University of San Diego School of Law
13th Annual Climate and Energy Law Symposium

Virtual Power Plants and the Climate Challenge

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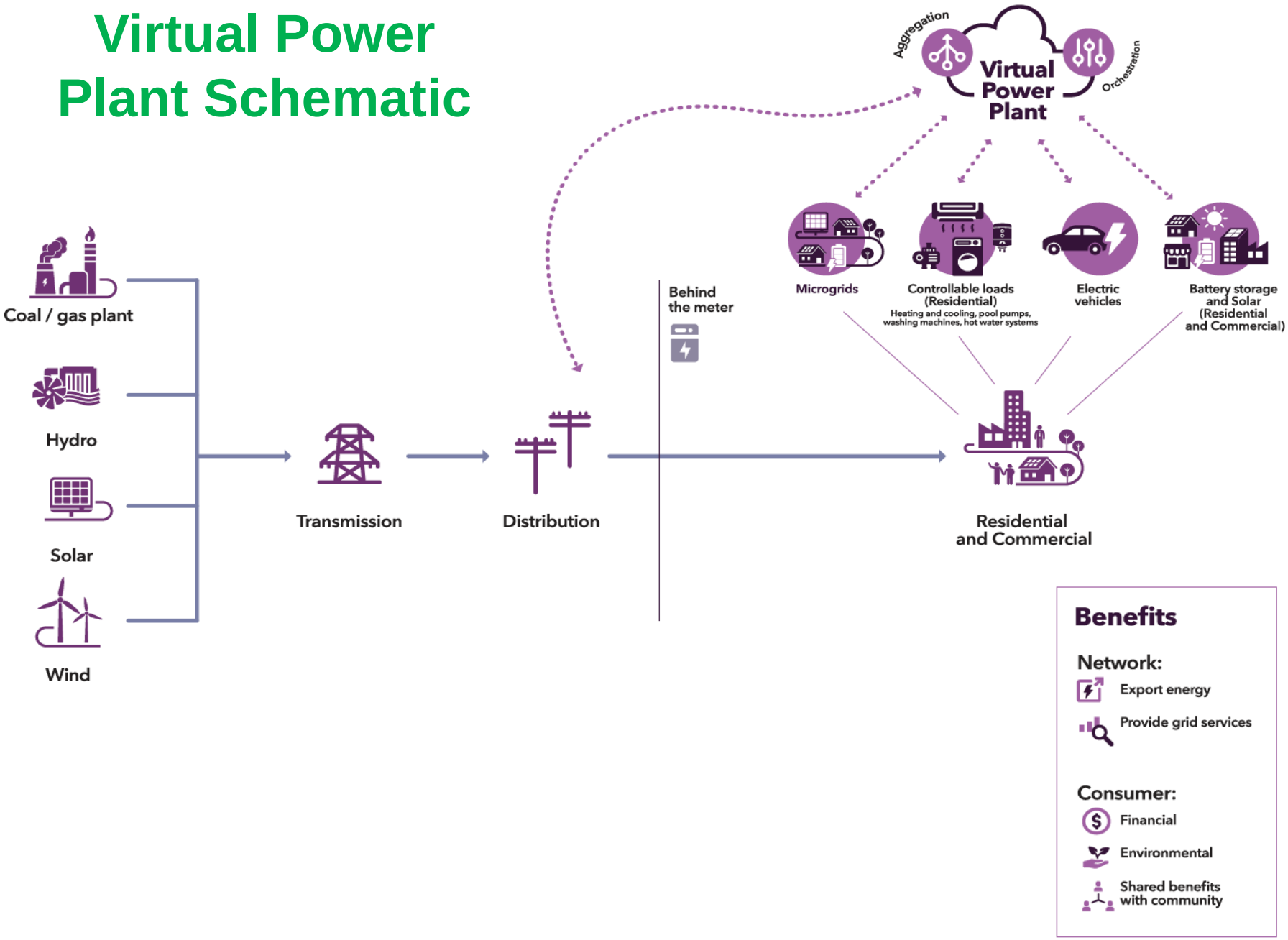
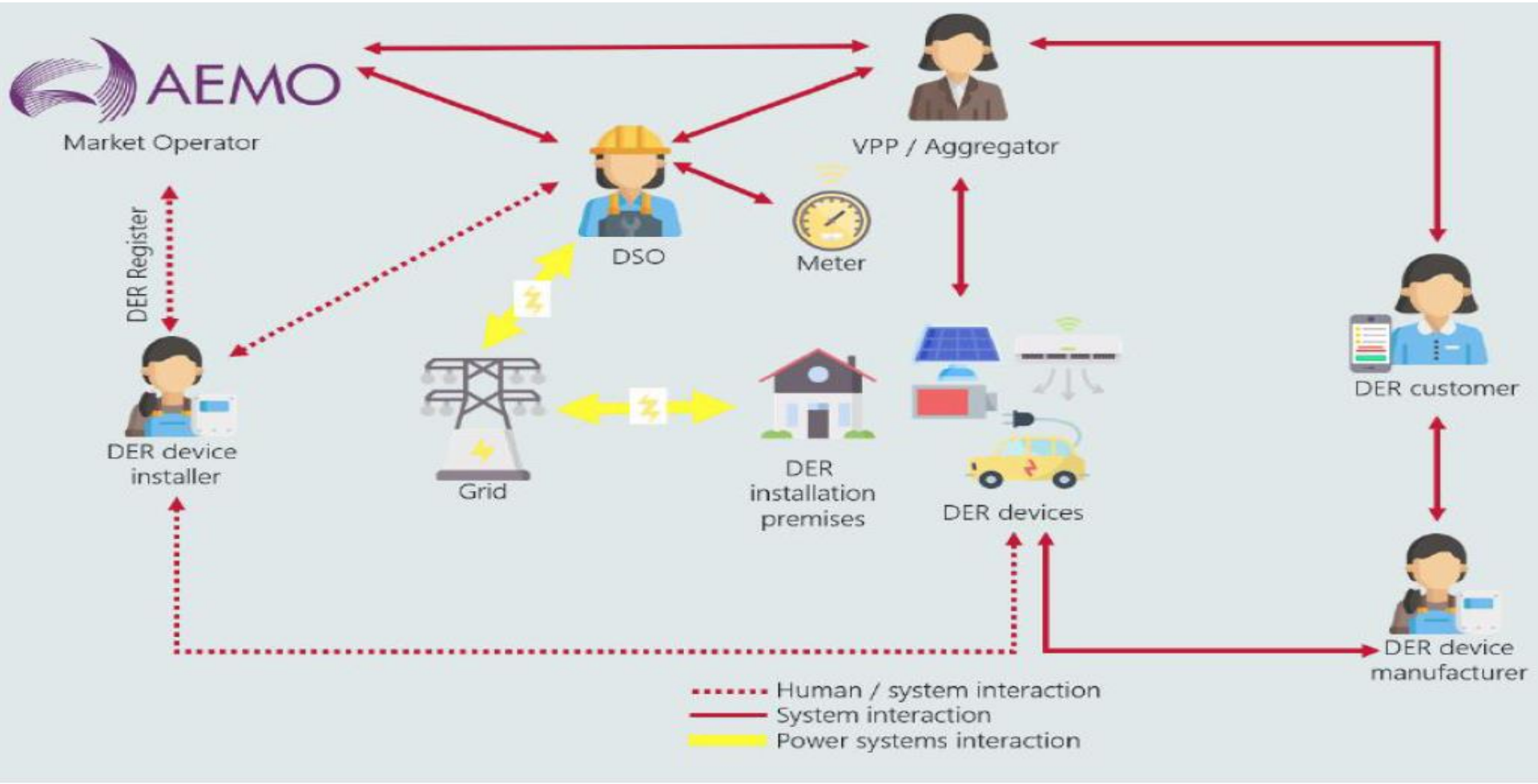
What is a Virtual Power Plant?

"A collection of privately owned distributed energy resources that can be interconnected and that operate together, but can be controlled centrally, allowing dispersed resources to respond to supply and demand."

Virtual Power Plant Schematic



A High Level Overview of the Actors and Interactions of the DER Ecosystem



Source: Australian Energy Market Operator 2021

Figure 5.3 Sonnen Eco Compact. (Courtesy of Kevin B. Jones.)

The Battery as a Distributed Energy Resource

1. Dynamic Pricing and Solar Energy Arbitrage
2. Demand Charge Reduction
3. Home Consumption of Solar
4. Back Up Energy Storage

Does this add up to a viable Business Case ?

FERC Order 841

On 2/15/18 FERC found existing RTO tariffs to not be J&R and required RTOs to revise tariffs to establish participation models for storage and rules must recognize the physical and operating characteristics of storage.

Requires RTOs to establish a participation model that must:

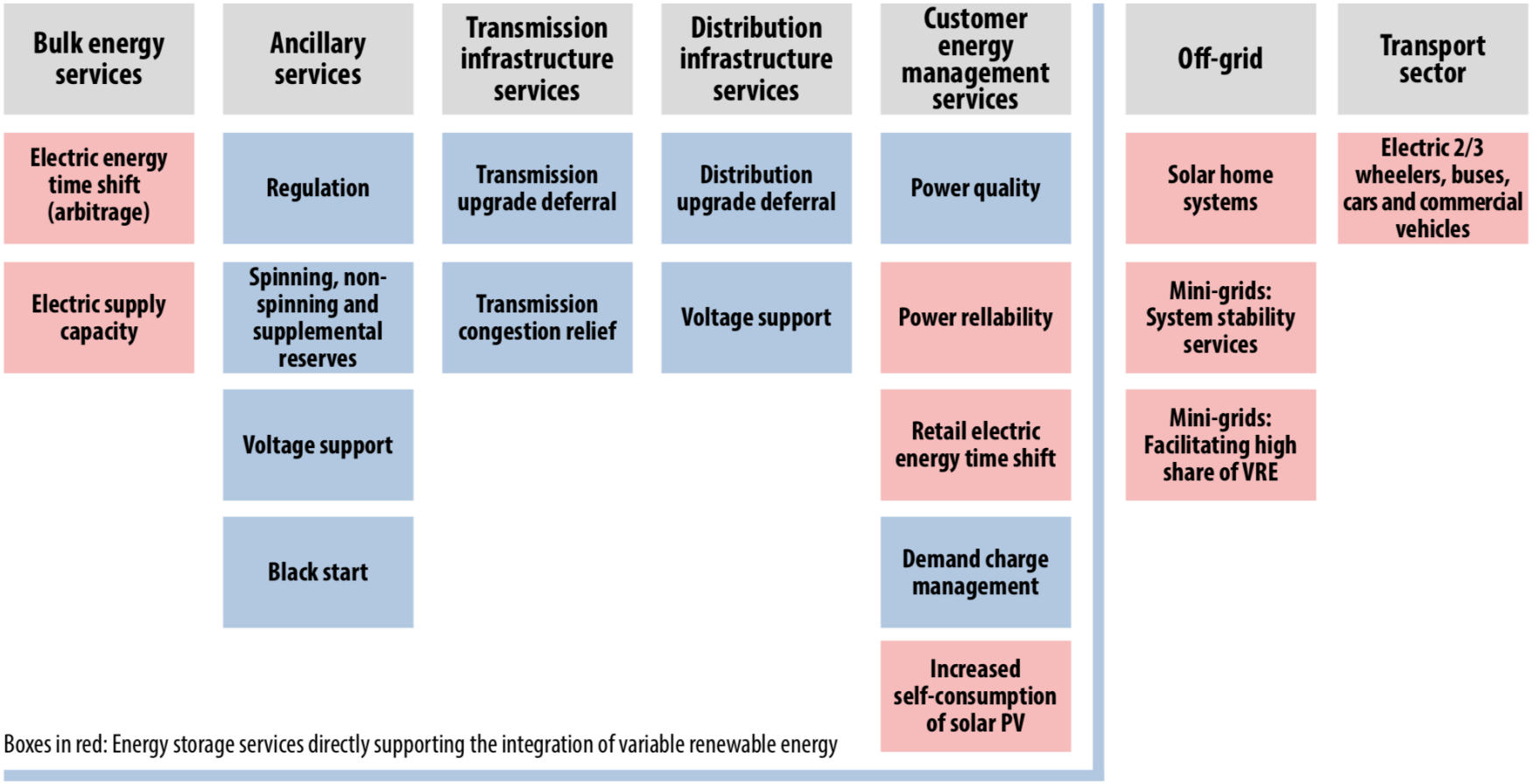
- Ensure participating resources are eligible to provide **all capacity, energy, and ancillary services** the resource is technically capable to provide
- Execute all storage wholesale transactions **at locational marginal price**
- Ensure resource **can be dispatched and set the wholesale price**
- **Recognize physical and operational characteristics** of storage
- Establish a **minimum size requirement** that does not exceed 100 kW
- **Allow storage to de-rate capacity** to meet minimum run-time requirements

FERC Order 2222

On September 17, 2020, FERC issued Order No. 2222 aimed at increasing participation of distributed energy resource (DER) aggregations in the energy, capacity and ancillary services markets operated by RTOs. By requiring the development of market rules for the participation by DER aggregations in RTO/ISO organized markets, Order No. 2222 seeks to address the barriers that individual DERs face due to their inability to meet the size and operational requirements necessary to qualify as market participants.

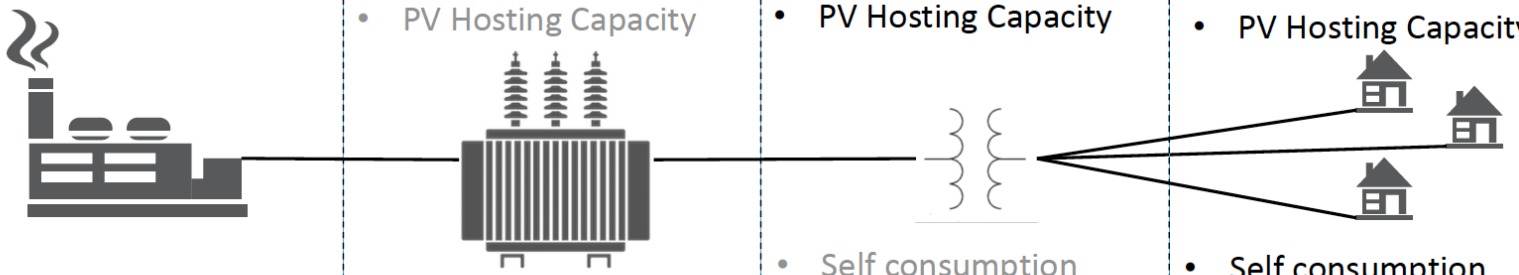
Order No. 2222 defines a DER as "any resource located on the distribution system, any subsystem thereof or behind a customer meter." The broad definition is technology-neutral and encompasses both current and future technologies.

Figure ES1: The range of services that can be provided by electricity storage



Locational Value Drives Effective VPP Demonstrations

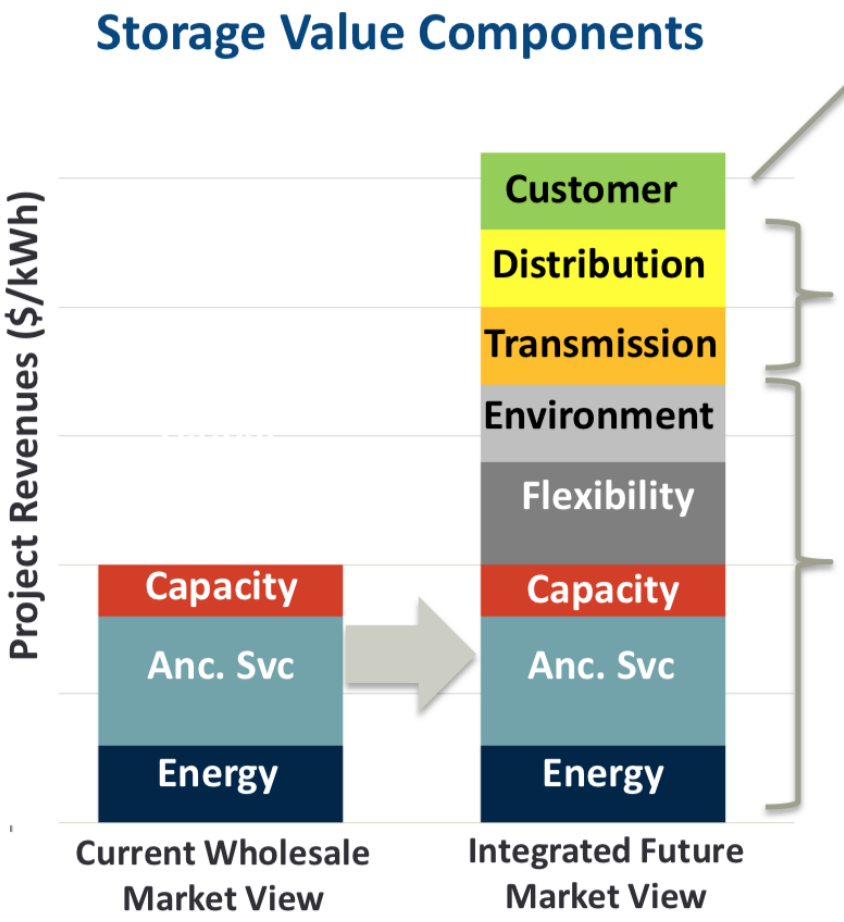
	Transmission and Generation	Distribution and Substation	Community	Customer
Utility Value Streams	• Renewable Integration • Energy Arbitrage • Frequency Regulation • Transmission Deferral • Black Start • Voltage Support	• Renewable Integration • Demand Reduction • Energy Arbitrage • Frequency Regulation • Voltage Support • Distribution Deferral • Transmission Deferral • PV Hosting Capacity	• Renewable Integration • Demand Reduction • Energy Arbitrage • Frequency Regulation • Voltage Support • Distribution Deferral • Transmission Deferral • PV Hosting Capacity	• Renewable Integration • Demand Reduction • Energy Arbitrage • Frequency Regulation • Voltage Support • Volt Var Optimization • Distribution Deferral • Transmission Deferral • PV Hosting Capacity
Customer Value Streams			• Self consumption • Backup Power	• Self consumption • Time-of-use bill management • Demand Charge Reduction • Backup Power



Values Streams Increase Closer to Customer

Battery Storage Value Streams

Maximizing storage's potential requires capturing multiple value streams. But new regulatory frameworks are needed to capture the full value.



Customers

- Increased reliability (reduced outages)
- Increased engagement in power supply
- Retail bill savings

Utility Infrastructure

- Deferred or avoided investments in distribution and transmission infrastructure

Wholesale Markets

- Traditional value drivers: energy arbitrage, fast-response capabilities, and avoided capacity
- Realizing additional value due to higher quality A/S
- Flexibility and clean-energy products will provide additional revenue opportunities in the future

Source: Brattle Group

VPP Case Studies

Southern California Edison

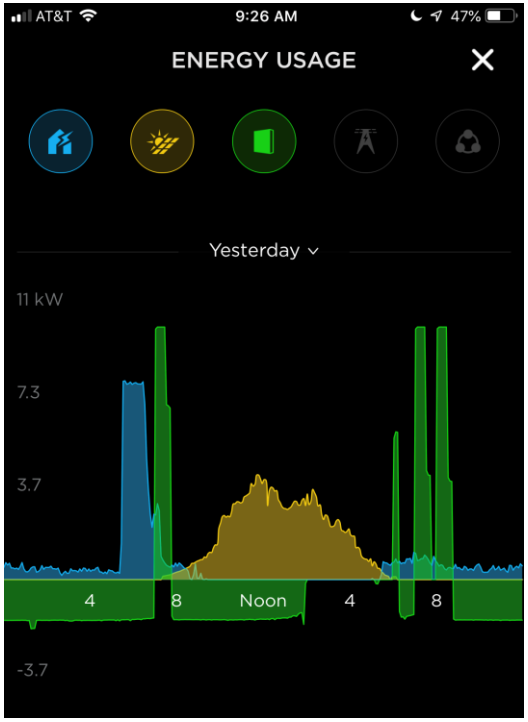
- Sunrun
- 300 customers
- $250 one-time incentive
- Est. 1,500 customers, 5-7.5 MW gird capacity in Phase II.

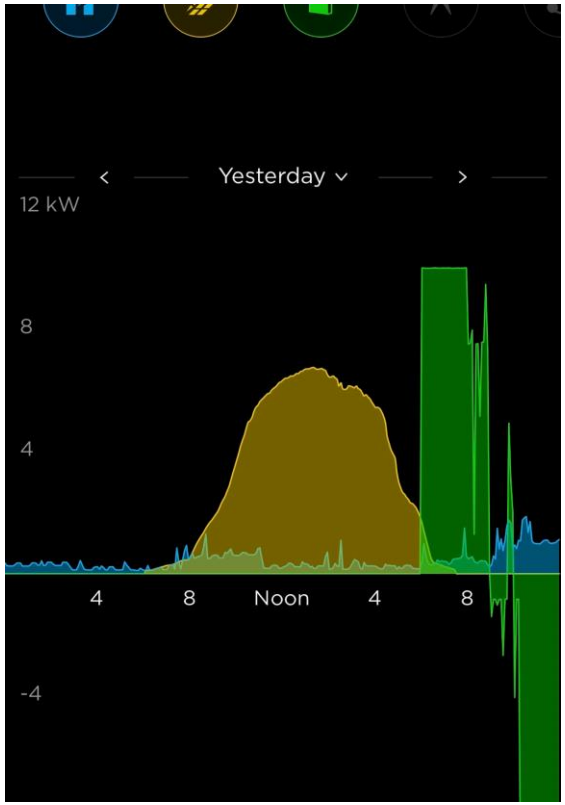
Green Mountain Power

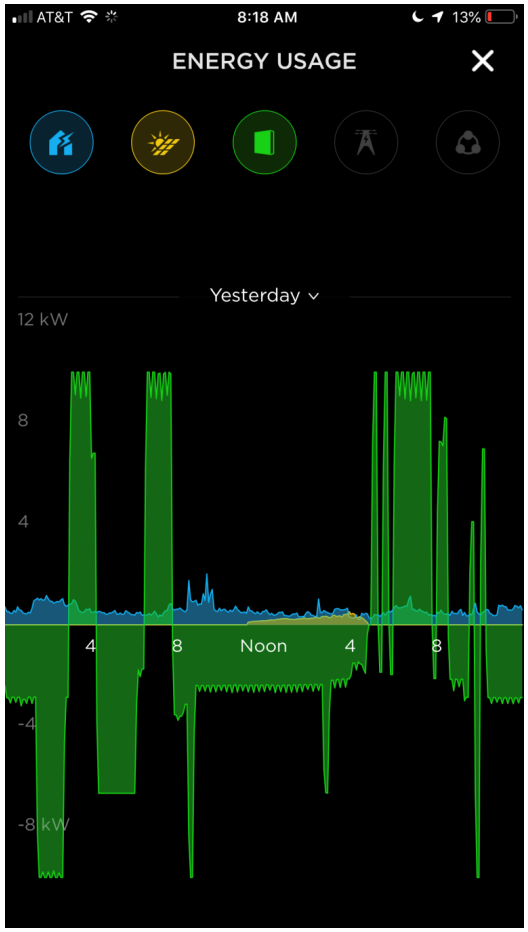
- Tesla PW2 + software
- 2000 units, 10MW
- Utility owned & in rates.
- Customer pays $15/mo.
- $13.50/mo. Optional FR.

Australia Energy Market Operator

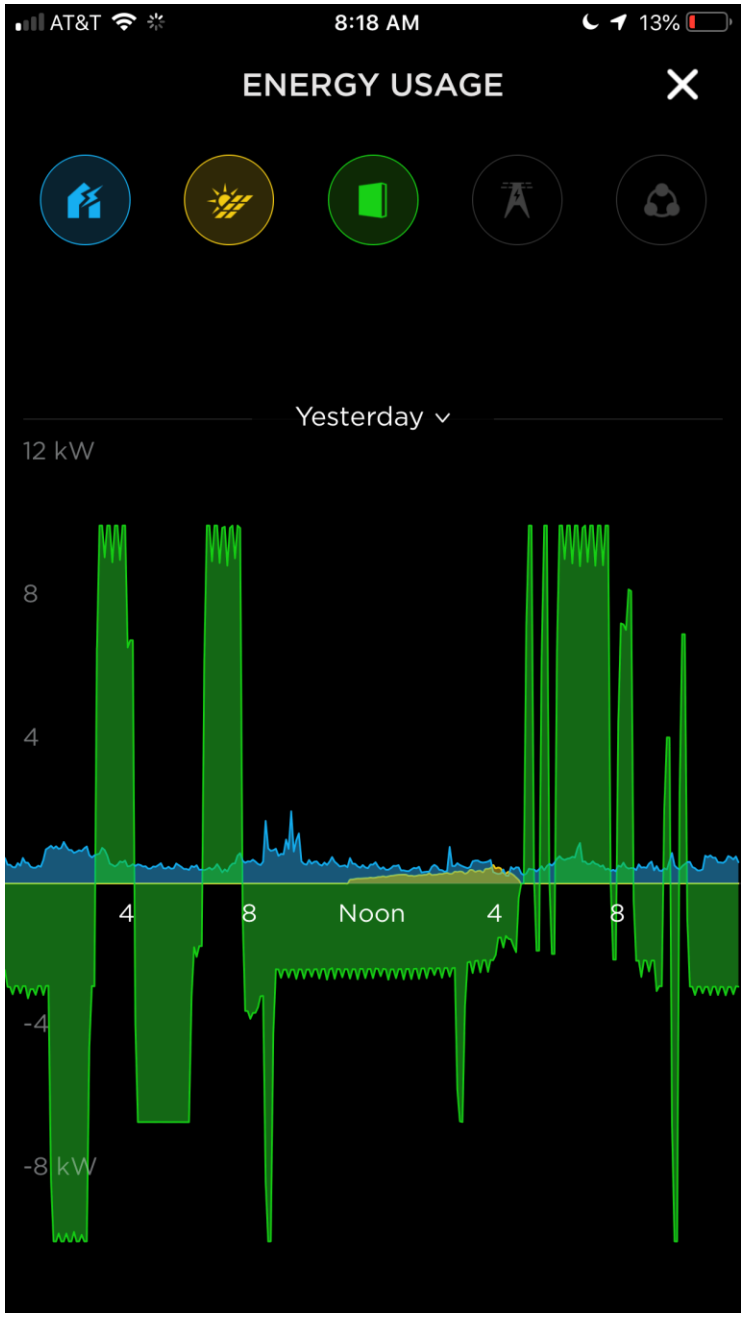
- 8 VPP portfolios
- 31 MWs
- 7,150 customers
- Frequency control, energy, local network service







The Battery as a DER


AT&T
8:18 AM
13%
ENERGY USAGE
Yesterday
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8
4
4
8
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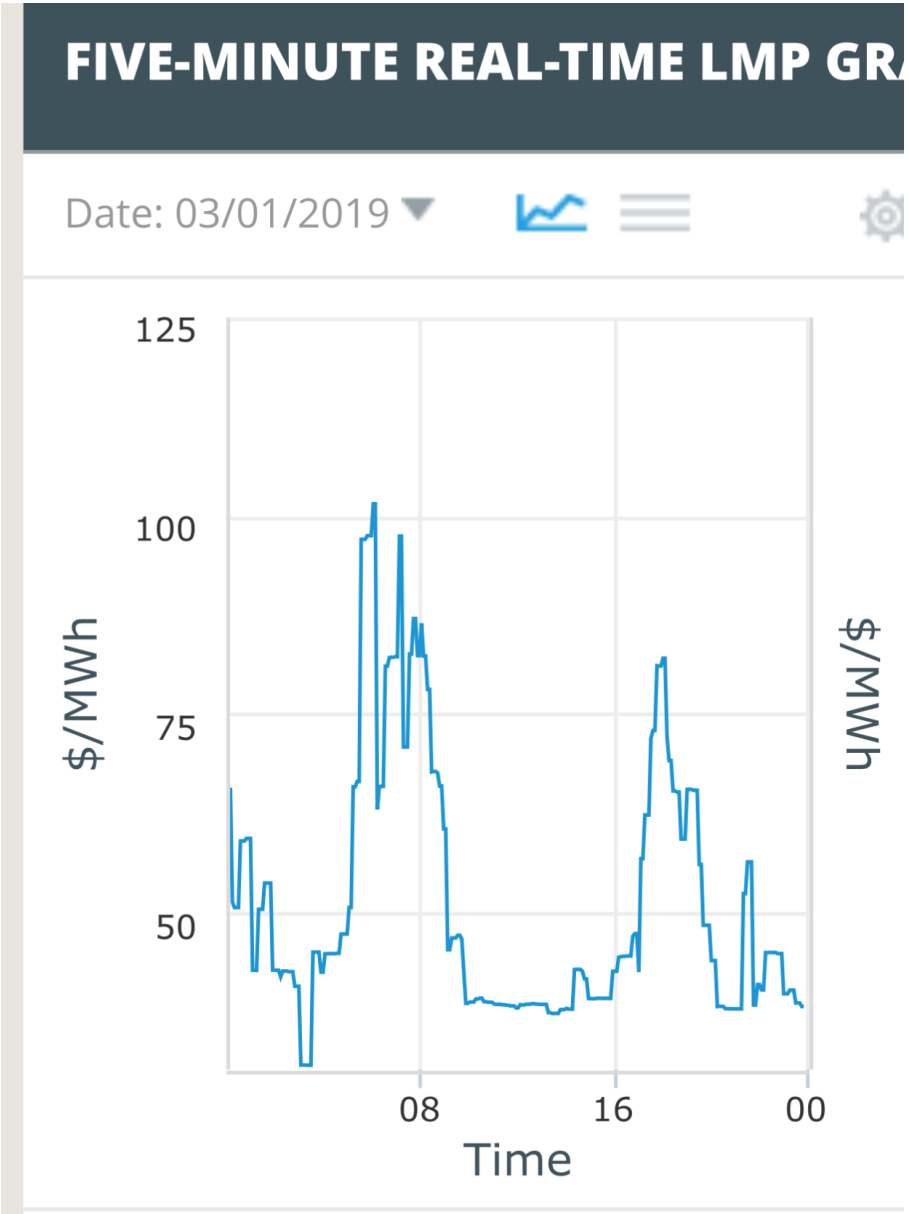
-8 kW


FIVE-MINUTE REAL-TIME LMP GR
Date: 03/01/2019
125
100
75
50
$/MWh
$/MWh
08
16
00
Time

GREEN MOUNTAIN POWER
Generating Possibilities Together
Josh Castonguay, Vice President
Chief Innovation Executive

163 Acorn Lane, Colchster, Vermont 05446
(802)655-8764

Year	1	2	3	4	5	6	7	8
Benefits (Revenue)								
RNS	$ 849,728	$ 890,392	$ 933,281	$ 969,557	$ 987,752	$ 1,003,486	$ 1,019,928	$ 1,036,609
FCM	$ -	$ 710,414	$ 583,450	$ 587,339	$ 599,086	$ 627,125	$ 692,257	$ 768,554
ISO NE Day Ahead Energy	$ -	$ 243,159	$ 229,866	$ 224,079	$ 218,247	$ 212,310	$ 207,098	$ 201,839
ISO NE Operating Reserve	$ -	$ 160,959	$ 160,429	$ 160,272	$ 160,066	$ 159,975	$ 159,882	$ 159,845
ISO NE Frequency Reg	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Customer Payments	$ 381,600	$ 381,600	$ 381,600	$ 381,600	$ 381,600	$ 381,600	$ 381,600	$ 381,600
Total Benefits	$ 1,231,328	$ 2,386,524	$ 2,288,626	$ 2,322,846	$ 2,346,751	$ 2,384,496	$ 2,460,766	$ 2,548,447
Costs								
Program Costs (Make-whole, Software)	($34,100)	($94,816)	($90,895)	($89,772)	($88,639)	($87,505)	($86,511)	($85,518)
Revenue Requirement	($3,795,113)	($2,848,230)	($2,618,308)	($2,427,054)	($2,263,513)	($2,111,572)	($1,959,631)	($1,821,868)
Total Costs	($3,829,213)	($2,943,046)	($2,709,203)	($2,516,827)	($2,352,152)	($2,199,077)	($2,046,142)	($1,907,386)
Net Benefit to Non-Particpating Customers	**($2,597,886)**	**($556,522)**	**($420,577)**	**($193,981)**	**($5,401)**	**$185,420**	**$414,624**	**$641,061**

Year	9	10	11	12	13	14	15	Total
Benefits (Revenue)								
RNS	$ 1,051,758	$ 1,066,797	$ 1,041,773	$ 950,732	$ 794,860	$ 559,568	$ 249,551	$ 8,872,062
FCM	$ 848,593	$ 931,670	$ 989,397	$ 957,122	$ 818,995	$ 600,281	$ 298,233	$ 6,203,510
ISO NE Day Ahead Energy	$ 196,153	$ 190,385	$ 178,389	$ 156,078	$ 124,785	$ 84,013	$ 37,863	$ 1,667,271
ISO NE Operating Reserve	$ 159,755	$ 159,705	$ 153,618	$ 138,042	$ 113,659	$ 78,780	$ 34,728	$ 1,278,045
ISO NE Frequency Reg	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Customer Payments	$ 381,600	$ 381,600	$ -	$ -	$ -	$ -	$ -	$ 2,805,827
Total Benefits	$ 2,637,858	$ 2,730,157	$ 2,363,177	$ 2,201,973	$ 1,852,299	$ 1,322,642	$ 620,376	$ 20,826,715
Costs								
Program Costs (Make-whole, Software)	($84,513)	($83,506)	($70,142)	($31,774)	($30,890)	($30,005)	($29,070)	($691,520)
Revenue Requirement	($1,712,784)	($1,618,201)	$0	$0	$0	$0	$0	($17,764,627)
Total Costs	($1,797,297)	($1,701,707)	($70,142)	($31,774)	($30,890)	($30,005)	($29,070)	($18,456,147)
Net Benefit to Non-Particpating Customers	**$840,561**	**$1,028,450**	**$2,293,035**	**$2,170,199**	**$1,821,409**	**$1,292,637**	**$591,306**	**$2,370,568**

Green Mountain Power 13 Month Peak Event Success

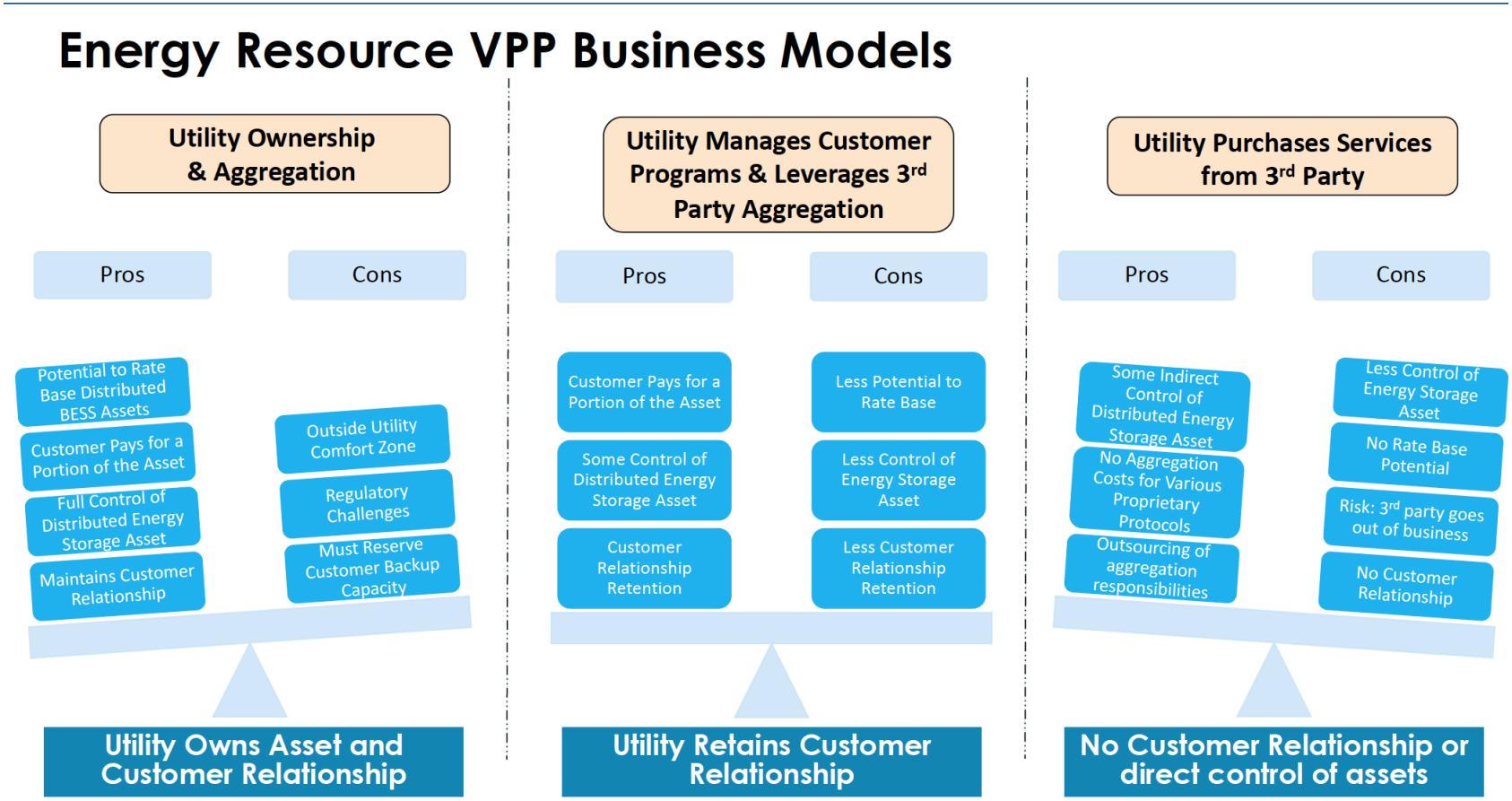
	Peak Date	kW Reduced	Total Value
RNS	2/2/18	316	$3,359
RNS	3/19/18	761	$8,086
RNS	5/31/18	1574	$16,738
RNS	6/30/18	1570	$16,687
RNS	7/2/18	-	$0
RNS	8/28/18	-	$0
FCM	8/29/2018	2981	$353,598
RNS	9/5/18	3000	$31,895
RNS	10/25/18	3800	$40,401
RNS	11/14/18	4000	$42,527
RNS	12/4/18	3300	$35,085
RNS	1/21/19	5000	$53,159
RNS	2/12/19	-	$0
			$601,532

RNS – Regional Network Service (ISO-NE Transmission Charges)

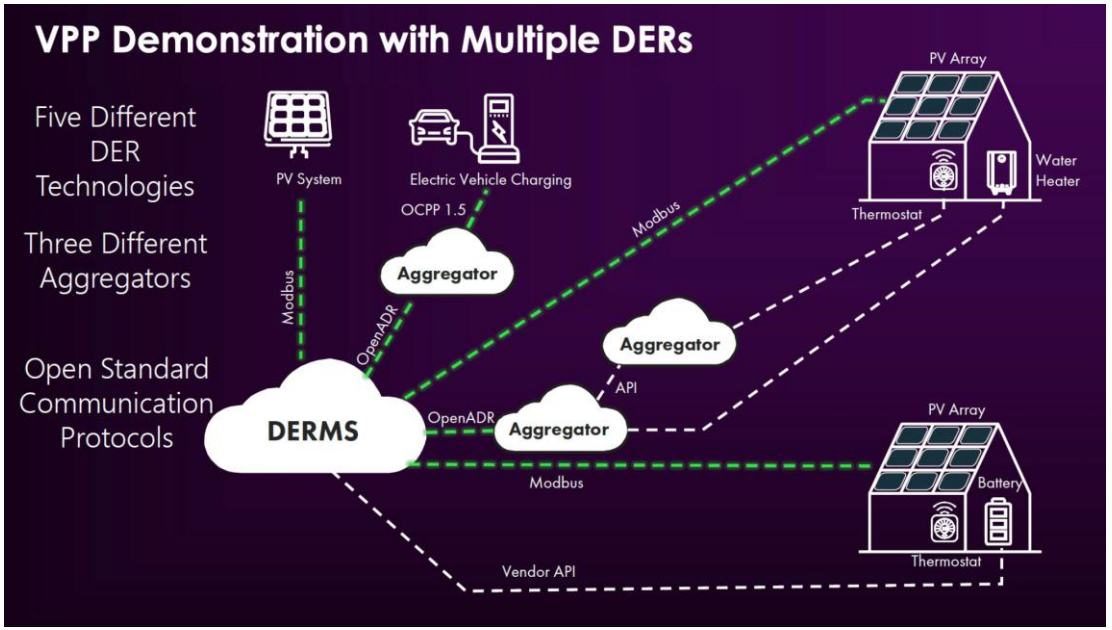
FCM - ISO-NE Forward Capacity Market

“What takeaways are there from these pilots”

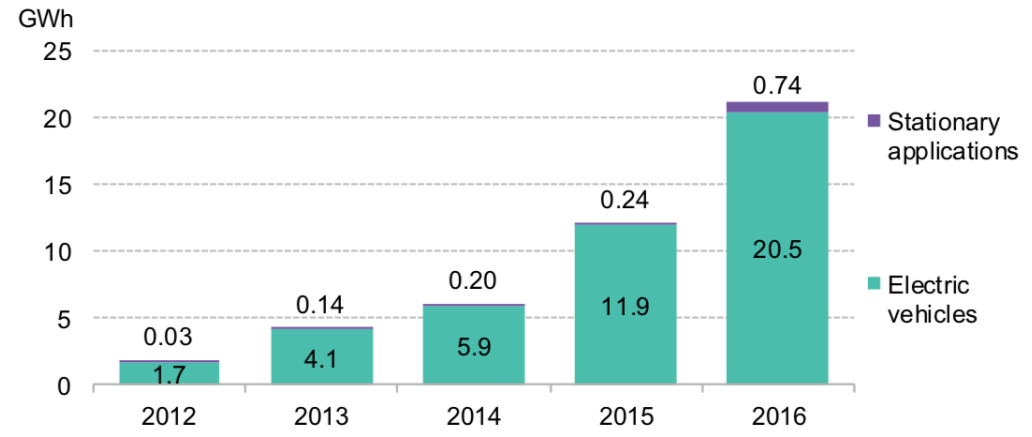
There remains a lot of uncertainty and tension over what is the best business model?



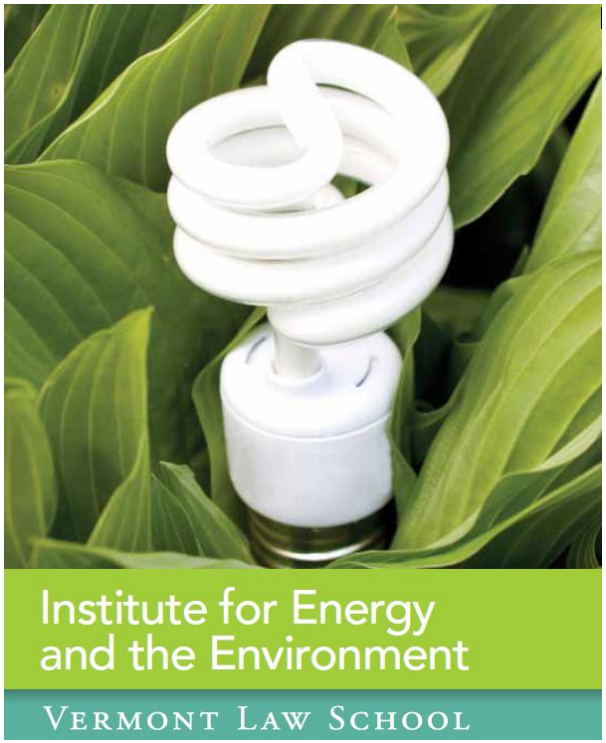
Standard communication protocols between utilities and DER aggregators remains a challenge



Lithium-ion battery global annual sales volume



Growth in EV battery storage capacity offers opportunity to more quickly scale VPPs if we can add them to the VPP resource mix.



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