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THAMMASAT UNIVERSITY

PEA
SMART GRID

โครงการศึกษาความเป็นไปได้
โครงการระบบโครงข่ายไฟฟ้าอัจฉริยะของ
การไฟฟ้าส่วนภูมิภาค

Meeting #4 – Smart Grid Use Case

8 มกราคม 2567

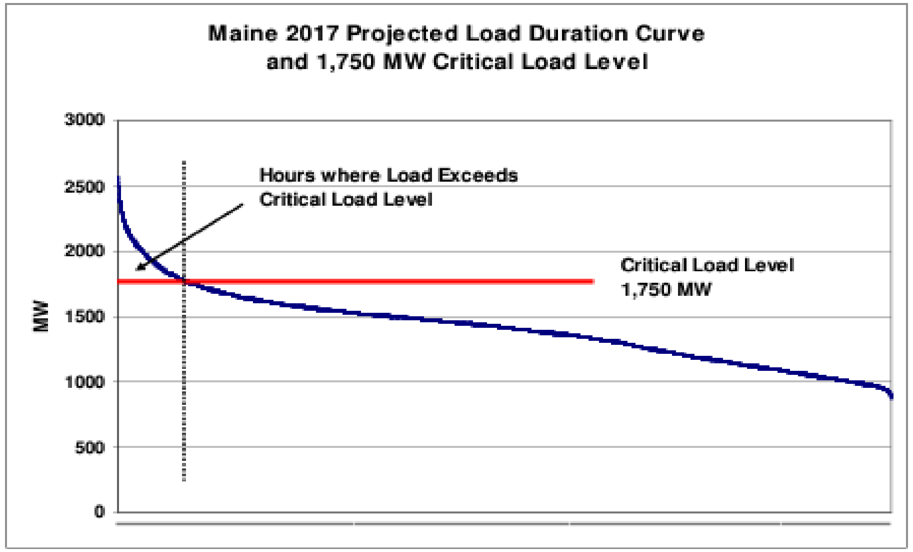
9:00 – 12:00

AGENDA

- U.S. Case Studies (Boothbay & Brooklyn)
- Smart Grid Design & IRR (ปลวกแดง & เชียงใหม่)

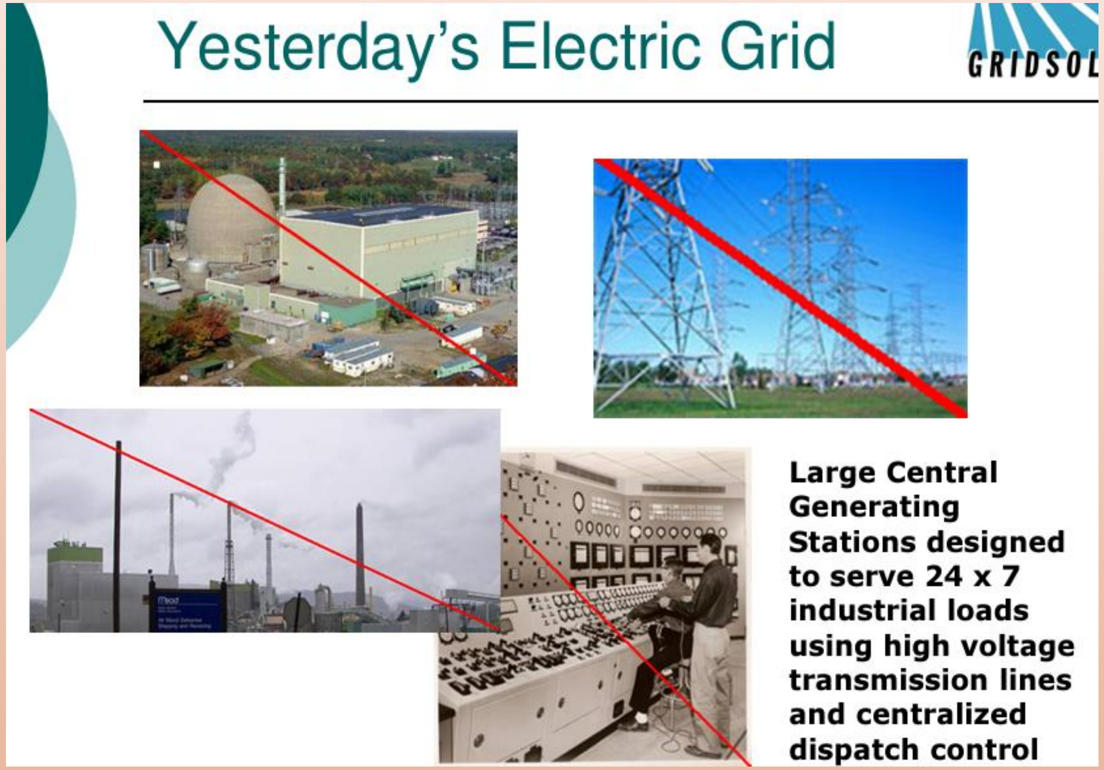
Smart Grid is a Non-Transmission Alternative (NTA)

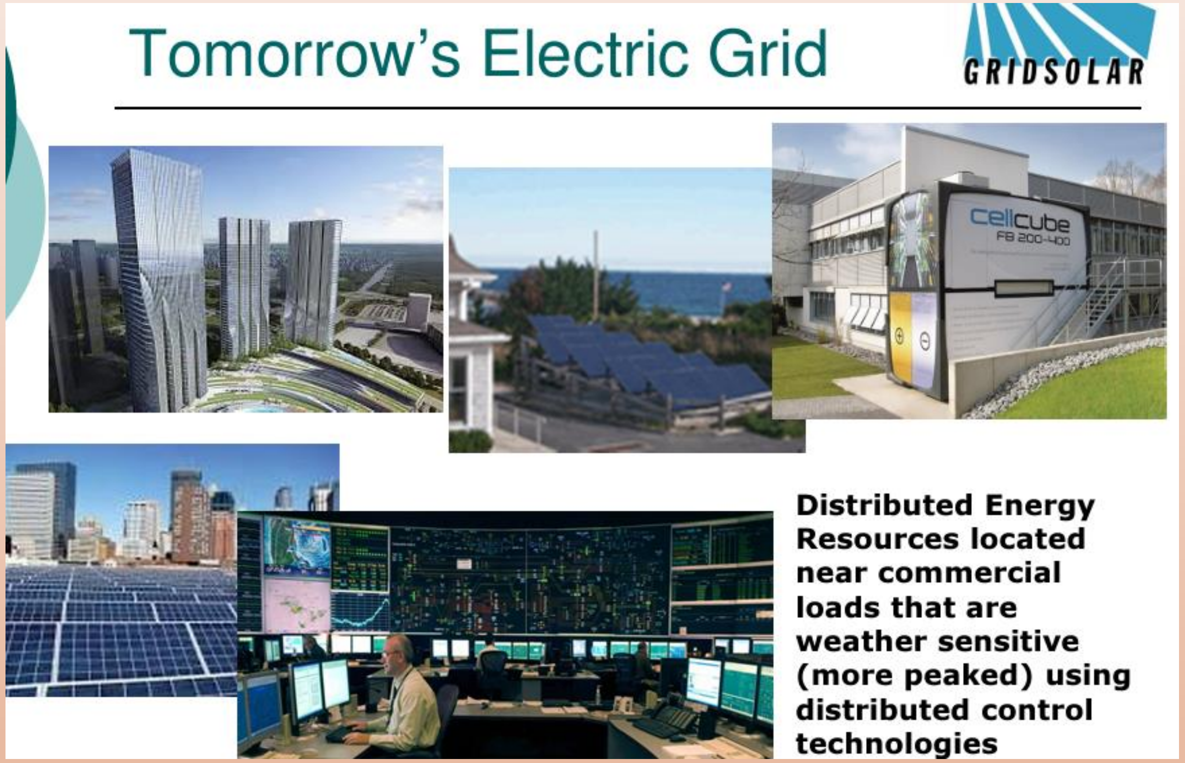
- **Grid Reliability is gener**
  Peak Load Problem



- **Transmission Solution** – Build more Transmission to bring power from away into the Region
- **Non-Transmission Alternative or "NTA" Solution** - Manage Load and develop new Distributed Generation within the Region

Yesterday vs Tomorrow Power Grid





Case Studies from Leading U.S. projects : Non-Wire Alternatives : NWA

CASE STUDIES

Case studies (listed alphabetically by utility or key project implementer[2] if different from the utility, followed by project name):

1. Arizona Public Service (APS)—Punkin Center
2. Bonneville Power Administration (BPA)—South of Allston
3. Central Hudson Gas & Electric—Peak Perks Targeted Demand Management Program
4. Con Edison—Brooklyn Queens Demand Management (BQDM) Program
5. Consumers Energy—Swartz Creek Energy Savers Club
6. GridSolar—Boothbay
7. National Grid—Old Forge
8. National Grid—Tiverton NWA Pilot
9. Southern California Edison (SCE)—Distribution Energy Storage Integration (DESI) 1
10. SCE—Distributed Energy Storage Virtual Power Plant (VPP)

- **Successful delays and deferrals of infrastructure upgrades**—The majority of the 10 case studies demonstrated success in helping to delay or permanently defer infrastructure upgrades.
- **Flexibility**—NWA projects offer the ability to implement solutions incrementally and in phases as load grows. This allows opportunities to approach load growth uncertainty flexibly and help avoid large up-front costs.
- **Cost Savings and Allocations**—While many of the case studies were unable to report cost data and analysis, projects such as Con

Non-Transmission Alternatives : NTA

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https://sg.tueng.org/sg-doc1/

U.S. Case Studies

FIGURE 2: CASE STUDY PROJECT TIMELINES

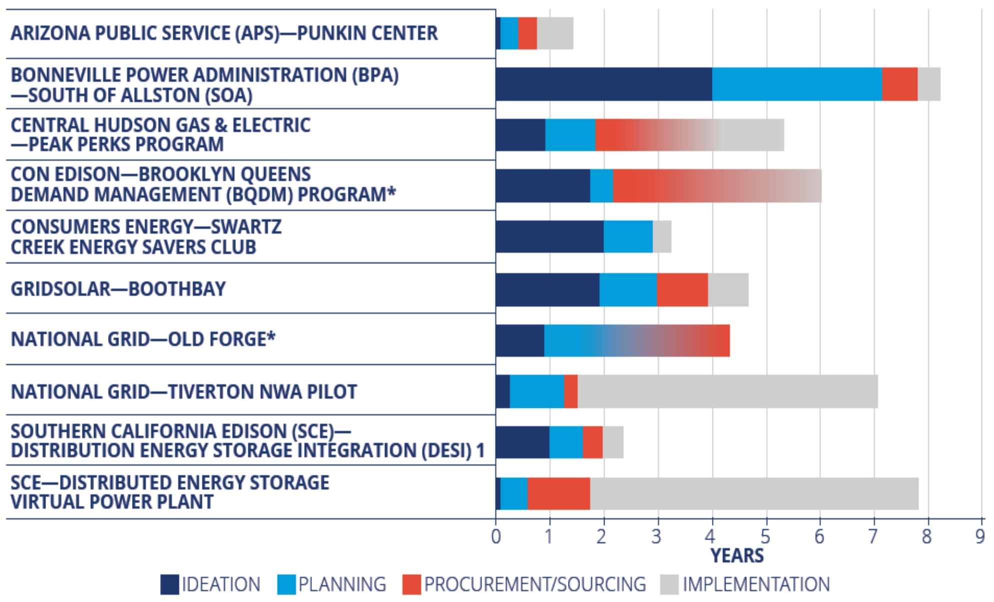

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TABLE 2: NON-WIRES ALTERNATIVES CASE STUDIES BY PROJECT SIZE, STATUS, AND TECHNOLOGIES

UTILITY, KEY PROJECT IMPLEMENTER—PROJECT NAME	PROJECT SIZE	STATUS	ENERGY EFFICIENCY	DEMAND RESPONSE	SOLAR PV	ENERGY STORAGE	GENERATION	BACKUP GENERATORS	FUEL CELLS	COMBINED HEAT AND POWER	CONSERVATION VOLTAGE OPTIMIZATION	NOTES
ARIZONA PUBLIC SERVICE—PUNKIN CENTER	2 MW, 8 MWh	A: Q1 2018				●						
BONNEVILLE POWER ADMINISTRATION—SOUTH OF ALLSTON	200 MW Inc. 200 MW Decr. 100 MW Relief	A: July 2017 T: Sept. 2018		●			●					
CENTRAL HUDSON GAS & ELECTRIC—PEAK PERKS DEMAND MANAGEMENT PROGRAM	16 MW	A: 2016		●				●				
CON EDISON—BROOKLYN QUEENS DEMAND MANAGEMENT (BQDM) PROGRAM	52 MW	A: 2014	●	●	●	●			●	●	●	
CONSUMER ENERGY—SWARTZ CREEK ENERGY SAVERS CLUB	1.4 MW	A: Oct. 2017	●	●								
GRIDSOLAR—BOOTHBAY	1.85 MW	A: Q4 2013 T: Q2 2018	●	●	●	●		●				Thermal and electric storage
NATIONAL GRID—OLD FORGE	19.8 MW, 63.1 MWh	In development				●						
NATIONAL GRID—TIVERTON NWA PILOT	330 kW	A: 2012	●	●								
SOUTHERN CALIFORNIA EDISON—DISTRIBUTION ENERGY STORAGE INTEGRATION (DESI) 1	2.4 MW, 3.9 MWh	A: May 2015			●							
SOUTHERN CALIFORNIA EDISON—VIRTUAL POWER PLANT (VPP)	85 MW	A: Dec. 2016		●		●						Storage systems applied as DR

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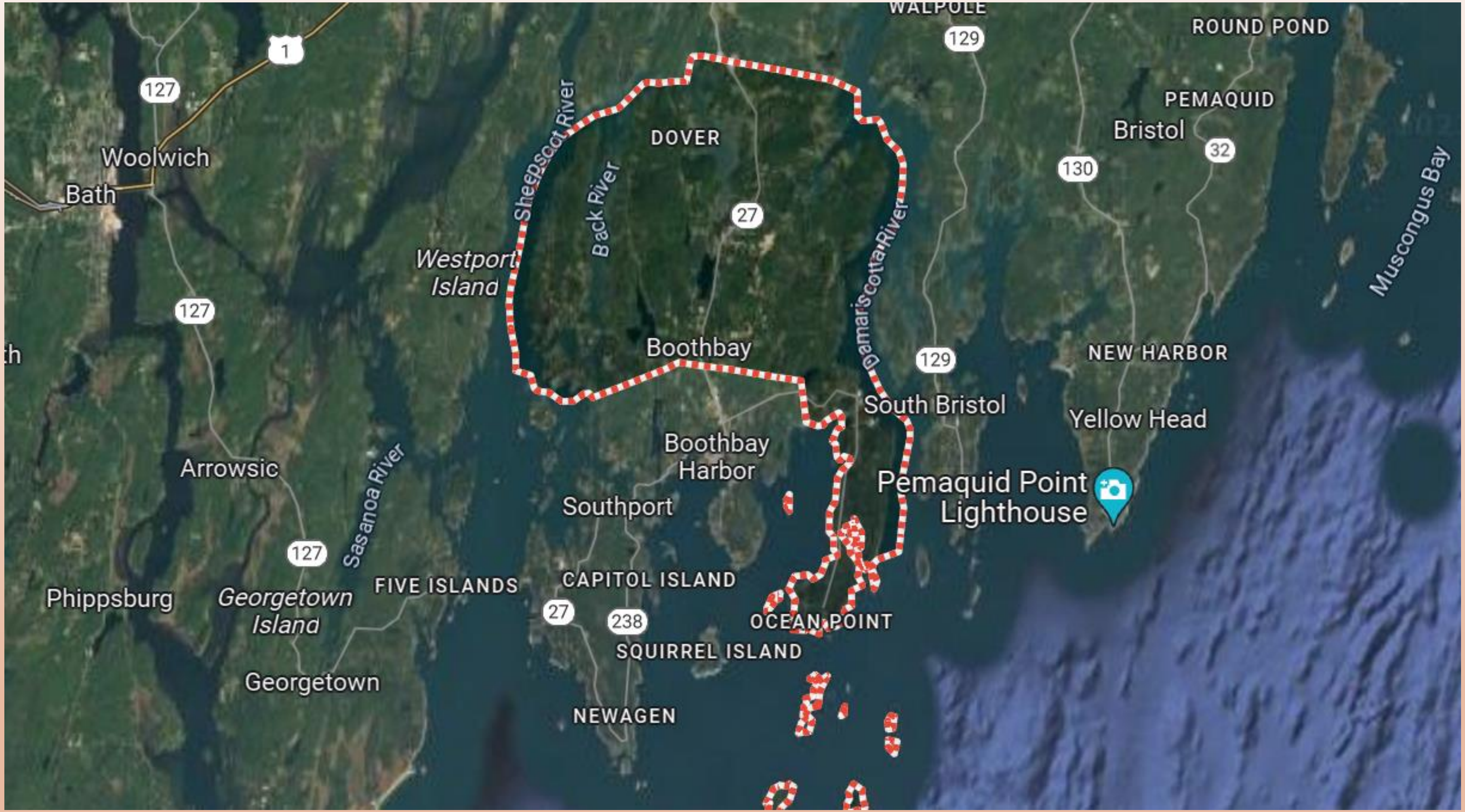
Case Studie #1 - BOOTHBAY



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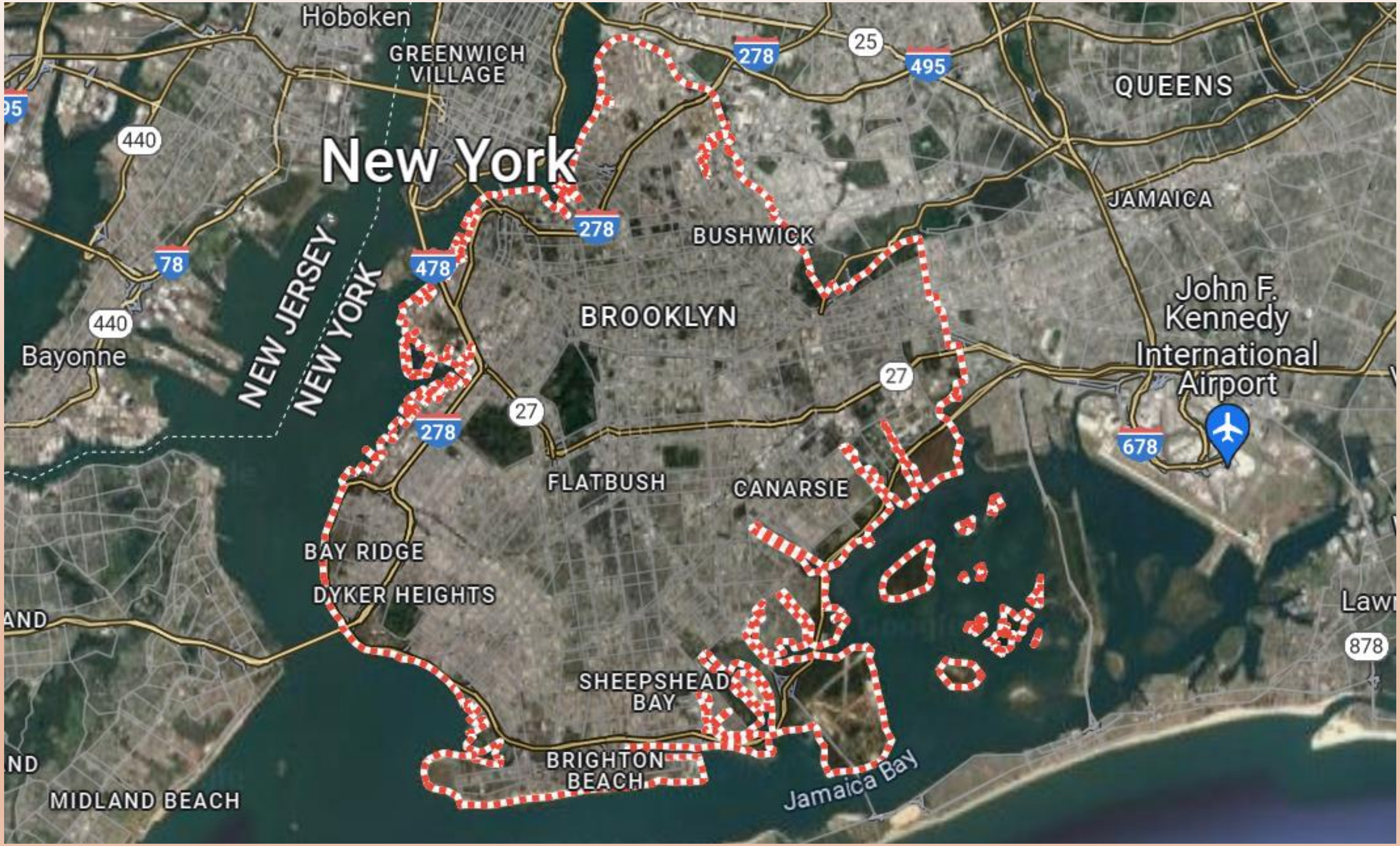
Case Studie #2 - BROOKLYN



https://www.utilitydive.com/news/bqdm-program-demonstrates-benefits-of-non-traditional-utility-investments/550110/

PEA Transmission Lines Investment plan

โครงการพัฒนาระบบส่งและจำหน่าย ระยะที่ 2

หน่วย : ล้านบาท

รายปี	เหนือ	ตะวันออกเฉียงเหนือ	กลาง	ใต้	รวม
2563	751	384	3,083	478	4,696
2564	4,474	4,573	10,482	5,082	24,611
2565	3,753	4,203	5,858	3,819	17,633
2566	2,605	2,373	4,570	3,173	12,721
2567	2,741	2,961	3,316	3,095	12,113
2568	1,292	1,348	1,720	1,200	5,560
รวมวงเงินลงทุนทั้งสิ้น	15,616	15,842	29,029	16,847	77,334

Area กฟอ.ปลวกแดง – Smart Grid Investment

0816101	กฟอ.ปลวกแดง

trans	2,068	
meter	74,892	
batt	1,034	
V2G parti	2,247	3.00%
DR parti	749	1.00%
Smart DT	100,000	
Smart CEMS	8,000	
Smart ESS	400,000	
V2G impl	10,000	
trans exp	206,800,000	
CEMS exp	599,136,000	
BESS exp	413,600,000	
V2G exp	22,467,600	
DERMS exp	7,489,200	
GMM exp	3,744,600	
Integr. exp	2,068,000	
Comm exp	6,204,000	
Total invest	1,261,509,400	

		6000	2.20%	5.00%	4.00%
	ต้นทุน				
ปีที่	ต้นทุนคงที่	ต้นทุนสื่อสารข้อมูล	ต้นทุนปฏิบัติการและบำรุงรักษา	ต้นทุนรวม	รายได้ประมาณการ (before)
1	1,261,509,400			1,261,509,400	
2		12,408,000	27,753,207	40,161,207	4,200,000,000
3		12,408,000	27,753,207	40,161,207	4,368,000,000
4		12,408,000	27,753,207	40,161,207	4,542,720,000
5		12,408,000	27,753,207	40,161,207	4,724,428,800
6		12,408,000	27,753,207	40,161,207	4,913,405,952
7		12,408,000	27,753,207	40,161,207	5,109,942,190
8		12,408,000	27,753,207	40,161,207	5,314,339,878
9		12,408,000	27,753,207	40,161,207	5,526,913,473
10		12,408,000	27,753,207	40,161,207	5,747,990,012

NPV expense	1,473,302,949

Area: กฟอ.ปลวกแดง – Financial Return

1.00%	3.00%	2.00%	15.00%	2.00%	
Financial Return					
รายได้ จากลด เวลา ไฟดับ	รายได้ เก็บค่าไฟ ได้มากขึ้น	ลดรายได้ จาก DR	เพิ่มรายได้ จาก EV Time Shift	รายได้ จาก ไม่ตก ไม่ดับ โหลดเกิน	ผลตอบแทน ทางการเงิน
42,000,000	126,000,000	(840,000)	18,900,000	2,520,000	188,580,000
43,680,000	131,040,000	(873,600)	19,656,000	2,620,800	196,123,200
45,427,200	136,281,600	(908,544)	20,442,240	2,725,632	203,968,128
47,244,288	141,732,864	(944,886)	21,259,930	2,834,657	212,126,853
49,134,060	147,402,179	(982,681)	22,110,327	2,948,044	220,611,927
51,099,422	153,298,266	(1,021,988)	22,994,740	3,065,965	229,436,404
53,143,399	159,430,196	(1,062,868)	23,914,529	3,188,604	238,613,861
55,269,135	165,807,404	(1,105,383)	24,871,111	3,316,148	248,158,415
57,479,900	172,439,700	(1,149,598)	25,865,955	3,448,794	258,084,752
NPV financial interna return					**1,556,171,875**
FIRR					**5.62%**

Area: กฟอ.ปลวกแดง – Economic Return

5	1.00%	1.00%	2	1		
Economic Return						
ลดจ่าย จดหน่วย ออกบิล	ลดจ่าย สูญเสีย ในระบบ	ลดจ่าย จาก สมดุลย์ เฟส	ลดจ่าย แก้ไฟ	ลดจ่าย ประเมิน ผิดพลาด	ลด/เลื่อน การลงทุน INFRA	ผลตอบแทน ทางเศรษฐกิจ
4,493,520	42,000,000	42,000,000	1,797,408	898,704	200,000,000	291,189,632
4,493,520	43,680,000	43,680,000	1,797,408	898,704	200,000,000	294,549,632
4,493,520	45,427,200	45,427,200	1,797,408	898,704	200,000,000	298,044,032
4,493,520	47,244,288	47,244,288	1,797,408	898,704	200,000,000	301,678,208
4,493,520	49,134,060	49,134,060	1,797,408	898,704	200,000,000	305,457,751
4,493,520	51,099,422	51,099,422	1,797,408	898,704	200,000,000	309,388,476
4,493,520	53,143,399	53,143,399	1,797,408	898,704	200,000,000	313,476,430
4,493,520	55,269,135	55,269,135	1,797,408	898,704	200,000,000	317,727,901
4,493,520	57,479,900	57,479,900	1,797,408	898,704	200,000,000	322,149,432
NPV economic internal return						2,753,661,494
EIRR						86.90%

Area กฟอ.ปลวกแดง : Non-Monetary Return

Non-Monetary Return			
ตอบ สนอง ผู้ใช้ไฟ ดีขึ้น	ประเมิน ผิดพลาด ->ข้อมูล ไม่ถูก	ยืนหยุ่น ต่อการ เปลี่ยน แปลง	เสถียร ภาพ ระบบ ไฟฟ้า
H	H	H	H
H	H	H	H
H	H	H	H
H	H	H	H
H	H	H	H
H	H	H	H
H	H	H	H
H	H	H	H
H	H	H	H

Area: กฟจ.เชียงใหม่ – Smart Grid Investment

0101101	กฟจ.เชียงใหม่

trans	1,140	
meter	90,283	
batt	228	
V2G parti	2,708	3.00%
DR parti	903	1.00%
Smart DT	100,000	
Smart CEMS	6,000	
Smart ESS	200,000	
V2G impl	10,000	
trans exp	114,000,000	THB
CEMS exp	541,698,000	THB
BESS exp	45,600,000	THB
V2G exp	27,084,900	THB
DERMS exp	9,028,300	THB
GMM exp	4,514,150	THB
Integr. exp	1,140,000	THB
Comm exp	3,420,000	THB
Total invest	746,485,350	THB

		4000	2.20%	5.00%
	ต้นทุน			
ปีที่	ต้นทุนคงที่	ต้นทุนสื่อสารข้อมูล	ต้นทุนปฏิบัติการและบำรุงรักษา	ต้นทุนรวม
1	746,485,350			746,485,350
2		3,420,000	14,929,707	18,349,707
3		3,454,200	15,079,004	18,533,204
4		3,488,742	15,229,794	18,718,536
5		3,523,629	15,382,092	18,905,721
6		3,558,866	15,535,913	19,094,779
7		3,594,454	15,691,272	19,285,726
8		3,630,399	15,848,185	19,478,584
9		3,666,703	16,006,667	19,673,370
10		3,703,370	16,166,733	19,870,103

NPV expense	**839,823,591**

4.00%
รายได้ประมาณการ (before)
2,120,000,000
2,204,800,000
2,292,992,000
2,384,711,680
2,480,100,147
2,579,304,153
2,682,476,319
2,789,775,372
2,901,366,387

Area: กฟจ.เชียงใหม่ – Financial Return

1.00%	3.00%	2.00%	25.00%	10.00%	
Financial Return					
รายได้ จากลด เวลา ไฟดับ	รายได้ เก็บค่าไฟ ได้มากขึ้น	ลดรายได้ จาก DR	เพิ่มรายได้ จาก EV Time Shift	รายได้ จาก ไม่ตก ไม่ดับ โหลดเกิน	ผลตอบแทน ทางการเงิน
21,200,000	63,600,000	(424,000)	15,900,000	6,360,000	106,636,000
22,048,000	66,144,000	(440,960)	16,536,000	6,614,400	110,901,440
22,929,920	68,789,760	(458,598)	17,197,440	6,878,976	115,337,498
23,847,117	71,541,350	(476,942)	17,885,338	7,154,135	119,950,998
24,801,001	74,403,004	(496,020)	18,600,751	7,440,300	124,749,037
25,793,042	77,379,125	(515,861)	19,344,781	7,737,912	129,738,999
26,824,763	80,474,290	(536,495)	20,118,572	8,047,429	134,928,559
27,897,754	83,693,261	(557,955)	20,923,315	8,369,326	140,325,701
29,013,664	87,040,992	(580,273)	21,760,248	8,704,099	145,938,729
NPV financial interna return					**879,965,765**
FIRR					**4.78%**

Area: กฟจ.เชียงใหม่ – Economic Return

5	1.00%	1.00%	2	1		
Economic Return						
ลดจ่าย จดหน่วย ออกบิล	ลดจ่าย สูญเสีย ในระบบ	ลดจ่าย จาก สมดุลย์ เฟส	ลดจ่าย แก้ไฟ	ลดจ่าย ประเมิน ผิดพลาด	ลด/เลื่อน การลงทุน INFRA	ผลตอบแทน ทางเศรษฐกิจ
5,416,980	21,200,000	21,200,000	2,166,792	1,083,396	100,000,000	151,067,168
5,416,980	132,288,000	22,048,000	2,166,792	1,083,396	100,000,000	263,003,168
5,416,980	137,579,520	22,929,920	2,166,792	1,083,396	100,000,000	269,176,608
5,416,980	143,082,701	23,847,117	2,166,792	1,083,396	100,000,000	275,596,986
5,416,980	148,806,009	24,801,001	2,166,792	1,083,396	100,000,000	282,274,178
5,416,980	154,758,249	25,793,042	2,166,792	1,083,396	100,000,000	289,218,459
5,416,980	160,948,579	26,824,763	2,166,792	1,083,396	100,000,000	296,440,510
5,416,980	167,386,522	27,897,754	2,166,792	1,083,396	100,000,000	303,951,444
5,416,980	174,081,983	29,013,664	2,166,792	1,083,396	100,000,000	311,762,815
NPV economic internal return						2,442,491,336
EIRR						190.83%

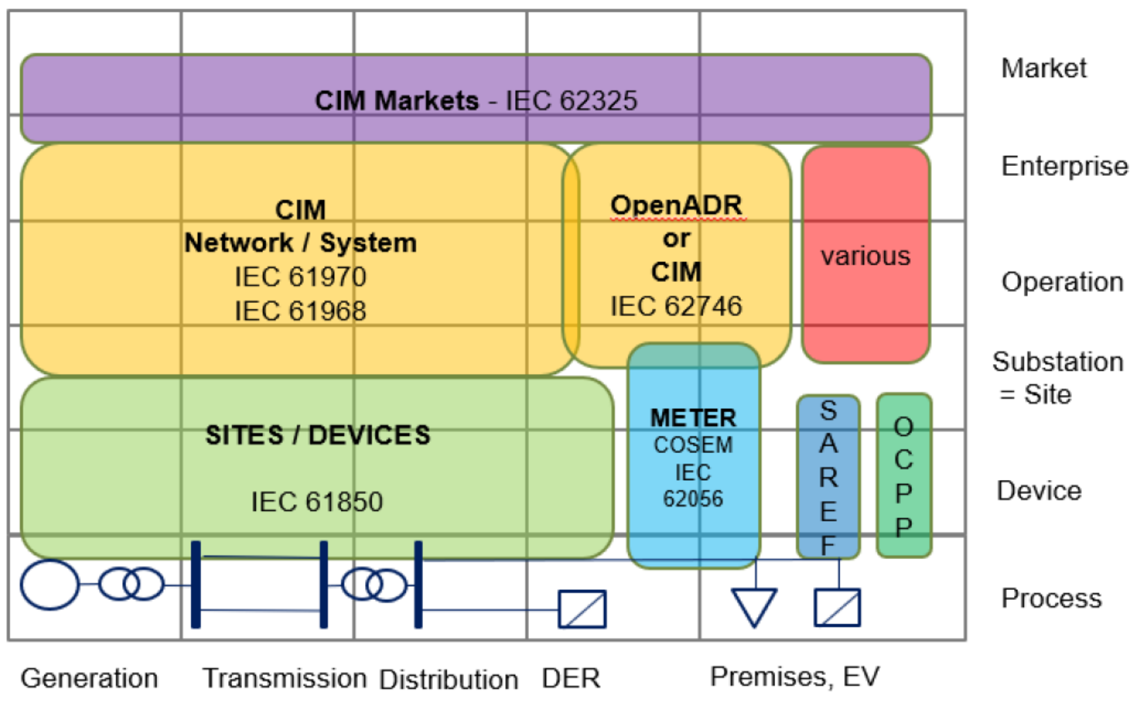
Design PEA Smart Grid

PEA Smart Grid Integration Framework

- Smart Meter Integration Solutions
- Demand Respond Solutions
- Energy Storage System Solutions
- EV Charging Integration Solutions
- Microgrid Integration Solutions
- Renewable Energy Integration

Standard Driven Integration

Focus on EEC area



U.S. DEMAND RESPONSE TREND

Smart Electric Power Alliance

POLICY UPDATE

- The **U.S. Supreme Court upheld the Federal Energy Regulatory Commission's (FERC) Order 745**, which established DR compensation in the wholesale energy markets does fall under FERC's jurisdiction, essentially leaving the DR market as it was before earlier legal challenges.
- **Rules for DR in Northeast wholesale markets are growing stricter.**
  - PJM Interconnection (PJM) is now requiring year-round performance.
  - ISO-New England (ISO-NE) is penalizing capacity resources (including demand response resources that take on a capacity obligation) for not producing energy or reserves when capacity is scarce.

DR PROGRAM TRENDS

- **Demand response programs using smart thermostats are growing in popularity** as utilities expand their offerings to include direct install, self install and bring your own thermostat programs. These programs increase customer choice, allow greater visibility into customer devices, and provide energy savings to both customers and utilities.
- **Utilities are continuing to adopt behavioral programs** as a way to increase customer engagement, provide customers with energy savings, and curb energy usage during peak hours.
- **A number of efforts are under way to better coordinate energy efficiency and demand response at the utility level.** Examples here include combined program offerings and incentives, coordinated program marketing and education, market-driven coordinated services, and building codes and appliance standards.

2 Bloomberg New Energy Finance, July 2017, "Electric Vehicle Outlook 2017", https://about.bnef.com/electric-vehicle-outlook/.

ADVANCED DR APPLICATIONS AND TRENDS

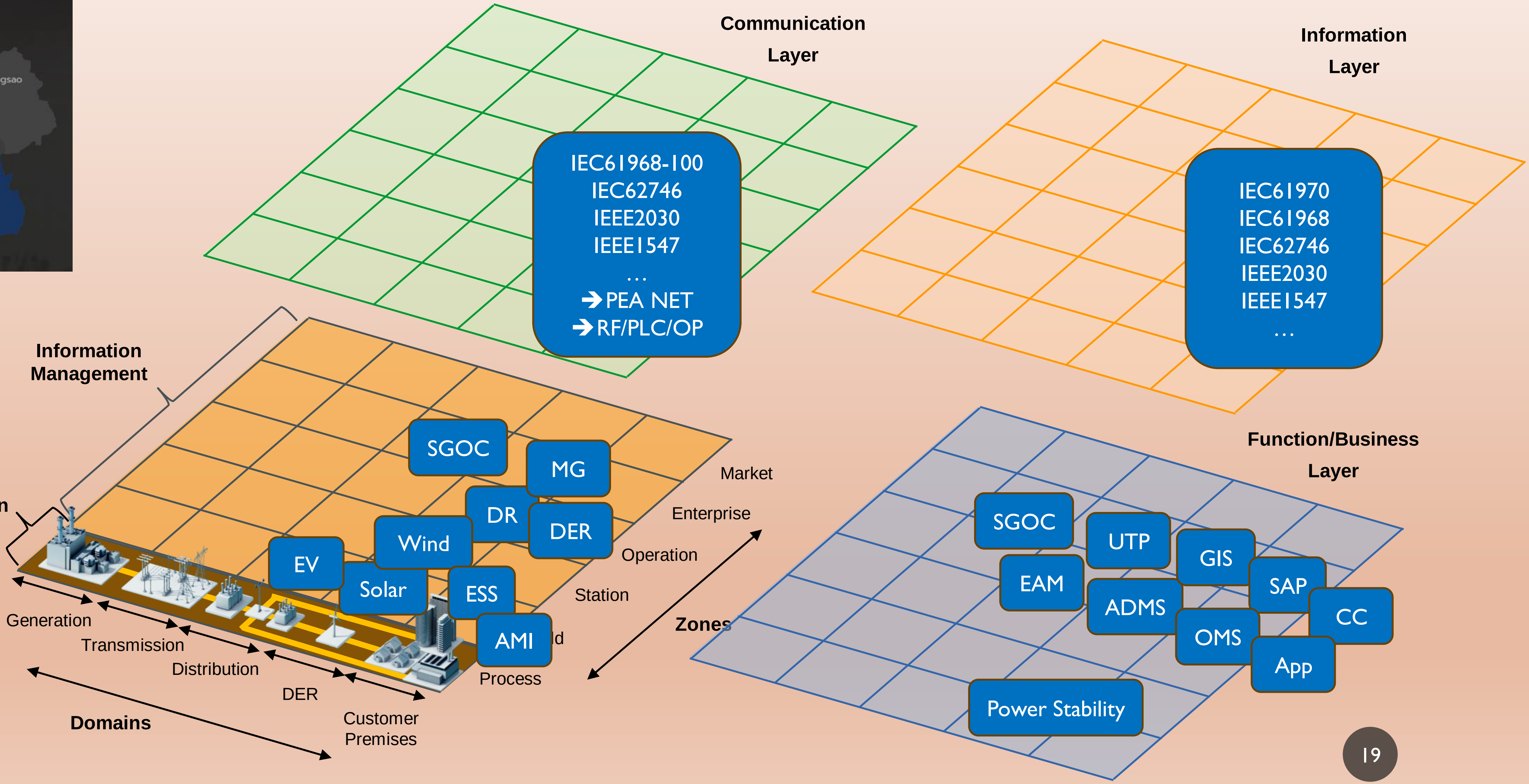
- **Electric vehicles are quickly becoming one of the largest flexible loads on the grid**, with annual electricity consumption by EVs expected to reach 400 terawatt-hours (TWh) annually by 2040.[2] These vehicles have the capability to absorb excess renewable energy production and minimize peak impacts through managed charging.
- **Utilities are increasingly looking to target DR in specific distribution-level areas with high load growth or infrastructure constraints.** Ten percent of the utilities providing DR data for SEPA's Utility Survey have leveraged locational deployment of DR for non-wires grid upgrades (commonly known as non-wires solutions or alternatives). Another 60% are planning, researching, or considering such an approach.

DR AND DER CONVERGENCE

- While traditional forms of demand response continue to be deployed today, newer forms of DR are emerging in the industry and being integrated with other distributed energy resources (DERs). This transition and expansion in demand response markets are being driven by a few key trends.
  - **Needs at the grid edge:** DER growth and constraints along the electric system are opening up opportunities for demand response to play a greater role along the grid edge.
  - **Consumer products entering the power space:** Newer demand response technologies (e.g., smart thermostats and other complementary technologies) are enabling easier deployment for certain demand response programs.
  - **Integration:** New platforms and programs are combining DR with other DERs. Examples include deploying energy storage for demand response applications, and using demand response to buffer renewable generation variability along the grid.

PEA Smart Grid + Vendor Solutions

EEC area



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