The National Academies of
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TRANSPORTATION RESEARCH BOARD

Energetic Value: The Design and Economics of Microgrids at Airports

Wednesday, March 20, 2019
2:00-3:30 PM ET

Purpose

Discuss research from the Airport Cooperative Research Program (ACRP) Synthesis 91/Transit Cooperative Research Program (TCRP) Synthesis 137: Microgrids and Their Application for Airports and Public Transit.

Learning Objectives

At the end of this webinar, you will be able to:

- Understand microgrids and their application at airports
- Identify the steps required to evaluate a microgrid at their facility
- Understand the design and installation challenges for airports
- Describe a case study of microgrid use at an airport

ACRP Webinar

Energetic Value — The Design and Economics of Microgrids at Airports

March 20, 2019

TRB

ACRP AIRPORT COOPERATIVE RESEARCH PROGRAM

Rima Oueid
U.S. Department of Energy

- DOE Senior Policy Advisor
- Advisor on energy infrastructure project finance, microgrids, and investment strategies
- Energy Finance Advisor on Hurricane Sandy Task Force
- Provided technical, financial, and strategy assistance for NJ TransitGrid
- Topic panel and report contributor
  - Microgrids and Their Application for Airports and Public Transit
- University Of Chicago Booth School Of Business MBA, University of Illinois Bachelor of Science

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www.trb.org/ACRP

Today's Speakers

Eric Mannarino, Arup

and

Brendan Reed, San Diego International Airport

Presenting

ACRP Synthesis 91

Microgrids and Their Application for Airports and Public Transit

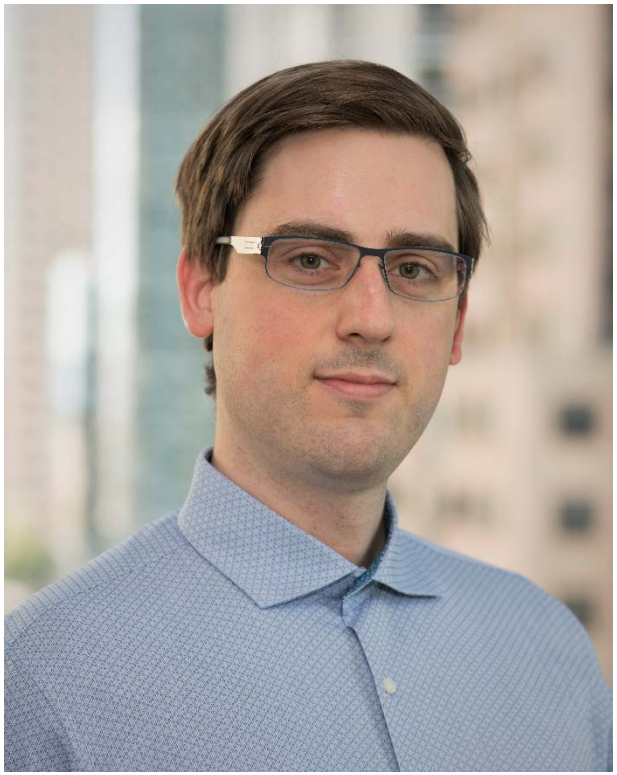
Microgrids and Their Application to Airports and Public Transit

Eric Mannarino, MS, PE
Arup

March 20, 2019

Eric Mannarino, MS, PE
Co-Author

- Electrical Engineer, Arup
- DER, Microgrid, and Critical Power Design
- AC/DC Microgrid and BSS Research
- Certified Professional Engineer, CA



ACRP Synthesis 91 Oversight Panel

Joshua D. Abramson, Eastwood Airport Management, Panel Chair

Debbie K. Alke, Montana DOT

Gloria G. Bender, TransSolutions, LLC

David A. Byers, Quadrex Aviation, LLC

David N. Edwards, Jr., Greenville-Spartanburg Airport District

Brenda L. Enos, Burns & McDonnell

Linda Howard, Independent Aviation Consultant

Patrick W. Magnotta, FAA Liaison

Matthew J. Griffin, Airports Consultants Council Liaison

Liying Gu, Airports Council International – North America Liaison

Adam Williams, Aircraft Owners & Pilots Association Liaison

Christine Gerencher, TRB Liaison

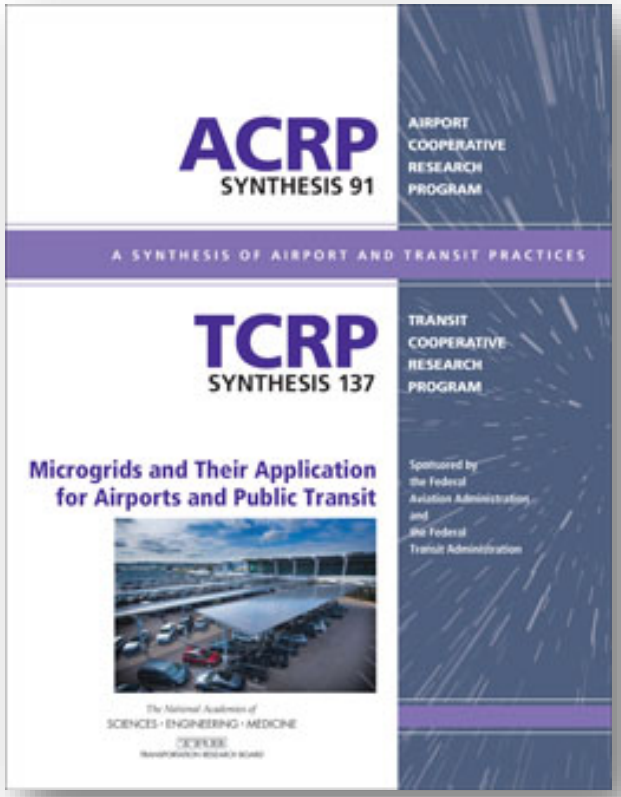
ACRP Synthesis 91: *Microgrids and Their Application for Airports and Public Transit*

- Microgrids as a solution to power reliability and resiliency issues
- Identifies considerations and potential difficulties in implementing microgrids
- Identifies and documents the benefits for airports in adopting microgrids
- Identifies key steps in the development process
- Presents means for stakeholders to organize airport microgrid deployment
- Presents additional case studies for the use of microgrids at various facilities
- Published August 2018

Microgrids and Their Application for Airports

A Research Synthesis

- What are Microgrids?
- The Benefits to Airports and Public Transit Agencies
- Opportunities
- Barriers and Considerations
- Microgrid Costs
- Cost Savings and Monetization Strategies
- Case Studies



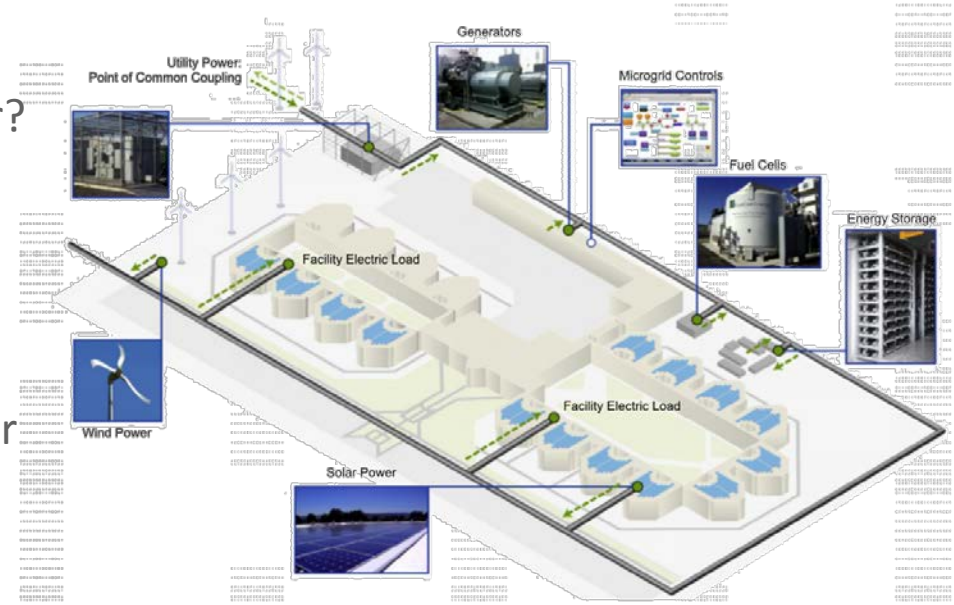
Drivers of Adoption

- Site resilience and reliability
- Increasing costs of fossil fuels
- Falling costs of Battery Storage Systems (BSS) and Distributed Energy Resources (DER)
- The need to balance intermittent DERs
- Climate goals and clean energy mandates
- Changing regulatory environment
- Increasing frequency of extreme weather events

An Introduction to Microgrids

- Department of Energy (DoE) Microgrid Definition
  - A group of interconnected loads and DERs within a clearly defined electrical boundary that act as a single controllable entity with respect to the grid
  - A Microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or grid-islanded mode

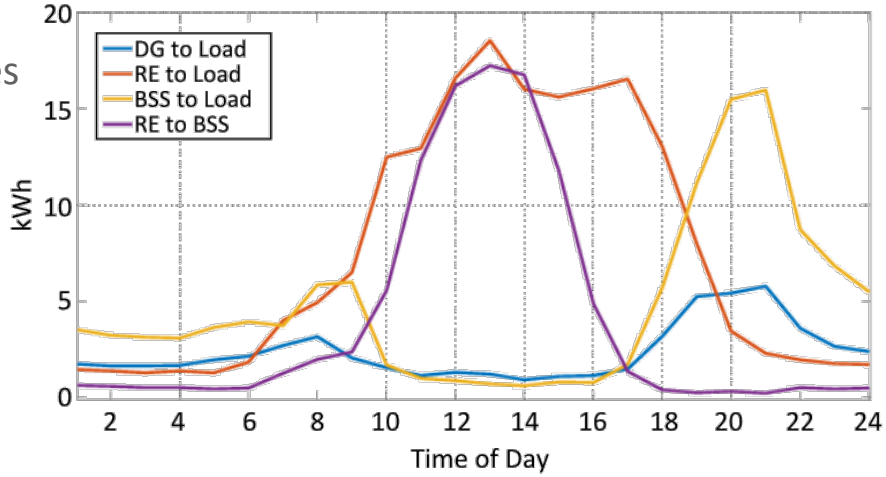
- What does a microgrid allow for?
  - Grid modernization
  - Enhanced integration of DERs
  - Reliable and resilient power supply for critical loads



Ton, D. and Smith, M. (2012). The U.S. Department of Energy's Microgrid Initiative. *The Electricity Journal*, 25(8), pp.84-94.

Advanced Microgrids

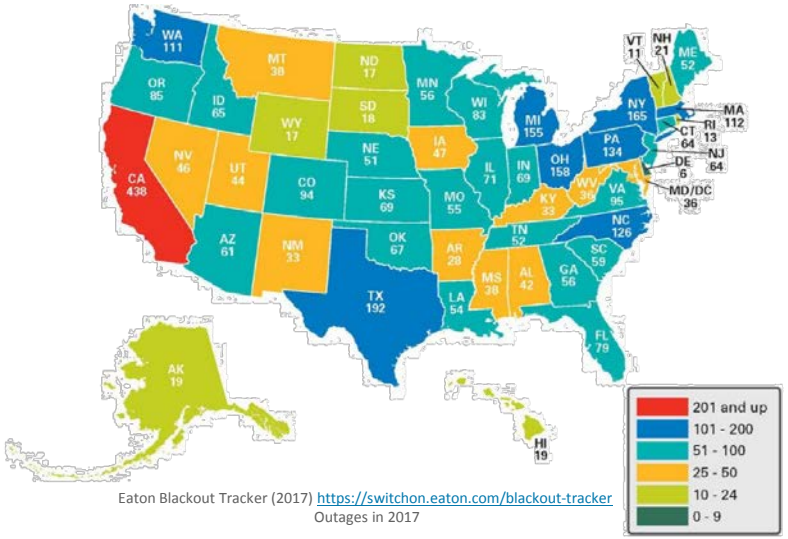
- Improving the resilience of the local grid
  - 2-way communication with the grid
  - Local compensation for the variability of Renewable Energy
  - Ancillary Services: VAr Support, Voltage Regulation, Frequency Regulation
- Dynamic dispatch algorithms
  - Response to time-of-use pricing
  - Mitigation of peak demand charges
  - Minimizes carbon cost of energy
  - Predictive dispatch
  - Outage management
- Improved Cybersecurity
  - Integrated controls
  - Advanced monitoring



Aldaouab, I. and Daniels, M.C. (2018). Model predictive control energy dispatch to optimize renewable penetration for a microgrid with battery and thermal storage. *2018 IEEE Texas Power and Energy Conference (TPEC)*, 1-6.

Microgrids at Airports

- Improved power reliability
- Improved energy resiliency
- Energy cost savings
- Cost risk reduction
- Improved sustainability



Eaton Blackout Tracker (2017) https://switchon.eaton.com/blackout-tracker
Outages in 2017

State	Total number affected	Total duration	Total number of outages	Average number affected	Average duration
AK	503,113	20,365	225	3,225	138
AL	2,636,805	18,533	461	8,214	69
AR	1,883,787	22,812	296	7,752	122
AZ	2,036,543	45,961	530	4,860	138
CA	22,203,596	338,829	4,297	6,022	133
CO	2,329,892	38,518	594	4,895	99
CT	3,180,301	23,511	593	6,752	75
DC	2,532,401	4,225	179	19,041	49
DE	540,389	6,126	136	4,868	91
FL	25,348,824	51,226	848	38,819	105
GA	4,930,187	30,783	558	11,767	95
HI	2,055,710	16,340	273	10,542	93
IA	1,159,482	24,774	422	3,313	89
ID	1,157,012	21,811	373	3,582	85
IL	6,222,885	40,164	871	9,233	88
IN	2,500,043	42,882	686	4,546	100
KA	784,860	9,690	376	2,625	41
KY	2,004,924	26,500	326	7,537	126
LA	3,783,204	20,040	451	10,657	79
MA	4,356,364	34,019	823	7,039	68
MD	4,237,501	12,881	377	15,522	77
ME	4,371,598	17,250	309	16,435	93
MI	12,489,964	75,966	1,369	10,937	97
MN	2,254,450	26,875	458	6,369	90
MO	2,492,058	43,970	628	5,538	111

State	Total number affected	Total duration	Total number of outages	Average number affected	Average duration
MS	844,023	13,795	259	4,117	77
MT	676,671	50,166	337	2,696	212
NC	6,003,038	58,624	982	7,570	96
ND	395,386	11,945	191	2,636	84
NE	919,030	38,456	319	3,508	172
NH	2,811,383	16,624	278	12,721	117
NJ	5,760,505	41,461	910	8,414	89
NM	917,411	9,138	195	5,881	68
NV	1,142,085	18,987	402	3,389	66
NY	18,359,431	88,657	1,528	14,606	103
OH	7,024,677	86,544	1,349	634	105
OK	2,220,750	13,625	498	5,093	42
OR	3,700,739	42,551	690	6,458	98
PA	7,095,095	74,134	1,256	7,131	103
RI	1,161,957	4,425	105	14,897	79
SC	2,479,440	19,774	439	6,984	71
SD	308,784	7,268	162	2,357	68
TN	2,520,456	37,821	584	5,651	102
TX	11,476,011	60,306	1,603	9,329	71
UT	1,862,762	22,986	346	6,303	103
VA	5,369,718	51,590	069	7,500	105
VT	607,749	14,647	141	5,194	172
WA	5,627,646	71,806	1,020	6,863	118
WI	2,965,277	46,175	774	4,633	100
WV	2,035,031	15,709	359	7,042	79
WY	222,374	9,925	94	2,965	153

Eaton Blackout Tracker (2018). https://switchon.eaton.com/blackout-tracker - Outages from 2008 - 2017

Barriers and Considerations for Airport Microgrids

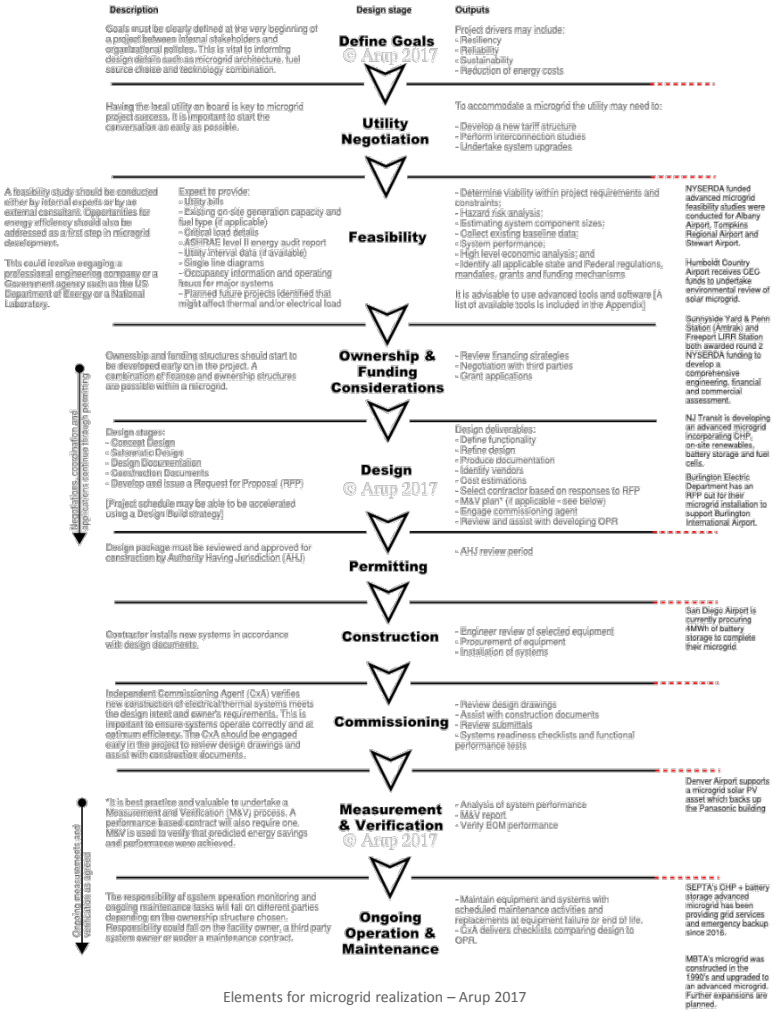
- Technical
  - High energy demand
  - Operational continuity
- Financial
  - Low energy costs
  - Valuing resiliency
- Regulatory/Policy
  - FAA safety requirements
  - Security and access
- Operational and organizational
  - Conflicting stakeholder interests
  - Complex O&M and procurement
- Utility interconnection

Opportunities in Airports

- Technical
  - Physical space and capacity
  - Dedicated site personnel
  - Advantageous demand profiles
  - Existing microgrid components
- Financial
  - Federal Tax Credit (ITC) eligible
  - Access to revenue streams
  - P3, PPA, etc.
- Regulatory/Policy
  - Organizational sustainability goals
  - Internal resiliency goals
  - Energy market participation

Microgrid Design Process

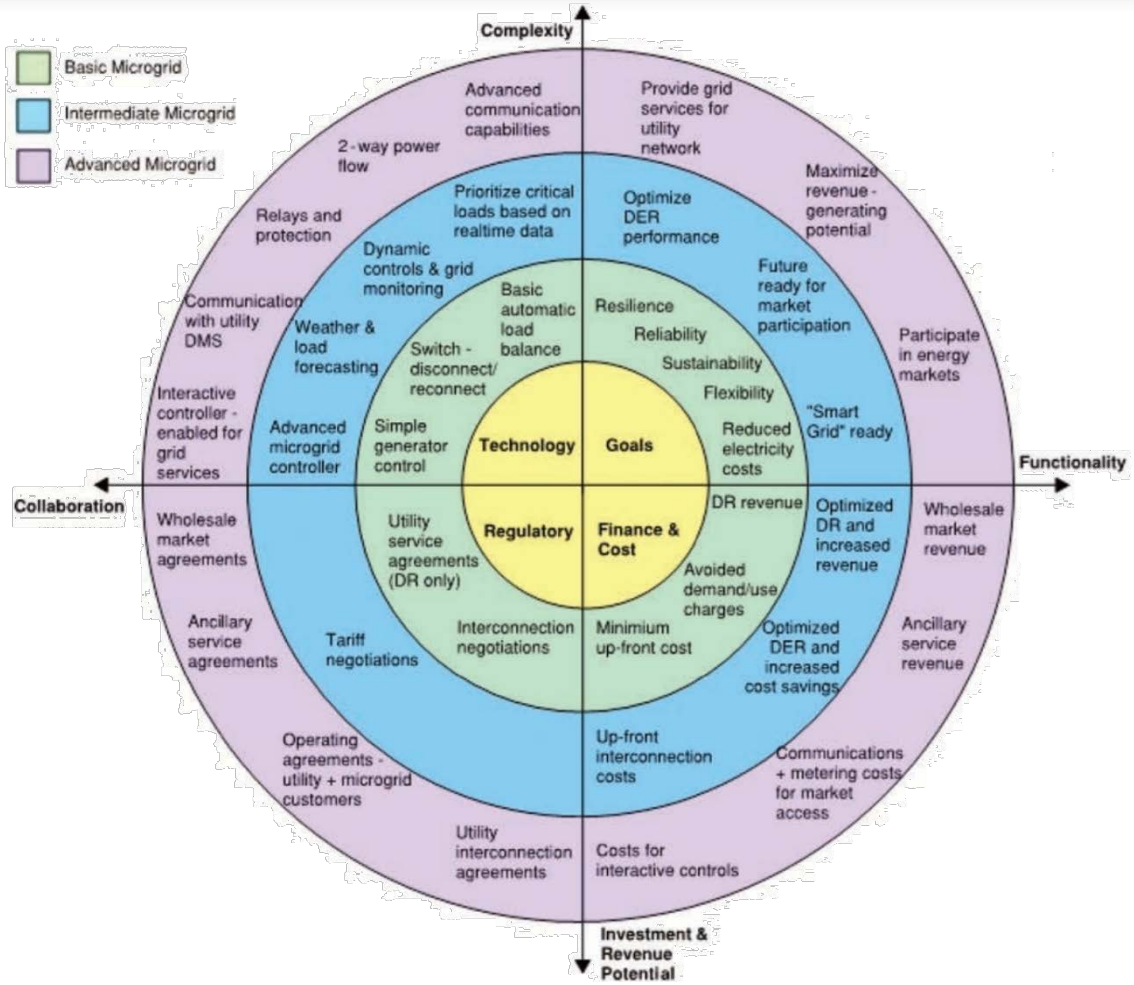
- Developing a microgrid is complex
- What is the project scope?
- How do we design a microgrid?
- What does it do?
- Will a microgrid work for this site?



Elements for microgrid realization – Arup 2017

Microgrid Design Goals

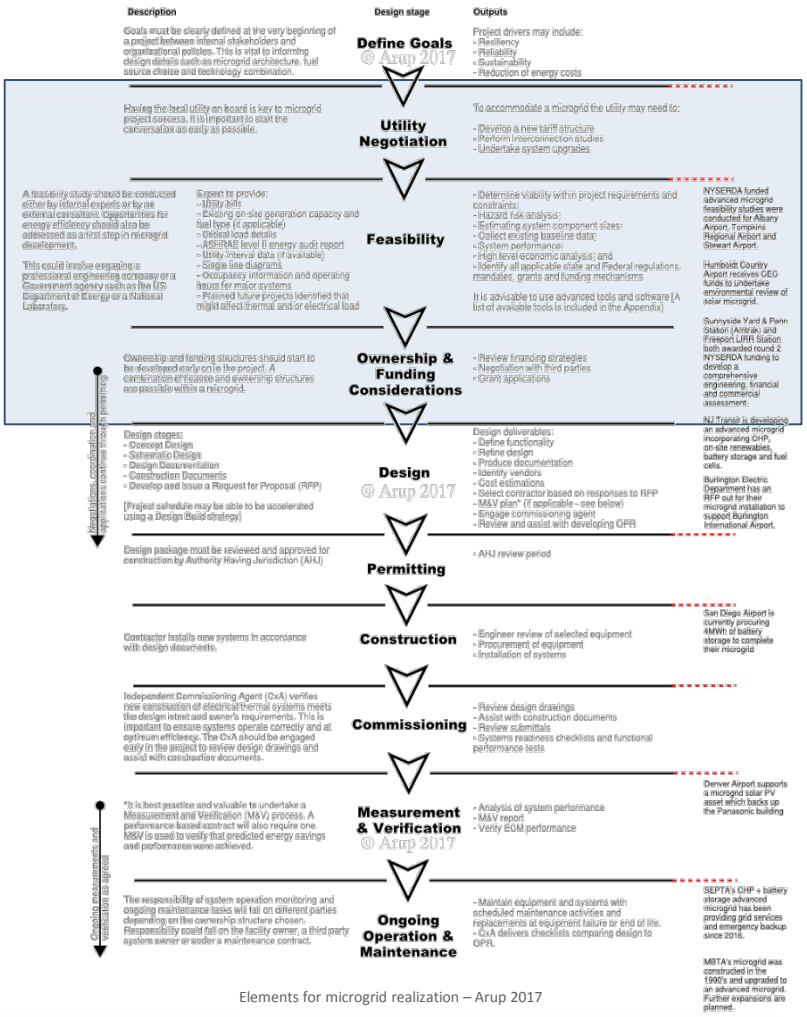
- Capabilities
- Assets
- Internal goals
- Economics
- Regulation



Microgrid variation attributes – Arup 2017

Project Development: Financing

- Utility negotiations
- Feasibility analysis
- Basis of Design (BOD)
- Project scheduling
- Ownership and Financing



Elements for microgrid realization – Arup 2017

What is the Cost of a Microgrid?

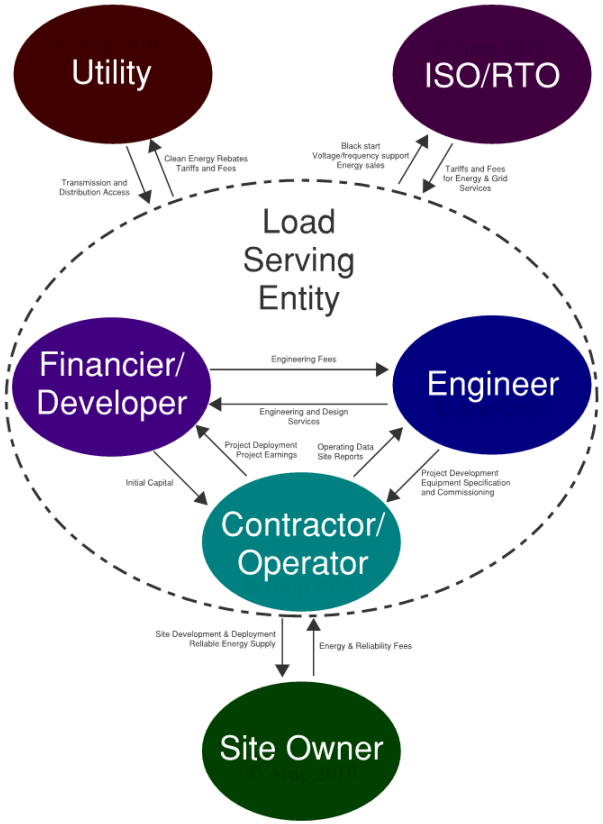
- Many varied factors affect the cost to implement a microgrid
- Bespoke nature of current microgrid systems may lead to high costs
- Limited information exists on the extended O&M costs
- Developing a business case is often difficult

Component	Cost Ratio	Description
Energy resources	30-45%	Energy storage; controllable loads; DG (renewable generation, CHP)
Switchgear protection and transformers	20%	Switchgear utility interconnection (including low-cost switches, interconnection study, protection schemes, and protection studies)
Communications and controls	10-20%	Standards and protocols; control and protection technologies; real-time signals; local supervisory control and data acquisition (SCADA) access; power electronics (smart inverters, DC bus)
Site engineering and construction	30%	A&E (system design and analysis); system integration, testing and validation
Operations and markets	5-15%	Operation and maintenance; market (utility) acceptance

Griffith, S. (2016). Powering Microgrids for the 21st-Century Electrical System. *National Electrical Manufacturers Association*.

Microgrid Ownership Models

- Single party owner
- Shared ownership
- Third party owner
- Utility ownership

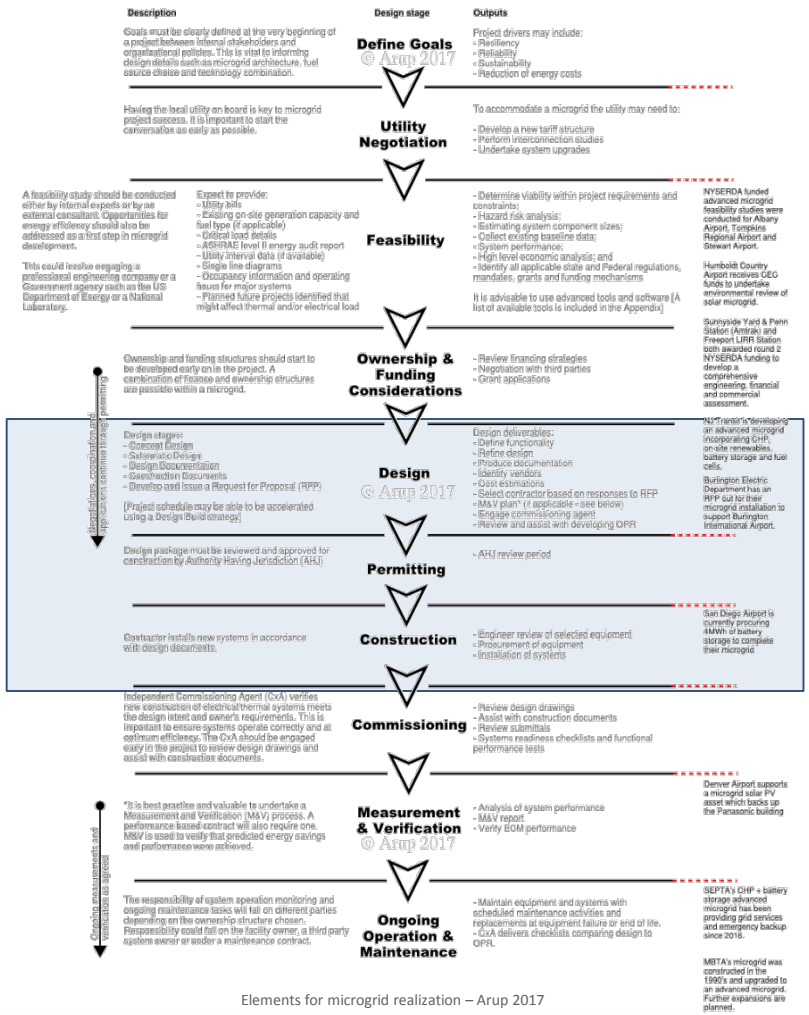


Third Party Ownership
(PPA)

Examples of capital and service exchanges in a third party ownership model – Arup 2019

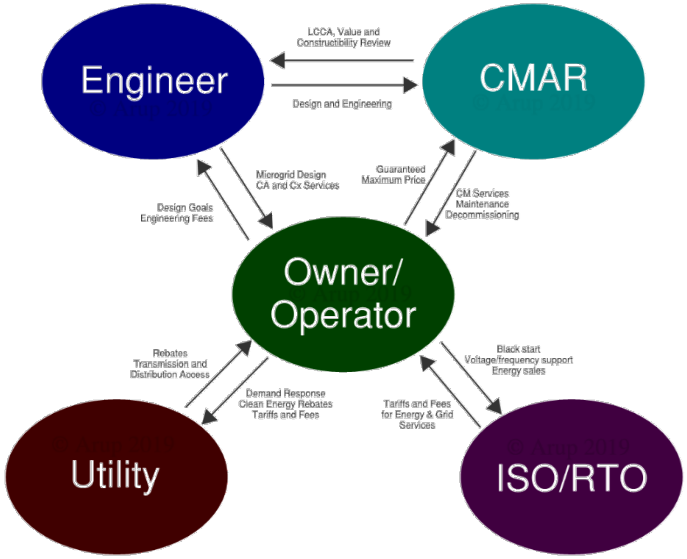
Project Development: Design

- Systems Design
- Phasing
- Permitting
- Equipment specification
- Construction



Microgrid Delivery Models

- Design-bid-build (DBB)
- Design-build-finance (DBF)
- Integrated project delivery (IPD)
- Public-private partnership (P3)
- Construction manager at risk (CMAR)

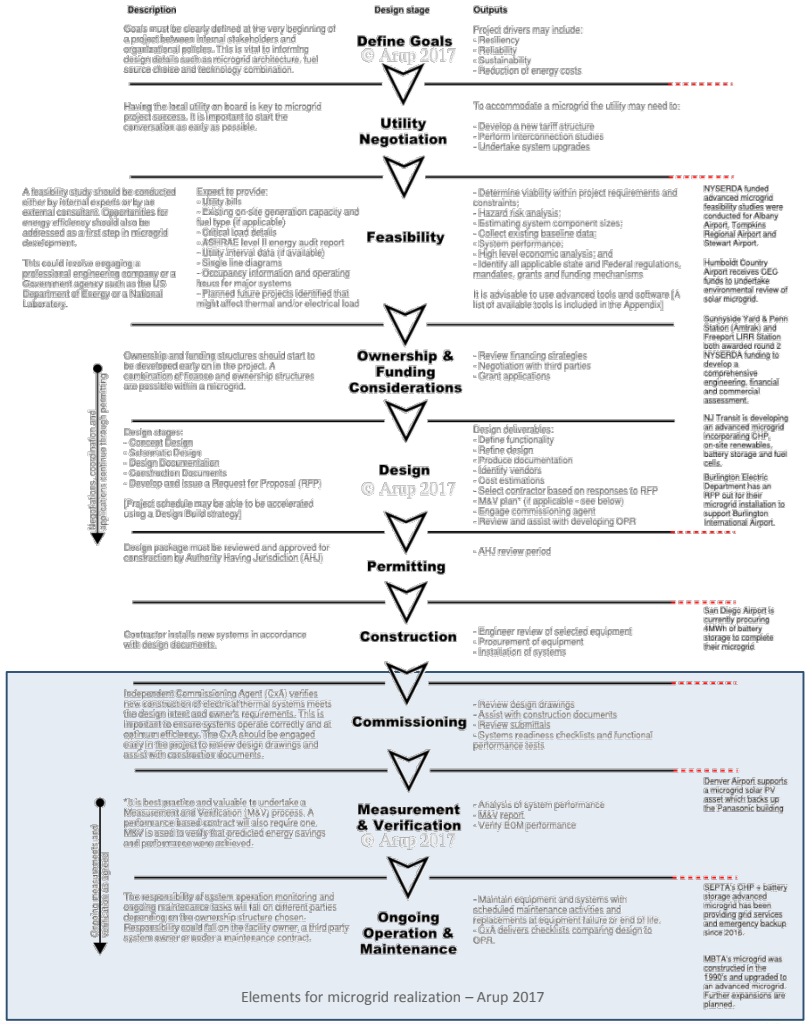


Construction Manager at Risk (CMAR)

Examples of capital and service exchanges using CMAR project delivery – Arup 2019

Project Development: Commissioning Operations

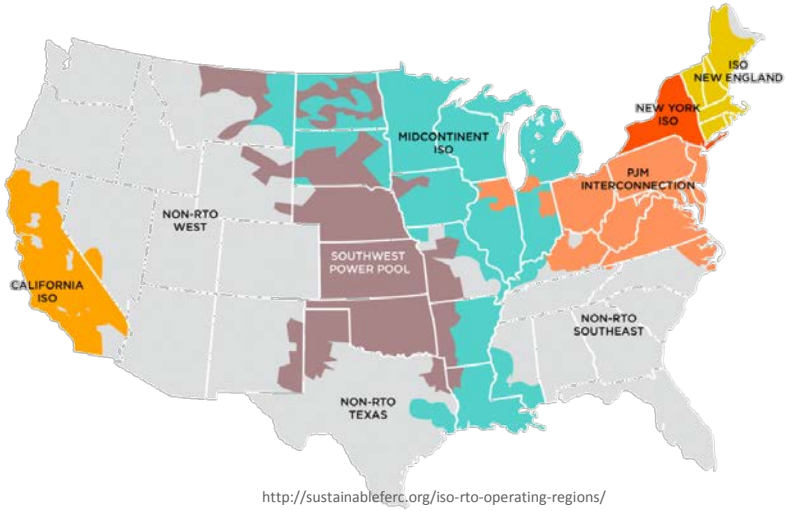
- Commissioning
- Operations testing
- Measurement & verification
- Retro-commissioning
- Ongoing O&M



Elements for microgrid realization – Arup 2017

The Benefits of Microgrids

- ISO/RTO services
  - Capacity markets & energy arbitrage
  - Frequency regulation
  - Spinning/Non-spinning reserves
  - Black start



http://sustainableferc.org/iso-rto-operating-regions/

- Utility services
  - Demand response
  - Transmission or distribution upgrade deferral
  - Emissions credit programs

- Owner/Operator goals
  - Clean energy integration
  - Business continuity

FOR ADDITIONAL INFORMATION

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https://www.nap.edu/catalog/25233/microgrids-and-their-application-for-airports-and-public-transit

Leveraging a (Sort of) Microgrid at a US Airport

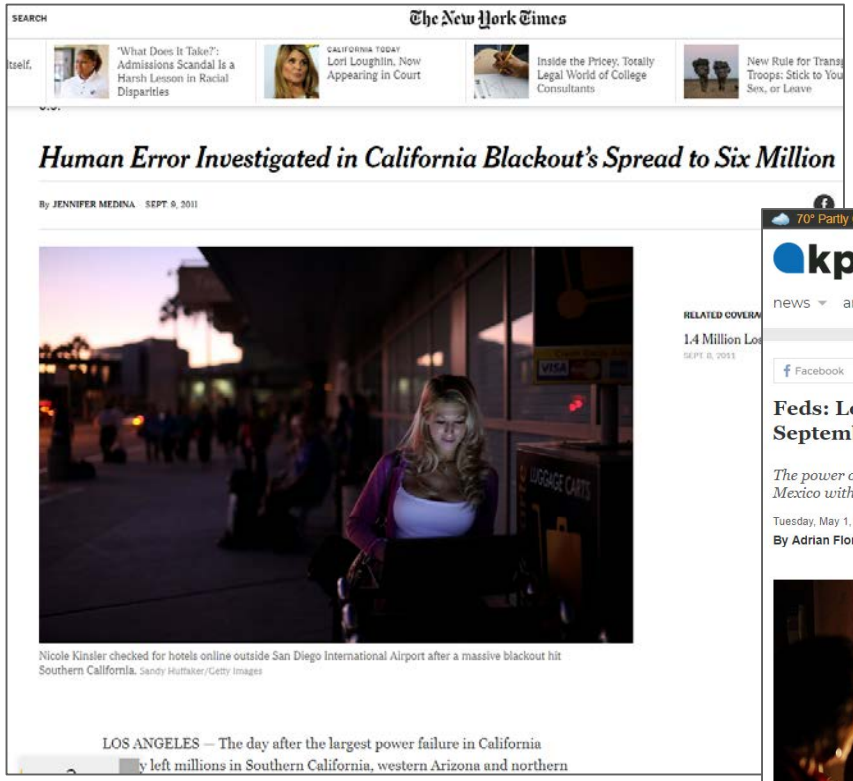
Brendan J. Reed, CEM, LEED-AP
San Diego County Regional Airport Authority
San Diego International Airport

Brendan J. Reed
ACRP-Synthesis 91 Panel Member

- Director of Planning & Environmental Affairs, San Diego County Regional Airport Authority
- 18+ Years in Environmental Policy
- US Caucus Chair, ACI-NA Environmental Affairs Committee
- AEE Certified Energy Manager
- LEED Accredited Professional

Context Setting

Context Setting



SEARCH

The New York Times

'What Does It Take?': Admissions Scandal Is a Harsh Lesson in Racial Disparities

CALIFORNIA TODAY
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Inside the Pricey, Totally Legal World of College Consultants

New Rule for Trans Troops: Stick to You Sex, or Leave

Human Error Investigated in California Blackout's Spread to Six Million

By JENNIFER MEDINA SEPT. 9, 2011

Nicole Kinsler checked for hotels online outside San Diego International Airport after a massive blackout hit Southern California. Sandy Huffaker/Getty Images

LOS ANGELES — The day after the largest power failure in California
y left millions in Southern California, western Arizona and northern

70° Partly Cloudy

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Feds: Loss Of Arizona Power Line Caused Massive September Blackout

The power outage left millions across the Southwestern U.S. and Northern Mexico without electricity for numerous hours.

Tuesday, May 1, 2012

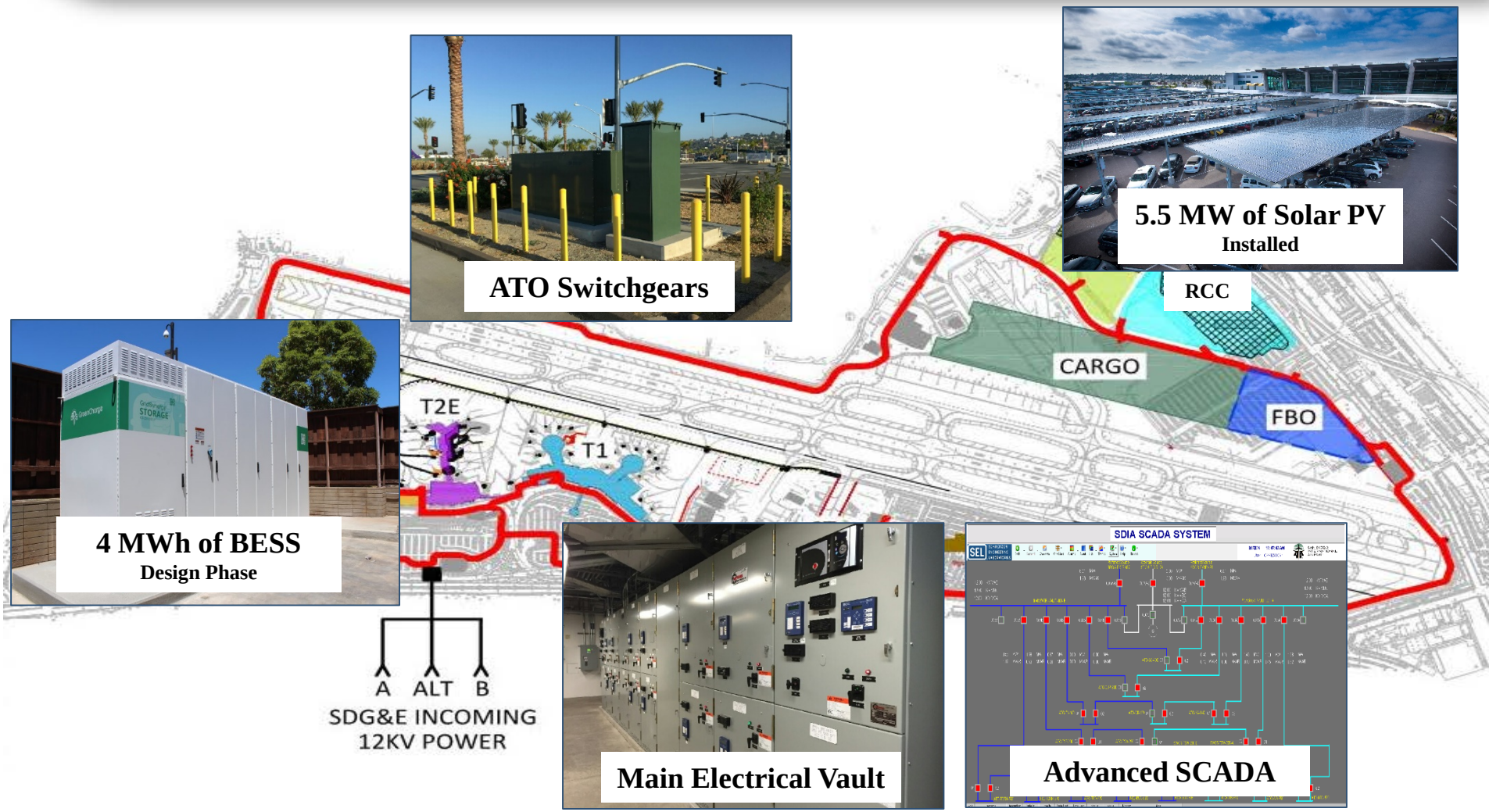
By Adrian Florido, Nadine Arroyo Rodriguez

PHOTO BY SANDY HUFFAKER / GETTY IMAGES

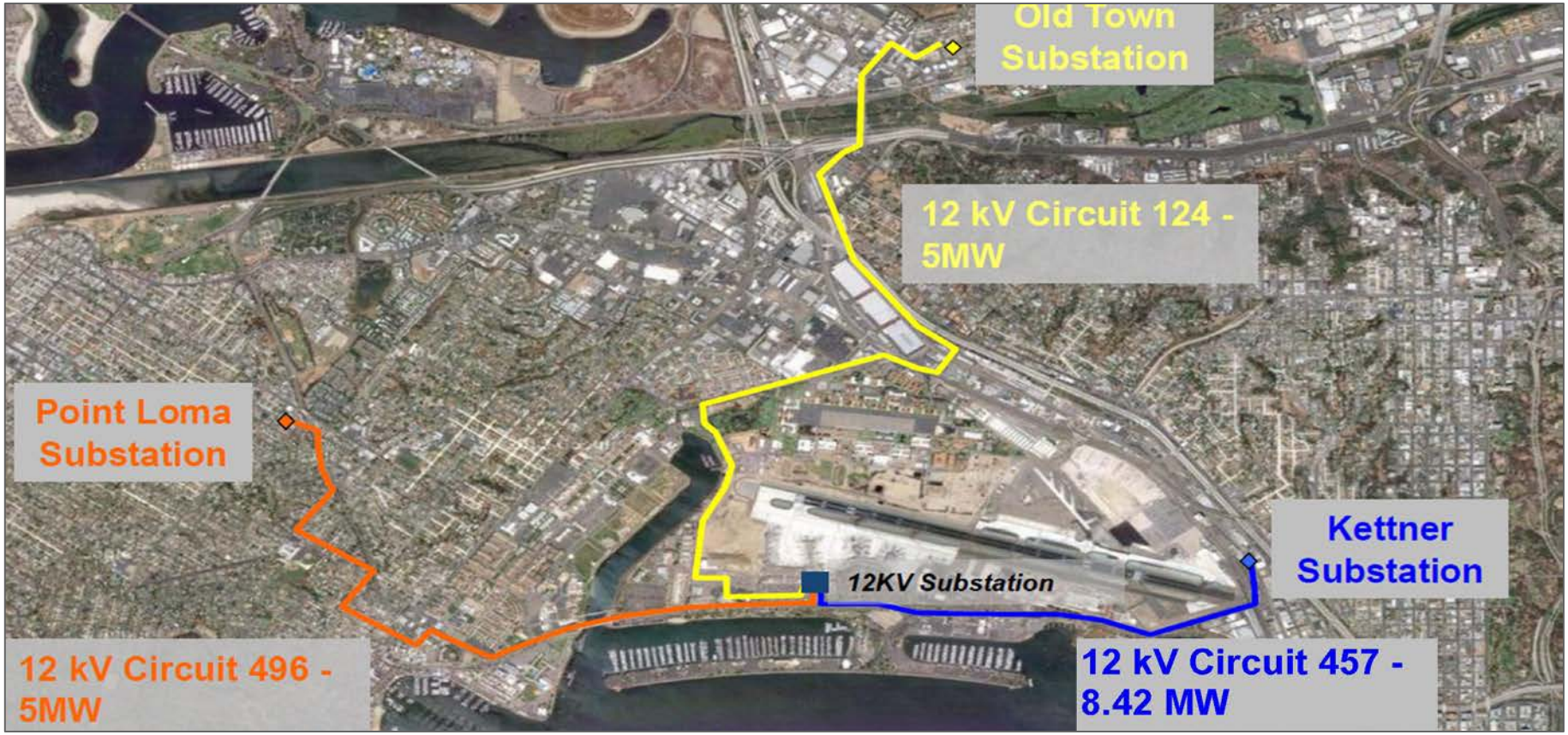
Above: Workers serve pizza to customers outside of Filippi's Pizza after a massive blackout hit Southern California September 8, 2011 in San Diego, California.

"The Great Blackout of 2011"

Campus-Wide 12-kV Distribution System



Connection to Regional Grid



Backbone of Sustainable Energy Plan

- Integrated & phased planning document
- Main Goals:
  - Conservation & Efficiency
  - Carbon Neutrality
  - Interdependence & Resiliency
  - Cost Containment
  - Regional & Industry Leadership
- Informs capital program & operations
- Available at www.san.org/green

Backbone of Sustainable Energy Plan

Contribution to SAN's long-term energy goals:

- Allows "upstream" redundancy for grid interconnections
- Provides flexibility with siting of distributed energy resources
- Improves opportunities for direct access (commodity buying)
- Reduces electricity rates & demand charges
- Demonstrates climate, energy, & "smart airport" leadership

And if everything goes as planned…

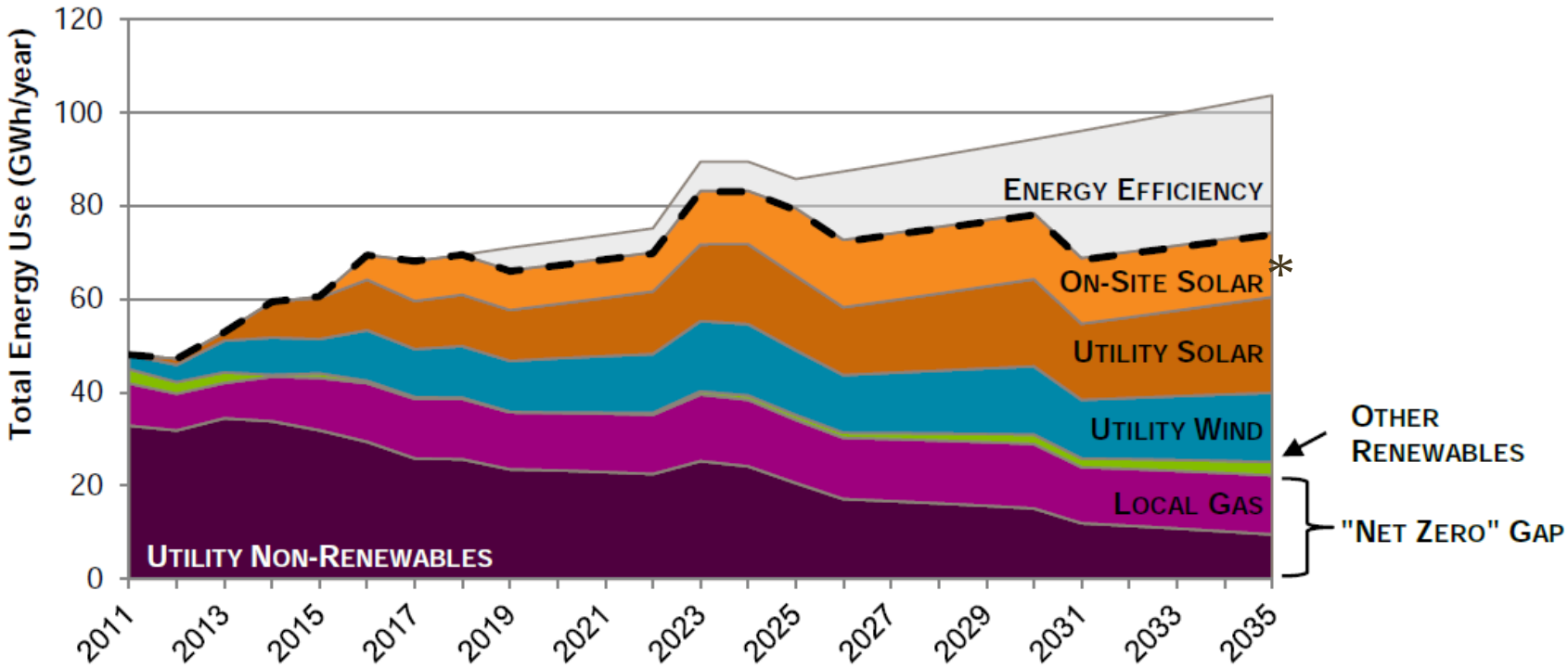
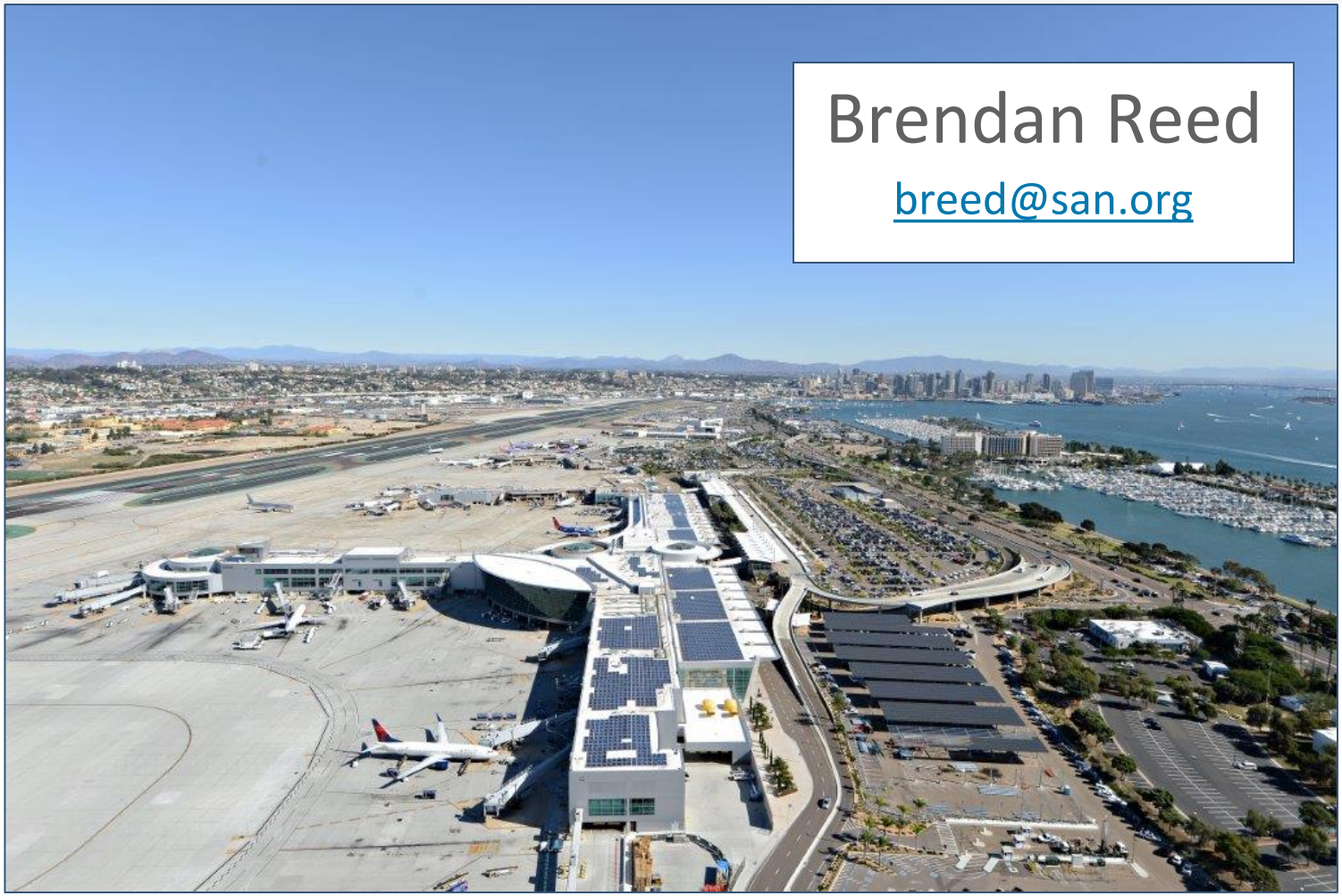


Figure 10: Integrated Roadmap

*Includes Battery Energy Storage Systems (BESS)

SAN Strategic Energy Plan - 2019 Update (DRAFT)

FOR ADDITIONAL INFORMATION



Brendan Reed

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Today's Participants

- Rima Kasia Oueid, *U.S. Department of Energy,* rima.oueid@hq.doe.gov
- Eric Mannarino, *Arup,* Eric.mannarino@arup.com
- Brendan Reed, *San Diego International Airport,* breed@san.org

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- Conducts research to find solutions.
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Report 110: *Evaluating Impacts of Sustainability Practices on Airport Operations and Maintenance*

Report 151: *Developing a Business Case for Renewable Energy at Airports*

Report 141: *Renewable Energy as an Airport Revenue Source*

Synthesis 53: *Outcomes of Green Initiatives: Large Airport Experience*

Synthesis 93: *Sustainability's Role in Enhancing Airport Capacity*

Synthesis 77: *Airport Sustainability Practices*

Synthesis 69: *Airport Sustainability Practices—Drivers and Outcomes for Small Commercial and General Aviation Airports*

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April 18

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May 22

The Making of a Smart Airport — Preparing for the Internet of Things