Low Carbon Policies and Transmission Investment Analysis in a New Multi-region US Power Sector TIMES Model

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Presentation Outline

- Motivation for Development of a New US Modeling Framework
- Model Design, Regional Structure, and Data
- Data Handling Approach and Techniques
- Low Carbon Portfolio Standard and Transmission Investment Analysis

The Importance of a US Regional Perspective

- Any US carbon policy will have greatly varying cost implications across regions of the country, depending on:
  - Existing electricity generation technology mix
  - Available renewable and fossil resources
  - Energy use patterns
  - New technology availability, cost, and incentives
  - State and regional climate, energy, and environmental policies
- These regional differences play *some* role in the political debate surrounding US carbon policy

Geography Increasingly Matters

- The cost of a transition to a low carbon energy system depends critically on geographical relationships, including those between:
  - Renewable resources, electricity loads, and transmission capacity
  - Biofuels production, transport and use
  - Captured CO2 transport and sequestration
- Following make it even more relevant for USA:
  - Diversity
  - Distances
  - Volumes

New Tools for Geographically Rich Data

- The data to support such detailed geographical analysis exists in the US
- Existing tools (bottom-up optimization) are not able to utilize this data in a resource-efficient, transparent way
- An extended Veda-TIMES framework has been developed to manage voluminous input data and analyze results data
  - Data table development using rules
  - GIS results viewer

Model Design, Regional Structure, and Data

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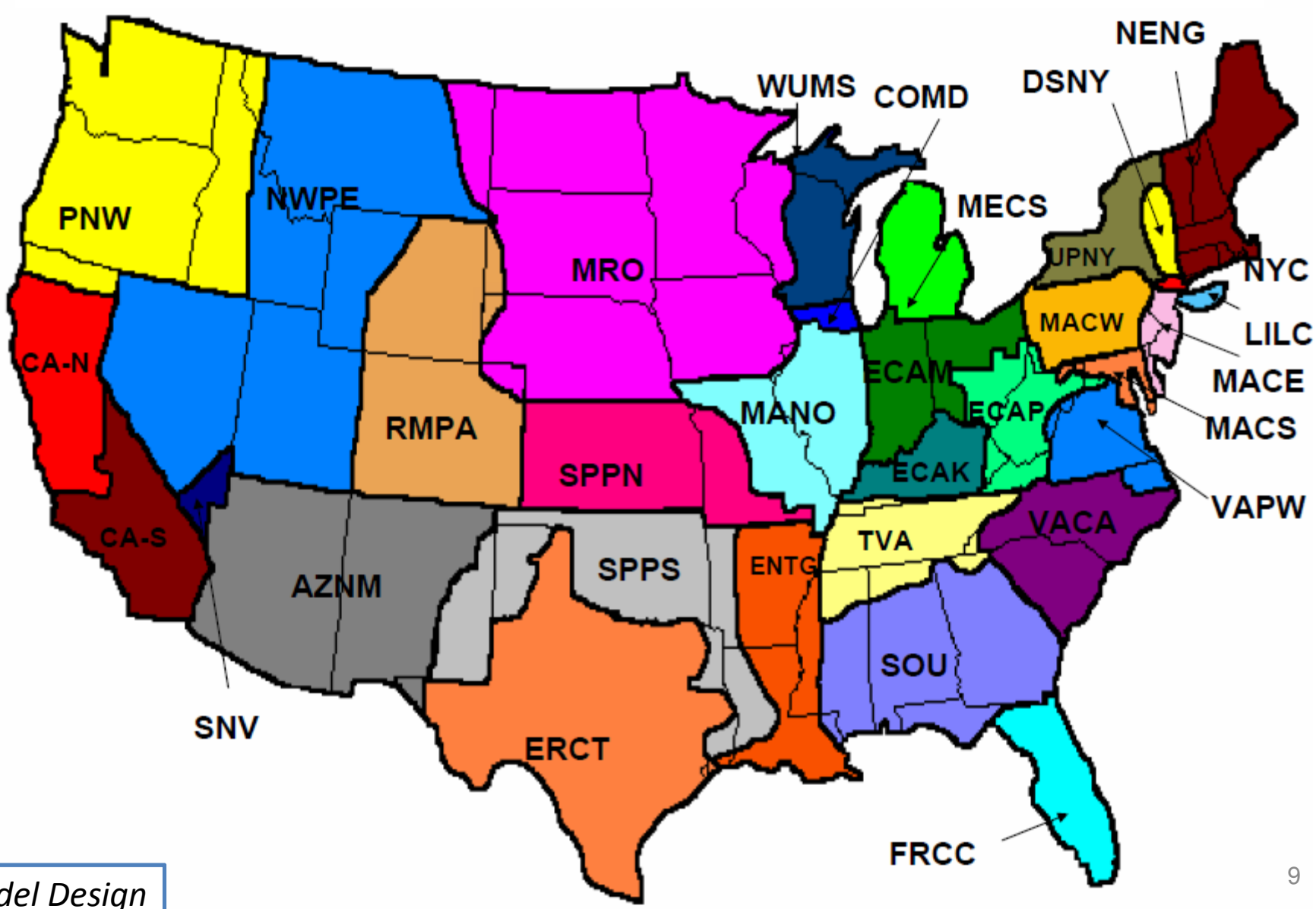
Design Principles and Development Pathway

- Employ flexible geographic resolution driven by the native resolution of the source data in each sector
- Utilize best publicly available data
  - NEMS and IPM-EPA are major sources
- Develop new data handling tools as needed to manage data and interpret results
- Full sector model planned; power sector developed and in use for analysis

Regional Structure

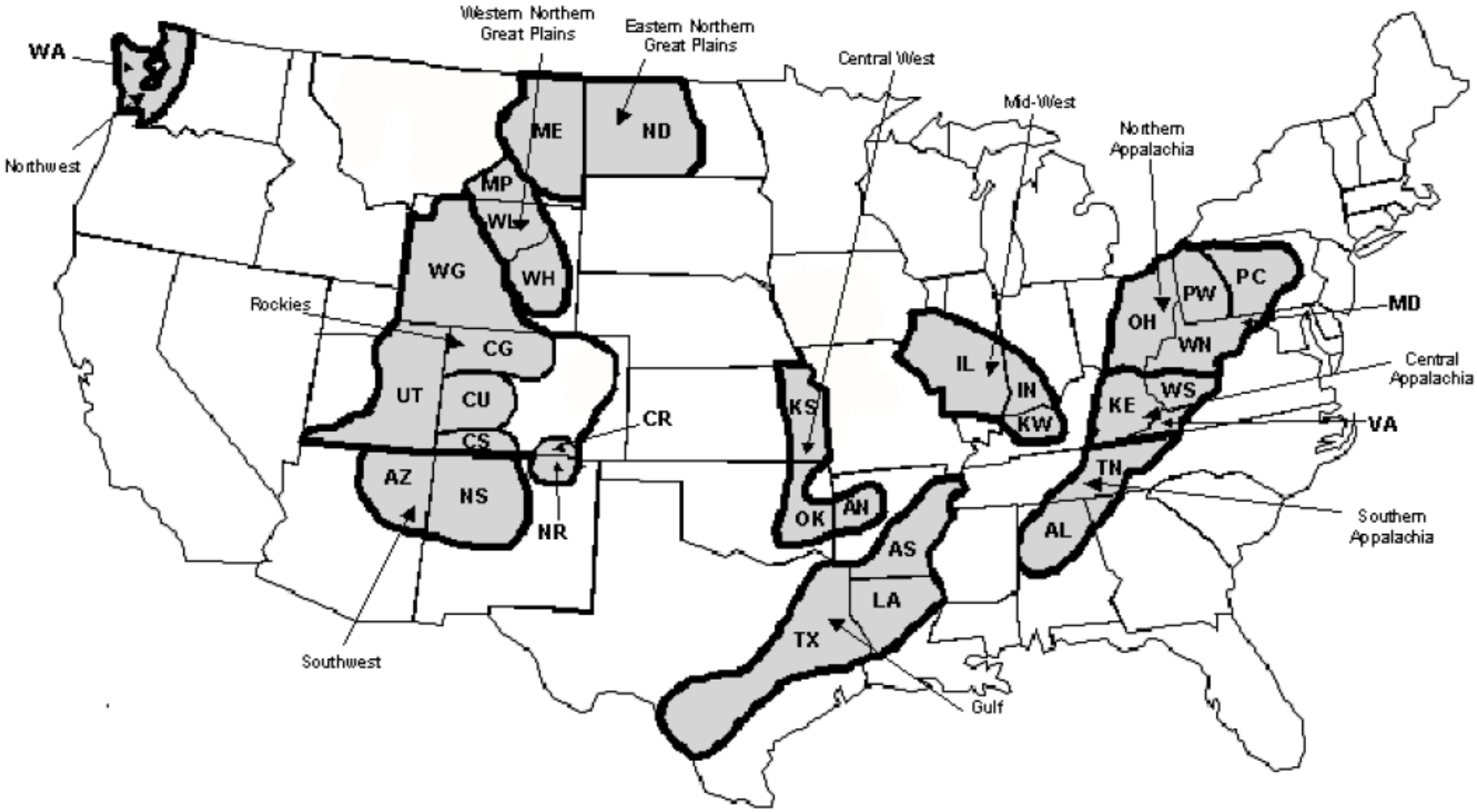
- The regional structure of each of the underlying datasets is preserved to minimize "massaging" of the source data, for example:
  - *Electricity generation* is located in NERC sub-regions that represent key transmission grids and bottlenecks
    - Capacity expansion is tracked by state, to allow for state policy modeling
  - *Coal* is tracked from 30 source regions by coal type and sulfur content
  - *Electricity demand* (later end use demands) are modeled within census divisions
- Contrast with other MARKAL-TIMES models that require all supply, transformation, and demand processes to occur within a single set of regions

Electricity Generation Regions



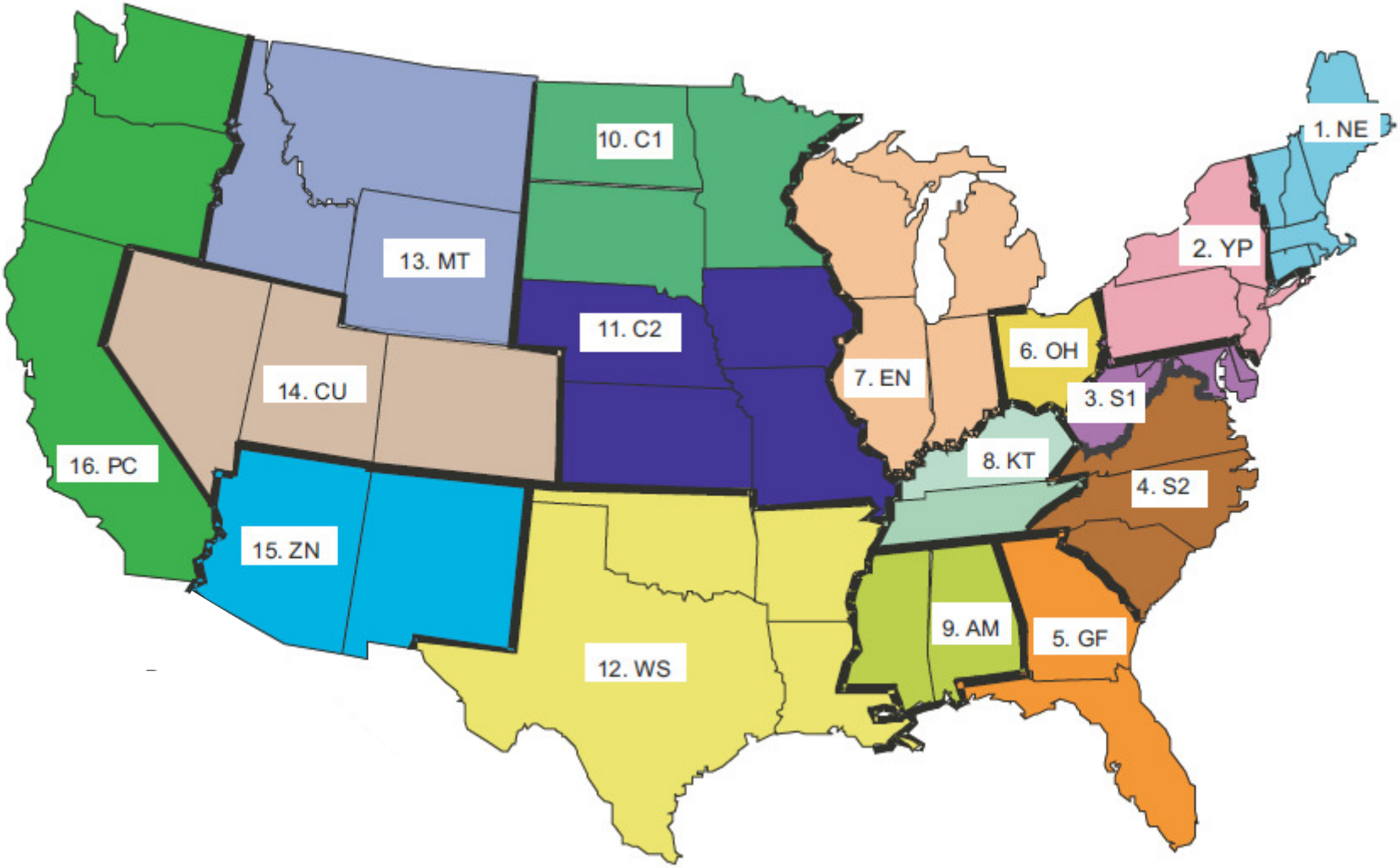
Model Design

Regionalized Coal Supplies



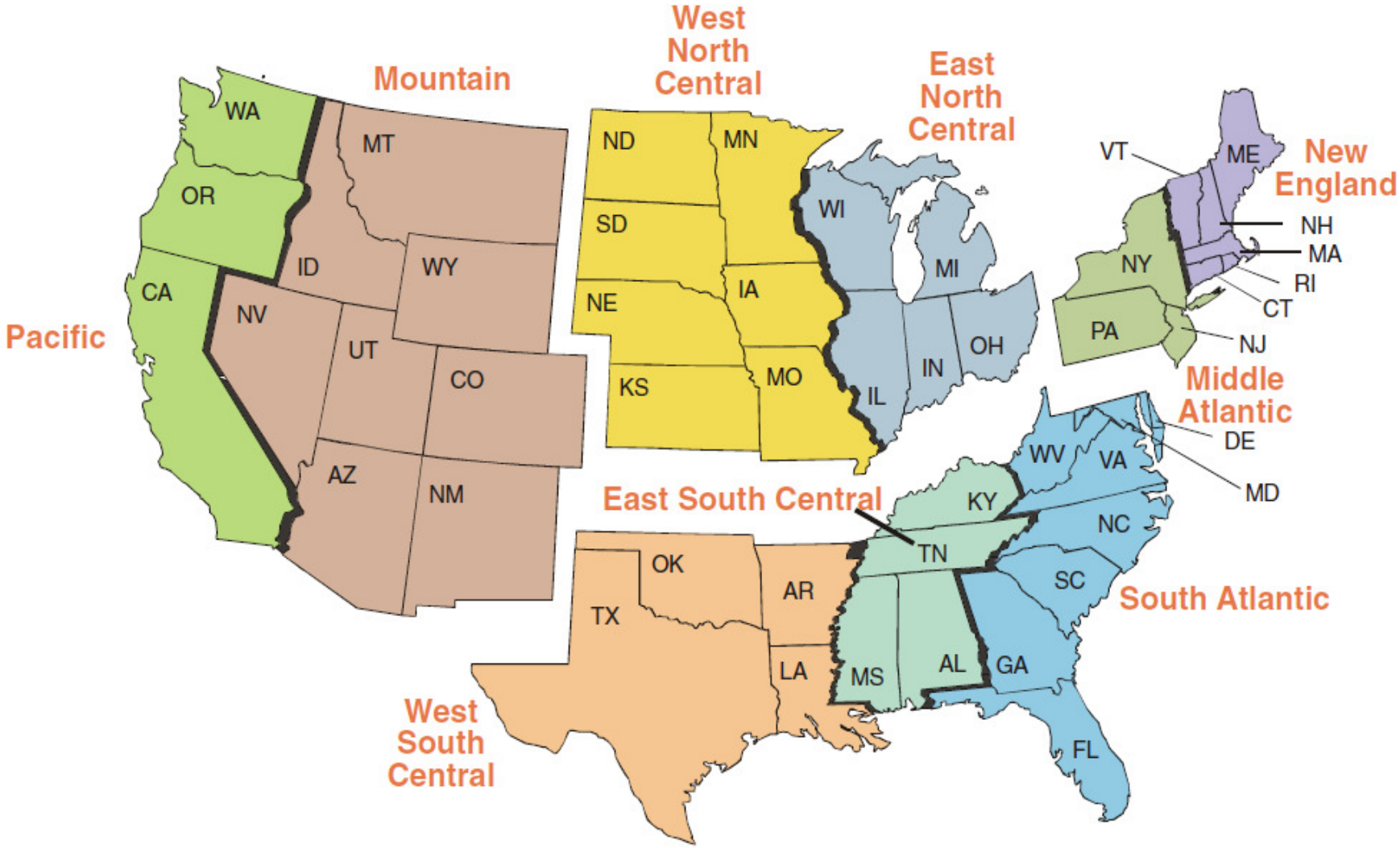
Model Design

Biomass Supply Regions



Model Design

End Use Demand Regions



Model Design

Data Sources

Sector	Source	Comments
Biomass Supply	AEO 2010 supply curves	16 supply regions
Coal Supply	IPM 2006	31 supply sources, 3 types, 6 sulfur grades
Coal Transportation	IPM 2006	Matrix of 96 coal types to 135 power plant groupings
Natural Gas (to power sector only)	IPM 2006 supply curves	Transportation markups to power regions
Existing Power Plants	IPM NEEDS 3.02 ARRA	32 NERC subregions 15000 plants, indexed by state and county
New Power Plants	AEO 2010/AEO2011	Indexed by state
Renewable Potential	AEO 2010	
Transmission Capacity	IPM2006	Among 32 NERC subregions
Electricity Demand	AEO 2010 results	Census divisions, 4-step load curve in two seasons based on IPM data

Data Handling Approach and Techniques

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Basic Approach

- Expands the Veda-TIMES framework for managing data development, model construction and management, and analysis
- Key challenge is the immense number of trade links, e.g. 15 coal types X 30 coal regions X 30 PP regions, and 5000 coal plants with flexible inputs
  - 125,000 coal-emission-related inputs
  - 6600 trade links
  - 8000 emission-related UCs
  - 15000 existing plants and 5000 new plants

Existing Policies and Constraints

- Emissions
  - Summer NOx limit for participating states
  - Sulfur limits by plant and national cap
- State renewable portfolio standard
- Retirement
  - Existing plants retire on a plant by plant basis by age
  - Older plants are charged increasing VAROM; can make an economic decision to go out of service
- Annual build rate cost steps to prevent excessively quick run up in new capacity: nuclear, PV, wind
- Renewable potential: capacity factors and cost steps by NEMS region

Low Carbon Portfolio Standard and Transmission Investment Analysis

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Power Sector Analysis: Two Policies

- Low carbon portfolio standard: 90% by 2050
  - Partial credit for gas combined cycle (50%) and coal/gas with CCS (90%)
  - Parametric scenarios with varying speed of ramping up the standard
- Investment in improved transmission grid
  - Interregional capacity expansion permitted for $100/kw
  - Test value of relieving grid bottlenecks

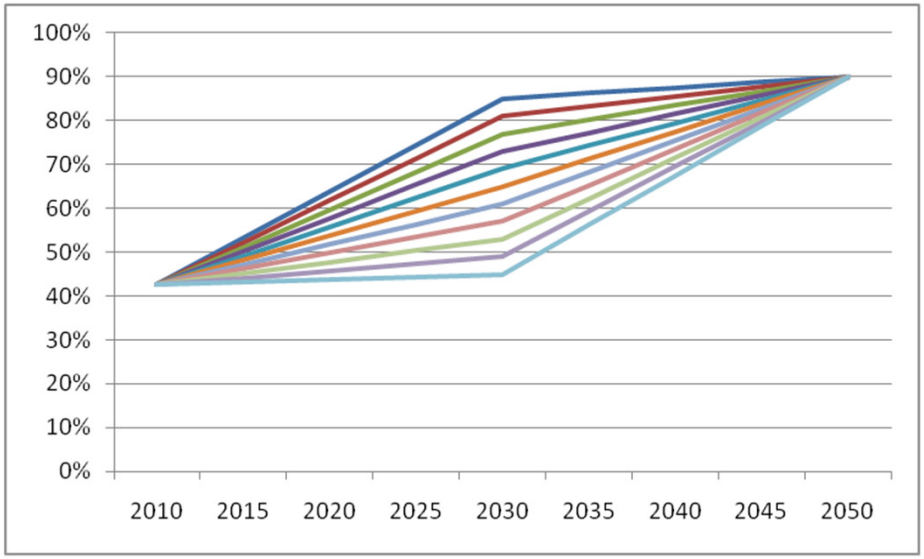
Results

Scenario Definitions

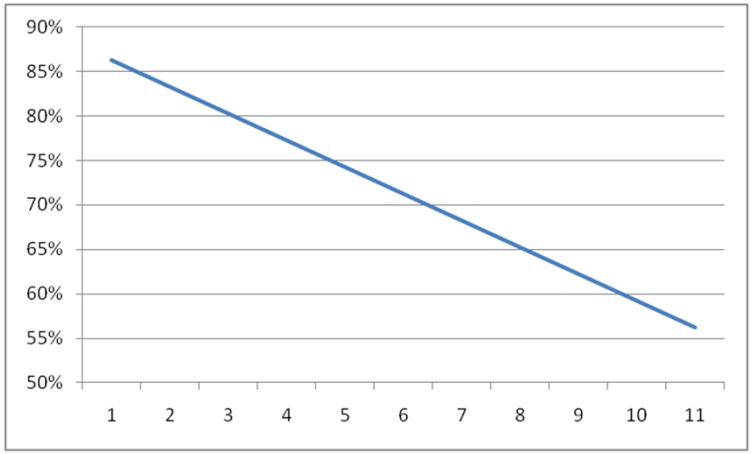
LCEP Definition

Type	Credit
Wind, Solar, Biomass, Geothermal, Hydro, Nuclear	1.0
Sequestration	0.9
Gas – Combined Cycle	0.5

LCEP Scenarios



LCE shares - 2035



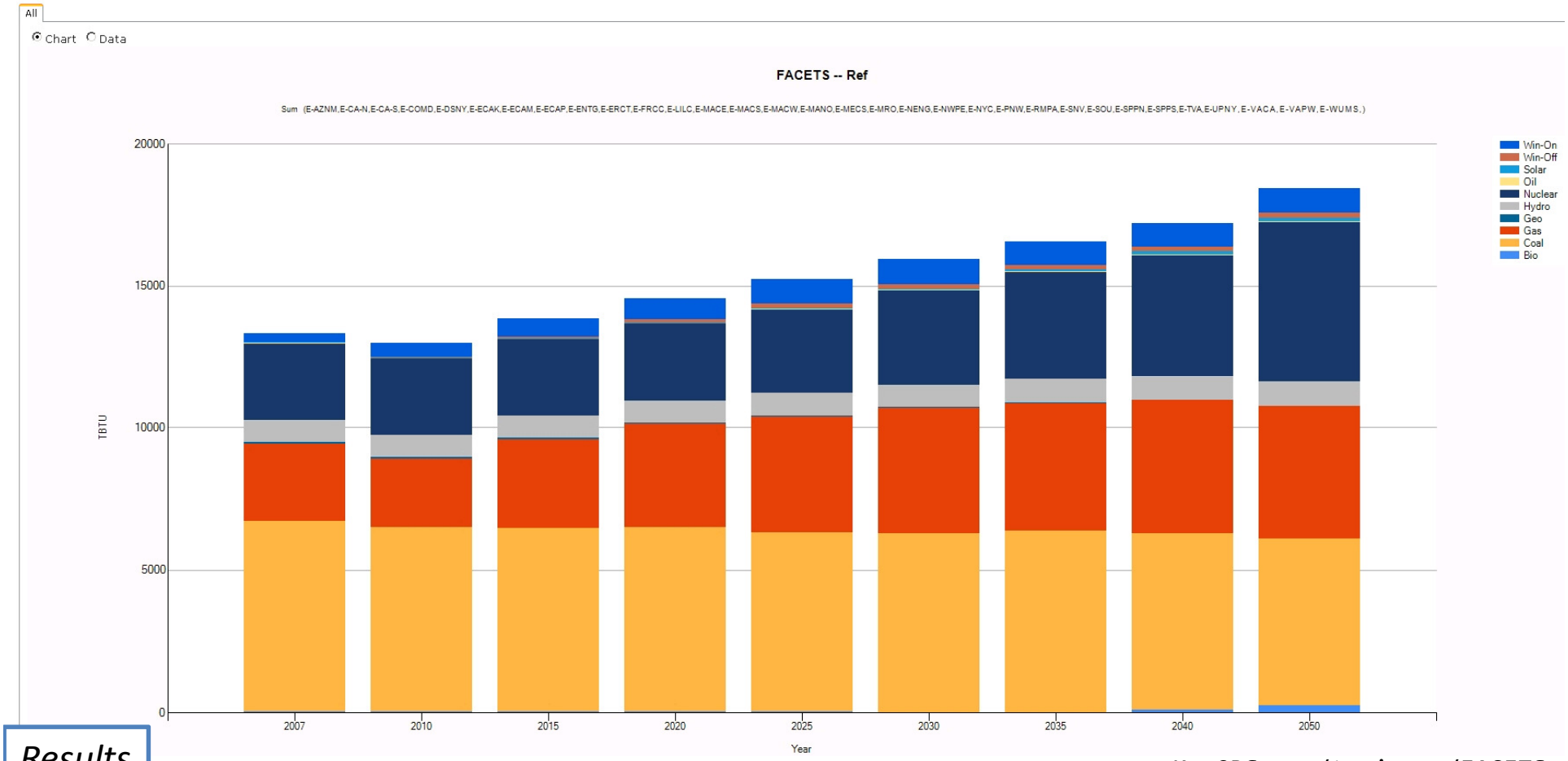
With and without grid expansion ($100/kw)

Results

Reference Case

www

Electricity generation (USA)



Results

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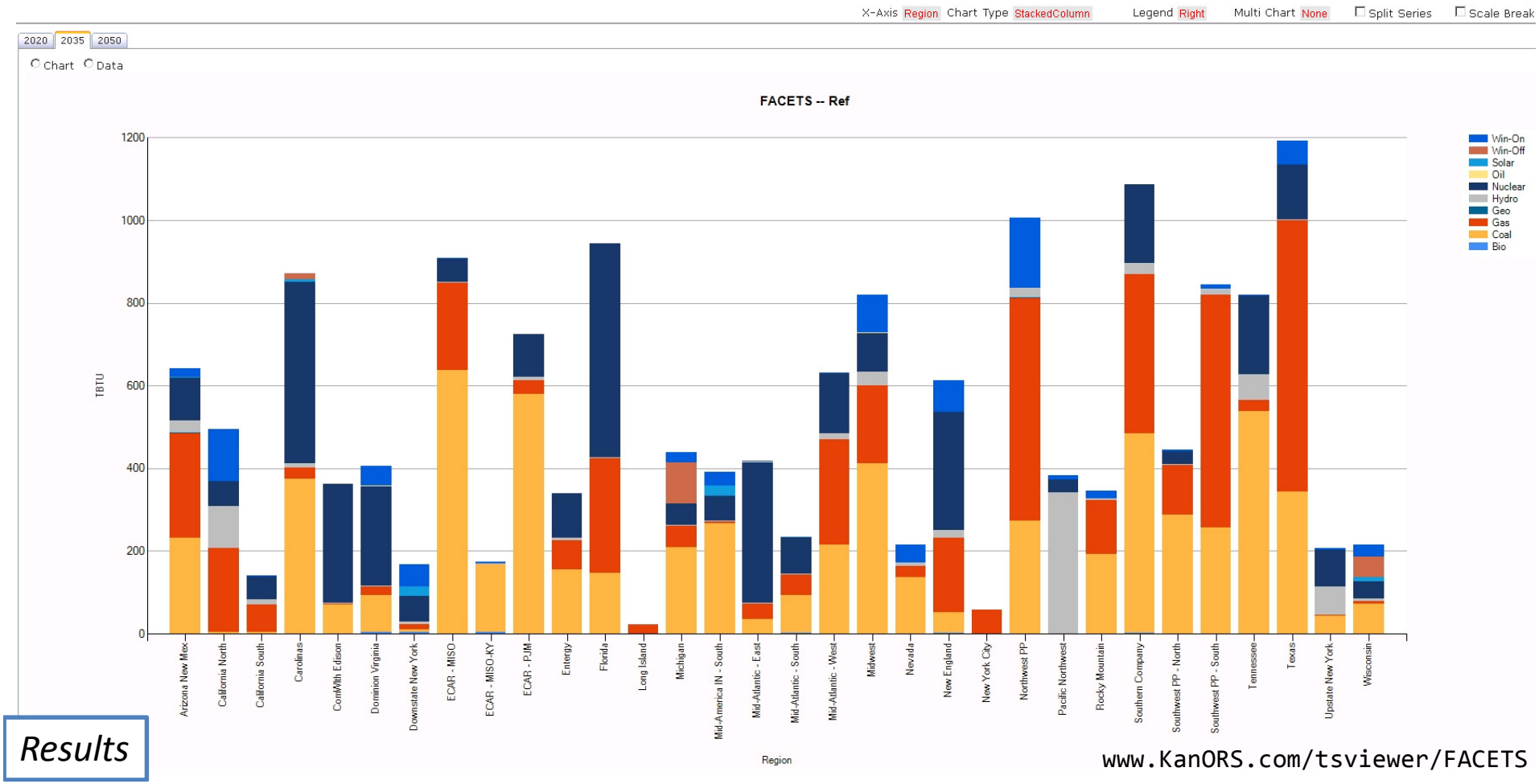
Reference Case [2035]

www

ELC generation by Region



Results

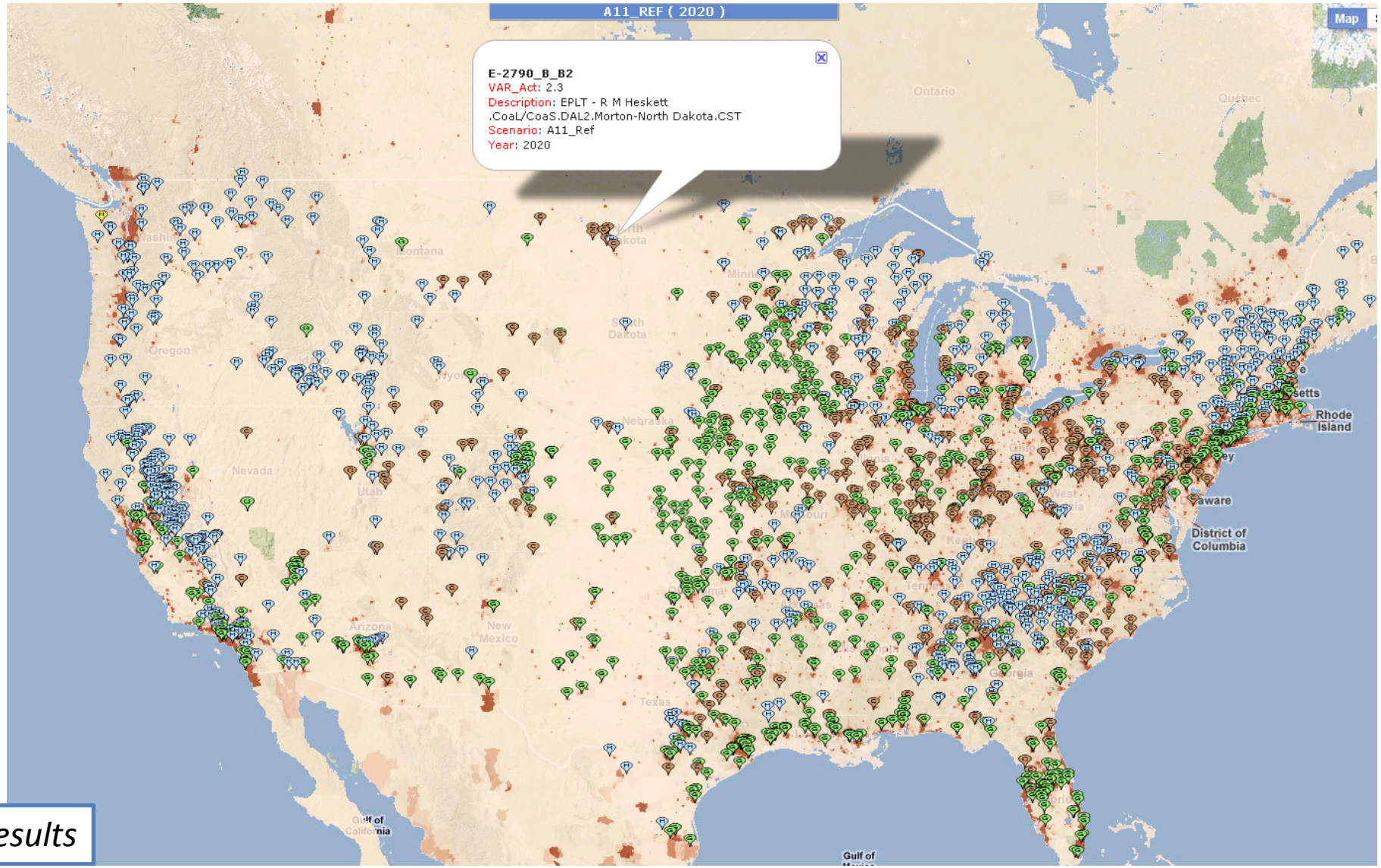
www.KanORS.com/tsviewer/FACETS

Reference Case [2020]

www

Coal, Gas and Hydro generation

www.KanORS.com/gistrade/FACETS

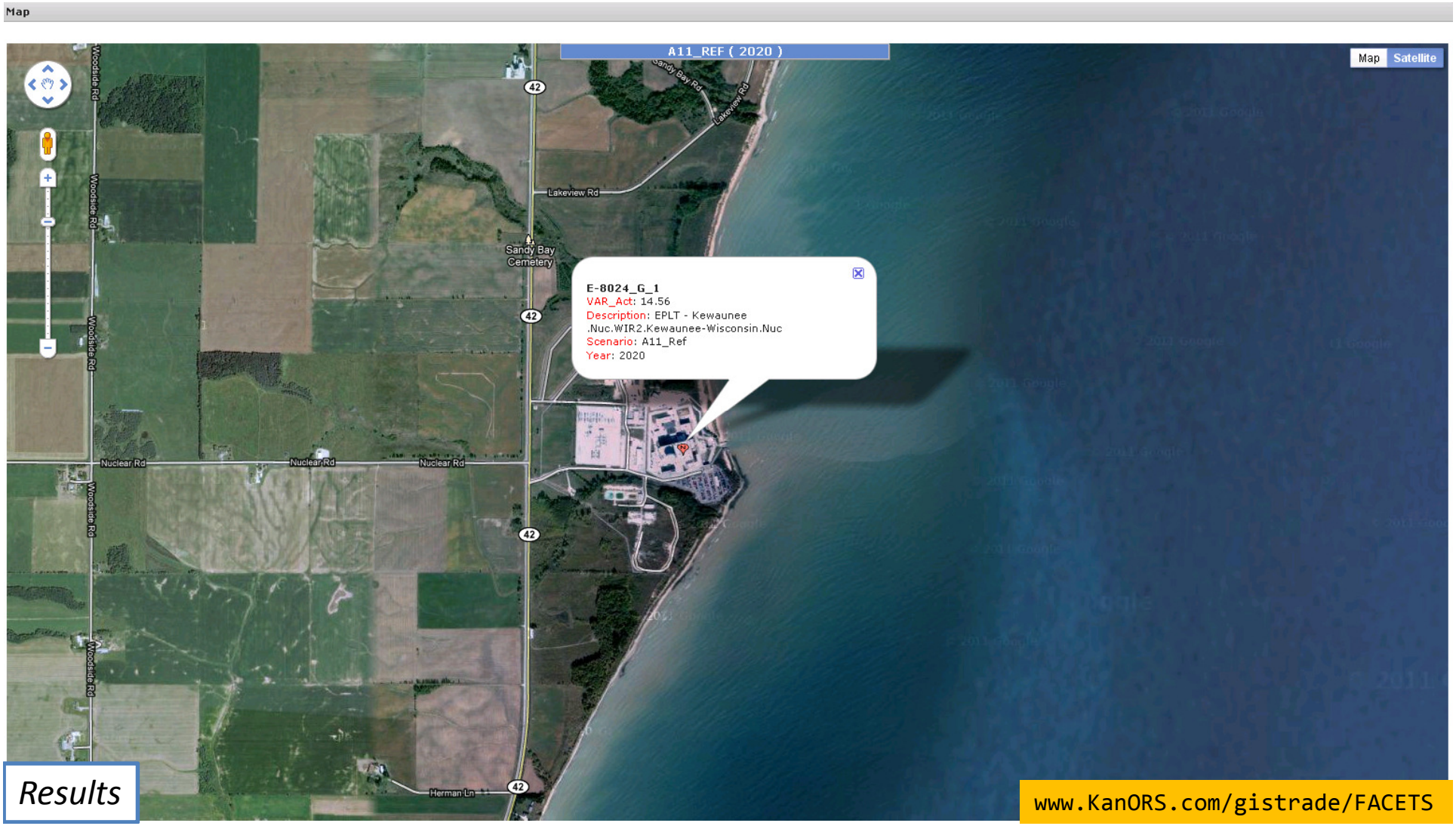


Results

Reference Case [2020]

www

Can actually locate plants



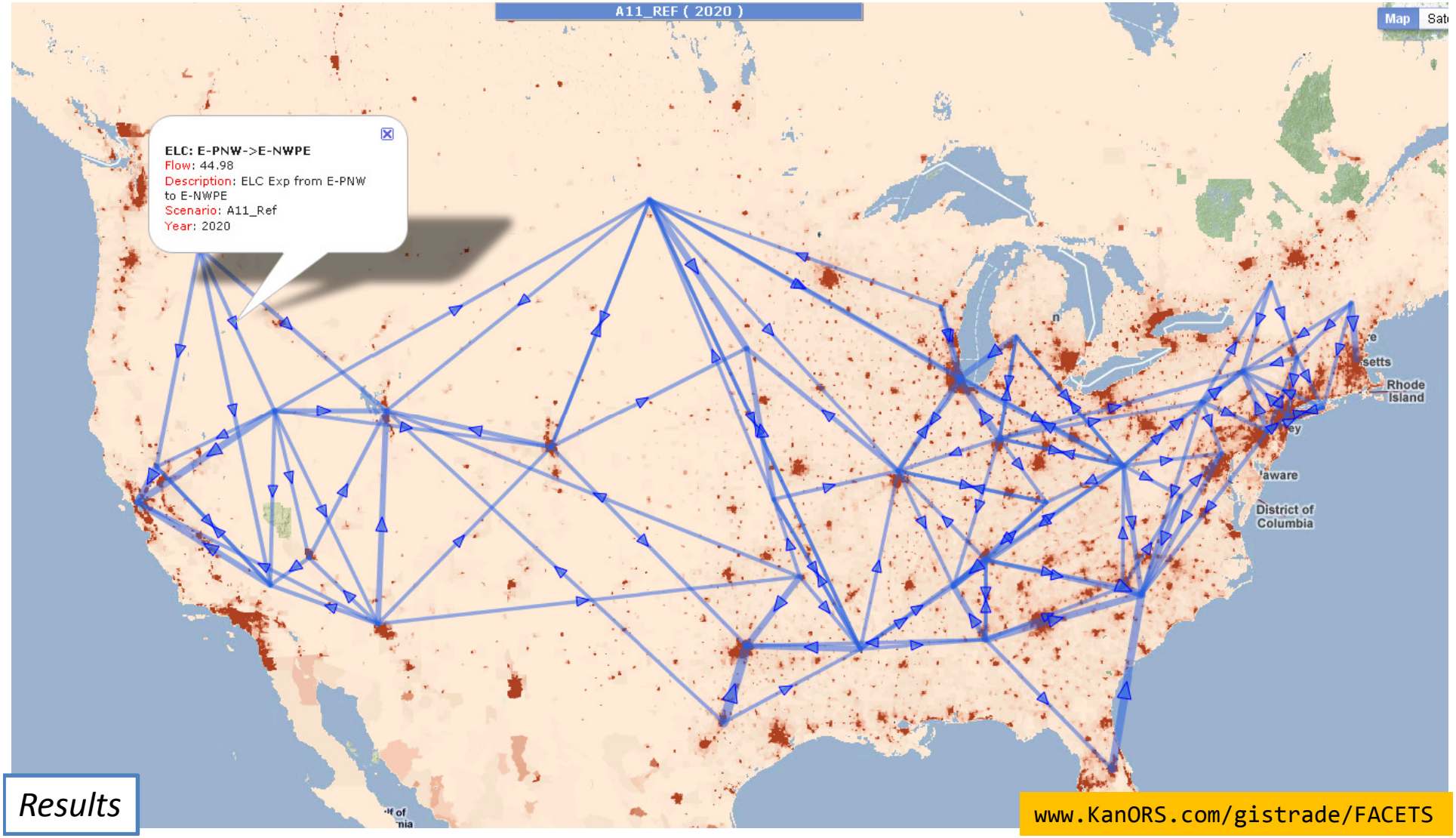
Results

www.KanORS.com/gistrade/FACETS

Reference Case [2020]

www

ELC Trades

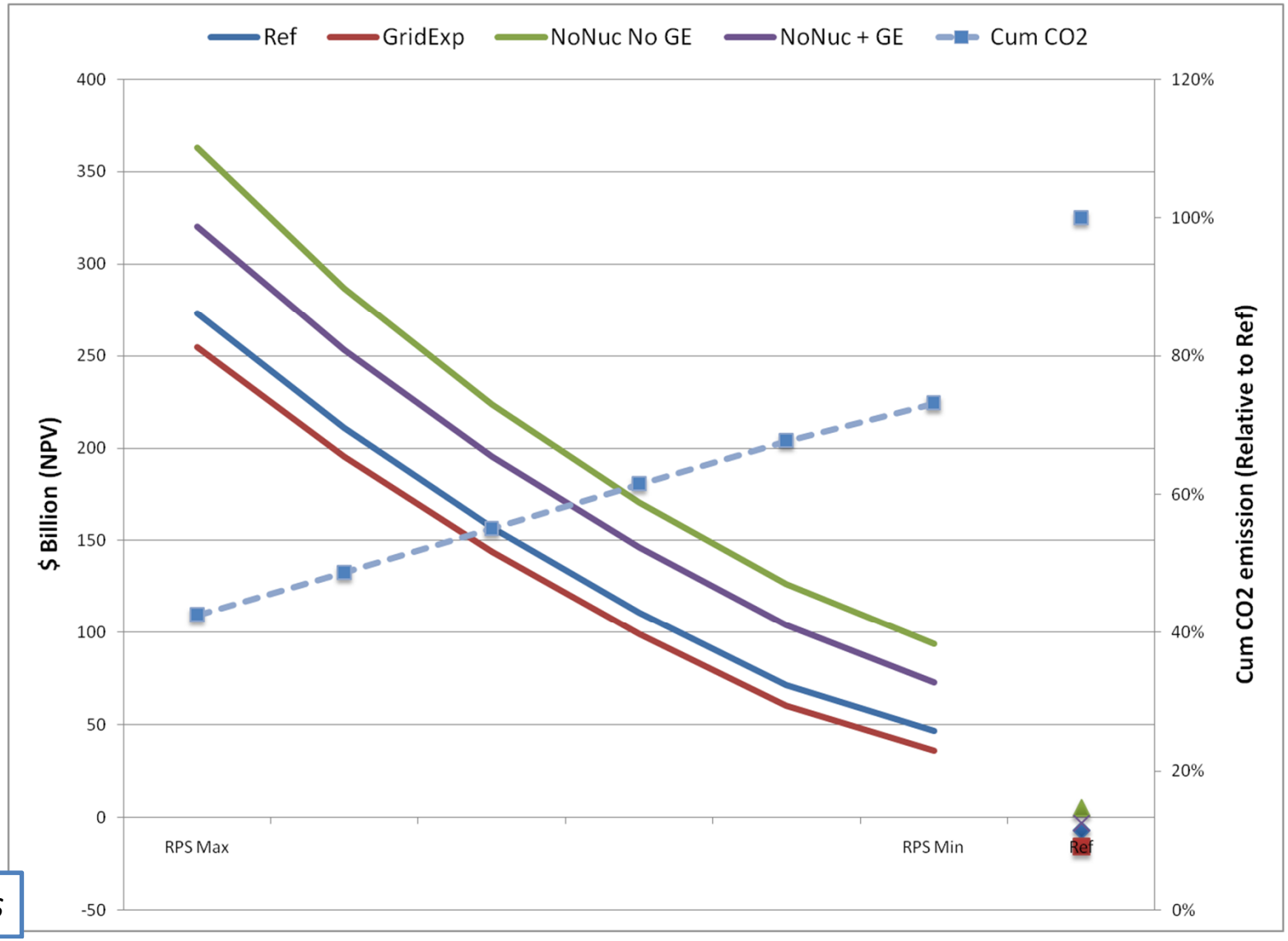


Results

www.KanORS.com/gistrade/FACETS

Policy Cases

Total costs and Cum Emissions

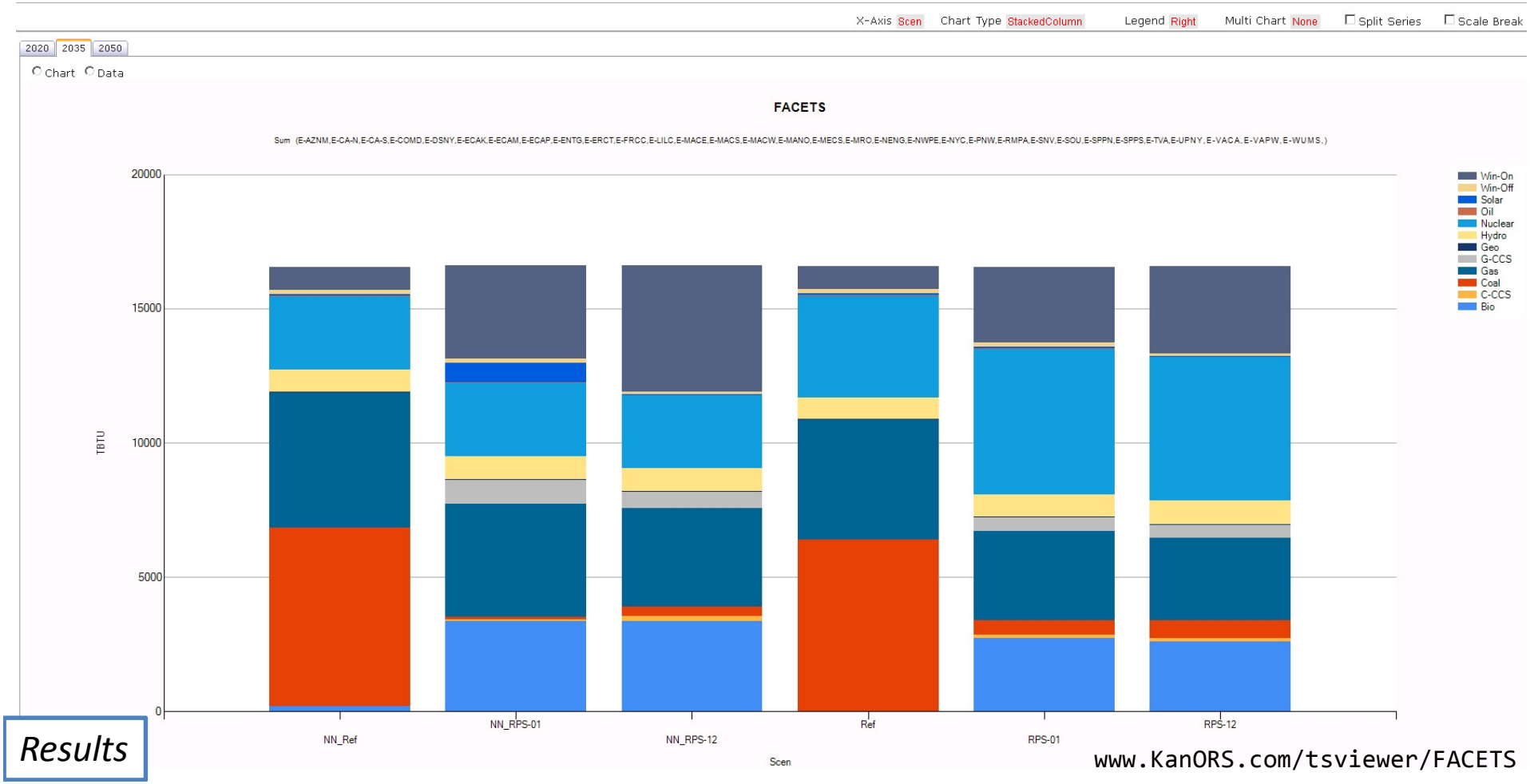


Results

Policy Cases

www

ELC generation mix



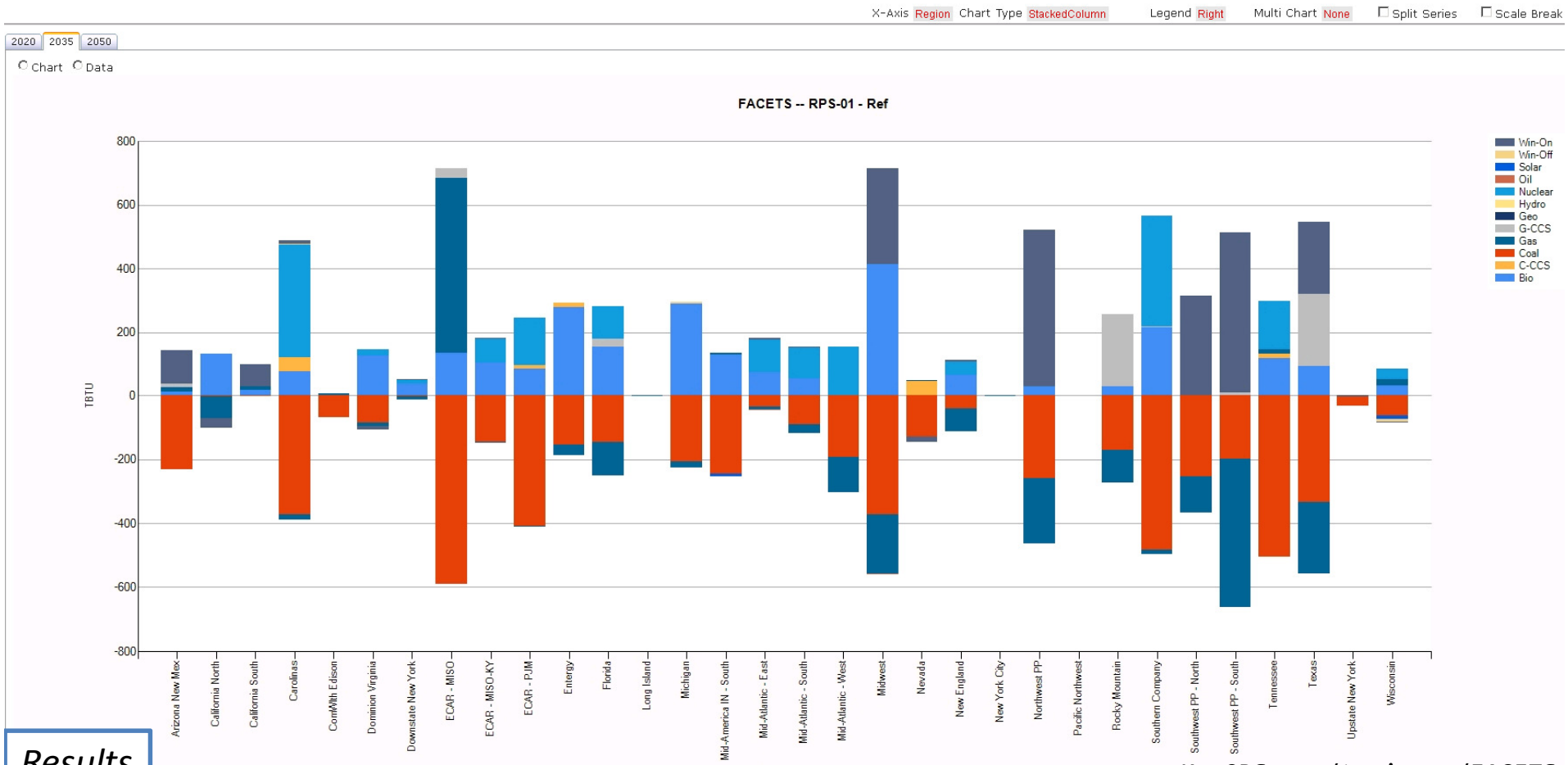
Results

www.KanORS.com/tsviewer/FACETS

Policy Case-Ref Case (2030)

www

ELC generation *changes* by Region



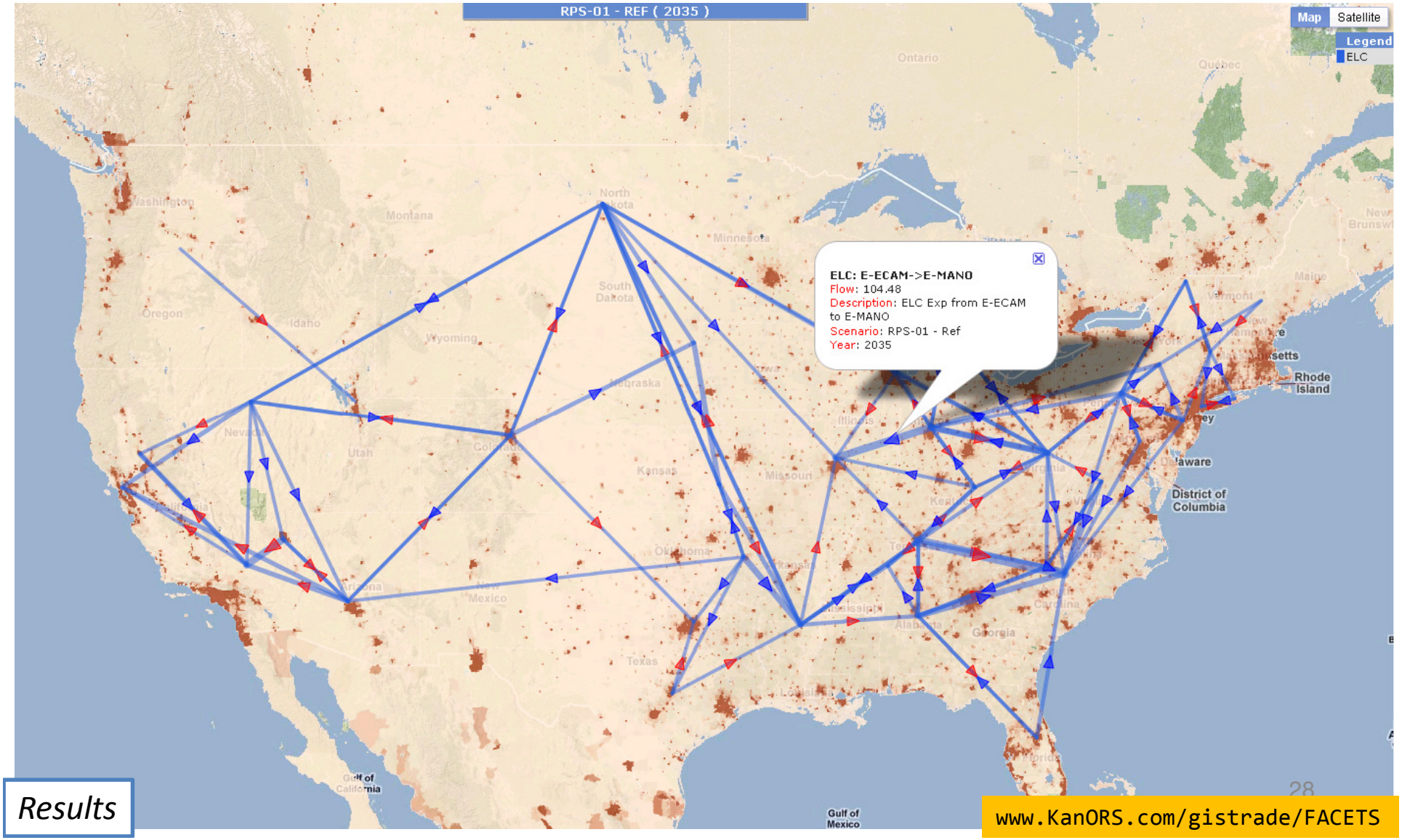
Results

www.KanORS.com/tsviewer/FACETS

Policy Case-Ref Case (2035)

www

Changes in ELC trade



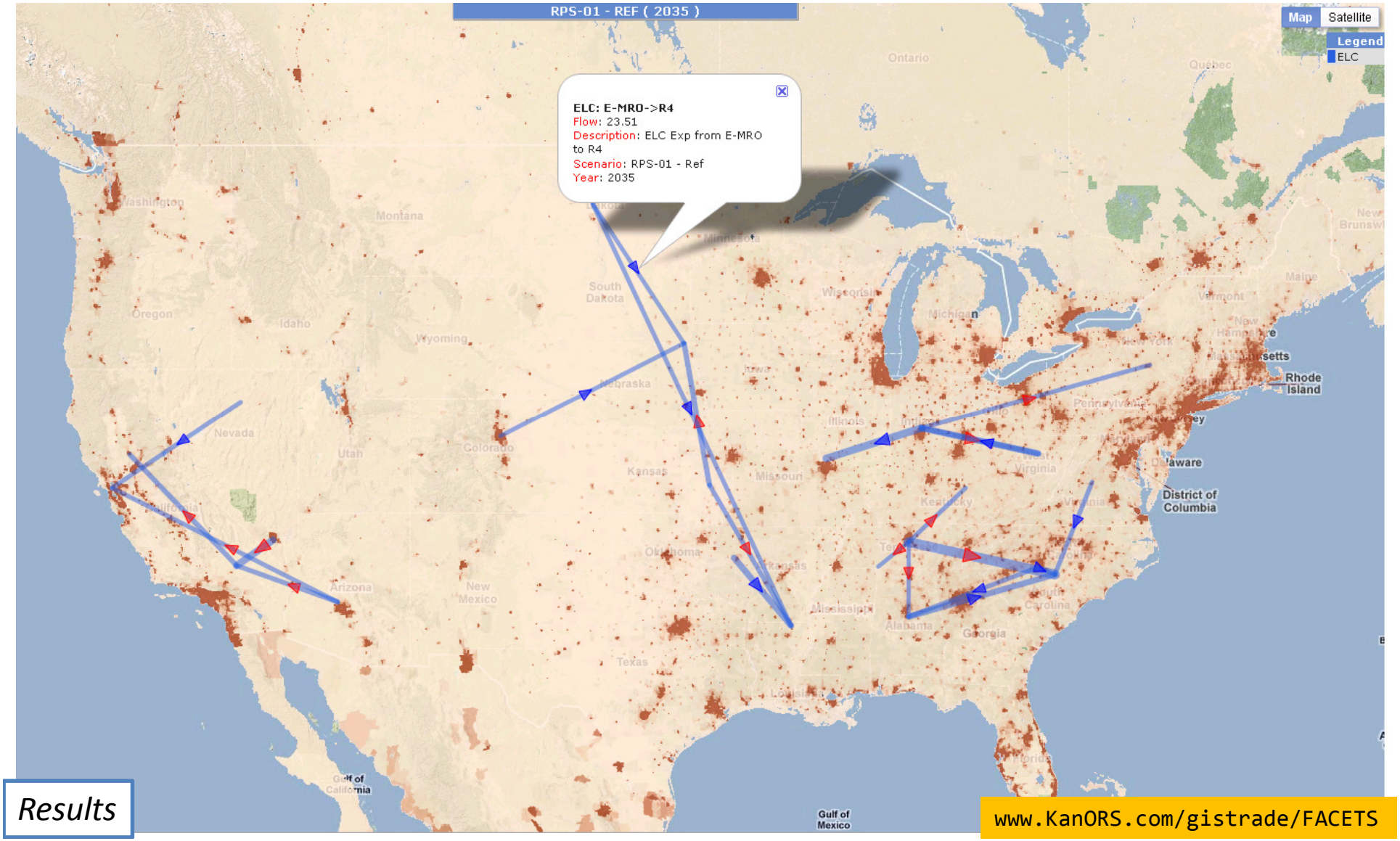
Results

www.KanORS.com/gistrade/FACETS

Policy Case-Ref Case (2035)

www

Changes in ELC trade (>20 TBTU)



Results

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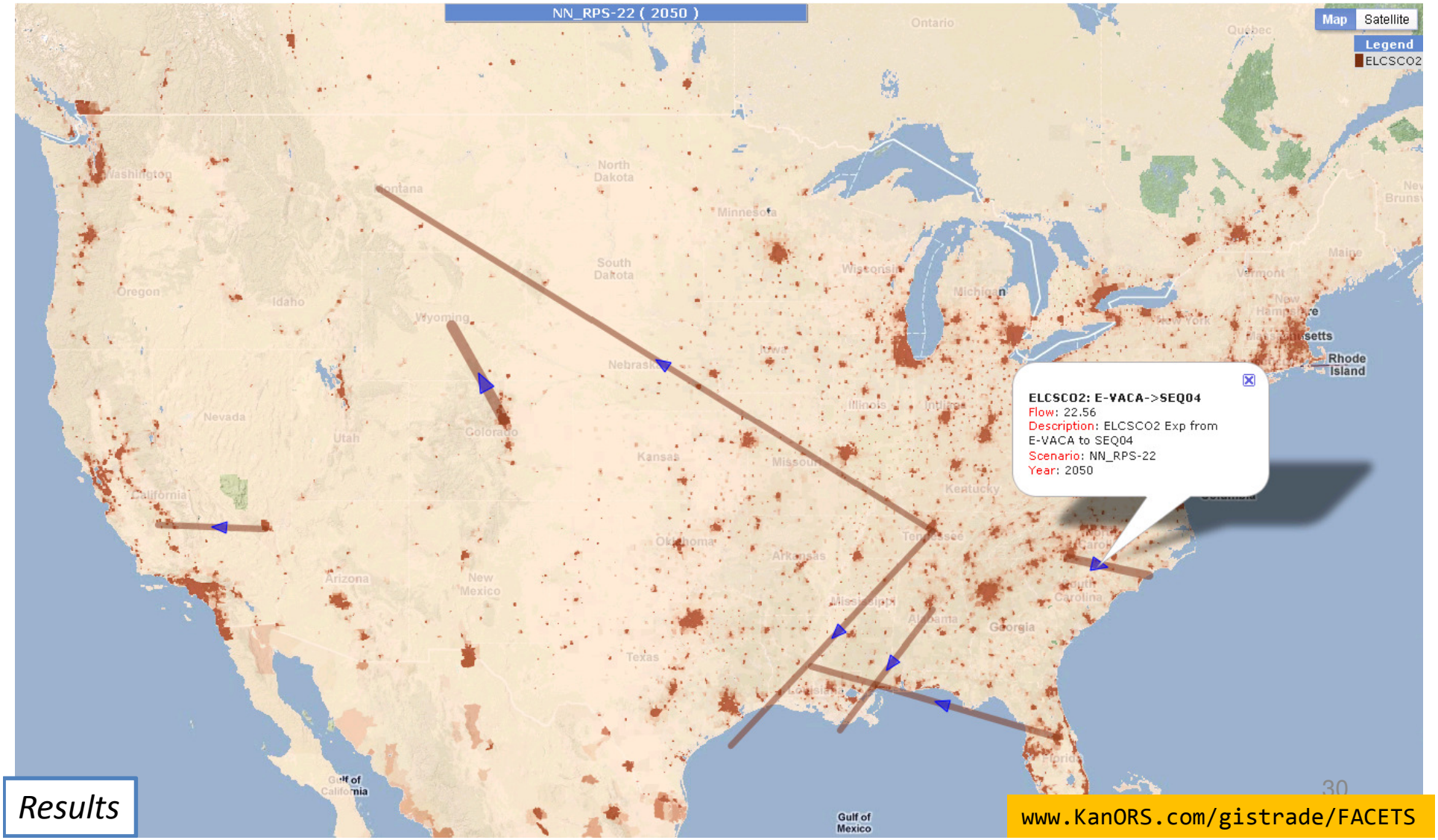
Policy Case (2050)

www

CO2 sequestration

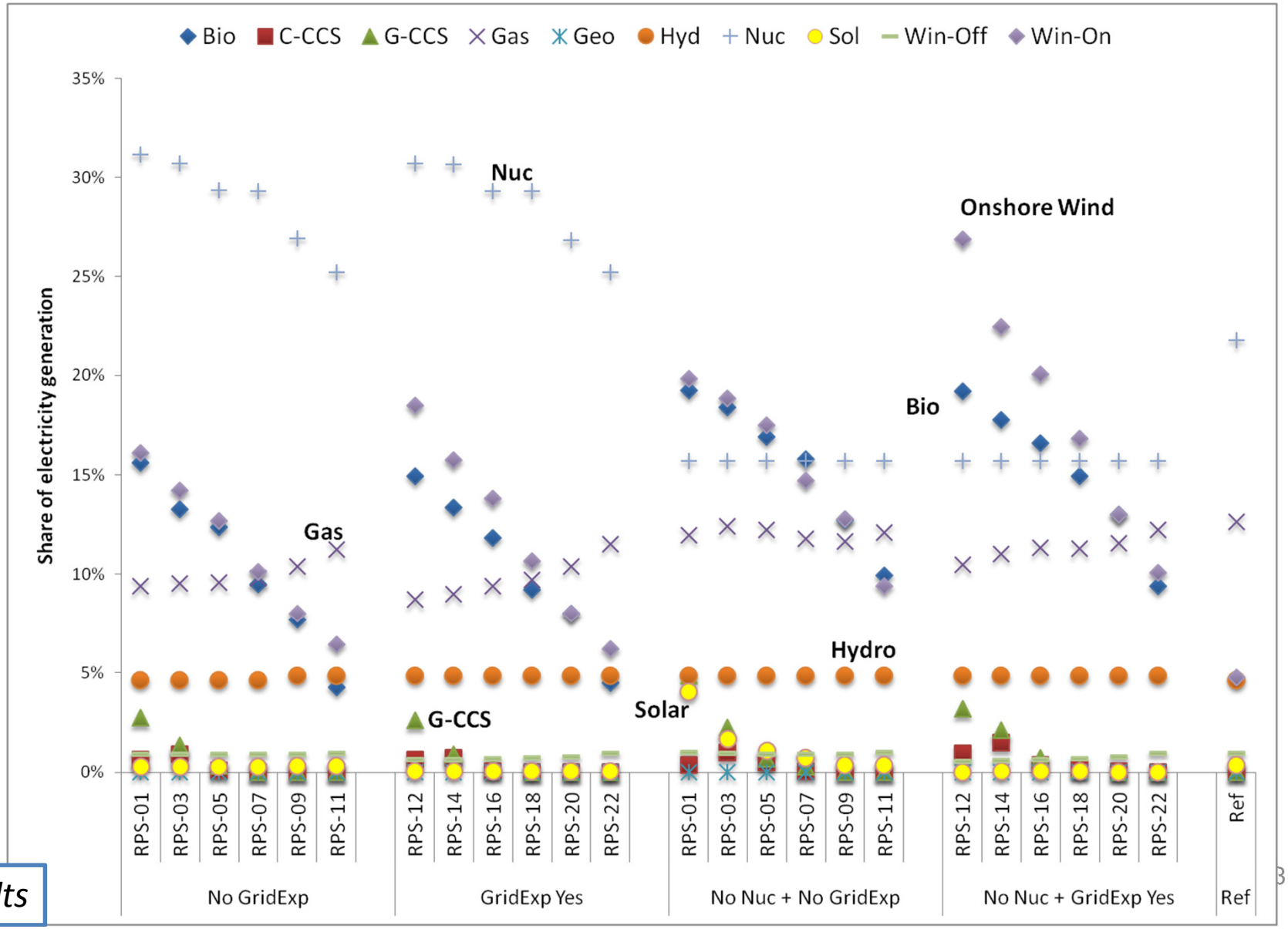


Results

www.KanORS.com/gistrade/FACETS

Policy Cases

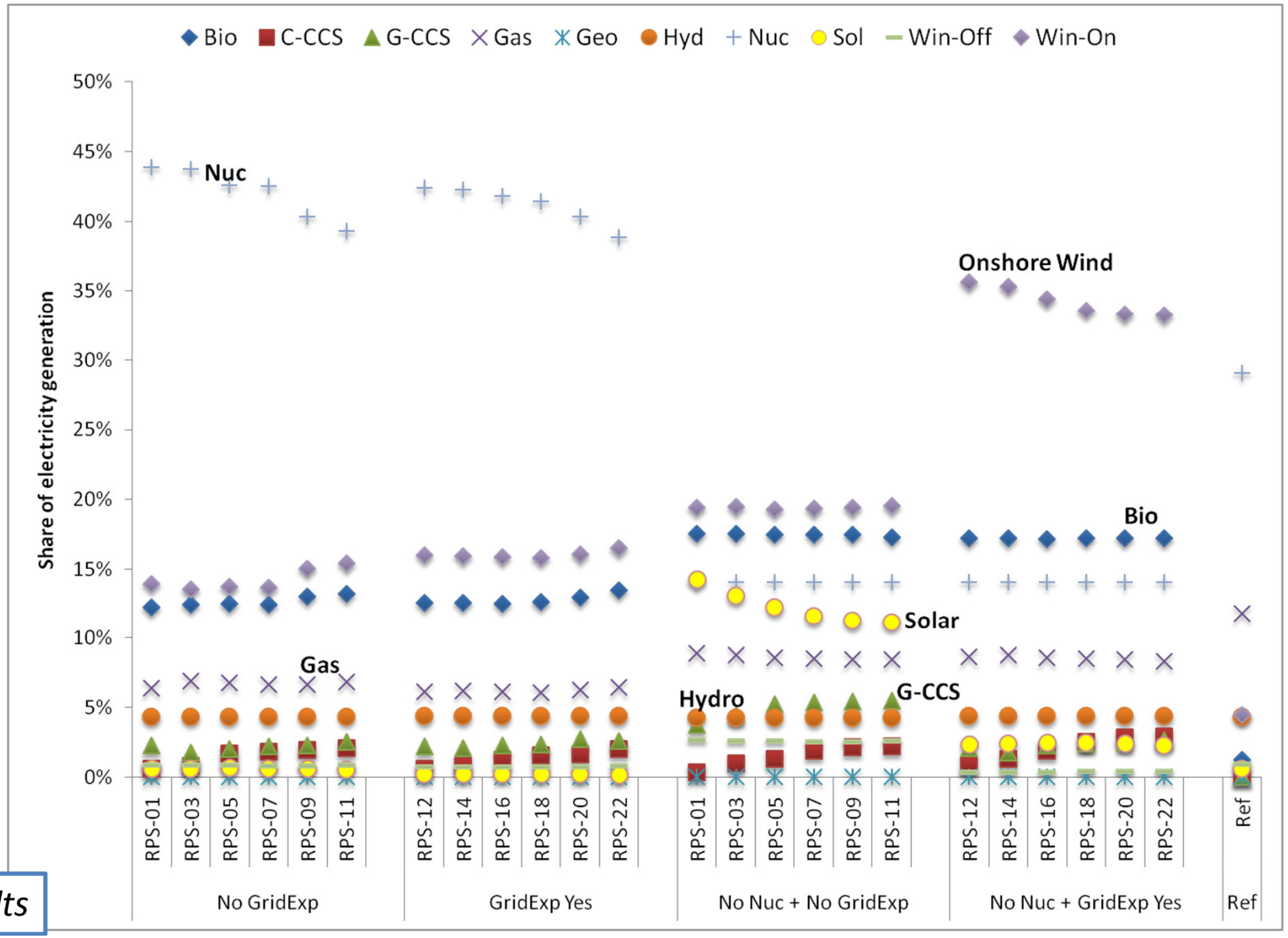
ELC generation summary - 2035



Results

Policy Cases

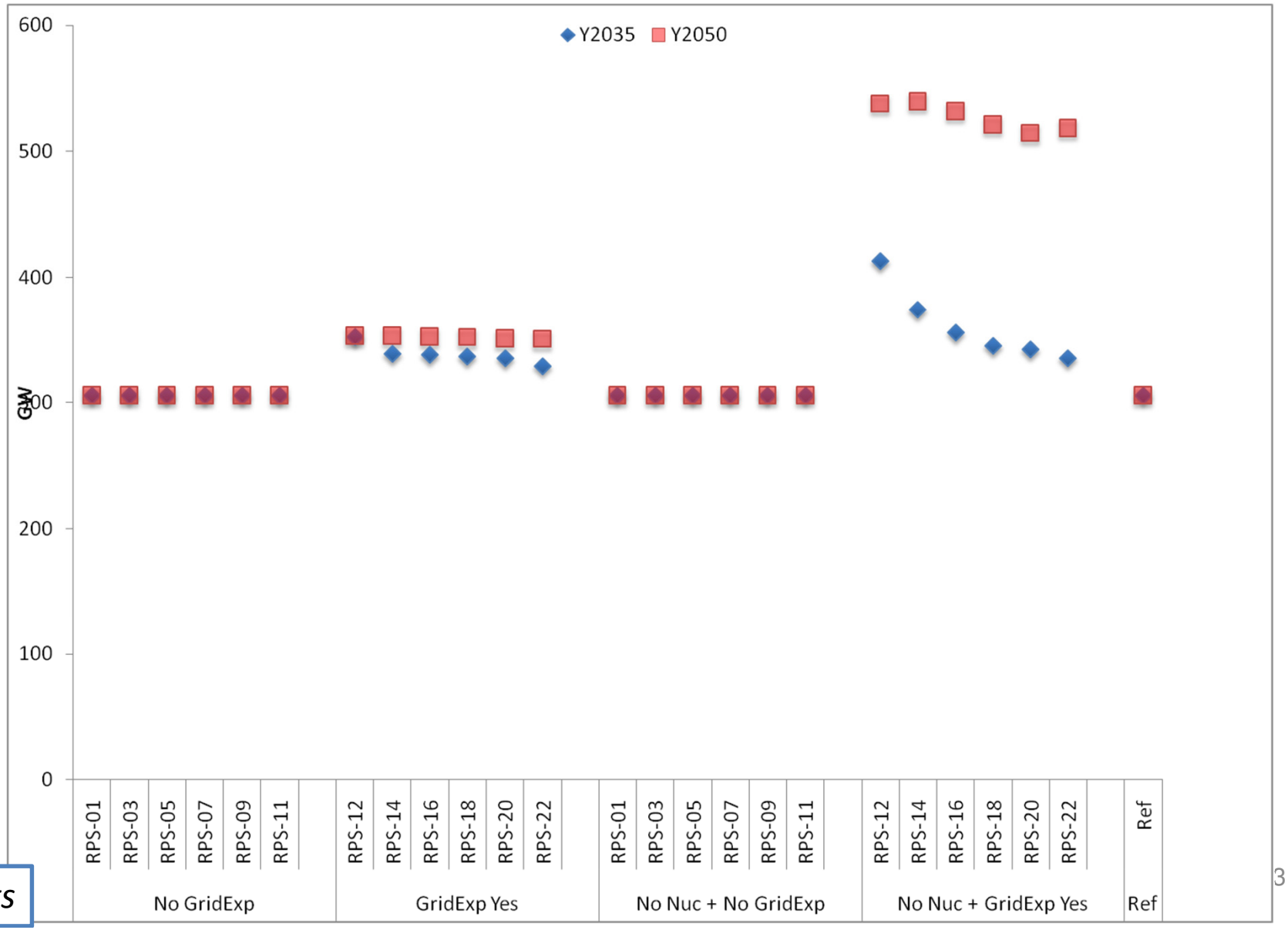
ELC generation summary - 2050



Results

Policy Cases

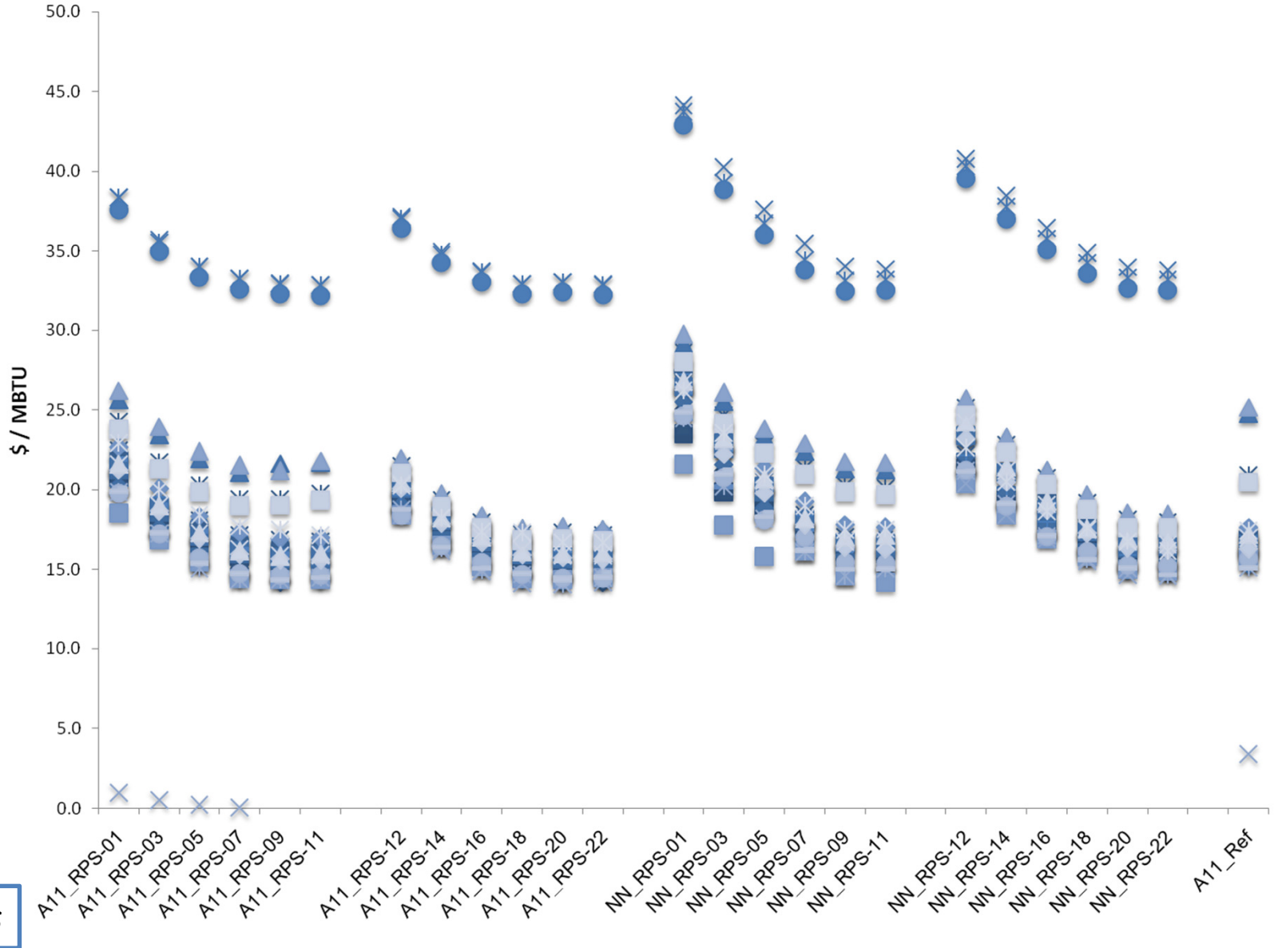
Inter-grid transfer capacity



Results

Policy Cases

Electricity Prices (Summer day)



Results

And…

- Work on building other supply and demand sectors will start soon.
- These scenarios are available on the web and one can look at many more results:

www.KanORS.com/tsviewer/FACETS
www.KanORS.com/gistrade/FACETS

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