NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Advancing Energy Analysis through High Performance Computing at NREL

Rob Leland

August 20, 2018

Swiss-US Energy Innovation Days, Lausanne, Switzerland

NREL at a glance

1,800

Employees

plus >**400** early career researchers and visiting scientists

World-class

facilities, renowned technology experts

nearly 750

Partnerships

with industry, academia, and government

Campus

operates as a living laboratory

$872M annually

National economic impact

NREL missions and capabilities

Renewable Power

Solar

Wind

Water

Geothermal

Sustainable Transportation

Bioenergy

Vehicle Technologies

Hydrogen

Energy Efficiency

Buildings

Advanced Manufacturing

Government Energy Management

Energy Systems Integration

High-Performance Computing

Data and Visualizations

High-performance computing

Applied mathematics

Computational science

Visualization and data

Systems

Technologies

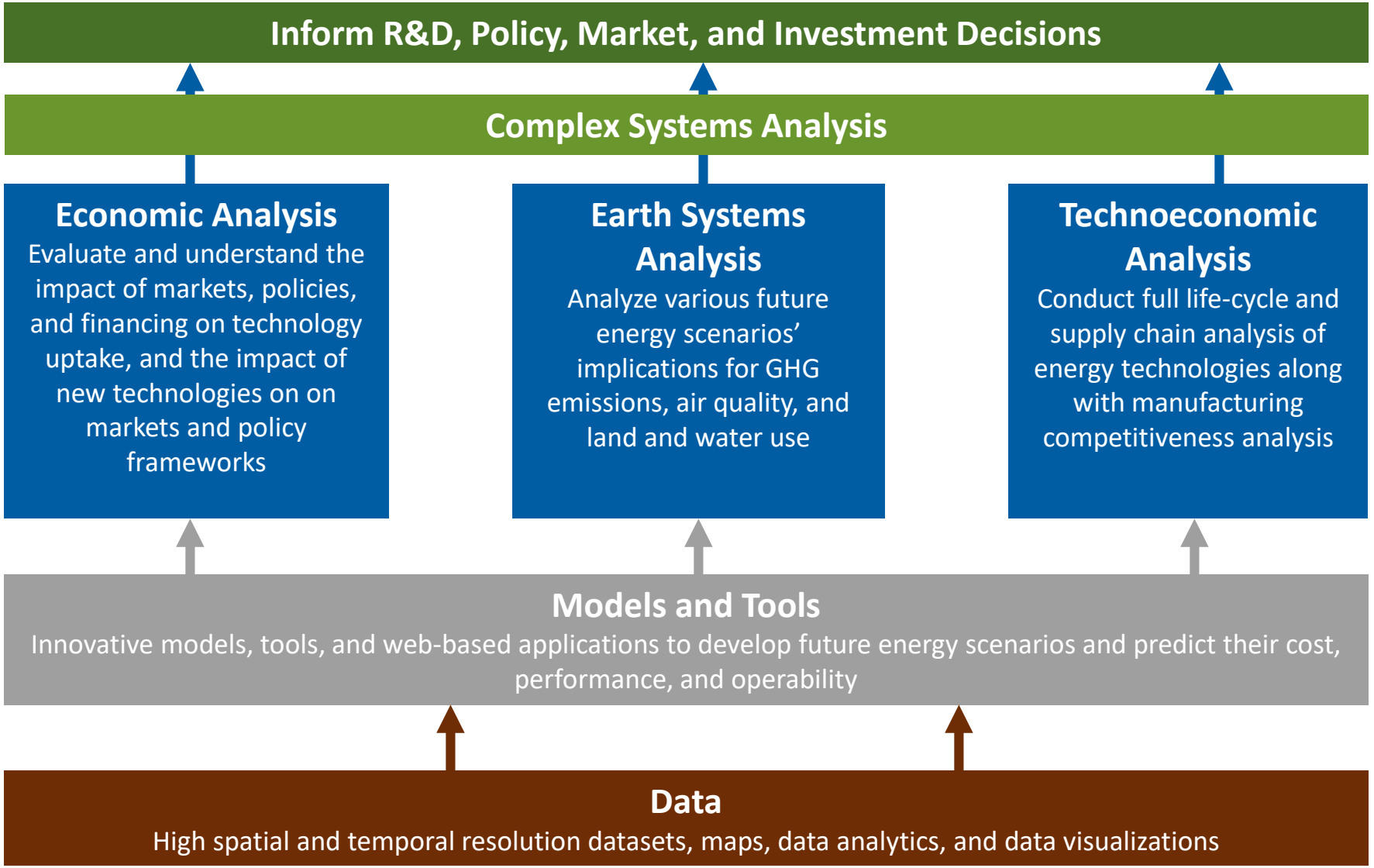
Policies

Resources

Markets

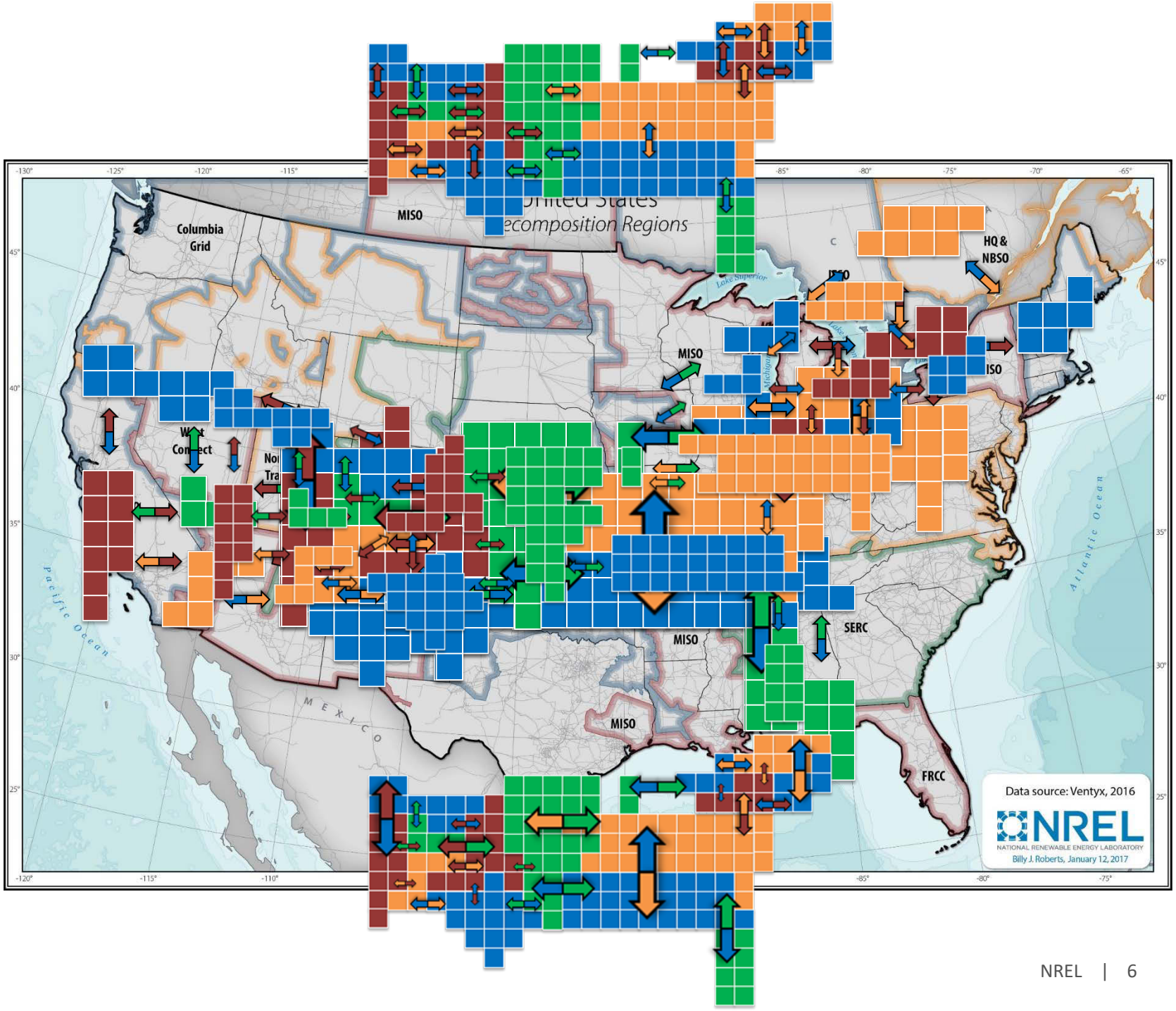
energy analysis

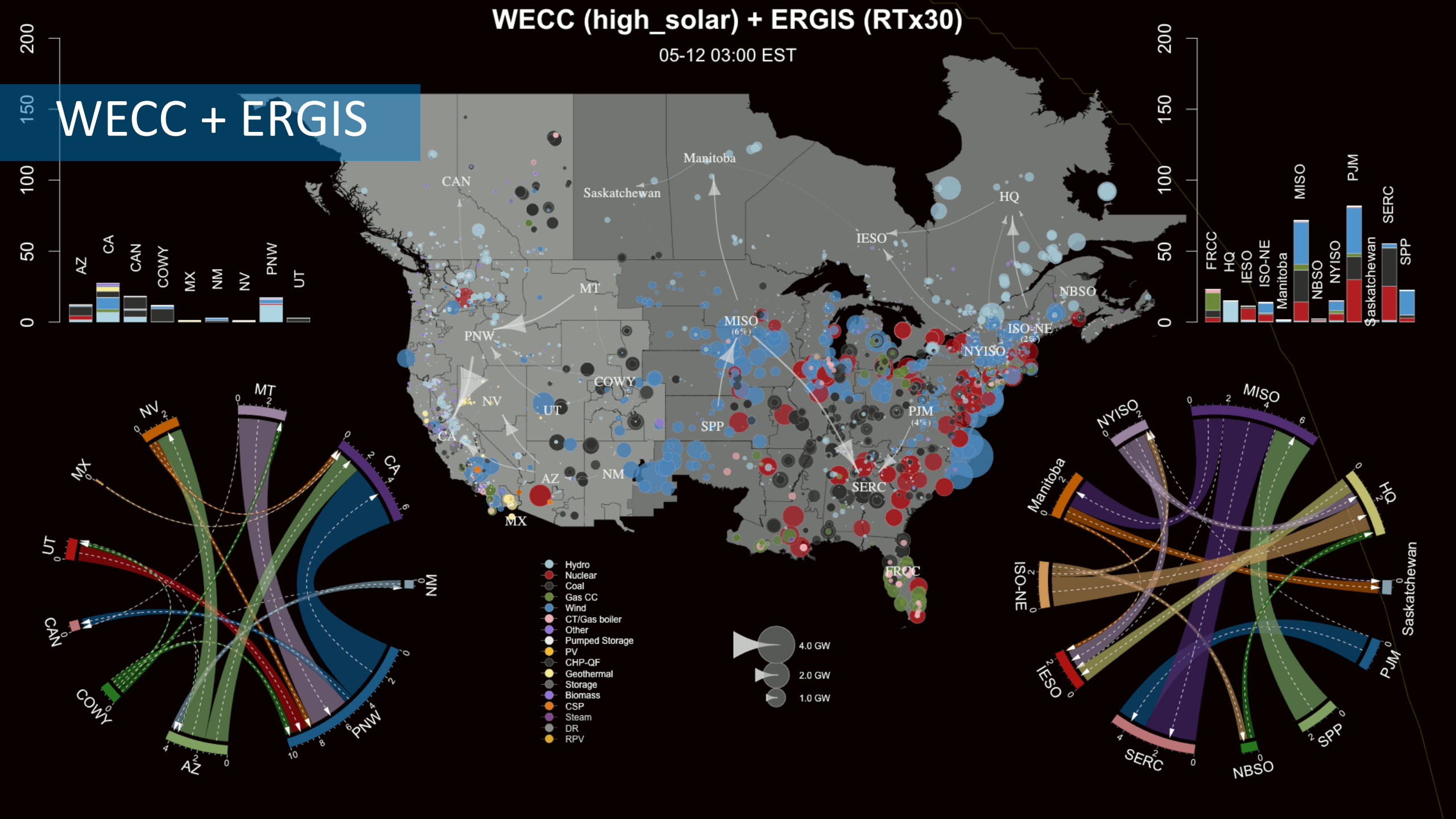
Energy analysis at NREL



Advanced computational methods

- Respects regional operating borders
- Methods solve now in days, not years
- Captures information asymmetries between operators
- Full representation of 98,000 nodes
- Every generator and transmission line




WECC (high_solar) + ERGIS (RTx30)
05-12 03:00 EST
WECC + ERGIS
AZ
CA
CAN
COWY
MX
NM
NV
PNW
UT
FRCC
HQ
IESO
ISO-NE
Manitoba
MISO
NBSO
NYISO
PJM
Saskatchewan
SERC
SPP
Hydro
Nuclear
Coal
Gas CC
Wind
CT/Gas boiler
Other
Pumped Storage
PV
CHP-QF
Geothermal
Storage
Biomass
CSP
Steam
DR
RPV
4.0 GW
2.0 GW
1.0 GW

The North American Renewable Integration Study (NARIS)

National Resources Canada | Ressources naturelles Canada | SENER Secretaría de Energía

RIGOR

State-of-the art methods and state-of-the art data applied to all three countries at once

CONSISTENCY

In data, assumptions, methods used for all three countries (five interconnections)

SCALE

Geographically the largest study of its kind, allowing us to study new things

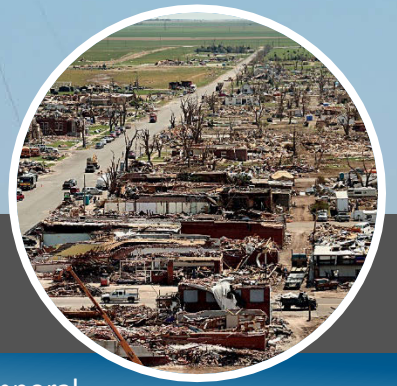
https://www.nrel.gov/analysis/naris.html

Where we're headed

Continental systems

Spatial

Components



Temporal

Microseconds

Decades

SYSTEM STABILITY

Model transients

Bound dynamics / resiliency

Feedback

POWER PRODUCTION

Weather X 50

Constraints

Behavior of market participants

Feedback

CAPACITY EXPANSION

Optimize infrastructure

Resiliency

Cost

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Thank You

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Models and tools

Model/Tool Name	Web Address
Advanced Energy Systems Design	https://www.nrel.gov/technical-assistance/advanced-energy-systems-design.html
Regional Energy Deployment System (ReEDS)	http://www.nrel.gov/analysis/reeds/
Resource Planning Model (RPM)	http://www.nrel.gov/analysis/models_rpm.html
Systems Advisor Model (SAM)	http://sam.nrel.gov/
PVWatts	http://pvwatts.nrel.gov/
Solar Deployment System (SolarDS)	http://www.nrel.gov/docs/fy10osti/45832.pdf
Jobs and Economic Development Model (JEDI)	http://www.nrel.gov/analysis/jedi/
Distributed Generation (dGen)	http://www.nrel.gov/XXXX
Biomass Scenario Model (BSM)	

Data and resources

Data/Data Resource	Web Address
Open Energy Information Platform (OpenEI)	http://en.openei.org/wiki/Main_Page
Annual Technology Baseline and Standard Scenarios (ATB and Standard Scenarios)	http://www.nrel.gov/analysis/data_tech_baseline.html
Transparent Cost Database	http://en.openei.org/wiki/Transparent_Cost_Database
Wind Integration Datasets (and solar?)	http://www.nrel.gov/electricity/transmission/wind_integration_dataset.html
Utility Rate Database	http://en.openei.org/wiki/Gateway:Utilities
RE Project Finance	https://financere.nrel.gov/finance/
Regulatory and Permitting Information Desktop (RAPID) Toolkit	http://en.openei.org/wiki/RAPID

OpenCarto and key resource data sets	
Visualization Platform	e.g, http://www.nrel.gov/analysis/re_futures/data_viewer/
Developer Platform for data API's	http://developer.nrel.gov/
Clean Energy Solutions Center	www.cleanenergysolutions.org
Geospatial Toolkit	
Geothermal Data Repository (GDR)	
Geothermal Prospector	
RAPID (Regulatory Roadmap) Toolkit	
Renewable Energy Probabilistic Resource Adequacy (REPRA)	

Tools for electricity modeling at multiple scales

Global

U.S.

Regional/ Balancing Area

Generator

Geographic scale

IAMs, CGEs
Global energy-economic-climate

SolarDS
Rooftop PV adoption

ReEDS
National policy, market, technology analysis

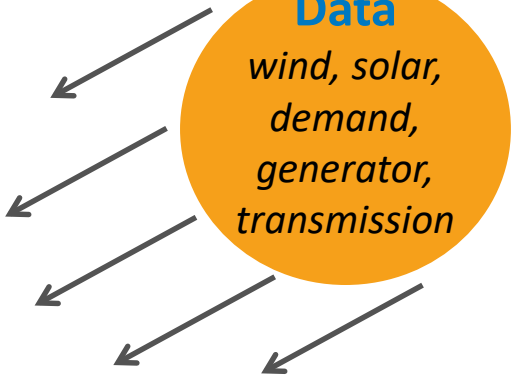
RPM
Regional integrated resource planning

ABM
Agent Based Models of Customer Behavior

Capacity Expansion Models

System Models

Production Cost / Grid Simulation Models



PLEXOS
Security-constrained unit commitment & economic dispatch

FESTIV
Automatic generation control (AGC) & dispatch

SAM
Hourly plant output

Temporal resolution

Annual

Seasonal/Diurnal

Hourly

Sub-hourly