Emissions Reductions from Renewable Energy and Energy Efficiency in California Air Districts

EPA State Climate and Energy Program

June 14, 2011

Jeremy Fisher, PhD – Synapse Energy Economics

Supported by the CEC Public Interest Energy Research Program

Synapse Energy Economics

- Synapse Energy Economics
  - Research and consulting firm in Cambridge, MA
  - 25 technical experts in energy and environmental issues
    - Electric generation & transmission planning
    - Market structures & ratemaking
    - Efficiency & renewable energy, and
    - Environmental quality
  - Technical support for policies leading to a sustainable, efficient and equitable energy economy.

Public Interest Energy Research Program

Supports public interest energy research & development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace

- Program Research Areas
  - Energy Efficiency & Demand Response
  - Renewable Energy & Advanced Electricity Generation
  - Transmission & Distribution
  - Climate & Environment
  - Transportation

Background

- SIP requirements in California require further reductions;
- Most sources controlled at end-of-pipe
- Seeking emissions reductions from efficiency (EE) and renewable energy (RE)
  - Where do benefits accrue?
  - Who benefits?

Research Goals

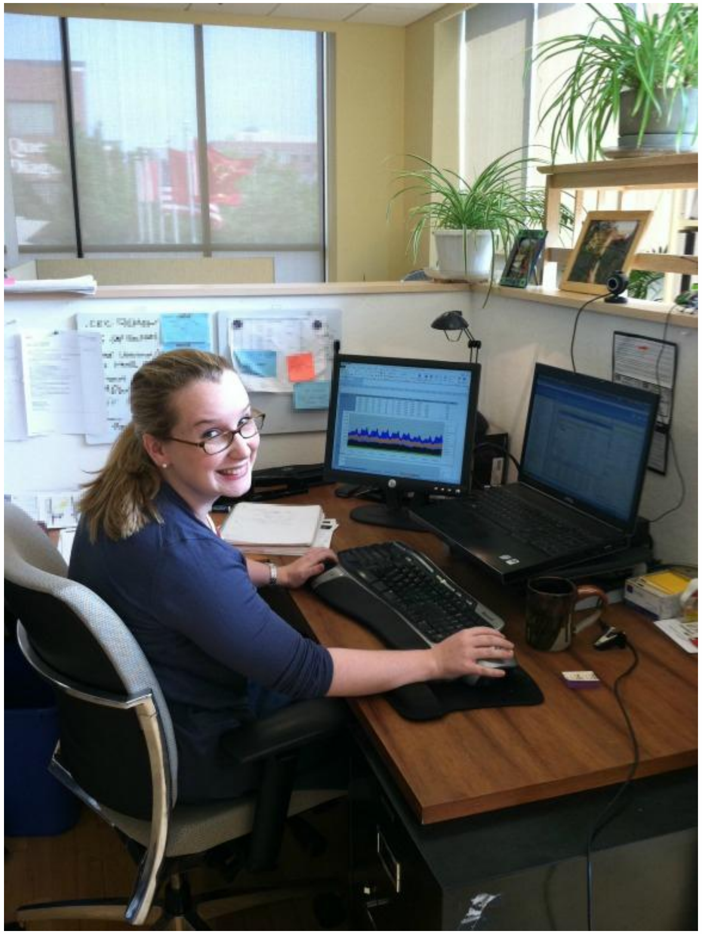
- Pilot project for California
- Industry-standard dispatch (simulation) model
- Provide flexible tool for air districts
- Final paper currently under review by CEC

Conclusions

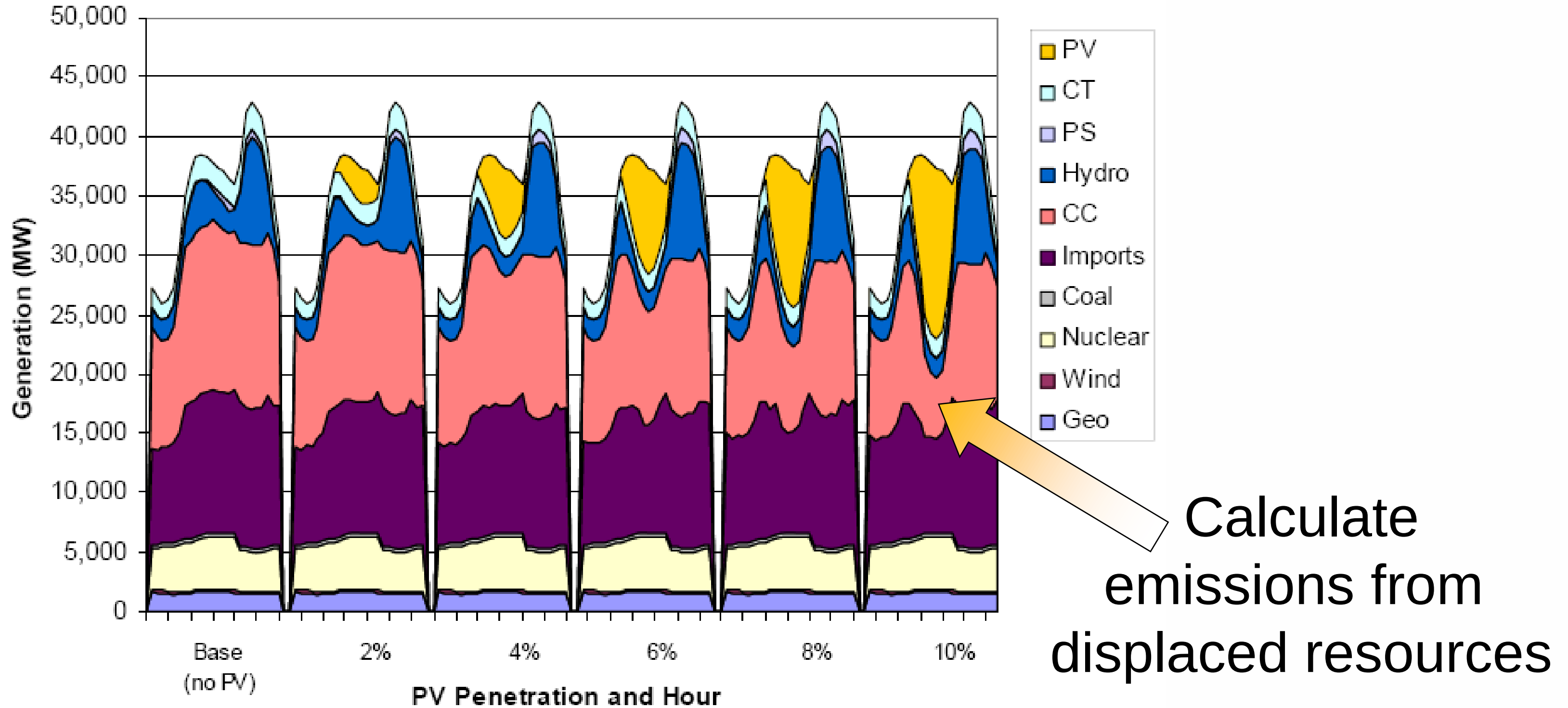
- Simulation Model
  - Provides platform for energy / air quality discussion
  - Numerous and subtle complications
  - Grid is large, complex, and interconnected… but we can simulate it
- Output & Results
  - Benefits spread over large geographic regions
  - Displacement can occur far from source
  - Shape and structure of the grid counts
  - Signal-to-noise questions

Dispatch Models

- Standard industry practice
- Simulation model is forward-looking
  - Relies on accurate input data
  - Thousands of generators with dozens of characteristics
  - Costs for fuels and operations, energy contracts
  - Hourly demand from dozens or hundreds of utilities
  - Transmission availability
- Simulation model uses rules, constraints, and economic principles to “optimize” dispatch
- Provides detailed assessment of system operations
- Requires significant expertise

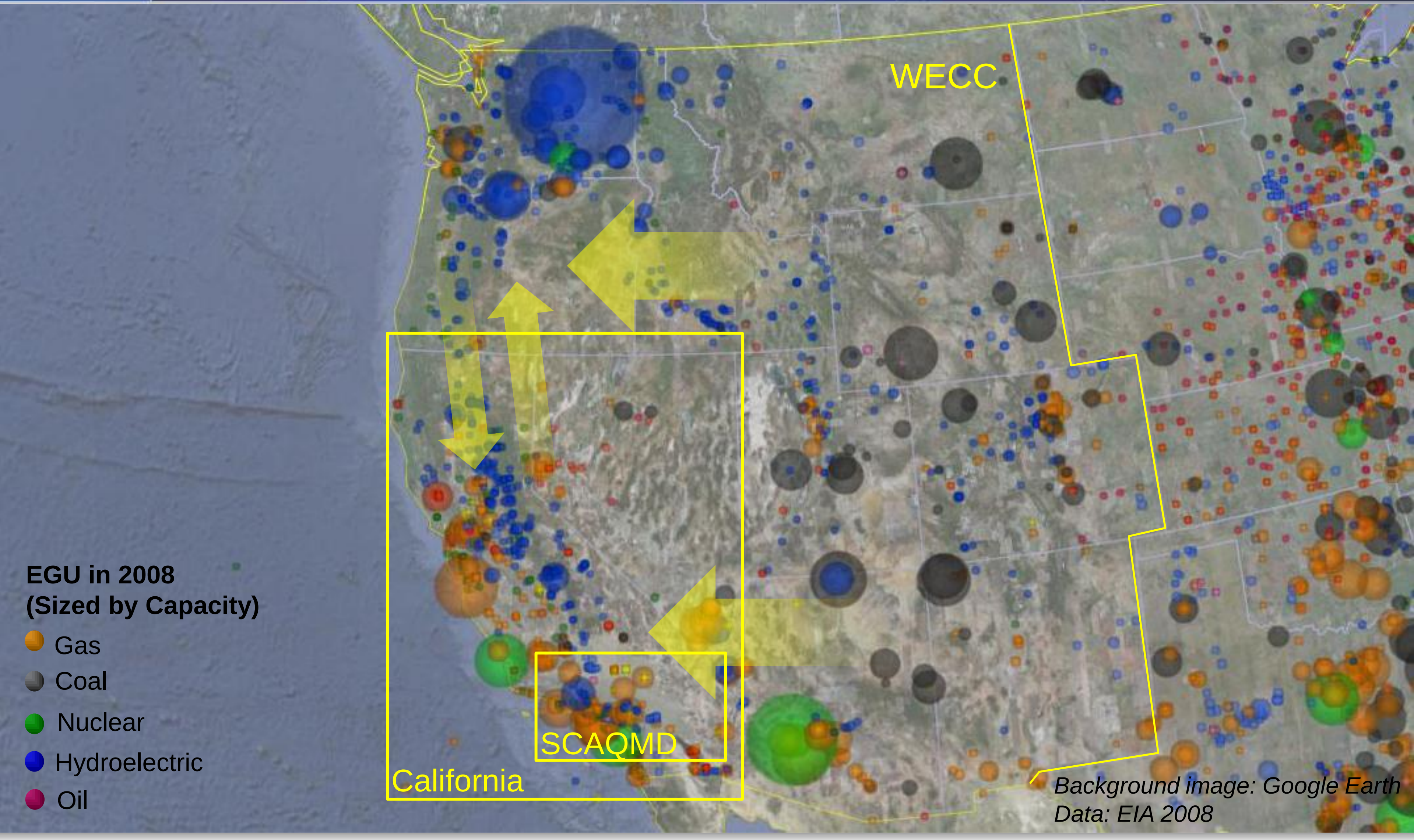


- Displaced generation and emissions
  - Changes at the "margin" relative to a baseline
  - Require a baseline run, and specific EE/RE scenario runs
  - Examine which resources back down with increasing EE/RE



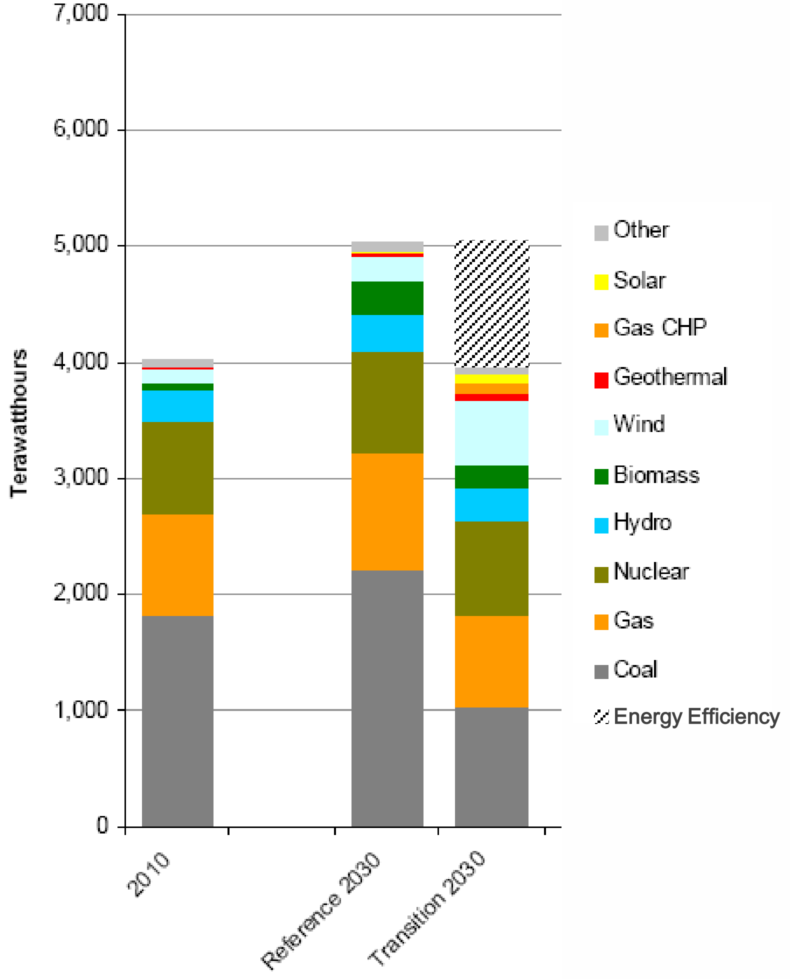
Denholm et al. 2008. Production Cost Modeling for High Levels of Photovoltaics Penetration. NREL

Analysis Window: Western Interconnect

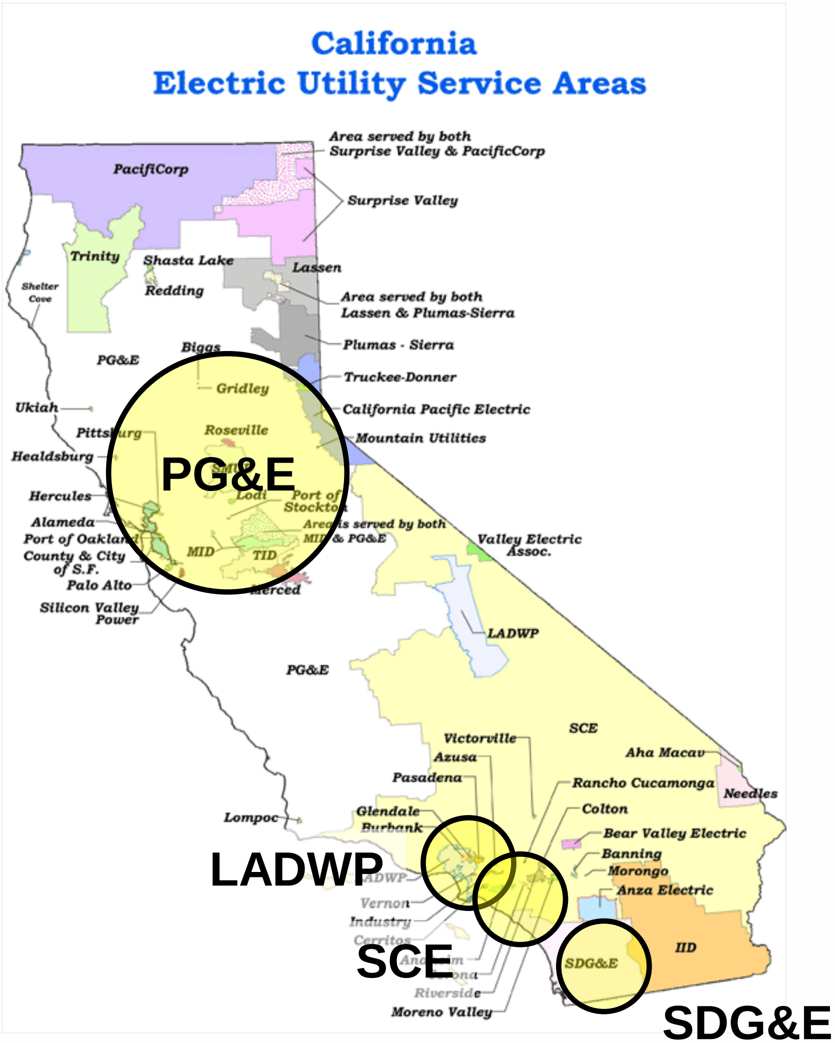


Building a Base Case

- Shape of the future grid
  - Which generating resources will be built or retired?
  - Expected load conditions, fuel costs, emissions prices
  - New transmission
  - Emissions from existing sources; future emissions controls?
- California project
  - CEC assumptions for 33% by 2020 renewable energy future
  - 2016 analysis year: 26% RE



16 Scenarios: Four Regions, Four EE/RE



1000 MW
Wind

1000 MW
Solar PV

333 MW
Baseload EE

10% Peak
Shaving EE

 |

Plug in inputs

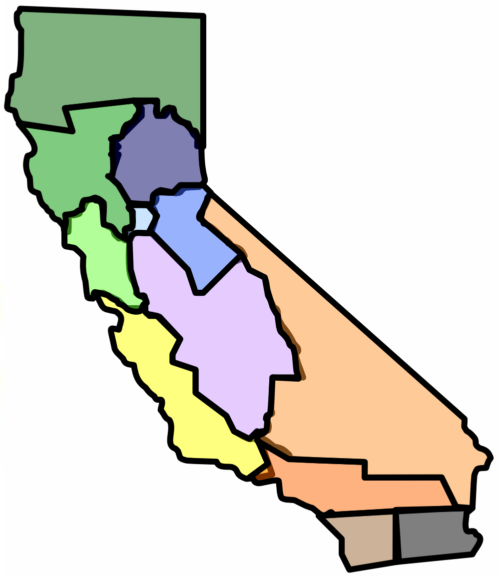
Hit “Go”

…six hours later...

Processing Model Output

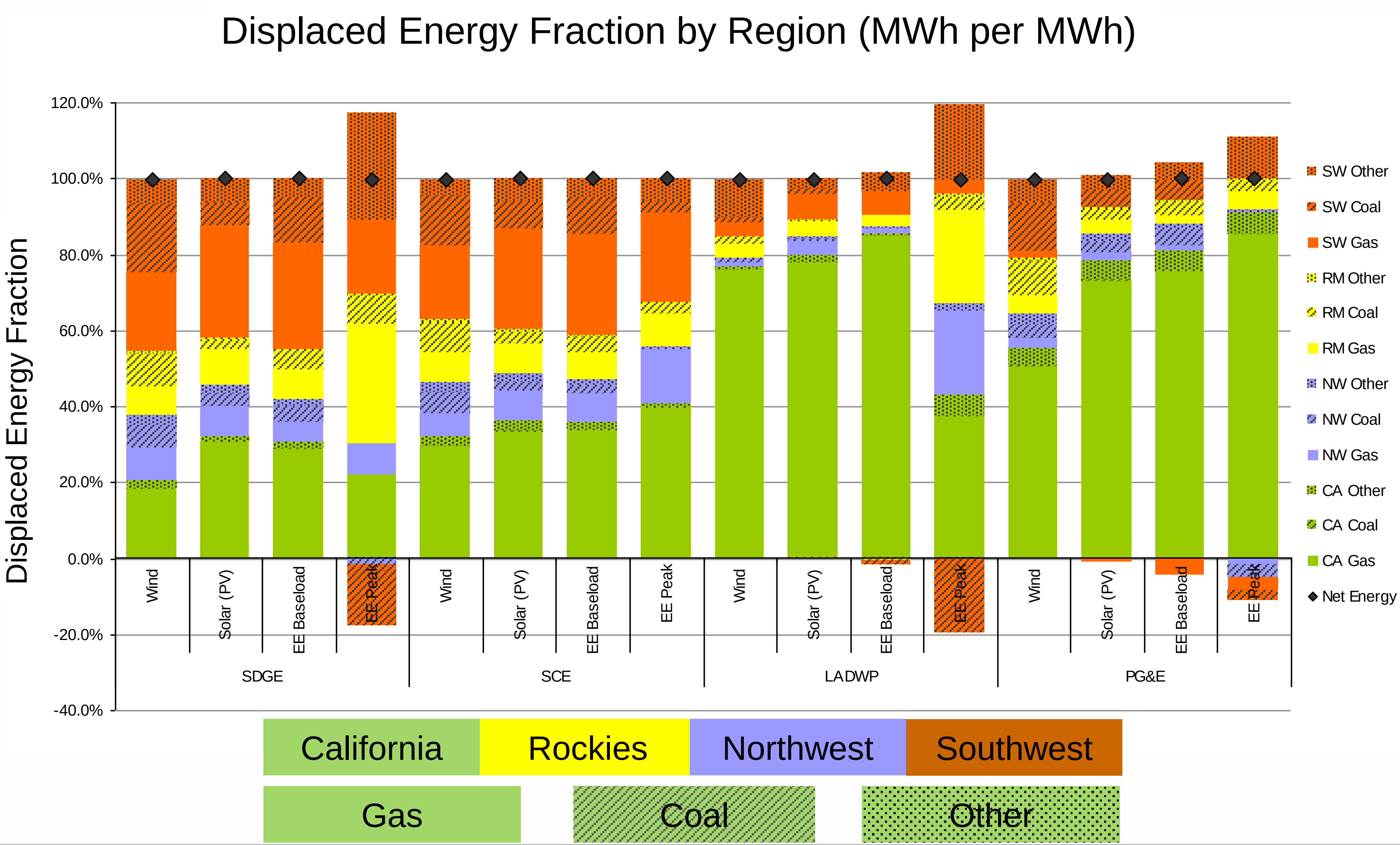
- Generation and emissions (NO_X, SO_2, and CO_2) for each power plant in the Western Interconnect
- Map plants to WECC regions and air districts
- Aggregate data by western region and air district
- Examine errors and uncertainty
- Build calculator from output results

WECC Regions

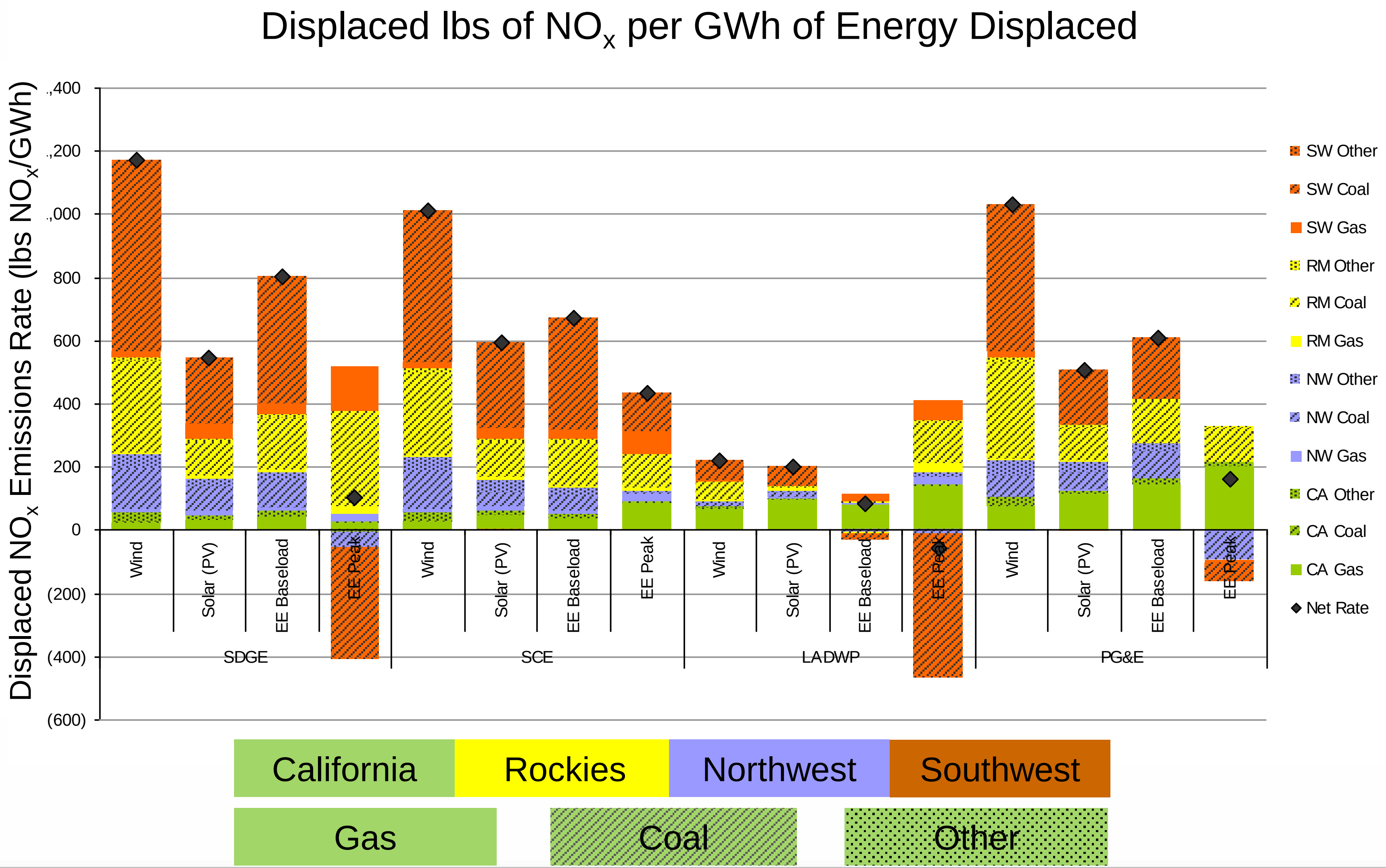


CA Air District Regions

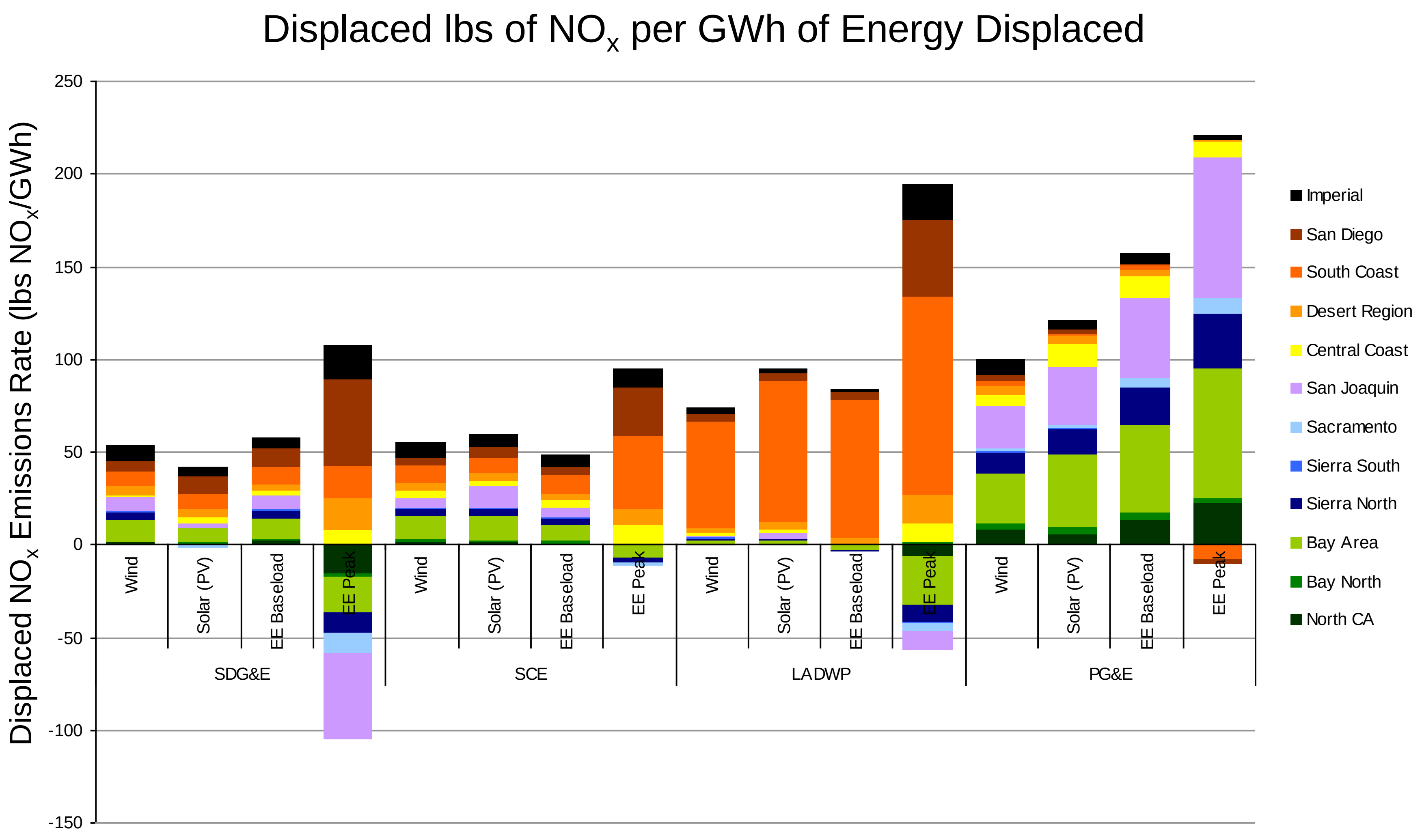
Results: Displaced Generation Fraction by Region & Fuel Type



Results: Displaced NO_X Emissions Rate by Region and Fuel Type



Results: Displaced NO_X Emissions Rate by Air District



Calculator

Step 1:
Choose RE/EE Type

EE/RE Measure
Wind (Onshore)

Step 2:
Choose utility region to implement

Utility Region
s Angeles Department of Water and Pov

Step 3:
Choose project capacity, in MW

Project Size (MW)
500.0

Do not alter capacity factor

Capacity Factor (%)
39.9%

Do not alter annual energy

Annual Energy (GWh)
1,751.3

Displaced Energy and Emissions by WECC Region

	Energy Displaced (GWh)	NO_X Displaced (tons)	SO_2 Displaced (tons)	CO_2 Displaced (tons)
California	1,348.2 *103.5*	63.9 *8.7*	9.8 *9.0*	552,882 *51,044*
Northwest	33.5 *78.2*	14.8 *93.4*	1.8 *11.1*	18,608 *83,418*
Rocky Mountain	104.0 *42.7*	55.6 *45.1*	31.8 *24.1*	65,189 *27,258*
Southwest	263.7 *104.8*	60.7 *83.4*	18.4 *38.3*	54,749 *78,497*
Total, Net		195.0 *125.4*	61.8 *31.2*	691,428 *75,090*

Displaced Energy and Emissions by California Air District Region

	Energy Displaced (GWh)	NO_X Displaced (tons)	SO_2 Displaced (tons)	CO_2 Displaced (tons)
North CA	1.0 *3.6*	-0.5 *1.5*	0.0 *0.0*	565 *1,607*
Bay North	5.6 *29.8*	0.1 *0.4*	0.1 *0.2*	680 *12,798*
Bay Area	44.1 *33.1*	1.8 *4.9*	2.6 *2.8*	19,712 *17,247*
Sierra North	17.7 *14.3*	0.7 *1.5*	0.1 *0.1*	8,614 *5,844*
Sierra South	0.1 *0.1*	0.1 *0.2*	0.0 *0.1*	64 *53*
Sacramento	2.6 *8.0*	-0.2 *0.5*	0.0 *0.1*	238 *3,452*
San Joaquin	19.3 *17.1*	1.3 *4.0*	1.7 *1.7*	9,017 *7,440*
Central Coast	-28.8 *16.1*	1.3 *0.3*	0.1 *0.1*	-16,266 *10,877*
Desert Region	9.3 *16.4*	2.4 *2.0*	1.2 *1.0*	5,401 *7,229*
South Coast	1,252.2 *46.3*	49.9 *3.2*	4.0 *11.7*	517,407 *27,387*
San Diego	11.2 *9.6*	3.8 *2.4*	0.0 *0.2*	6,967 *6,374*
Imperial	2.2 *3.5*	2.6 *0.7*	0.0 *0.1*	1,639 *1,687*

Expectations: Using a Dispatch Model for Displaced Emissions

- Dispatch modeling is restrictive
  - Requires extensive input assumptions, build-out scenarios for baseline, calibrated model inputs
  - Licensure and expertise are high cost
  - Data is proprietary
- Regional studies have *very* high value
  - No difference between modeling California and Intermountain West – same model
  - Economies of scale, spread costs and efforts, capture benefits across states
  - Output can be published in numerous forms, including calculators

Conclusions

- Benefits spread over large geographic regions
  - Significant displaced generation outside of California
  - Displaced resource type varies significantly
- Grid is complex, but analyzable
  - Transmission constraints can be important
  - Specific location and type of EE/RE project is important
  - Historic statistical analysis vs. forward-looking simulation model: results will differ

Acknowledgements

Synapse

Nicole Hughes, Chris James, David White, Bruce Biewald, & Ezra Hausman

CEC

Marla Mueller, Al Alvarado, Angela Tanghetti, Denny Brown, Ivin Rhyne

EPA

Greg Nudd, Art Diem, Ben Machol, Chris Stoneman, Robyn DeYoung

California Air Districts

Lisa Van de Water, Charles Anderson,

Jack Brouwer, UC Irvine

Mark Meldgin, PG&E

Contact Info

Jeremy Fisher, PhD

Synapse Energy Economics
jfisher@synapse-energy.com
617.453.7045

Marla Mueller

Air Quality Research Program
Public Interest Energy Research (PIER) Program
California Energy Commission
mmueller@energy.state.ca.us

Perspectives from a California Air District

Lisa Van de Water

San Joaquin Valley Air Pollution Control District

