Applying the Smart Grid to Climate Change Mitigation:

Emissions Impact Estimation Tool for Smart Grid Projects

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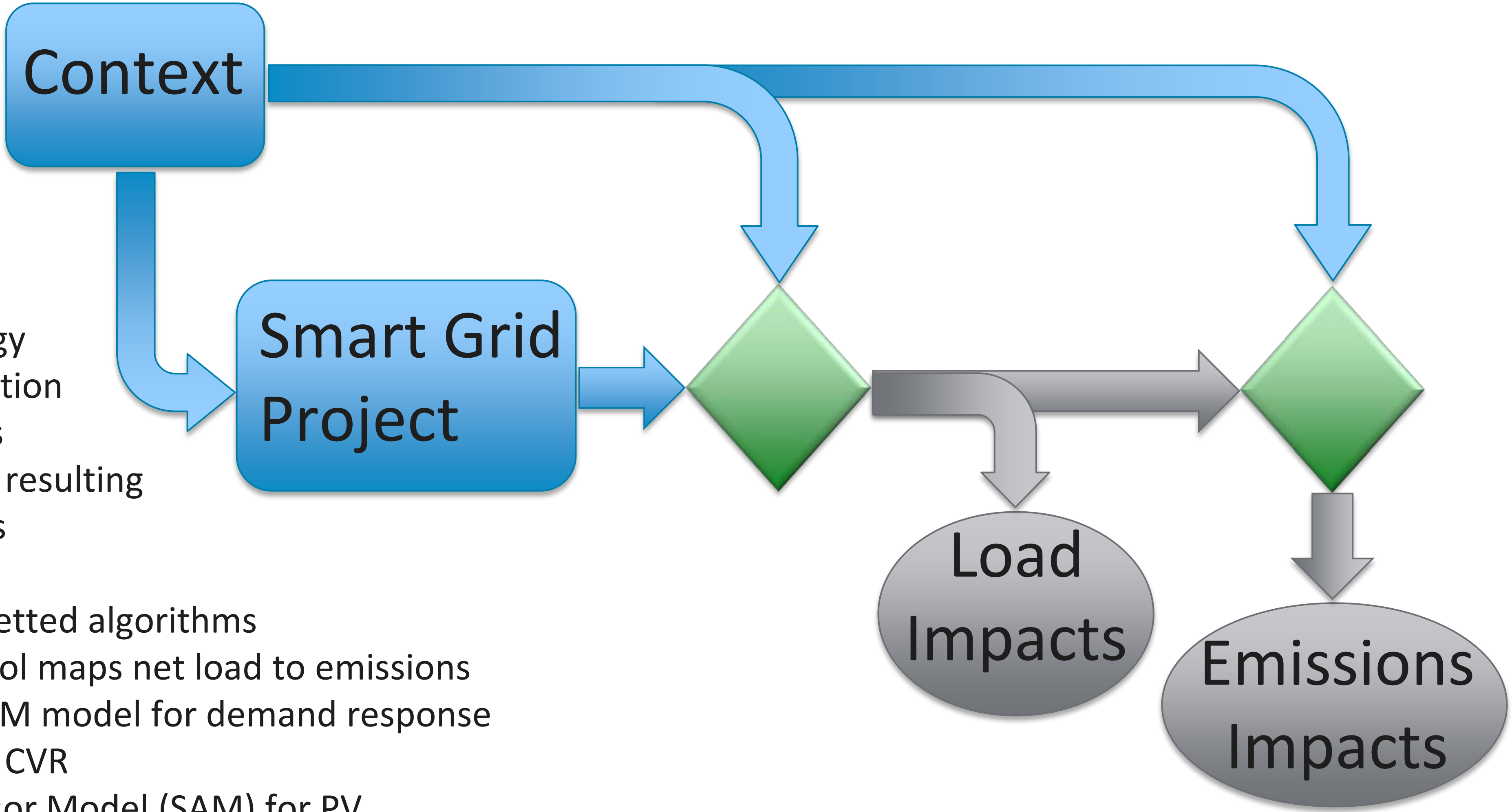
Emissions Quantification Tool

- Vision and Design
- Calculator working right now: eqt.pnnl.gov
- Demo
  - CVR
  - PV Hosting
  - Demand Response
- What's Next?

Smart Grid Emissions Impacts

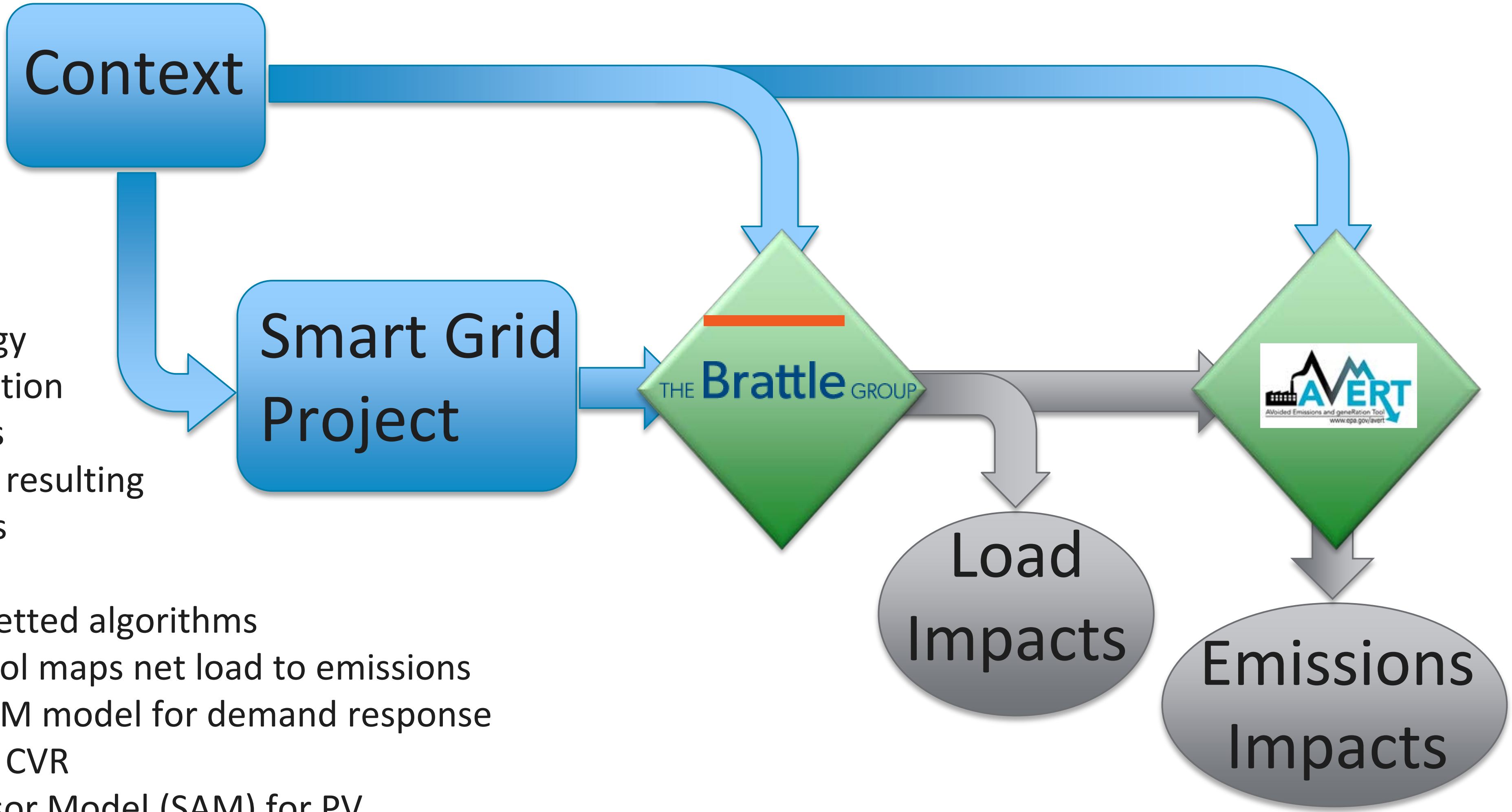
- Why is an emissions impact estimator important?
  - Add a value stream to smart grid business case
  - Allow stakeholders to quantify impacts and articulate benefits of project
  - Provide screening tool for comparing possible projects
  - Significant carbon reductions available from adoption of smart grid technologies (according to previous studies by PNNL and EPRI)
- Initial version completed January-September 2015, eqt.pnnl.gov

Methodology Overview



- Parameterizes
  - regional context
  - smart grid technology
  - scale of implementation
  - historical operations
- Computes and compares resulting
  - Load profile changes
  - Emissions impacts
- Modular, accesses well vetted algorithms
  - EPA's own AVERT tool maps net load to emissions
  - Brattle Group's PRISM model for demand response
  - Gridlab-D report for CVR
  - NREL's System Advisor Model (SAM) for PV

Methodology Overview (cont.)



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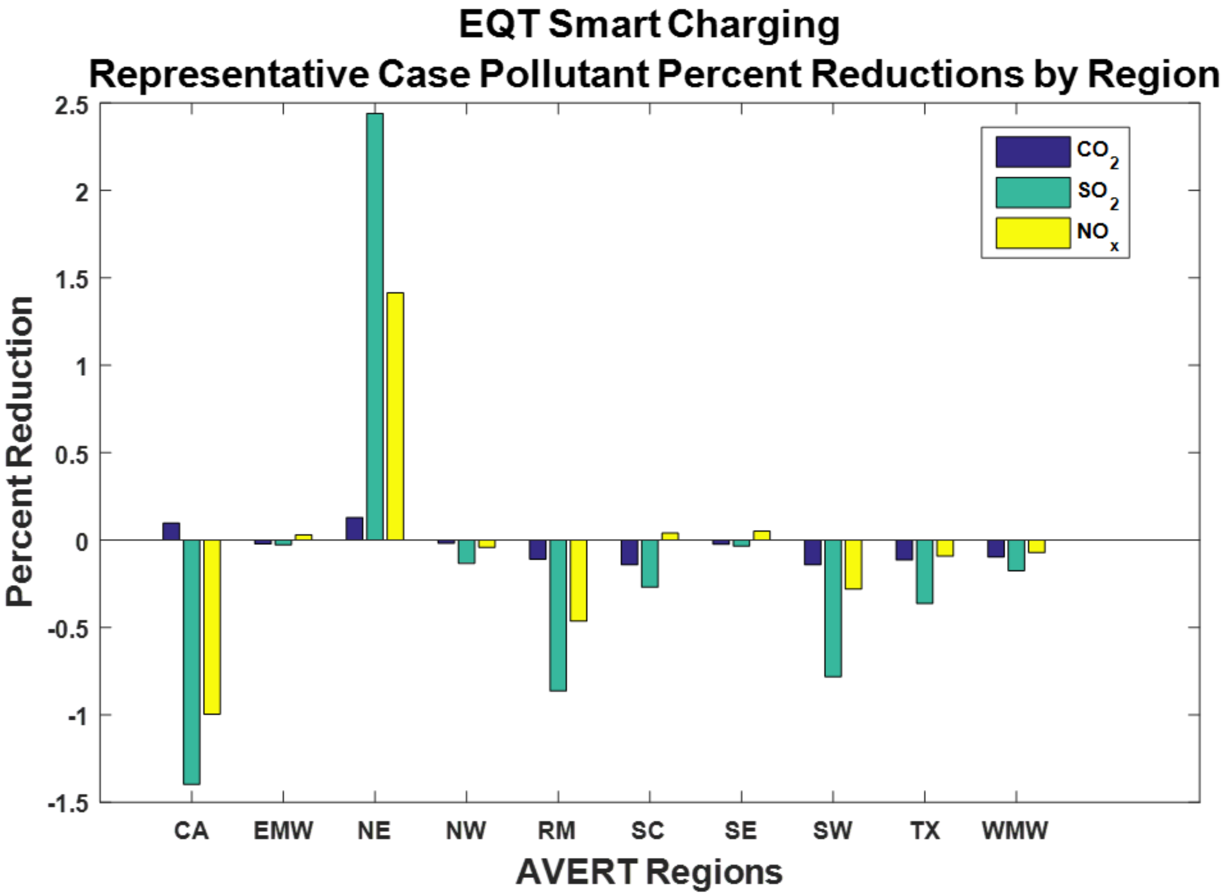
Example Analysis Enabled

- Specific conditions affect emissions impacts dramatically
- Time shifted demand can be served by
  - Different generators
  - Using **different fuel types**
  - At a different efficiency
- Smart charging (in figure) shifted load from evening to middle of the night
  - Northeast: Clear emissions reduction
  - Texas + Rockies: emissions increase
  - California: Carbon reduction but SO_2 and NO_x increase



Inputs: Flat rate charging baseline profile, converted to 2,000,000 EVs at a maximum power of 3.3kW
(Large number of EVs to showcase regional differences with comparable numbers)

eqt.pnnl.gov

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- Live in the browser…

(Log In)

Emissions Quantification Tool

PROJECTS ABOUT RESOURCES

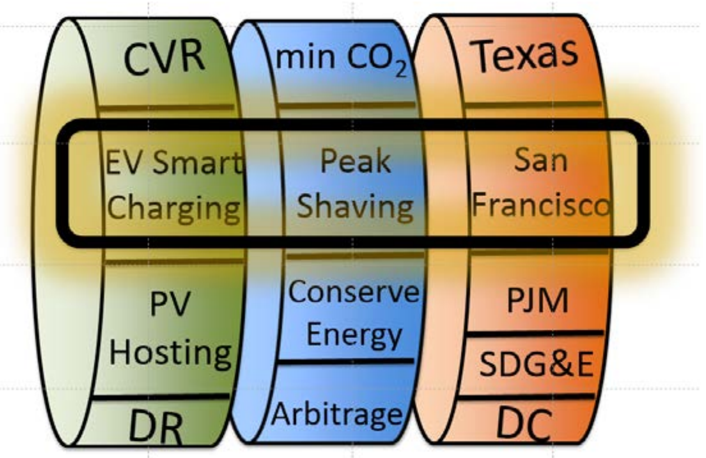
This calculator estimates the impacts of specific smart grid infrastructure projects on load profile and criteria pollutant emissions (i.e. SO_2, NO_x, and CO_2). Choose a common smart grid project type below to be guided through estimating the project's impact on energy usage and the resulting emissions. If you already understand the changes in your system's electric load and want to jump right to calculating emissions impacts, or wish to estimate a different use case, choose the custom project.

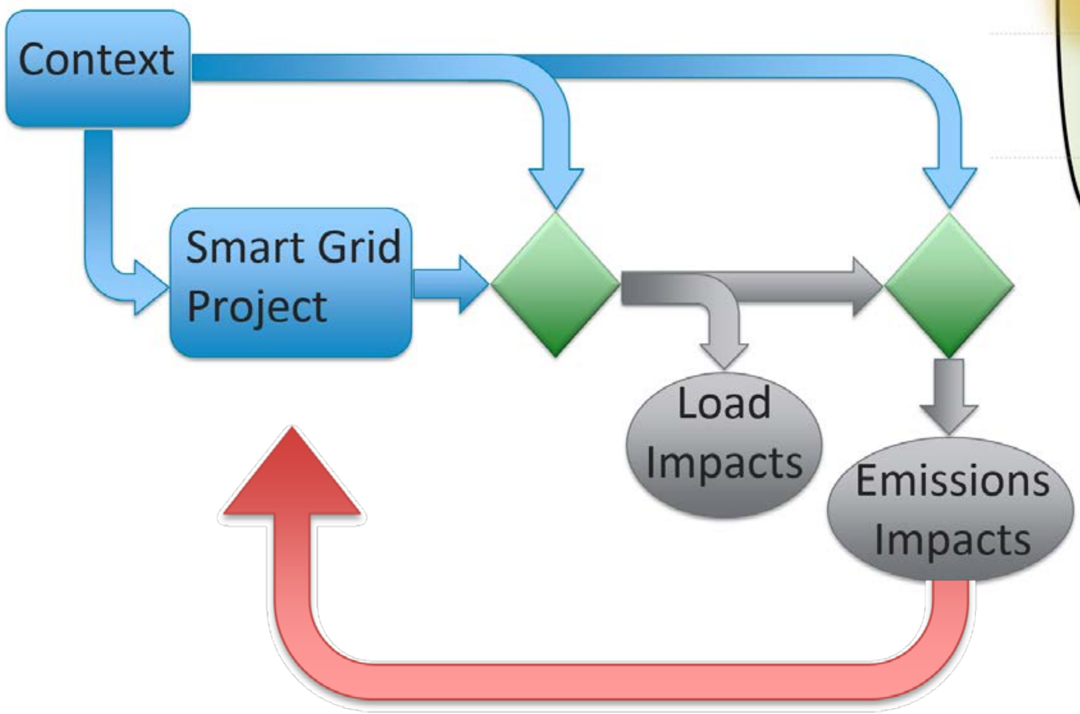
Choose a Project

Energy Storage for Annual Peak Shaving	Energy storage discharged to shave any peak over a threshold power, recharged during local minima
Photovoltaic (PV) Solar Generation	Smart grid enabled Solar PV generation installations
Advanced Metering Infrastructure (AMI)	Automated metering infrastructure to reduce truck rolls
Conservation Voltage Reduction (CVR)	Conservation voltage reduction operating year-round to maximize energy conservation
Smart-Charging	Coordinated overnight electric vehicle (EV) charging, compared to uncoordinated charging
Demand Response	Air-conditioner demand response based on daily and critical peak pricing
Custom	Calculate emissions consequences of user-provided pre- and post- smart grid project load profiles

What's next?

- Emissions Minimizing Use Case
- More guided modules
- Open ended technology/use case combinations
- Interactions
- Verify / Validate
- Emissions Mapping Engine
- Indirect Benefits
- Beyond Smart Grid
- Increase Adoption
- Publish Analysis

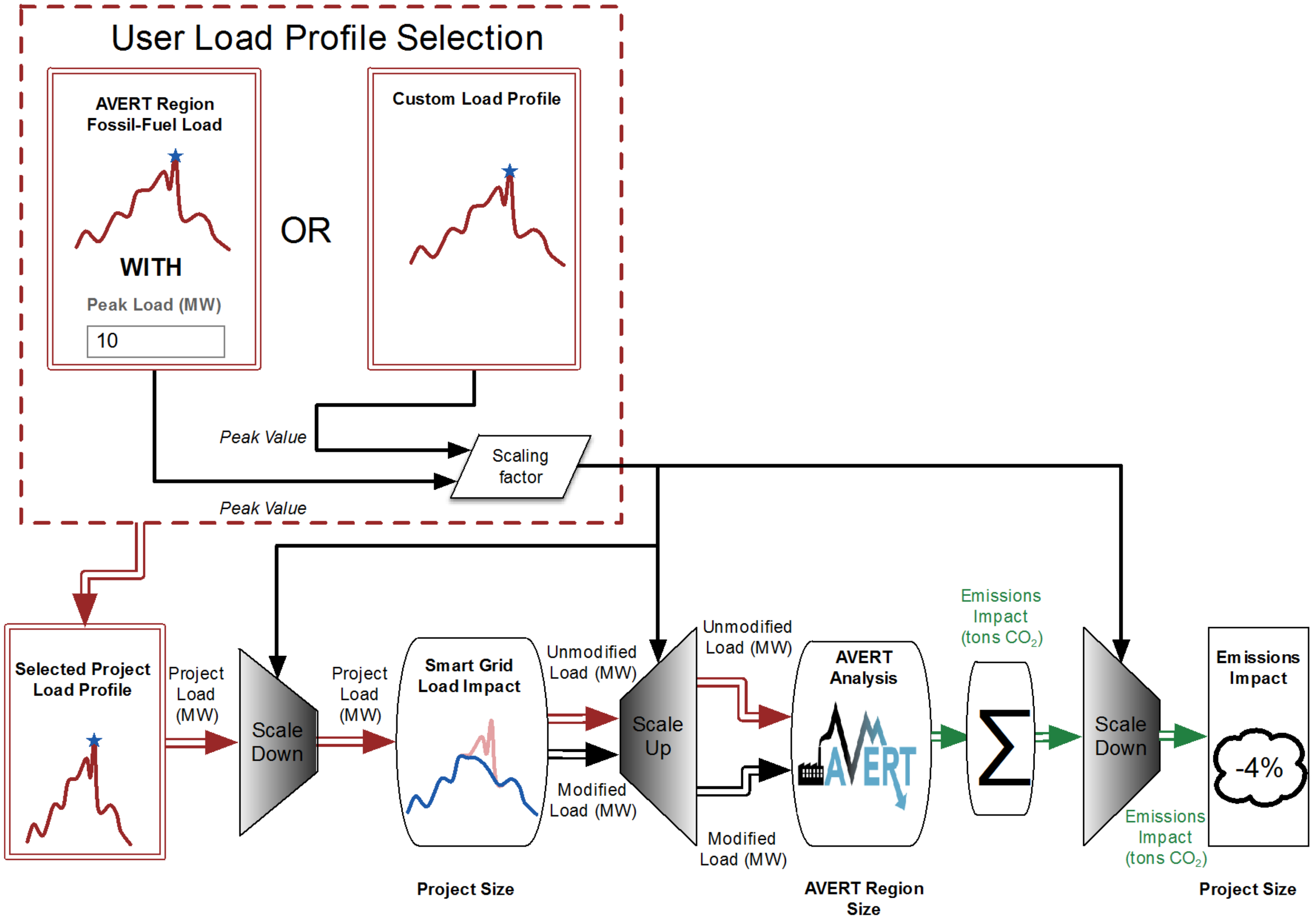




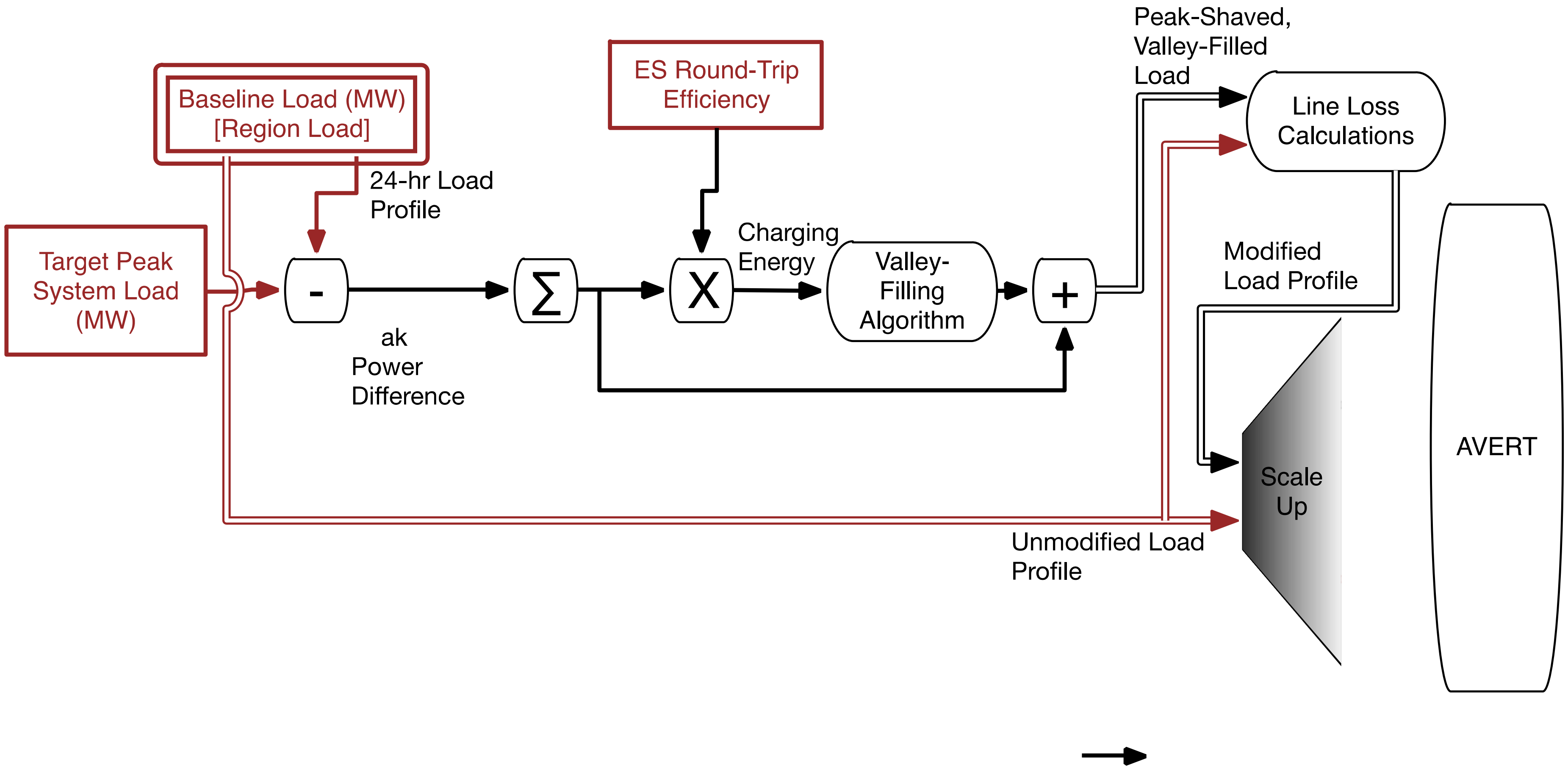
Questions for Project Manager?

Extra Slides

Calculation Overview



Energy Storage for Peak Shaving



DOE convened Steering Committee

Representative	Organization
Paul Thomas	American Electric Power
Matthew Russell	Austin Energy
Curt Kirkeby	Avista
Forest Small	Bridge Energy Group
Russ Conklin	DOE International Affairs
Laney Brown	Iberdrola
Laura Beane	Iberdrola Renewables
Brad Ramsay	NARUC
Don Chahbazpour	National Grid
Shrina Reavey	PEPCO
Hashim Navrozali	San Diego Gas and Electric
Jenny Roehm	Schneider Electric

Input from DOE Formed Steering Committee

- **Transparency paramount**
- Users will include:
  - utilities with carbon reporting requirements,
  - utilities looking to differentiate themselves,
  - utilities looking to include this in planning
  - corporations with sustainability goals,
  - state policy makers,
  - regulatory agencies,
  - technology vendors,
  - interested citizens
- Map all impact types all the way to emissions mass and dollar value
- Do map both direct and indirect impacts, but track separately:
  - fossil fuel dispatch changes, truck rolls, renewable hosting capacity
- Allow customization of inputs for credibility with local regulators, value for internal planning
- Standardize methods, provide meaningful defaults for wider adoption

Design Choices

- Transparency
  - Show all inputs, methods, outputs
  - Reproducible
  - Caution about modeling assumptions
- Modularity
- Calculator, not analytic engine
- Info, not attribution
- Versatility
  - Sophisticated users
  - Fully custom project type
- Year long hourly time series

- Technology + Use Case + Context
- Guided Modules
  - Custom
  - CVR for Energy Conservation
  - Photovoltaic solar
  - Energy Storage for Peak Shaving
  - Coordinated EV Charging
  - Demand Response with Air Conditioning Units
  - AMI (Advanced Metering for reduced truck rolls)

Energy and CO_2 Benefits Potential of a Smart Grid

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Question: Does a smart grid have a substantial role to play in the U.S. carbon management agenda?

Goal: Estimate potential benefits from 9 mechanisms

- *Directly,* from smart grid applications
- *Indirectly,* from reinvestment of cost savings for renewables integration or efficiency programs

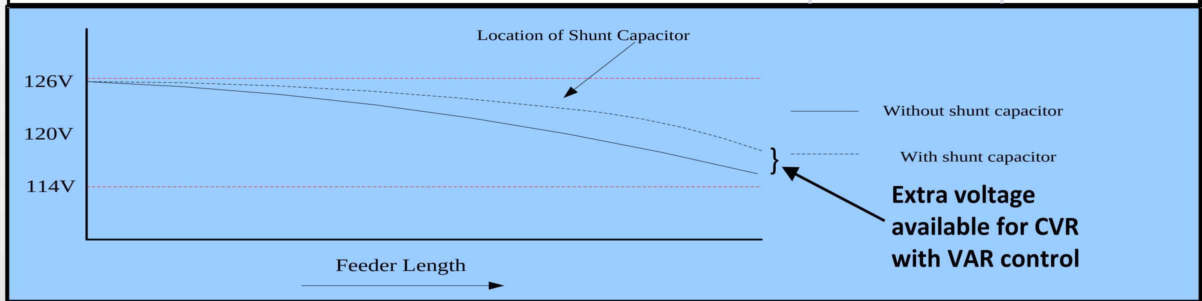
Funding: $150K, Office of Electricity Delivery and Energy Reliability, Smart Grid R&D Program

Review: Environmental Protection Agency

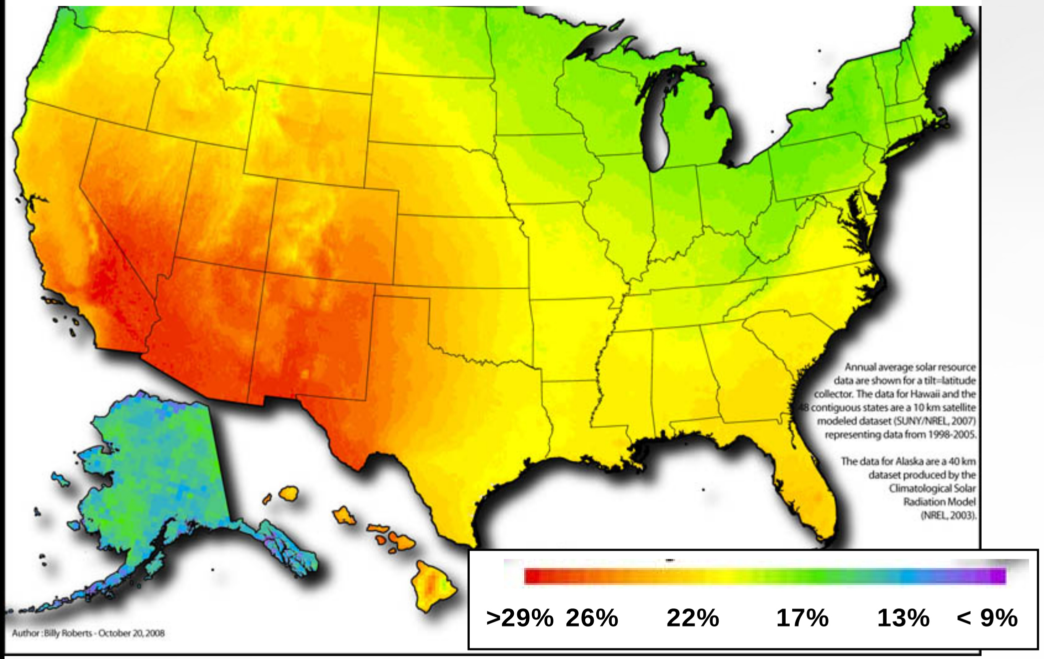
Team: Pratt (PI), Secrest, Schneider, Balducci, Kinter-Meyer, Katipamula, Sandquist, Gerkensmeyer

Key Findings (100% Smart Grid Penetration)

Mechanism	Electric Sector Energy CO_2 Reductions	
	Direct	Indirect
Conservation Effect of Consumer Information and Feedback Systems	3%	-
Joint Marketing of Efficiency and Demand Response Programs	-	0%
Diagnostics in Residential and Small/Medium Commercial Buildings	3%	-
Measurement and Verification for Efficiency Programs	1%	0.5%
Shifting Load to More Efficient Generation	< 0.1%	-
Support Additional Electric Vehicles (EVs) / Plug-In Hybrid Electric Vehicles (PHEVs)	3%	-
Conservation Voltage Reduction and Advanced Voltage Control	2%	-
Support Penetration of Solar Generation (RPS > 25%)	(1)	(2)
Support Penetration of Wind Generation (25% RPS)	< 0.1%	5%
Total, Share of U.S. Electric Sector Energy and CO_2 Emissions	**12%**	**6%**



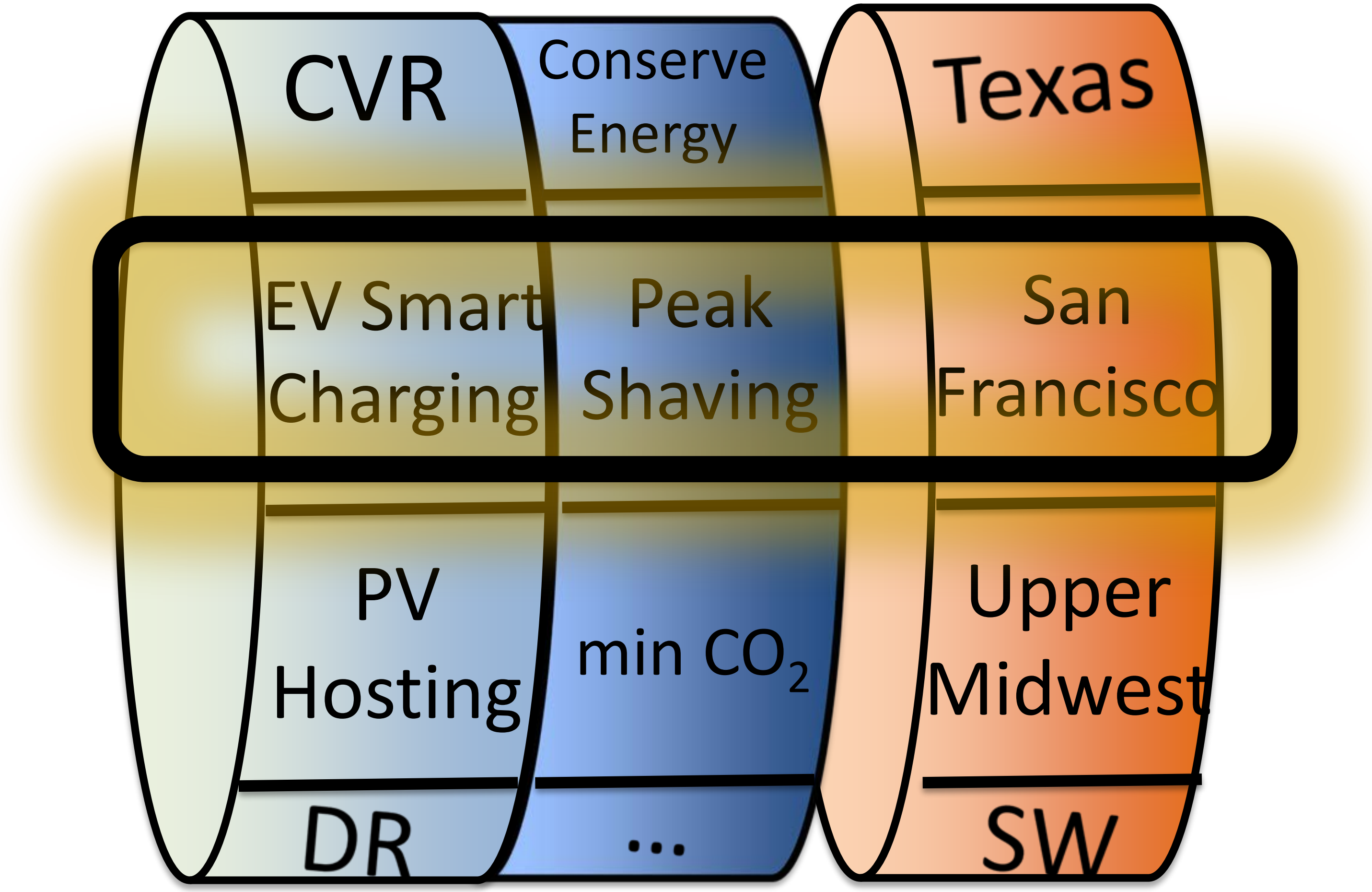
Annual Residential Solar Load Fraction at which Reverse Power Flow Begins



- Strategic link between SG and Carbon agenda
- Critical for SG to engage green advocates
- Obtained "buy-in" from EPA staff
- Adopted by IEA as the EU SG/Carbon benefits framework

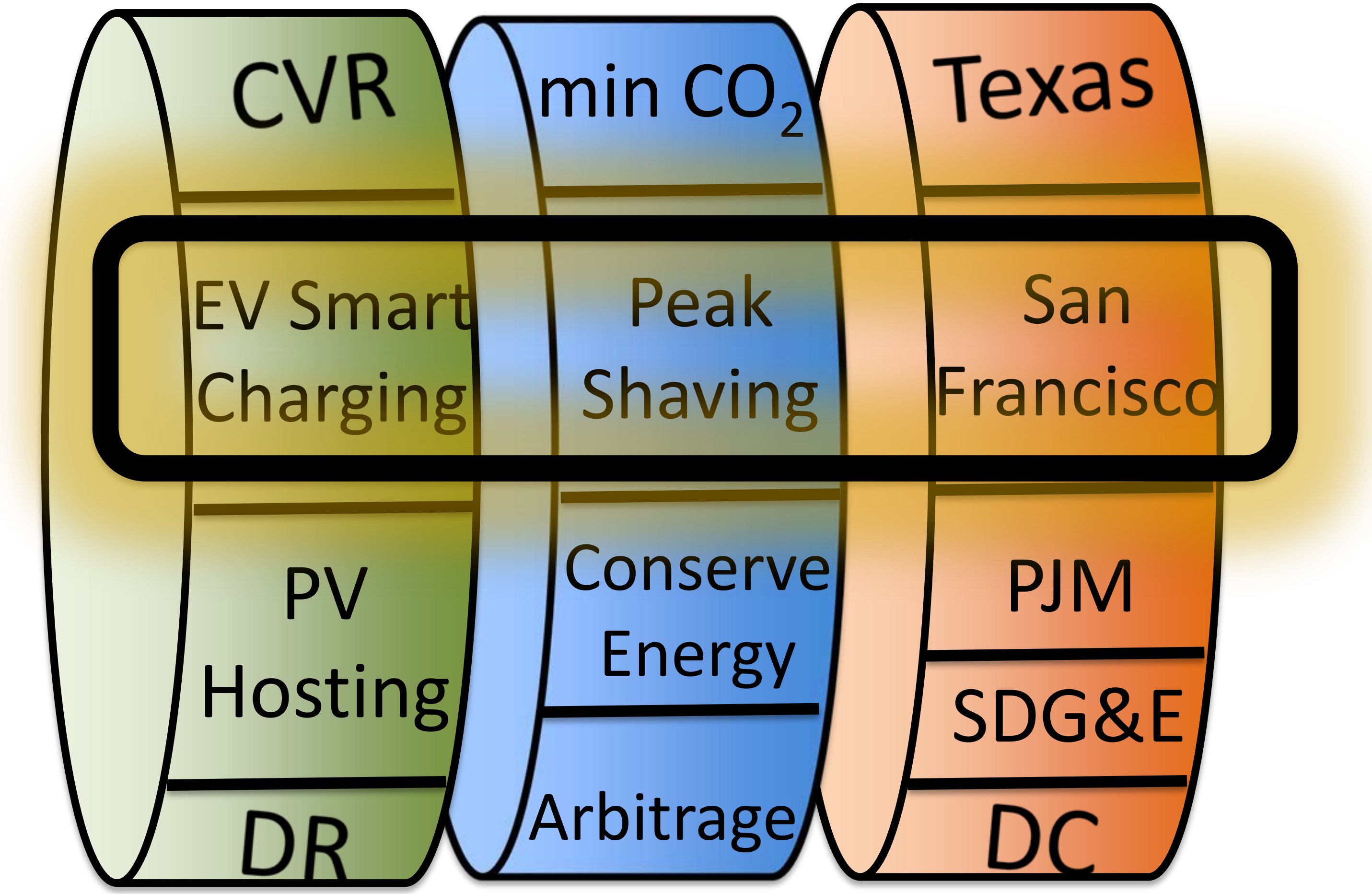
Technology + Use Case + Context

Currently, guided examples limit independence to two dials.



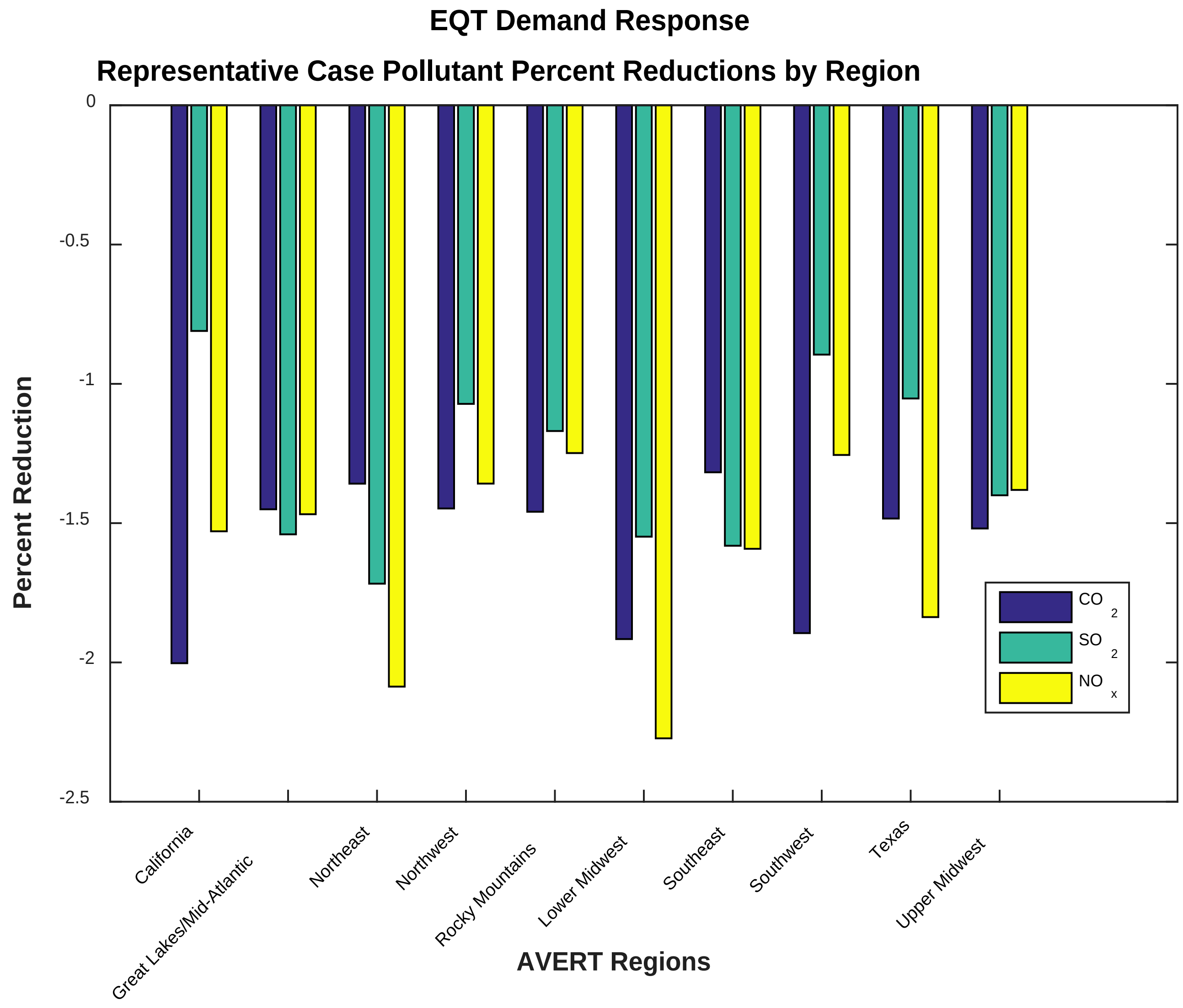
Project results depend on all three.

Technology + Use Case + Context



Project results depend on all three independently.

Regional Comparison: DR



- This particular DR project increased carbon footprint in all AVERT regions.
- Time shifting resulted in using fossil fuel sources with higher emissions.

Number of CPP Days: 10
Peak Period: 1400-800
Cooling Months: 5-9
% Central AC: 75%
Flat Rate: $0.14/kWhr
CPP Rate: $0.56/kWhr
Peak Rate: $0.28/kWhr
Fade Factor: 0.8