San Diego Smart Grid Study

Modernizing the Grid – MW Regional Summit

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Presentation Overview

- About EPIC
- Smart Grid Study Key Findings
- Smart Grid Study Details
  - Current/future state in San Diego
  - Gap Analysis
  - Cost-Benefit Analysis
  - Recommended technologies
  - Recommended RD&E Projects

About EPIC

- Academic and Research Center
  - University of San Diego School of Law
- Funded with settlement monies from a lawsuit against Duke Energy
- Agreement between San Diego District Attorneys Office and USD

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About EPIC

- EPIC's Mission
  - Educate the public and public officials concerning energy issues and policies;
  - Educate law school students about energy law and policy;
  - Conduct research and analysis on energy trends, policy options and their implications; and,
  - Encourage the use and development of less costly and more environmentally-friendly energy resources.

About EPIC

- Research and Analysis
  - Smart Grid Study
  - Public Goods Charge Fund
  - Renewable Energy Certificates (RECs)
  - Solar Laws
  - AB 1X Rate Caps
  - Solar Financing
  - Energy Legislation
  - Energy Regulation

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About EPIC

- Academic Program
  - Energy Law and Policy Course
    - Fall 2006
    - Taught by two local energy attorneys
    - Focus: Electricity and Natural Gas
  - Energy Law and Policy Clinic
    - Work with energy agencies to conduct legal and policy research

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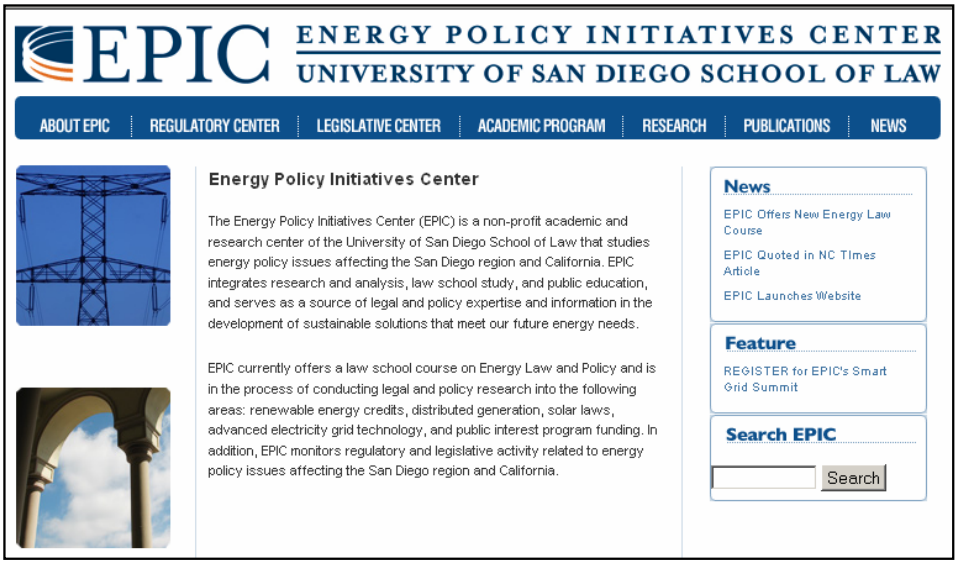
About EPIC

- EPIC Website: www.sandiego.edu/epic



Why Smart Grid Study?

- Convergence of CA Policy Goals
  - Efficiency and demand response
  - Renewables
  - Distributed generation

Can we maximize within the current system?

- Current Trends
  - Increase in distributed generators
  - Technological changes
    - E.g., storage, plug-in hybrids
  - Poor asset utilization
  - Aging distribution infrastructure

San Diego Smart Grid Study

- Goals
  - Assess technical feasibility
  - Assess cost effectiveness
  - Identify technology and regulatory barriers
  - Recommend a pathway to the Smart Grid
  - Recommend RD&D projects

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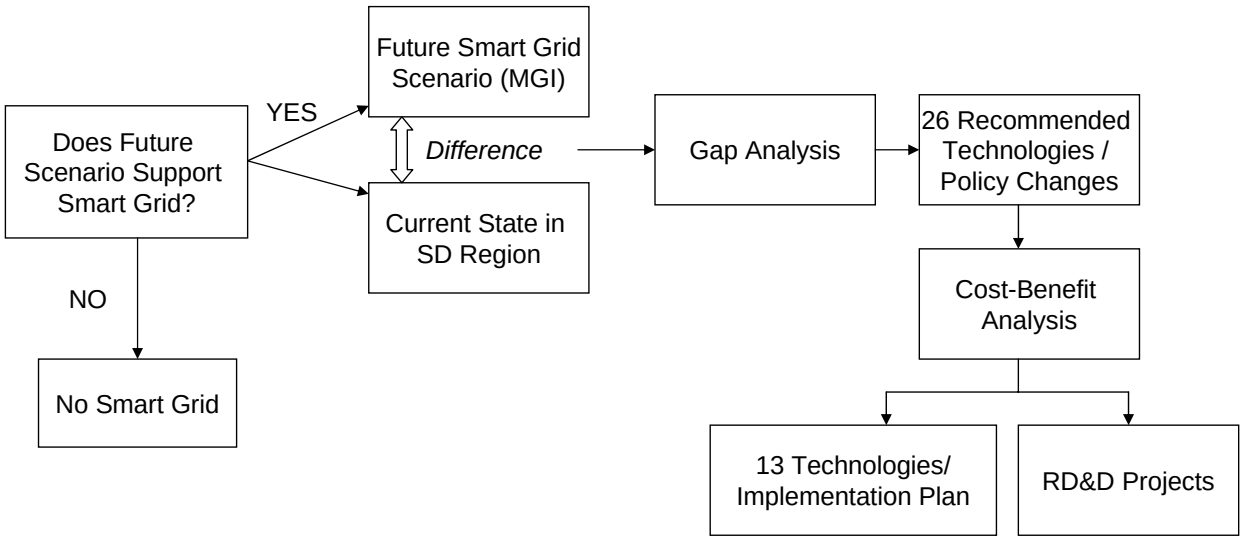
San Diego Smart Grid Study

- Study Process



Key Findings

- Future climate in San Diego region will be desirable for implementation of a Smart Grid
- Significant need for modernization
  - Host utility using some advanced technologies
  - Study identified 26 technologies to modernize grid
- Implementing selected Smart Grid technologies appears cost effective
  - Results of a preliminary cost-benefit analysis

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Bottom Line

- Preliminary cost-benefit analysis

Total Annual Benefits	**$141M**
System Benefits (20-years)	**$1,433M**
Societal Benefits (20-years)	**$1,396M**
Total Capital Cost	**$490M**
Annual O&M Cost	**$24M**

Current State in San Diego

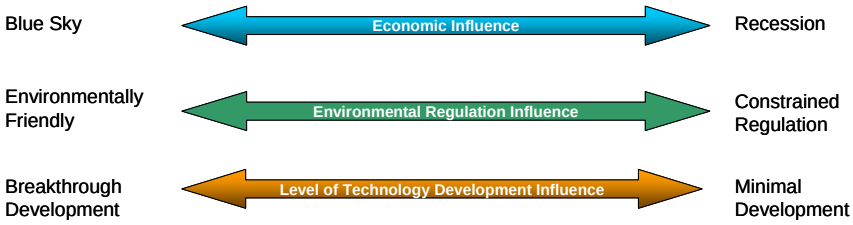
- Increasing number of customer-owned distributed generators in the region
  - E.g., 3,684 PV systems (23.3 MW) and growing
- Existing utility communication infrastructure are insufficient to support a Smart Grid
- California's "Loading Order" is changing resource planning
  - Emphasized efficiency, demand response, and renewables

Current State in San Diego

- SDG&E is implementing technologies and systems that are necessary for a Smart Grid, including:
  - Advanced Metering Infrastructure (AMI)
  - Substation automation program (multi-year)
  - Field SCADA switch rollout program
  - Set of exploratory demonstration projects
    - Broadband over power lines
    - Advanced transmission conductors
    - Sensors

Future State of San Diego

- Continued economic growth
  - Continued load growth
  - Need for reliability
- More environmentally restrictive regulation
  - More renewables, alternative fuels, EE, and DR
- Breakthrough technology in regional businesses
  - High tech region/lifestyle could drive power quality requirements



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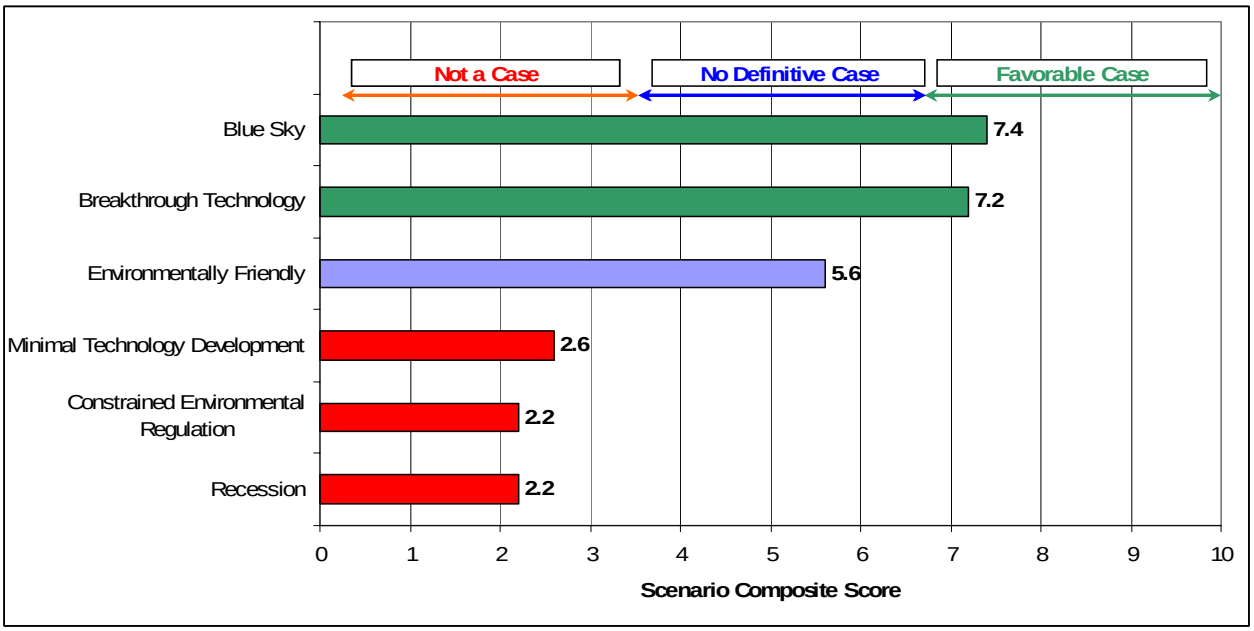
Future State of San Diego



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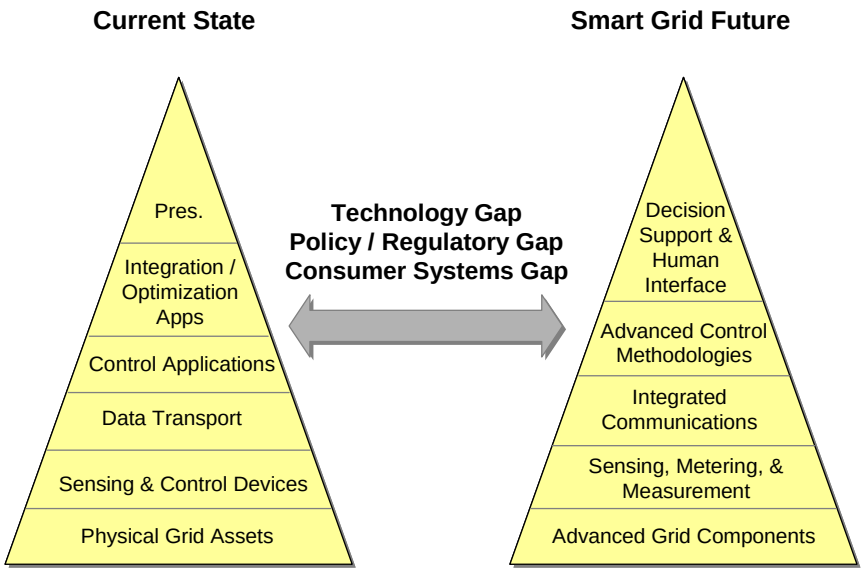
Gap Analysis: Comparing Today to the Future



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What is a Smart Grid?

The Smart Grid is the integration of technologies that can…

- Detect and address emerging problems before they impact service
- Make protective relaying the last line of defense, not the only defense
- Respond to local and system-wide inputs; know more about broader problems
- Incorporate extensive measurements, rapid communications, centralized advanced diagnostics, and feedback control that quickly return the system to a stable state after interruptions or disturbances.

What is a Smart Grid?

- Automatically adapt protective systems to accommodate changing conditions
- Re-route power flows, change load patterns, improve voltage profiles, and take other corrective steps within seconds of detecting a problem
- Enable loads and distributed resources to participate in operations
- Be inherently designed and operated with reliability and security as key
- Provide system operators with advanced visualization tools to enable essential human oversight

Improvement Initiatives

Improvement Initiative No.	Improvement Name
1	GATECH IPIC Dynflo distributed series impedance sensors
2	I-Grid Monitoring System (by Softswitching Technologies)
5	Consumer Portal
7	Ethernet over Fiber
9	4G WiMAX Fixed - Private Wireless
11	Zigbee / WiMedia / WiFi - Wireless
12	Semi-autonomous Agents
14	Advanced Visualization Methods (POM, ROSE, FFS, OPM, etc)
17	DER-based Microgrids
19	Advanced Energy Storage Systems
21	Advanced Grid Control Devices
23	Agent and Multi-Agent Systems
25	Distribution (Feeder) Automation

Cost Benefit Analysis

- Benefits Considered
  - Reduced congestion cost
  - Reduced blackout probability
  - Reduced forced outages/interruptions
  - Reduced restoration time and reduced operations and maintenance due to predictive analytics and self healing attribute of the grid
  - Reduced peak demand
  - Other benefits due to self diagnosing and self healing
  - Increased integration of distributed generation resources and higher capacity utilization

Cost Benefit Analysis

- Increased security and tolerance to attacks/ natural disasters
- Power quality, reliability, and system availability and capacity improvement due to improved power flow
- Job creation and increased gross regional product (GRP)
- Increased capital investment efficiency due to tighter design limits and optimized use of grid assets
- Tax savings for the utility from a depreciation increase
- Environmental benefits gained by increased asset utilization

Cost Benefit Analysis

- Three Scenarios Modeled
  - Earliest Positive Cash Flow
  - Maximum Benefits Early
  - Optimized IRR

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Cost Benefit Analysis Results

Scenario	Regional IRR* (%)	NPV ($M)	Point of Positive Cash Flow** (Yrs)	First Year Annual Benefits Top $50M
Earliest Positive Cash Flow	75%	403	3.5	2017
Maximum Benefits Early	26%	508	7.0	2012
Optimized IRR	44%	416	5.5	2014

* Internal Rate of Return normally refers to a single business entity, but here we have treated the San Diego region as a single entity to enable the calculation of a regional benefit, both systems and societal.

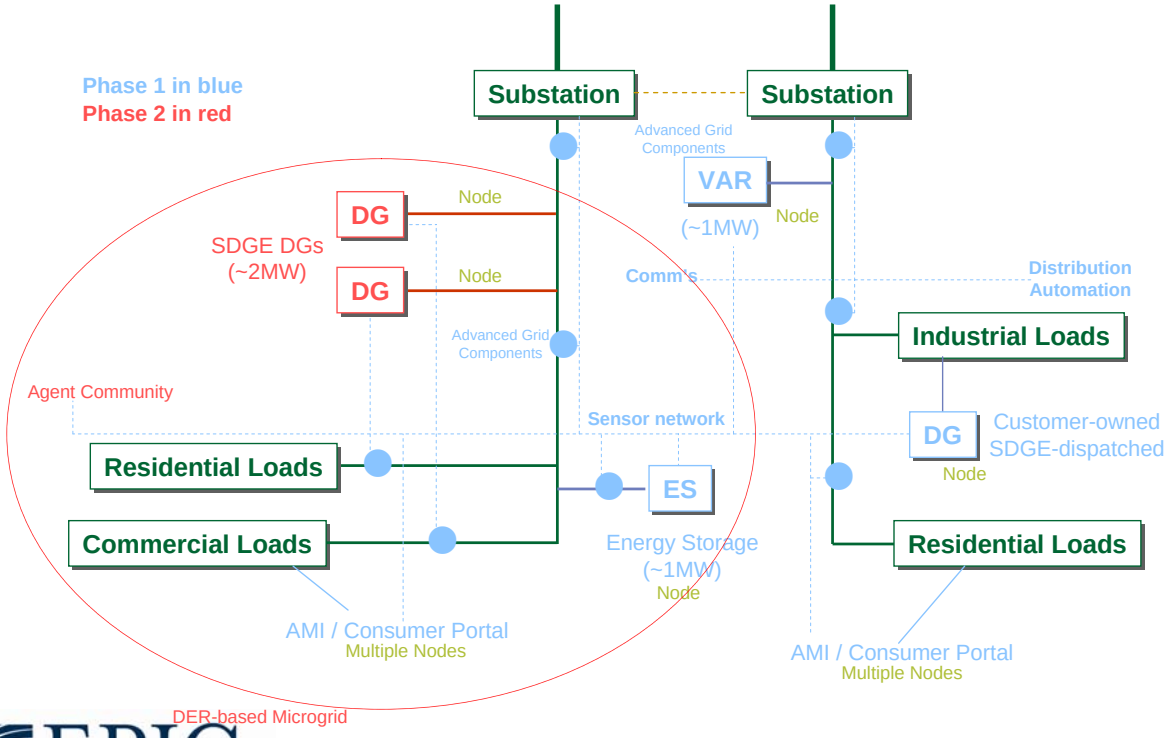
** Point of Positive Cash Flow is the collective cash flow analysis from all thirteen (13) improvement initiatives combined as a single overall program. Several improvement initiatives require continued investment for as much as 10 years, well beyond the point of positive cash flow, to achieve full implementation of the Smart Grid. The point of positive cash flow should not be used as a proxy for the simple payback of the scenario.

Implementation Plan Overview

Phase 1 (2007 – 2016)		
Improvement Initiatives	7 – Ethernet over Fiber 9 – 4G WiMAX Fixed - Private Wireless* 25 – Distribution (Feeder) Automation 1 – GATECH IPIC Dynflo distributed series impedance 2 – I-Grid Monitoring System 11 – Zigbee / WiMedia / WiFi - Wireless 21 – Advanced Grid Control Devices 14 – Advanced Visualization Methods 5 – Consumer Portal 19 – Advanced Energy Storage Systems	This grouping of improvement initiatives serves two purposes: (1) establishing the foundation for the complete Smart Grid, and (2) focuses on those initiatives most likely to improve reliability under a changing environment.
Phase 2 (2009 – 2013)		
Improvement Initiatives	9 – 4G WiMAX Fixed - Private Wireless* 12 – Semi-autonomous Agents 23 – Agent and Multi-Agent Systems 17 – DER-based Microgrids	This grouping of improvement initiatives serves two purposes: (1) expand the integration of consumer systems into the Smart Grid, and (2) provide additional options for improved reliability and economic electricity services.

* This Improvement Initiative is implemented as needed across both phases of the deployment.

Smart Grid Implementation



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Timeline for Implementation

Priority	II No.	Improvement Name	Timing*
1	7	Ethernet over Fiber	2007 – 2009
2	9	4G WiMAX Fixed - Private Wireless	2007 – 2009
3	25	Distribution (Feeder) Automation	2007 – 2011
4	14	Advanced Visualization Methods (POM, ROSE, FFS, OPM, etc)	2007 – 2009
5	1	GATECH IPIC Dynflo distributed series impedance sensors	2009 – 2013
6	2	I-Grid Monitoring System (by Softswitching Technologies)	2012 – 2016
7	11	Zigbee / WiMedia / WiFi - Wireless	2007 – 2010
8	21	Advanced Grid Control Devices	2007 – 2011
9	5	Consumer Portal	2008 – 2012
10	19	Advanced Energy Storage Systems	2008 – 2014*
11	17	DER-based Microgrids	2009 – 2013*
12	12	Semi-autonomous Agents	2009 – 2011*
13	23	Agent and Multi-Agent Systems	2009 – 2013*

* Moved the improvement initiative out one or two years to accommodate probable resource limitations based on the number of project starts and the maturity of the technology.

Recommended RD&D Projects

RD&D Project	Timing	Leading Initiative
WiMAX Pilot	2007 – 2008	Midhaul Communications (II-9)
Adv. Energy Storage Pilot	2007 – 2008	AES Integration (II-19)
DER-based Microgrid	2008 – 2009	DER-based Microgrids (II-17)
Agents Pilot	2008 – 2009	Semi-Autonomous Agents (II-12) Agent & Multi-agent Systems (II23)

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Policy and Regulatory Changes

- A consistent, long-term policy to provide clear market signals (real-time pricing, critical peak pricing, etc.) through local distribution-level programs.
- Incentives for use of advanced technologies to increase capacity, improve efficiency or reliability of resources.
- CEC supported evaluation of economic benefits of commercially available voltage stabilizing technologies (SVC, D-VAR, DSTATCOM, STATCOM, SuperVAR, etc).
- Policies that encourage open data architecture / access, interoperability, reliability standards, and capability to operate micro-grids in intelligent islanding modes.

Policy and Regulatory Changes

- New rate designs (e.g., real time pricing, premium power quality)
- Incentives to encourage consumers and SDG&E to invest in promising advanced technologies.
  - Ratemaking incentives
- Determine whether current policies inhibit the development of new rate designs.
- Policies that consider the societal benefits of infrastructure investments when determining cost effectiveness.

Thank You

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