefinitely." What quality standards would be expected of such data and who would be responsible for them?

RESPONSE: The LGC objects to this question as overly broad as it seeks information that the witness does not have and asks the witness to undertake additional research and analysis to develop new information as part of a data request, which is not an appropriate use of discovery. Notwithstanding the objection, the witness provides the following response:

These issues should primarily be between the vendor or third party and the individual customer, as it normally is in any open and competitive free market. Security, costs, and quality standards

should all depend on the particular use case or application. The utility should not be responsible for data storage costs, security issues, and quality standards once the data is released by a customer to a third party. There could be some built in options, perhaps on top of default settings, in some these matters that a customer could select when they choose to share their data. It would probably depend on the use case.

VI. Why the data platform should support retail level transactive energy system and potential benefits of such

Request No. EU to LGC 1-009 Witness & Respondent: Clifton Below

REQUEST: Page 9, line 5: Please outline where in the legislation the data platform is required to support the "development of a retail/distribution system level transactive energy systems (with) near real-time access to certain data"? If this is additional functionality, please provide an estimated costs and benefits, or if cost or savings estimates cannot be provided, please explain why not, and at least provide the benefits that could be seen from this in 5 years from the launch of the data platform.

RESPONSE: The LGC objects to this question as overly broad as it seeks information that the witness does not have and asks the witness to undertake additional research and analysis to develop new information as part of a data request, which is not an appropriate use of discovery. Notwithstanding the objection, the witness provides the following response:

The statute does not specifically state that the data platform is required to support development of transactive energy systems, nor does it anywhere preclude such. However, the purpose statement of the law (Chapter 286:1, NH Laws of 2019) does start off by saying "[i]n order to accomplish the purposes of electric utility restructuring under RSA 374-F . . ." it is necessary to develop a multi-use online data platform. RSA 374-F is pretty much all about developing, what today is known as "transactive energy systems" at both the wholesale and retail levels.

Let's look at the most widely accepted current definition of transactive energy systems developed by the Gridwise Architecture Council:

> A system of economic and control mechanisms that allows the dynamic balance of supply and demand across the entire electrical infrastructure using value as a key operational parameter.

Value is primarily denoted in dollars. The interstate wholesale market for the supply of electricity is a transactive energy system operated by ISO New England. However, it only covers part of the electrical infrastructure in the region, mostly on the bulk supply side at the transmission system level. The demand side of the equation, load and DERs in the retail market at the distribution system level, is largely disconnected and disabled from using "value," a.k.a. "appropriate price signals" as used in RSA 374-F:1, to help dynamically balance supply and demand. Dynamic balancing of supply and demand in electricity requires access to consumption, production, and system data in near real time, whether done under the traditional "command and control" model of a vertically integrated regulated monopoly utility or in restructured market based approach to supplying system resource needs. RSA 374-F:1 states that the "goal of restructuring is to develop a more efficient industry structure and regulatory framework" by "harnessing the power of competitive markets" to drive down costs and increase economic efficiency. "Increased customer choice and the development of competitive markets for wholesale and retail electricity services are key elements in a restructured industry . . . ." RSA 374-F:3, XIV further provides that "[t]he market framework for competitive electric service should, to the extent possible, reduce reliance on administrative process. New Hampshire should move deliberately to replace traditional planning mechanisms with market driven choice as the means of supplying resource needs."

As described in pp. 134-141 of Dr. Farid's testimony "the shared integrated grid is the leading industrial concept for New Hampshire to achieve its objectives" expressed in law and

development of a transactive energy system at the distribution system level "will enable animated and competitive retail electricity markets and help customers to obtain lower electric costs, reliable service, and secure energy supplies."[11] He completes his explanation of how the data platform enables a transactive energy system that enables a shared integration grid that best realizes the legislative objectives thus:

> *The statewide multi-use online energy data platform would allow for network-enabled distributed energy resources and devices to communicate the prices and quantities of electricity services that they provide or utilize in real-time. The data platform would allow customers to engage by sending and receiving their consumption and distributed generation data and reporting the status of energy storage capacity to charge or discharge, not unlike spinning reserve. The data platform would send and receive the price and quantity data inherent to the coordinated exchange of electricity at the community level. In short, there is no shared integrated grid without a data platform that engages the participation and communication of grid stakeholders. It is foundational.*

Beyond enabling realization of legislative objectives what is the benefit of the data platform enabling development of a retail/distribution level transactive energy system and why don't I have a number for that specific to New Hampshire now? First I'd say the benefit could be immense. It could allow New Hampshire to become a national leader in how to harness the power of competitive markets to dramatically accelerate the cost-effective development and integration of renewable energy resources to achieve our goals to decarbonize the electric grid and avert the worst of run away global warming. What might be the value of helping to save global eco-systems and civilization itself by providing leadership and a model of how we can actually collaboratively do this (the shared integrated grid), while at the same time helping our local communities to be environmentally and economically sustainable for generations to come? Priceless I'd say.

[11] Testimony of Dr. Amro M. Farid for City of Lebanon & LGC, Bates p. 14

Second, why don't I have a quantification of the value of such benefit? It's complicated as evidenced by the result of a multi-year project funded by the U.S. Department of Energy that culminated in a final report entitled ***Valuation of Transactive Systems.***[12] The abstract for the report states that the project was:

> *to formulate and test a methodology for valuation of systems where transaction-based mechanisms coordinate the exchange of value between the system's actors. Today, the principal commodity being exchanged is electrical energy, and such mechanisms are called transactive energy systems. The authors strove to lay a foundation for meaningful valuations of transactive systems in general, and transactive energy systems as a special case. The word valuation is used in many different ways. This report proposes a valuation methodology that is inclusive of many types of valuations. Many will be familiar with cost-benefit valuations, in which both costs and benefits are assessed to determine whether the assets are worth their cost. Another set of valuation methods attempt to optimize an outcome using available resources, as is the case with integrated resource planning. In the end, this report's methodology was most influenced by and most resembles the integrated-resource-planning approach.*[13]

It might be a very interesting exercise to apply the methodology in this report to a New Hampshire specific case study in the context of what this data platform could enable, but that is beyond my means to do as a volunteer in a data response, or really at any point in this proceeding. However, there are a few analyses that might give us an order of magnitude for the potential of TE. Appendix A to *Valuation of Transactive Energy* is entitled "An Estimate of the Potential Value of Supplying Grid Services Using Flexible Loads in Residential and Commercial Buildings - Summary of Results," by RG Pratt and N Fernandez, Pacific Northwest National Laboratory, 9-10-2014. At the request of DOE they "developed an estimate of $22B/year for the potential value of continuously engaging real-time-flexible loads in both residential and commercial buildings to provide grid services if deployed at the national scale." Presumably in

[12] Hammerstrom, Donald J., Corbin, Charles D., Fernandez, Nicholas, Homer, Juliet S., Makhmalbaf, Atefe, Pratt, Robert G., Somani, Abhishek, Gilbert, Erik I., Chandler, Shawn, and Shandross, Richard. Thu . "Valuation of Transactive Systems". United States. doi:10.2172/1256393. https://www.osti.gov/biblio/1256393.
[13] *Id*, p. A.1.

2014 dollars the NH share of that would be about $66 to $88 million/year based on NH's proportion of US 2018 electricity load (about 0.3%)[14] or 2019 population of NH as a share of the national total (about 0.4%).

A separate analysis reported on last year by a team from the Brattle Group, including Dr. Faruqui, on "The National Potential for Load Flexibility VALUE AND MARKET POTENTIAL THROUGH 2030" estimated the annual potential savings from additional flexible load in the US that could be enabled, in part, by transactive energy systems to be about $16.4 billion/year by 2030.[15] Again, using NH's load or population as an approximate share of total benefits, suggests potential value of $49 to $66 million per year.

Dr. Farid in his testimony also estimates "a very conservative" potential annual savings for New Hampshire from a fully enabled TE system in New England of about $6.8 million based on only savings in the day-ahead or real-time markets.[16]

Request No. EU to LGC 1-010 Witness & Respondent: Clifton Below

REQUEST: Page 9, line 12: Please identify the data sets described as "purely public data."

RESPONSE: The LGC objects to this question as overly broad as it seeks information that the witness does not have and asks the witness to undertake additional research and analysis to develop new information as part of a data request, which is not an appropriate use of discovery. Notwithstanding the objection, the witness provides the following response:

These data sets can be determined as part of the process of use case reconciliation, data mapping and platform development.

[14] Computed from https://www.eia.gov/electricity/state/.
[15] See slide 20: https://brattlefiles.blob.core.windows.net/files/16639_national_potential_for_load_flexibility_-_final.pdf.
[16] Testimony of Dr. Farid, p. 164.

These likely include any data that is publicly (non-confidentially) filed with the NHPUC, FERC, other government agencies or ISO New England in periodic reports or otherwise, such as in Liberty Utilities recent filing in DE 19-067 of its only slightly redacted "Salem Area Study 2020."[17] Data that is otherwise made publicly available, such as the type of system data, including topology, that is available through public web portals as described and linked to on pp. 159-160 of Dr. Farid's testimony would be public data. Rates and market information may also be public data. Most if not all aggregated community level data should also fall into the public data bucket.

VII. Issues around anonymized data

Request No. EU to LGC 1-011 Witness & Respondent: Clifton Below

REQUEST: Page 9, lines 18-20: For data "that has been effectively anonymized or aggregated such that it cannot be associated or attributed [to] any one individual customer" what safeguards should be in place to protect that data?

RESPONSE: Generally speaking, if customer data has been effectively anonymized or aggregated such that it cannot be associated or attributed to any one individual customer then it no longer meets the definition of protected individual customer data under RSA 363:37 and so I'm not sure there needs to be extensive safe guards in place to protect that data. In theory if a user of the system could make many calls for aggregated or anonymized data that overlapped a great deal and only varied slightly, they might be able to tease out instances of individual customer data. So, limitations on the volume of overlapping data aggregation or anonymization requests might be in

[17] https://www.puc.nh.gov/Regulatory/Docketbk/2019/19-064/MOTIONS-OBJECTIONS/19-064_2020-09-02_GSEC_SALEM_STUDY.PDF

order. Minimum thresholds for the public release of anonymized and aggregated data would also be appropriate.

Request No. EU to LGC 1-012 Witness & Respondent: Clifton Below

REQUEST: Page 10, line 5: Please reference any aggregation and anonymization standards you or the CPA's have considered for adoption.

RESPONSE: I think the Illinois standard for release of anonymized data sets of customer data (not just aggregation) seem appropriate for adoption. Illinois has been an early leader in making multi-tenant energy data available to commercial building owners for benchmarking and other purposes. They have also enabled access to large quantities of anonymized AMI meter data. As I understand it their standard for the release of actual individual customer data sets, provided anonymously, is that there is required be a minimum of 15 sets of data with no one data set representing more than 15% of the load. That may be reasonable for NH. A few other states use a similar 15/15 standard for the release of anonymized data. The New York Public Service Commission found that to be too restrictive of community level commercial account data and have lowered their standard for such aggregated data, such as for publicly available community level data by rate class, to require a minimum of 6 customers in a data set with no one customer accounting for more than 40% of the total, so NY has adopted a 6/40 standard for aggregation of commercial customers, while maintaining a 15/15 standard for aggregation of residential customer data.[18]

For the release of whole building energy data that includes tenant meter data, the New York PSC approved a 4/50 standard where "aggregated customer usage data is considered sufficiently anonymous to share publicly if (1) the aggregated group contains at least 4 individual accounts,

[18] NYPSC, April 20, 2018, Order Adopting Utility Energy Registry, available at: https://drive.google.com/file/d/1ZO-wdp2Wvb4zdHgw_Otdf1-FWLxlEec7/view

and (2) no one account represents more than 50% of the total load. Where a set of data fails to pass the 4/50 standard, the building owner may only receive the data with tenant consent."[19] For commercial class customers, we suggest that standard would also be appropriate for community level aggregated data, considering that small numbers of such C&I rate class customers in some New Hampshire towns. .

VIII. Issues around registration requirements

Request No. EU to LGC 1-013 Witness & Respondent: Clifton Below

REQUEST: Page 10, line 8: Please explain more fully what registration requirements you think should be in place that align qualifications in a manner that is "commensurate with the level of access sought".

RESPONSE: The LGC objects to this question as overly broad as it seeks information that the witness does not have and asks the witness to undertake additional research and analysis to develop new information as part of a data request, which is not an appropriate use of discovery. Notwithstanding the objection, the witness provides the following response:

The referenced text was with regard to "qualifications requirements for registration to access the data platform" and argues that it should be commensurate or proportionate with the level of access sought. For instance, a user that is a utility customer should have their identity verified, but should not have other significant qualifications required to access their own data. A user that only wants publicly available data should not be subject to NDAs or cybersecurity reviews, though confirmed identity and contact information would be appropriate. A property owner or their agent that only wants aggregated data for whole building energy use likewise should not be subject to NDAs or cybersecurity reviews either, though identity confirmation is more important

[19] NYPSC, April 20, 2018, Order Adopting Whole Building Energy Data Aggregation Standard, p. 2, available at: https://drive.google.com/file/d/1InjfbysYSwWuL_c0Dc8fov2BVfexSPz_/view.

than for just accessing more purely public information. Private party users that want access to individual customer data or other confidential data might be subject to more rigorous registration requirements, although if a customer provides informed consent to a third party to access their data for the purpose of publicly displaying it then requirements on that third party should reflect that fact, i.e. not be contrary to a boilerplate NDA requirements.

Once a Community Power Aggregation is formed under RSA 53-E it has the same legal obligations as the utilities as a service provider under RSA 363:38, pursuant to RSA 53-E:4, VI, which also expressly exempts such information from disclosure under RSA 91-A, so no NDAs should be required for them to access data for their customers. Municipalities and counties as subdivisions of the state should not be subject to cybersecurity reviews by private monopoly utilities to use the platform. They now routinely collect, securely hold. and protect confidential personal information and individual customer data to the extent protected by RSA 91-A.

IX. Issues around potential vendors

Request No. EU to LGC 1-014 Witness & Respondent: Clifton Below

REQUEST: Page 10, line 17: Please explain whether the software products developed by mPrest and Kavala Analytics have been certified by the Green Button Alliance or are compliant and able to be certified. How would these products minimize costs if they are external applications to the data platform? Who would benefit from these possible cost reductions?

RESPONSE: I am not aware that either referenced product has been certified by GBA or are compliant to do so, as that does not appear to have been one of their purposes to date. I suggest that these innovative developers of utility energy data platforms that already draw utility data from a large variety of different databases and systems using API interfaces that may incorporate other features of the data hub that is imagined for New Hampshire, including data privacy protection

and cybersecurity features, might be able to adapt their software to meet a major portion of the software development needs of this project

This might well be less expensive than starting from scratch with vendors that are not familiar with electric utility and other energy data databases and platforms. Discussions with each party by members of the LGC suggests that they are not simply looking for customers for their software as is, but are very interested in exploring the possibility of adapting or extending their software to meet the needs of the proposed statewide multi-use energy data platform.

X. Why property owners should be able to access whole building energy usage data through the platform

Request No. EU to LGC 1-015 Witness & Respondent: Clifton Below

REQUEST: Page 10, lines 9-12: Do you believe that property owners should have access to tenant energy usage and metering data via the platform even under circumstances where the tenants have their own utility account and meter? Please explain.

RESPONSE: Yes. If there are 4 or more tenants with their own utility meters and no one of them accounts for more than 50% of total load then the aggregate load data from such tenant meters, with ICD removed, should be made available without tenant permission as is the case in New York. If there are 3 or fewer such tenants, or if the property owner wants to see individual customer data, then those customers should be able to consent to providing their meter or consumption data to the property owner or their agent through the data platform on a one-time or continuing basis (such as through "connect my data') for a fixed term or until permission is revoked.

This would enable the property owner to properly benchmark and understand their whole building energy use, including in conjunction with utility sponsored energy efficiency programs and calculations of before and after EUIs. The NY PSC "Order Adopting Whole Building

Energy Data Aggregation Standard" referenced and linked to in the response to Request No. EU to LGC 1-012 elaborates on the need for and value of such data access.

In 2011 the Board of Directors of NARUC passed a resolution acknowledging "the need for commercial building owners and managers to access whole-building energy consumption data to support energy-efficient building operations" and encouraging "State public utility commissions seeking to capture cost-effective energy savings from commercial buildings to consider a comprehensive benchmarking policy that includes:

- Use of EPA ENERGY STAR automated benchmarking services and other benchmarking services, such as the Commercial Building Consumption Survey;
- Adopting methodologies to consistently and accurately credit program impact to benchmarking-driven energy efficiency programs; and
- Taking all reasonable measures to facilitate convenient, electronic access to utility energy usage data for building owners, including aggregated building data that does not reveal customer-specific data to protect individual customer privacy, as well as the sharing of customer-specific data to the extent provided for under State law and regulations."

XI. Why NDAs should not be required of all data platform users

Request No. EU to LGC 1-016 Witness & Respondent: Clifton Below

REQUEST: Page 10, lines 12-13: Please explain why "NDAs should not be required for users who do not seek access to any ICD or otherwise sensitive or confidential data."

RESPONSE: If a user of system is not seeking authorization to access any ICD or other data that is not public in nature, i.e. "sensitive or confidential data," then the remaining data that they access would be more in the nature of public data that need not be protected from release; hence no need for an NDA. It is my understand that the "Utility Data Registry" run by NYSERDA in New York

state provides community level aggregated energy consumption data publicly, over a web portal, where no NDA is required, and apparently not even registration. See https://data.ny.gov/Energy-Environment/Utility-Energy-Registry-Monthly-Community-Energy-U/m3xm-q3dw.

XII. A few more issues around potential vendors or software sources

Request No. EU to LGC 1-017 Witness & Respondent: Clifton Below

REQUEST: Page 10, line 17: How might mPrest's or Kavala Anaytics's software products be adapted to be the "core of an energy data hub"? Does either software vendor offer Green Button Connect capability currently? Who would be responsible for ongoing management of those products? Would those companies be hired as a contractor or brought on as platform operation staff? Please provide pricing for all products and services for mPrest and Kevala.

RESPONSE: Please see the response to Request No. EU to LGC 1-014 for a response to the first two questions. The data platform project manager or developer would be responsible for engaging and managing these companies and their products to the extent parts of them might be incorporated into the data platform hub. I do not have pricing for their products and services beyond what mPrest has publicly filed in this proceeding at tab 55 of the docket book.

Request No. EU to LGC 1-018 Witness & Respondent: Clifton Below

REQUEST: Page 10, line 19: Please explain fully how the "the open source Volttron software" satisfies the required functionality of SB284. Does Volttron software offer Green Button Connect capability currently? Please provide Volttron's pricing for all products and services.

RESPONSE: I did not assert that the Volttron software "satisfies the required functionality of SB284." I doubt that it has any Green Button Connect features, although I don't know that one way or the other. (It is possible that has features to accept connected Green Button data.) It was

developed by the Pacific Northwest National Laboratory with public funding from the US DOE and designed to be open-source software freely available, so I am unaware of any pricing. The point of the reference is that it is a software product closely related to energy data platforms that appears to offer free, and to some extent supported, access to software code that may be useful in developing code for the NH energy data hub/platform. Here is some of the information from the volttron.org website on one of its relevant features:

> **SECURE** From the beginning, VOLTTRON™ developers actively collaborated with cyber security experts and built security *into* the technology, rather than "bolting it on" later. The commitment has continued, with developers regularly upgrading features in response to emerging requirements and VOLTTRON™ user feedback.
>
> The platform applies a threat-model approach for determining software threats and vulnerabilities and how to reasonably reduce the attack surface and/or harm from a compromise. Through established mitigation strategies, VOLTTRON™ addresses a range of possible attack avenues and risks.

See also https://volttron.org/sites/default/files/publications/VOLTTRON_security_2017.pdf.

There may also be coding relating to interoperability that may be relevant: "Volttron makes it possible for diverse systems and subsystems, in and out of the energy sector, to interact and connect."

Q. Does that conclude your testimony?

A. Yes it does.

STATE OF NEW HAMPSHIRE

BEFORE THE

NEW HAMPSHIREPUBLIC UTILITIES COMMISSION

DE 19-197

Electric and Natural Gas Utilities

Development of a Statewide, Multi-use Online Energy Data Platform

REBUTTAL TESTIMONY OF KAT MCGHEE, M.ED., PMP

MEMBER OF THE LOCAL GOVERNMENT COALITION

OCTOBER 23, 2020

Q. Please identify yourself and previous involvement in this docket.

A. I am Kat McGhee. I filed Direct Testimony on my own behalf and for the Local Government Coalition. I've also participated technical sessions including those before the filing of testimony and collaborated in written commentaries and the development of user stories.

Q. What is your rebuttal testimony?

A. Staff asked 3 discovery questions of me while Eversource and Unitil (EU) made 19 discovery requests. Some elicited additional background and clarification of my direct testimony, while other questions from the utilities contrasted their positions with my own. My responses elaborate on my direct testimony, often in contrast to the Eversource/Unitil positions. I am submitting my responses to their discovery requests and questions as my rebuttal testimony. The standard discovery response formatting has been removed, except for the request number line. A few responses have had minor (non-substantive) typos fixed. Eversource and Unitil (EU) asked me 3 discovery questions that clarified several points in my direct testimony. I am submitting my responses to their discovery requests as my rebuttal testimony. The standard discovery response formatting has been removed, except for the request number line. A few minor (non-substantive) typos have been fixed and an e-mail address was removed..

Request No. Staff to LGC 1-1 Witness & Respondent: Kat McGhee

REQUEST: Reference McGhee Testimony at Page 9 of 22, Bates Page 27 of Local Government Coalition testimony, stating "The view of the required cost for this scale of project, when priced by an energy utility to build in-house vs. a more-nimble utility API company that specializes in this work, is likely not even close. In fact, initial discussions on project cost by the OCA Finance Director revealed that there are vast differences in project pricing depending upon whether or not you are looking at companies who dedicate their business to this type of data project and have a well-defined RFP." Please expand upon what aspects of the scope and timeframe and what levels of detail should be included in a "well-defined RFP" for the purposes of achieving the lowest possible project price from a bidder."

RESPONSE: The project scope, in terms of data-customer functionality, was defined during the technical session collaboration into a set of User Stories. (Identified customer data system outcomes).

Reaching agreement on 'what' will be delivered and to whom (users), provides needed insight for any technical team to begin defining more detailed specifications. Those specifications would include

additional layers of technical detail that cannot be known until the project team working on the implementation begins defining the functional specifications.

The systems' design, or 'how' it will be delivered, includes the levels of software systems' architecture required to allow for *inter and intra system operability* (how does the data hub work to deliver output to data consumers and how does it interact with the other data servers (API's) to supply that output?

The systems design requirements will also include the architectural decisions on:

relational data protocols (how are data relationships configured to bring the desired data together (aggregation)?

What level of *performance* is required to meet quality expectation?

System standards such as: *security* (2 factor authentication, etc.), *data privacy* (permissions for who can see what), *change management* (to track bug-fix status) and *versioning* (so all users are on the latest version of software).

Finally, the all-important integration of the New Hampshire electrical energy data standard or *NEEDS model* – must be agreed to by all utility stakeholders as the starting point to making the data handling work. Consensus around a uniform data standard model up front, provides a cohesion that gives any vendor confidence they are working on a well-conceived project.

Systems' design specification is required in order for the data hub to meets it goals and in fulfillment of RSA 286. But, since companies who provide these types of services to other states have worked on all of these systems' requirements before, they already understand the relative scope of work entailed and are not providing estimates to the PUC without having first-hand knowledge, having undertaken similar projects in the past. They may have 'plug and play' solutions or shortcuts to fulfilling these specs, of which the utilities would not likely be aware.

In my conversations with Utility API and Green Button Alliance, I was told that defining the NH logical data model standard and defining the User Stories (or "use cases"), along with the additional high level systems requirements that would be needed by any 21st century API-based data server system, is a fairly common level of detail for an initial utility data project RFP. Further detail from the utilities may be needed to define the volume of data to be handled. But, in relative terms, New Hampshire's utility customer base is small and for data API companies accustomed to working with larger energy markets, that translates into manageable (lower risk/lower cost).

The systems' requirements would be consistent for any data hub that the State of New Hampshire pursues, regardless of how it is built or delivered. But the specifications for how complex the design, implementation & testing phases of the project will be, and how long the project will take, are beyond my ability to define for the PUC without an RFP process.

In discussions with companies who work in this space, my understanding is that having the utilities be responsible for cleaning and providing the data in a standardized data feed is the best way to streamline and contain the costs. The NEEDS model will supply the consistent format that all the various data inputs will conform their data fields to, so the data becomes normalized into a useful format. If the API vendor has to do this task, it slows them in running their core tasks for the lowest cost turnaround. So, it does matter who does which pieces of this data project and also, how well they collaborate.

This is partly why I recommend engaging a company who does utility API work in my testimony. The best way to control the cost on a project that takes us to new places, is to leverage experience of those who have already been there. In this case, New Hampshire's utilities know their data and the security and privacy standards that need to be met in order to protect their customers. They are also intimately familiar with their own data and how the various utility data handling systems differ. We want to leverage that knowledge, but not to burden them with pieces of the project that are not their core business. This would require a learning curve that the utilities seem willing to undertake because they believe the statute requires it of them; but collaborating on that learning curve, across 3 companies' IT departments forces a level of complexity in communication, workload/cost-sharing and project management that is cumbersome and that, I presume, would make it more costly.

The RFP is a precursor to any project schedule. You could make a 'high-level' Time/Scope/Cost estimate a deliverable of your RFI/RFP. Consistent with my testimony, I believe Eversource and Unitil IT resources agreed that an agile project was preferable. This software methodology provides for regular communication and agreement, to avoid misunderstandings as you meet rapid milestones in a sprint process. This method is popular because it is proven to contribute to controlled costs and faster, desired results. A data API company that practices agile software implementations would likely be able to supply a technical project lead to work in collaboration with the utilities.

Request No. Staff to LGC 1-2 Witness & Respondent: Kat McGhee

REQUEST: Reference Testimony of Kat McGhee at Page 11 of 22, Bates Page 29 of Local Government Coalition testimony stating "the PUC can and should outline a process by which a technical project

lead who may be engaged by, but not employed by, the utilities is given the autonomy to manage the project without the influence of any (or all 3), of the major utilities…"

a. Please provide one or multiple examples of a recommended independent technical project leader.

b. Please provide one or multiple examples of a process to select and engage a technical project leader which the PUC should outline.

RESPONSE:

a. To me the term 'independent' means one without competing interests in the implementation of the Energy Data Hub. If a company that responds to the RFP already uses agile software processes, then this would mean the project leader from that vendor could fulfill the role of technical leader to the governance council as well. There are also certified 'scrum masters' with utility data experience, who could be hired onto the project to consult on behalf of the PUC. Scrum Master is the title given to an agile project leader once they have completed training on agile software development methodology. As a member of the Project Management Institute (PMI), I reached out to the NH president, Mark Lucas about how we would go about making a search of the local project management universe to find someone with specific expertise. He is happy to post an inquiry from the State of New Hampshire to conduct a search of people qualified to lead a utility data hub project using agile project management methods if we are interested in exploring unknown candidates in the region.

It was quite interesting to me that our ability to refine Use Cases was stymied before someone with agile and utility data systems' architecture expertise joined our technical sessions and post-session talks. Ethan Goldman, who is a volunteer expert witness on behalf of CENH , has a very specific set of skills emanating from his work in Vermont, that make him the type of project leader we need. I did not know him before Henry Herndon of CENH asked him to sit in on some calls; but, it was clear Ethan could see where the discussions were stalled, how to refocus us in a useful way and how to make strides in our talks with the utilities.

I was impressed with Ethan's communication skills as I have participated in multiple meetings where he listened to stakeholder concerns and added immediate value to move us forward. His detailed understanding of utility data and his knowledge of the kinds of issues that can arise during a utility data integration project convinced me that finding a person with applicable experience to be able to meet the concerns of all stakeholders is a critical success factor for the State of New

Hampshire to consider. Ethan is clearly comfortable with the agile software development process and I thought this was worth mentioning. He brought a great deal of clarity to the process of re-working the Use Cases into User Stories so that everyone could find common understanding. This is the skill-set that will help run an effective and meaningful project.

So, although I think very highly of Ethan as a resource with explicit energy data architecture experience, which I see as uncommon, I see the choices as follows, we can:

1) Pick a utility data vendor partner who can run an agile software process and utilize their expertise as part of the software project to supply and experienced team leader who communicates regularly with the Data Hub Council and the utilities.
2) Secure as a project leader a consultant who will be responsible for an agile team of technical data software resources from our API vendor and the utilities; that can be done via a search with PMI-NH.org or via a technical head-hunter firm, or monster.com or another online service for finding talent.
3) Look at the very specific skills that exist within the docket's intervenors service list, for someone with the experience we need.

b. As with any search process, the first step is to identify the skills you are seeking in your Technical Project Leader. Just as with the User Stories, when you identify the outcomes you expect, it leads to a process whereby we can more easily determine if the candidate meets the requirements. In the case of the NH Data Hub project team leader, I recommend including the following experience:

i. Agile technology project leader (scrum master training or equivalent)
ii. Utility data experience (3 years minimum)
iii. Data systems' architecture expertise (5 years +)
iv. API architecture experience (expertise preferable)
v. Excellent communications skills

Request No. EU to LGC 1-022 Witness & Respondent: Kat McGhee

REQUEST: Page 22, line 14: What are the elements of the distributed energy system beyond the utility areas that you would like the data platform to portray? Given SB284's required functionality of utility customer usage data, what other data, if any, would come from this area of the distributed energy system beyond the utilities?

RESPONSE: The easiest way to respond to this question is to put it in terms of metered energy data. If the State of New Hampshire and the PUC are to order the design and implementation of a statewide, online, energy data hub, it would be inefficient and short-sighted, to confine it to electric utility data in front of the meter. The ability for community aggregators and municipal governments to secure and use their data to manage energy costs is a major driver of providing easier access to all our energy data in a consumable form. All energy contributing to the state's generation must have a way of being captured so that the true 'big picture' of our needs and use is available in the data.

The bill called out the need for utility customer data because without the data that the utilities' control, a centralized data hub could not be created. It should not be inferred that because the utilities were compelled to include their customer data, other contributing forms of electric generation, storage, and consumption information, nor system data, would be excluded from an energy data hub. This would defeat the purpose of having access to 'statewide' energy data. The bill language discusses the strategic advantages of having access to energy data that can be turned into information; that information can be used in support of ongoing PUC efforts like grid modernization and energy efficiency plans.

Distributed energy sources, behind the meter, could be required to provide whatever uniform data elements are defined in the New Hampshire Electric Energy Data Standard (NEEDS) model. Whether this is accomplished in the initial rollout or is part of a phase plan that must be implemented as technical hurdles are addressed, is an answer for those who will be assessing the technical challenges on the ground. I am not a technical person. I cannot provide the fields. But uniform energy data collection is the only way we will be able to roll up data into useful information. There is no language that excludes distributed renewable forms of energy generation, storage, load, or system data from the equation. We do not know the significance of the role of each energy data type for our state in the near and not so near future. In order to build a hub that is 'future proof', we must make it capable of including whatever energy types are contributing to the overall load requirements of our communities and state.

Request No. EU to LGC 1-023 Witness & Respondent: Kat McGhee

REQUEST: Page 23, line 8: Please explain fully what is meant by "an automated energy data hub"?

RESPONSE: I used the word 'automated' to describe the use of an API (a set of functions that access the features or data of an operating system, application, or other service) or series of API's to pull energy data from various sources into a centralized database or a virtual data server.

The concept of an Energy Data Hub is just another way of saying energy data platform. The term was first coined in Clean Energy New Hampshire's testimony. I used the term in my testimony to be consistent with that nomenclature. For the purposes of clarity, hub and platform are synonymous.

To me, automated means we are not pulling raw data from different sources manually into static spreadsheets in order to be able to manipulate it into useful information. An automated energy data hub is a centrally located software application that allows users to slice and dice their energy data in a way that makes it useful to them. Without solving for a way to include distributed energy sources in our data collection/automation, we are severely limiting the value of the project in terms of future use.

Request No. EU to LGC 1-024 Witness & Respondent: Kat McGhee

REQUEST: Page 23, line 10: Please explain fully what is meant by "support automated reporting." What types of reports and reporting functionality are desired? Please identify who would request the reporting and who would provide responses.

RESPONSE: At a high level, the User Stories defined during the Technical Sessions and surrounding meetings provided a set of 'expected outcomes' for consumers of the hub data. Users will be able to roll up community level data, (this ideally includes all generation sources within the 'community portfolio' aka. 'data aggregation' and be viewable by a unique time period), in order to create a picture of energy use at the level needed for analysis and energy planning. This is a reporting output of the data hub and it has already been defined in the expected outcomes of the User Stories. I do not have 'automated reporting' requirements beyond the User Stories. There have been several conversations about User Apps being designs to leverage New Hampshire's energy data platform as a source of energy reporting and analysis. But that is beyond the scope of the proposed project. The ability to report on ones' own town energy picture is an example of the User Stories' scenarios that are already included in the requirements.

The question of 'who would provide the responses?' is indicative of the status quo for how data is managed today. If the system is automated it is designed to support self-service of data by the user based upon their permissions to view and use the system.

Example:

The Chair of my town's energy committee, much like April Salas of Hanover, has been diligently working to provide cost benefit analysis on solar investments to our elementary school rooftops for years. The Energy Committee is at a loss trying to get the information to quantify savings to our Board. The

folks on our energy committee are technical, competent and work regularly with the utilities. But the system is not automated – so they are forced to work on manual data dumps from disparate sources and the results are still not sufficiently comprehensive to illustrate the entire picture needed to show their homework to the town selectman and budget committee. This is among the consumer problems an automated energy data hub is intended to address. They should be able to have access to their own data and be able to make sense of it.

So, the answer to your last question is, the energy data hub user would request the data and the platform would respond with that data.

Request No. EU to LGC 1-025 Witness & Respondent: Kat McGhee

REQUEST: Page 23, line 24: Please describe the steps stakeholders have taken to determine whether User Stories are "reasonable" and the cost of implementing them is in the best interest of ratepayers. For all such determinations please provide all reference material used and calculations used to support these claims.

RESPONSE: The LGC objects to this queston as overly broad as it seeks information that the witness does not have and asks the witness to undertake additional analysis and develop new information as part of a data request, which is not an appropriate use of discovery. Notwithstanding the objection, the witness provides the following response:

My use of the term ‘reasonable’ was in reference to teleconferences with Unitil and Eversource where we provided access to and in some cases walked through and provided access to the User Stories developed from the Use Cases across the docket, as a set of concrete ‘outcomes’ the platform (or hub) would deliver. There were also IT people who had reviewed the User Stories and commented in those meetings that they brought greater clarity to the objective outcomes of the hub. There were no particular objections to the outcomes described for any of the user categories.

There are no reference materials that relate to the reasonableness of specific outputs and what is in the best interest for the ratepayer. The User Stories document was designed in direct response to the identified needs of the various user categories. Customer, Third Party, CPA, Grid Modernization Group, Government (PUC), utility.

https://docs.google.com/spreadsheets/d/1WSQELIC9anFVvl_Txqdih0jPTEjeuH_j-ZtjXRcT-NbU/edit?ts=5f60da54#gid=1299256911

Improved energy efficiency, greater ease of use/time savings for distributed energy aggregators and municipalities, more accurate grid planning and modernization efforts are all insights into the portfolio of electric energy generations that an energy data hub can solve for the New Hampshire energy consumer, whatever their role. Someone more conversant in economics might be able to quantify value of being able to secure this information to the various electric energy consumers of New Hampshire. See also the estimate provided by Prof. Amro Farid in his testimony at Bates p. 164.

Request No. EU to LGC 1-026 Witness & Respondent: Kat McGhee

REQUEST: Page 24, line 18: Please define "supporting relational data-sets" in terms of required or additional functionality of the platform. Who would benefit from their inclusion?

RESPONSE: Supporting relational data sets does not describe additional functionality. In James Brennan's testimony for the OCA, the originating department in the State of New Hampshire, he discusses the importance of relational data sets in support of a data base structure that can roll up data, so it is useful.

The raw data in any database is just a set of 'building blocks". It's the proverbial 'gobbledygook' without a set of defined relationships between the data being collected that tells the system how to organize and 'inter-relate' the data for display back to the user seeking information.

The relationships that exist between those blocks must be defined so that the information derived can be provided in a meaningful way. This is all I meant by relational data sets. It is a tech industry term that has been referred to in other testimony, so I did not think I would have to provide further elaboration. I am not a software developer, but I have worked in the software engineering environment and I trust that this layman's definition will suffice.

In a relational data base, which the statewide, online energy data hub would be to meet any of its objectives, relational data sets are a feature.

Request No. EU to LGC 1-027 Witness & Respondent: Kat McGhee

REQUEST: Page 24, lines 26-28: Please provide the definition of "state of the art security" that was discussed or shared with the User Stories and any relevant security standards referenced.

RESPONSE: There is no such reference on Bates page 24, so assumed page 23 was intended. This phrase was used as shorthand because I have no background in data security protocols or products. What I do know is that the statute requires that the energy data be secured to the level of security that is expected by the customers and stakeholders, including the utilities.

The details of those methods, (like 2-factor authentication, encryption etc.) are for the technical collaborators (including the utilities) to decide in meeting the requirement for data security. The term 'state of the art' simply means the best practice as it currently exists.

Request No. EU to LGC 1-028 Witness & Respondent: Kat McGhee

REQUEST: Page 25, line 6: Do you believe the PUC should investigate cost as a consideration of the project? If so, would the PUC need to understand the scope of the platform in order to determine the initial and ongoing cost? If not, what is the justification for disregarding the method used to determine public benefit and what metrics would you replace cost/benefit analysis with?

RESPONSE: I believe it is the responsibility of the PUC to investigate costs and determine the benefits of the project. That does not mean one can conduct a cost benefit analysis as though the value was equal to the sum of the parts. The experts in utility data API solutions will need to join in an RFI/RFP process in order to examine both the initial scope and types of maintenance models that could be pursued and their associated costs.

I have no way of assessing whether the current methods used for assessing public benefit remain sufficient for this exercise. I believe having access to energy data is the crucible for governments around the nation and around the globe, so I'm pretty sure our investment will be both timely and cost effective in the long run. This is the missing piece in being able to manage our energy resources. If all energy consumers do not benefit from improved efficiency and planning, I would be surprised because that is a primary driver of all of our efforts who work in this space. But I concede that this software project will have costs a non-technical project will not, so it may be difficult for the commissioners to put the project costs into context with the significant benefit having access to our changing energy data will provide.

Please also see the responses of witness Below to EU to LGC 1-001 and 1-002.

Request No. EU to LGC 1-029 Witness & Respondent: Kat McGhee

REQUEST: Page 25, line 24: Please provide examples of what is meant by elusive efficiencies.

RESPONSE: The term 'elusive efficiencies' came from my notes of a keynote speech by Damir Novosel, President and Founder of Quanta, who spoke to us at the Boston Copley during the ISO-NE 10 year Regional Systems Planning conference, one year ago, on September 10th, 2019. The President of Transmission for Eversource, Katherine Prewitt was a conference panelist.

Mr. Novosel made the point in his keynote that the most elusive and essential aspect of integrating distributed generation assets successfully into the energy grid is our inability to 'see' the contribution of behind the meter load reducers. Or, as my friend Pat Martin puts it, you cannot manage what you cannot measure. The benefits of being able to leverage greater energy efficiency remains elusive expressly because we are unable to centralize and use our energy data today in a strategic way. Refer to my prior anecdote as to the efforts of the Hollis Energy Committee or those of fellow-LGC member, April Salas' testimony on the experiences of the Town of Hanover. These are just 2 New Hampshire towns who have found quantifying and managing their actions toward greater energy efficiency 'elusive'.

Request No. EU to LGC 1-030(a) Witness & Respondent: Kat McGhee

REQUEST: Page 26, line 21: Please provide examples of the type of companies you recommend here, and for each please provide pricing for their services.

RESPONSE: The LGC objects to this question as overly broad as it seeks information that the witness does not have and asks the witness to undertake additional analysis and develop new information as part of a data request, which is not an appropriate use of discovery. Notwithstanding the objection, the witness provides the following response:

The utilities participated in early Tech Session demos by companies like Utility API, Packetized Energy and later demos by mPrest and Kevala. These companies work in the utility data collection and display space.

I do not have pricing information for any of their services. Obviously, without discussing the specifics of a particular project, including the volume of data to be hosted and the amount of collaborative effort required to ready the data for use, no estimate would be reliable. The point I was trying to make is that companies who are competing in the space of energy data services are familiar with the idiosyncrasies of managing multiple utility data sources, security, permissions, change management, versioning etc. Because their services might price in these features and functionality, it is a good assumption they can offer them without the same effort it would take an in-house utility IT department to conceive, design, develop and test these from scratch.

Mr. Brennan, of the Office of the Consumer Advocate, who has a background in software management, engaged in talks with a few such vendors relatively early in the process to get some idea of pricing for a project of this type. He was able to talk about what type of model the platform would require, so that the vendors had a good sense of the project scope. As a result of those discussions, Jim was

convinced that the estimates being expressed by the utilities were much higher than the cost of executing an API based service as his original diagram conceived. Large companies (like IBM's involvement in this space) tend to price projects higher because they require specialized technical expertise. They know they can command a high price because they are trusted on the technology. But, just as technology products come down in price over time, the cost of implementing utility data systems is a space with competitive players, and prices have come down.

Mr. Brennan and I, both with experience in managing IT projects, agree that leveraging the lower cost option is the right approach for New Hampshire.

Request No. EU to LGC 1-030(b) Witness & Respondent: Kat McGhee

REQUEST: Page 27, line 7: Why would a "fee for service model" not be appropriate when the third parties selling services to customers would receive financial benefits from the development of such a platform?

RESPONSE: The role of distributed generation assets in the electric energy market is the rub isn't it? Third parties may appear to the utilities to be the pesky competitors nipping at heels of traditional bulk generation supplied through the interstate transmission grid. But, those 'financial benefits' are a result of a market share that is being encouraged by regional grid planning goals for shaving peak, reducing load, properly integrating non-traditional generation assets and reducing emissions. So perhaps, all of these benefits are a worthy trade-off for encouraging clean energy producers work, rather than charging them, to use a system that is helping us achieve state and regional goals.

If the energy data hub is well conceived and developed, everyone involved in the energy market benefits, including regulators and utilities. If only certain stakeholders pay to access the system, it is not an equal resource to enable the desired clean energy transition.

I am of the opinion that this energy data hub should not be viewed as a utility application that other energy market participants pay for the privilege to access. The utilities will also benefit from this data access, in planning, partnering on behind the meter projects and supplying more robust data to regulators as analysis for strategic distribution investments. The utilities are playing an essential role in bringing the energy hub into being, but in my mind, that does not mean they are intended to reap greater benefit from the system, than smaller competitors or other stakeholders.

Everybody pays, or nobody pays would be how I would explain it. But then, the utilities have bigger pockets, can leverage economies of scale and depending upon the vendor relationship, may have

easier direct access to data; the stakeholder relationship in using the energy data hub has many ways to become unequal. That is why I argue against a fee for service.

Request No. EU to LGC 1-031 Witness & Respondent: Kat McGhee

REQUEST: Page 27, lines 8-11: If parties other than the utilities are to participate and benefit from the "modern grid infrastructure" without contributing to this infrastructure, does this paradigm provide a competitive advantage?

RESPONSE: The small renewable company owners in New Hampshire can barely eek out a living on what we are doing to incent their contributions to the distributed grid. We keep failing to pass a proper ceiling for net metering caps. I admit that getting the balance right during a transition for a changing market is not easy and will not be done without some wrangling over turf, tools and tariffs.

But, these third parties are contributing to the infrastructure; they are building the distributed piece of the state's infrastructure and educating the public, one project at a time. It is a different model than the traditional utility model, but it is what we have chosen to pursue. We should stop sending mixed messages and simply figure out how to integrate our grid as we keep saying is our intention.

The energy data hub is not part of the physical energy infrastructure – though it will play an integral role in its management. The energy data hub is the way we will jointly engage with our infrastructure as a whole and manage it to the benefit of all customers.

Request No. EU to LGC 1-032 Witness & Respondent: Kat McGhee

REQUEST: Page 27, lines 13-18: Please describe the role of a "more-nimble utility API company" in building out the internal data mapping from utility backend systems to the Logical Data Model and the "behind the API" work required to get access to these disparate utility data sources. How might an external organization such as this deliver such work more efficiently and cost-effectively than the utility IT itself?

RESPONSE: The utility can absolutely supply a clean data feed that conforms to the logical data model easier and with greater institutional knowledge than any vendor. A data project of this type has got to be a collaborative effort. If we decide to build a virtual platform that handles data from the utilities and other metered, distributed resources through a series of data handling API's, I think just as the utilities have more knowledge of their own data handling, the utility data companies that already do this work, will be able to craft an API software solution faster than the utilities, and for more streamlined costs.

Request No. EU to LGC 1-033 Witness & Respondent: Kat McGhee

REQUEST: Page 27, line 18: Please provide any documentation available on the services offered by non-utility providers. What is the scope of cost estimates provided?

RESPONSE: The LGC objects to this question as overly broad as it seeks information that the witness does not have and asks the witness to undertake additional analysis and develop new information as part of a data request, which is not an appropriate use of discovery. Notwithstanding the objection, the witness provides the following response: I do not possess any cost estimates.

Request No. EU to LGC 1-034 Witness & Respondent: Kat McGhee

REQUEST: Page 28, lines 15-20: Please describe what means the Commission might use to determine whether the delivered value of a platform such as this is cost beneficial, particularly with the "unknowns" described in this testimony.

RESPONSE: All systems development involves unknowns. The nature of any systems' project is that you are creating functionality that was previously unavailable.

The immediate benefits to energy consumers, stakeholders and planners are reflected in the User Stories' outcomes. The tangential benefit of having insights like those described by the President of Quanta in his keynote address at the ISO-NE 10 Year Strategic Planning regional meeting were quite clear. This is where the energy sector is going and having access to our energy data is the missing piece. What price do we put on that? I believe the commissioners are more qualified to answer that question than me.

We have a golden opportunity to leverage this project to New Hampshire's advantage as was defined in front of NH PUC Commissioners and the Governor's Office of Strategic Initiatives, who were in attendance at that ISO/NE 10-year Strategic Regional Planning meeting. Creating data access and transparency was called out as the most significant missing piece of the puzzle to properly integrating distributed generation assets.

I guess the proper question is what will it cost us to attain our goals? Or what is the opportunity cost of failing to attain our goals. This project is not seen by non-utility stakeholders and the other intervenors on this project as another customer-utility interface. It is seen as a lynchpin for grid modernization and energy efficiency efforts.

Request No. EU to LGC 1-035 Witness & Respondent: Kat McGhee

REQUEST: Page 29, line 2: Please explain fully the "differing views on approach even amongst the 3 major utilities."

RESPONSE: In conversations with 2 of the 3 utilities (Unitil and Eversource), it was apparent that company cultures varied and those differences boiled down to different levels of receptivity to the concept of modernizing data access in furtherance of more strategic statewide energy use. The response from Liberty Utilities was a welcomed, yet distinct perspective. I had not had an opportunity to speak with their representatives on Liberty's position on the project.

Request No. EU to LGC 1-036 Witness & Respondent: Kat McGhee

REQUEST: Page 29, line 5: Please explain what elements of this new paradigm you are referring to in the testimony that the utilities have not embraced. How is it in the best interest of the project to give "the autonomy to manage the project without the influence of any (or all 3), of the major utilities" who own and best understand the utility data and are considered a stakeholder and user of the platform?

RESPONSE: This is a key question in term of stakeholder perspective. From the utilities' perspective they are the prime stakeholders for the project. It is a valid position based upon your points above. The point I am making is that the software project is not best owned/managed/conceived by the utilities. To ensure decisions are made in an agnostic way, no stakeholder should be designing features that benefit or disadvantage their competitors. It's just not good practice from a process standpoint and if the state were asking a solar vendor like ReVision Energy to run the project, the utilities would cry foul as well. There should be distance between the software project and the utilities as stakeholders. That doesn't mean the utilities are not prime collaborators on the project. But if this turns into a utility project, it will reflect the utilities' stockholder's perspective and it will resemble other projects they have undertaken for their customers. That is not the goal. The energy data hub is broader than the interests of the utilities by design and how the software project is structured needs to reflect that important distinction.

Request No. EU to LGC 1-037 Witness & Respondent: Kat McGhee

REQUEST: Page 30, line 6: Please explain how the legislation requires "systems data" within the platform.

RESPONSE: I never said the legislation requires systems data. I merely pointed out that it does not preclude the use of systems data. The specific references to energy data do not suggest that customer

data is the only form of data to be used. I was making this point in my testimony because Eversource had started to suggest that their interpretation was that customer data was the only data called out in the bill language, that is not the case.

Multi-use Energy Data Platform

Under 378:51 Online Energy Data Platform Established.

I. The commission shall require electric and natural gas utilities to establish and jointly operate a statewide, multi-use, online energy data platform. The data platform shall:

a. ***Consist of a common base of energy data for use in a wide range of applications and business uses****.*

'A common base of energy data' does not determine whether system data, as necessary for the performance of certain data outputs, is to be included. The requirements in the User Stories for how 'data seekers' (to use OCA's term) will use the system to perform energy stakeholder tasks, should be the driver of what the common base of data must include. The desired functionality drives the base data needed to achieve specific outcomes.

As I tried to explain in Technical Sessions and beyond, there are no bad data types or more expensive data groups that can save us money if we ignore them. Discussions around what we are trying to achieve and whether we can achieve those goals without compromising security etc., are the conversations that matter and will lead to a successful outcome. Excluding entire types of data is an untenable position when designing a data system. My point was not that system data was required. My point was that saying systems data was not specified or to be included is not accurate.

Request No. EU to LGC 1-038 Witness & Respondent: Kat McGhee

REQUEST: Page 31, line 14: Please describe and cite the existing national energy data standard you are proposing which meets the current data platform requirements as defined.

RESPONSE: I am familiar with these data standards through the software engineers I've interacted with on this docket. Dr. Amro Farid has provided extensive testimony on the CIM (Common Information Model) standard as he has expertise on national and international work seeking to standardize how energy information is organized and protected.

Jim Brennan from OCA made me aware of the Green Button Alliance energy data handling protocols already established and he made sure that GBA was specified in the legislation; It is my understanding that ESPI Enhanced Serial Peripheral Interface Bus (eSPI), a synchronous serial communication

protocol, is also being considered as a way of establishing a method for handling large amounts of data in an efficient way. Because software professionals in the energy space are aware of work that has already been done to develop standards for use with energy data, there is concern that we incorporate standards such as these so as to make sure our statewide efforts can ultimately be compatible with regional and national energy data efforts if and when they are needed. It is simply good practice to lift our gaze and understand that we are not building access to our energy data in a vacuum. In order to make a sound and long-lasting investment in an energy data system, we must incorporate appropriate energy data standards to ensure our investment will not become rapidly obsolete. Please refer to Dr. Farid's efforts to document his position via testimony on behalf of LGC.

Request No. EU to LGC 1-039 Witness & Respondent: Kat McGhee

REQUEST: Page 33, line 1: Please elaborate on the statement that the "lens through which the utilities view data access is far too narrow" to embrace the needs of the distributed energy market. Are there examples of this that can be provided? If utilities have no ownership nor decision-making authority over the platform, and are similarly excluded from platform operation and ongoing management, what is the justification for recommending performance-based rate-making (PBR) and how would it work given the governance structure and utility roles as described in your testimony? Also, as no one has provided any data or support for the premise that any data platform would be used or to what degree, and this would be a wholly untested product, what is the reasoning for including the amount of platform usage as a performance metric in cost recovery, a mechanism that is going to be established before the platform is in use?

RESPONSE: In demonstrations from mPrest and Kevala we saw the incredible potential for the use of energy data. The kinds of strategic initiatives and efficiencies that access to energy data can enable are only limited by the imaginations of those in charge of managing them. Throughout the Technical Session proceedings, Eversource participants in particular kept stating that only customer data was involved, to the point where the PUC staff began making the same assumption. I believe that in some later calls, many of the intervenors who were working on the User Stories to help define what the system would do, conceded that they could live without system data for an initial rollout and work with the governance body on any additional data needs down the road. But the ability to define which benefits the system should provide is still an area of debate. We do not have a means of looking to any 'system' for energy investments, rate setting or optimization today. Is this an outcome we would like to obtain?

In a call with an Eversource representative the participants were told that entering into a discussion of systems' data was dangerous. Unitil on the other hand focused our conversations on the particular obstacles of particular types of system data, while readily admitting that on other types of system data, they foresaw no problem.

If we are asking a distributed generation market to augment traditional generation sources, we have to allow them to be self-sufficient in accessing the data that they need to see.

The model I suggest does not remove utility ownership or decision-making – it merely structures it in a way that creates a once-removed relationship that prevents direct ownership. The utilities ultimately own responsibility for the vendor partner who operates the platform (virtual or otherwise). In that role, the utilities will collaborate to provide vendor oversight and would thus be rewarded for meeting performance metrics. This model helps prevent a circumstance fellow-intervenors on DE19-197 from other state efforts have observed in other projects around the country; namely, that the utilities lack of interest in supplying data access meant that they built a platform that was hard to use and suboptimal in features. Without performance incentives, or disincentives, the utilities did the bare minimum because they did not see the business advantage to giving competitors energy data access. It's a conflict of interest. I do not want to see that happen in New Hampshire if we can benefit from the experience of others who have gone before us.

How do we know people will use the platform? Well, we know there are people attempting to combine energy data for their community investments who cannot easily access it today. We know that even among regulatory and utility energy data consumers, having a centralized data hub for energy information would be a vast improvement to support technical meetings and energy policy planning conversations. Some consumers may wait until they hear of an easy phone app that can help them see how their solar panels are offsetting their home energy bills, but we are in both an energy and a data age, so it is like asking if those in the early years of telecommunications could envision whether the phone might catch on. Access to energy data is a hot topic globally. We have a chance to partner on something bigger than what we're doing today. This question feels like a reference to so many utility customer-interfaces that nobody takes the time to use is part of the reason I think it's a really bad idea to give the project to the utilities to design.

I was not suggesting that the example of metrics I referenced were to be the metrics used. So, I don't believe I have to defend a potential metric. The metrics are not for me to decide. I am suggesting that there be metrics, in order to incent the desired supportive behavior from the utilities.

Request No. EU to LGC 1-040 Witness & Respondent: Kat McGhee

REQUEST: Page 38: The 13-member vision/strategic data council proposed includes 6 energy stakeholder members and a technical lead (a majority) who can financially benefit from the data platform. Please explain how you believe the costs of the energy data platform could be controlled based on this proposed governance structure.

RESPONSE: The PUC supplies the oversight for any governing body and no major cost or functional decisions are made without their approval. The proposed model would allow for sufficient autonomy that all stakeholder members would be involved in determining maintenance and small improvements by vote; there would be an annual maintenance budget, over and above the vendor fees, so that daily operational decisions would not require bothering the PUC. But with this framework, annual costs would be a known quantity once the initial project has been completed.

Voting rules do not have to be a straight majority that is TBD and there may be non-voting members on the committee. I do believe an odd number of voting members is a requirement for getting anything done. It sounds as though the concern here is that the utilities would not be in the majority for controlling outcomes. That is true. Since the utilities have the least to gain from having an effective energy data platform that removes their current control of energy data access, I see giving the utilities a majority vote by design, as counter intuitive.

I have no problem with the utilities participating fully in all aspects of the project. I have worked in large corporations and I do not see this collaboration in terms of us and them. But, for the sake of a healthy balance of stakeholders that leads to a healthy data hub, I see no reason to tilt the voting toward those who are least interested in seeing the project succeed. If we want to see a good use of the state's investment, we need to engage those who are most enthusiastic about doing something worthwhile in direction setting. They are not going to be building a tool for their private use and they will have fiscal parameters within which they must adhere. That is how we achieve the best outcome for the state of New Hampshire and for the ratepayer.

Most of the intervenors are in the clean energy space to reduce carbon emissions rapidly and they earn a living as a biproduct of that mission. Whether these stakeholders serve on the council or not, the

features of the tool, its maintenance plan and budget allocations will not earn them any more or less income. If by the question you are referring to the ability for distributed energy companies to more easily expand their businesses through better access to customer usage data, then that may be true. But I would argue that this expansion is long overdue and part of the impetus of the original legislation and if those goals were not achieved by this project, then it would have been derailed from its intent.

The technical lead role assumes that a qualified professional will be hired to drive the project to a successful outcome, without particular bias to any of the stakeholders. This project leader will be of value to the council in terms of objective input on the platform decisions from a technical perspective and an outcomes-based allegiance to the platform's goals. If the project outcomes are well defined, then knowing when those goals are met will not be in question. This confines the project timeline (being able to declare when done, is done) and also limits the contractual role and income of that technical lead depending upon his/her value to the council. If you are suggesting that someone who is paid to perform a project lead role is likely to prolong the project to preserve his/her own paycheck, that is an unfair projection. Any competent project manager is looking to bring their project in on time, with all features, and in budget. In this capacity, anyone hired to undertake the platform project will be a temporary resource to the council, unless it is decided that their continued participation would be of benefit to the platform maintenance and the council at large.

The functionality will be what is agreed to by the council members and put in place by the vendor partner or partners who execute the plan. The utilities will have significant input in that process and all along the way. The cost of the platform and any enhancements that will follow in subsequent years will not be determined by any stakeholder or stakeholder group alone. It will continue to be a collaboration of energy stakeholders and from this standpoint, I believe the allusion to cost containment being a problem if the utilities do not have a council majority is unfounded.

Q. Does this conclude your rebuttal testimony?

A. Yes, it does.