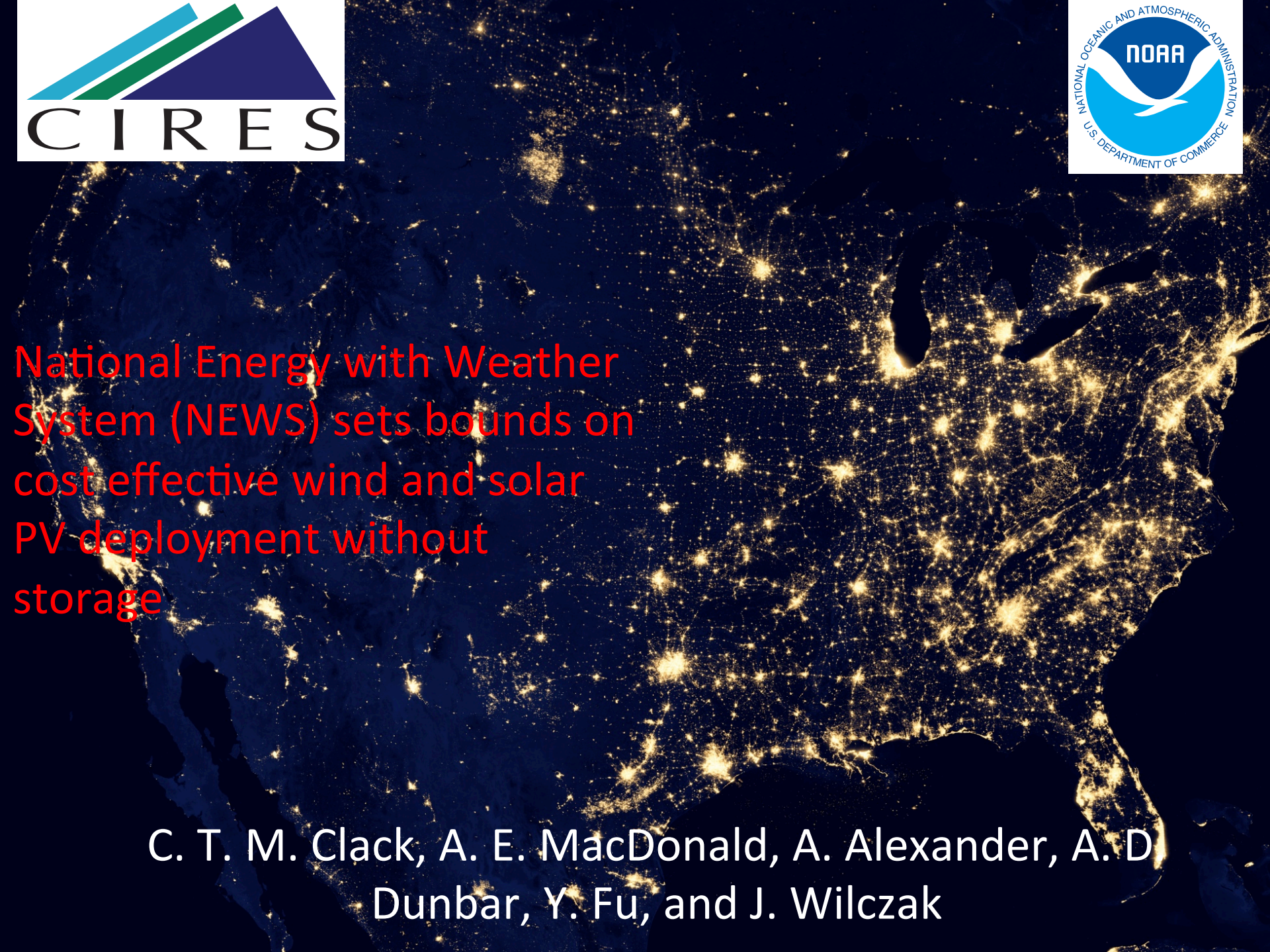
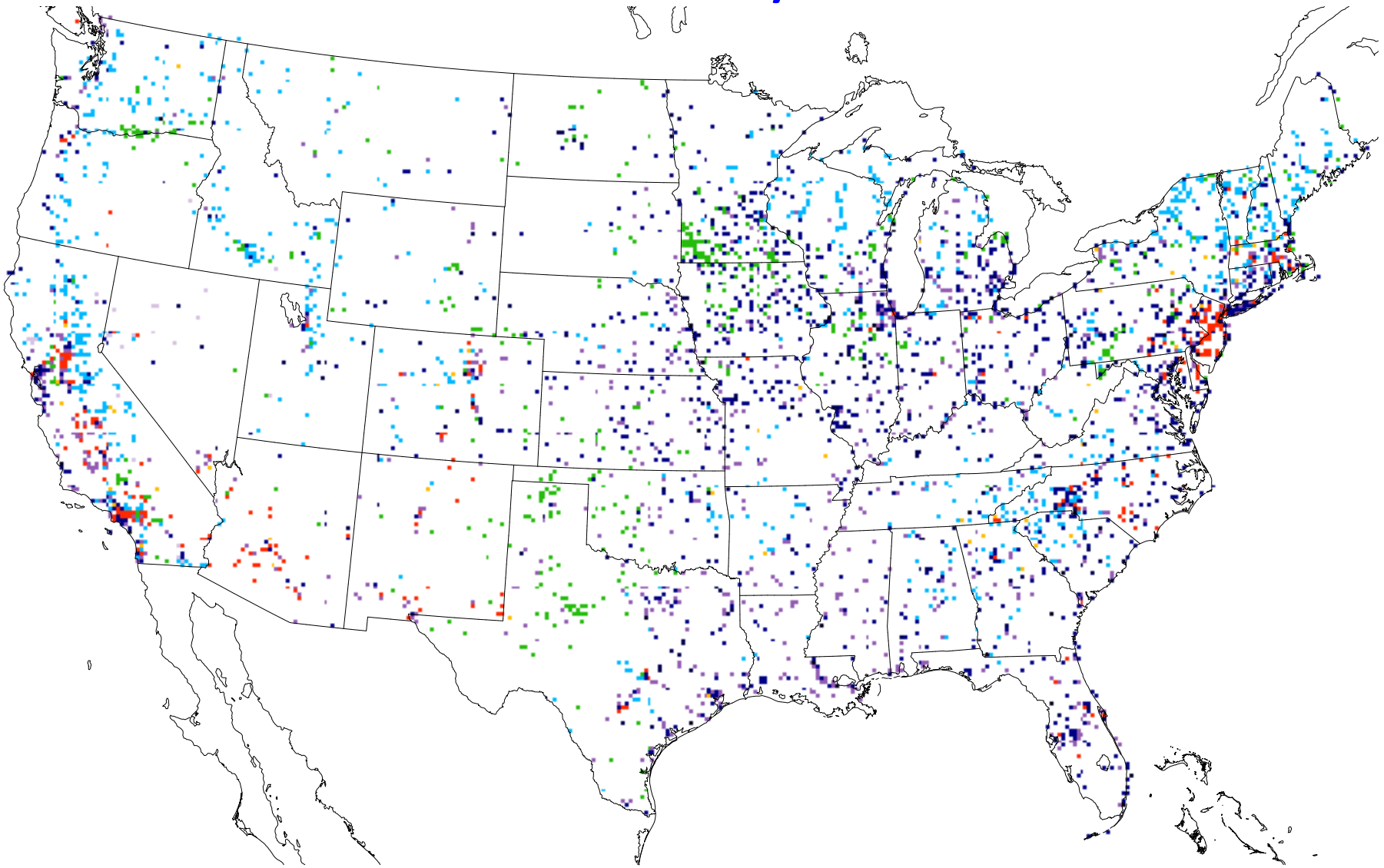


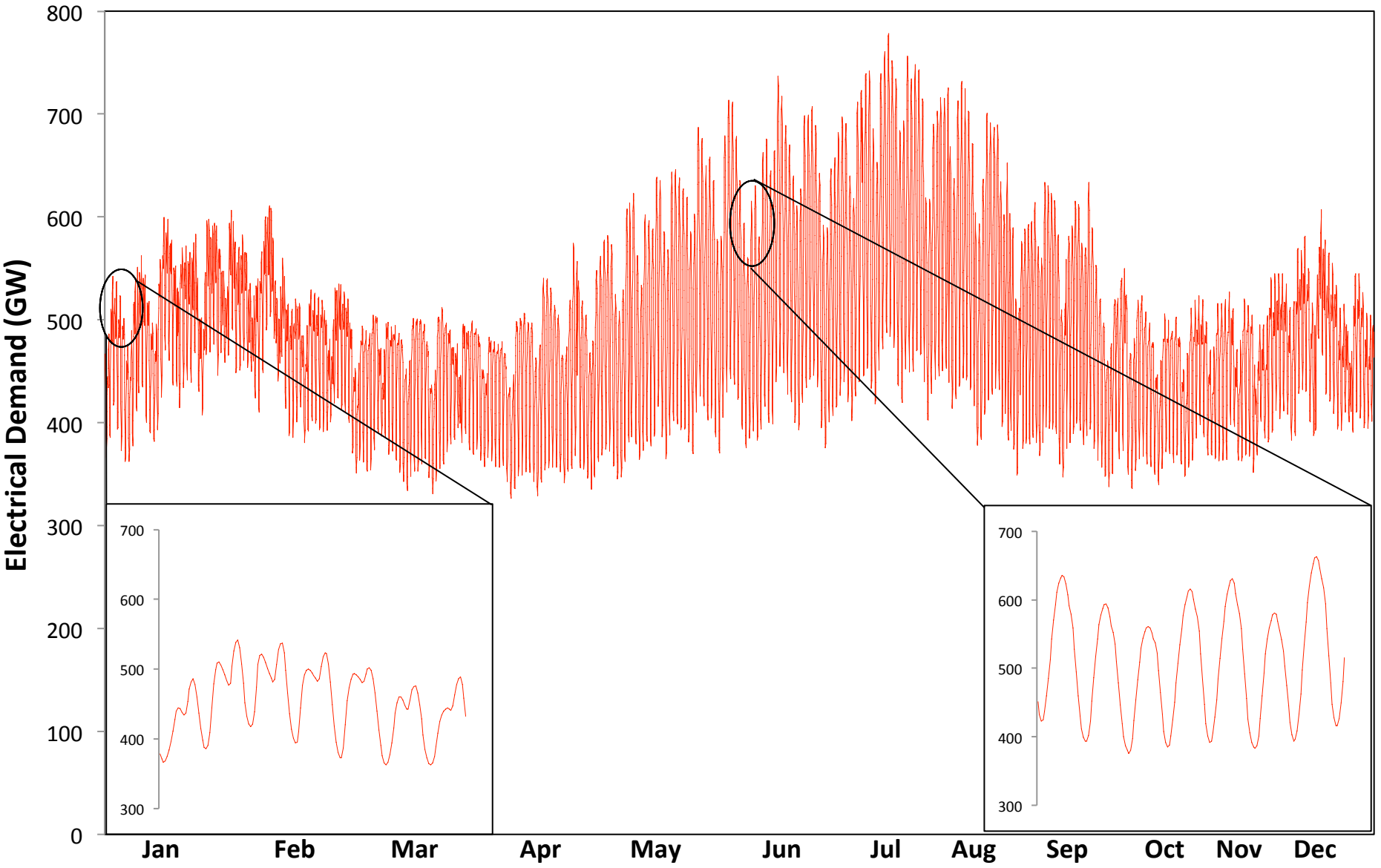
National Energy with Weather System (NEWS) sets bounds on cost effective wind and solar PV deployment without storage

C. T. M. Clack, A. E. MacDonald, A. Alexander, A. D Dunbar, Y. Fu, and J. Wilczak

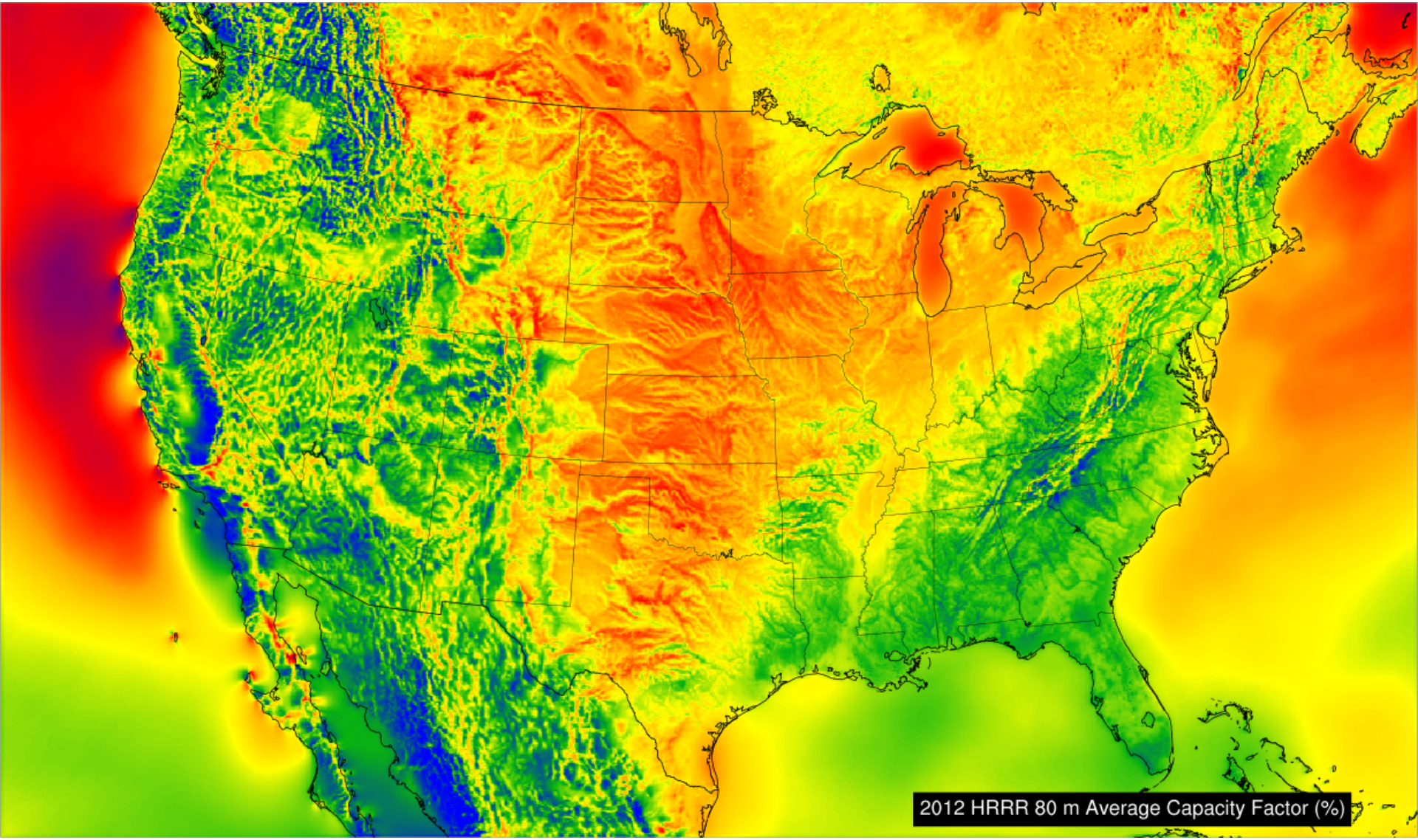
The Electric Power System in 2012



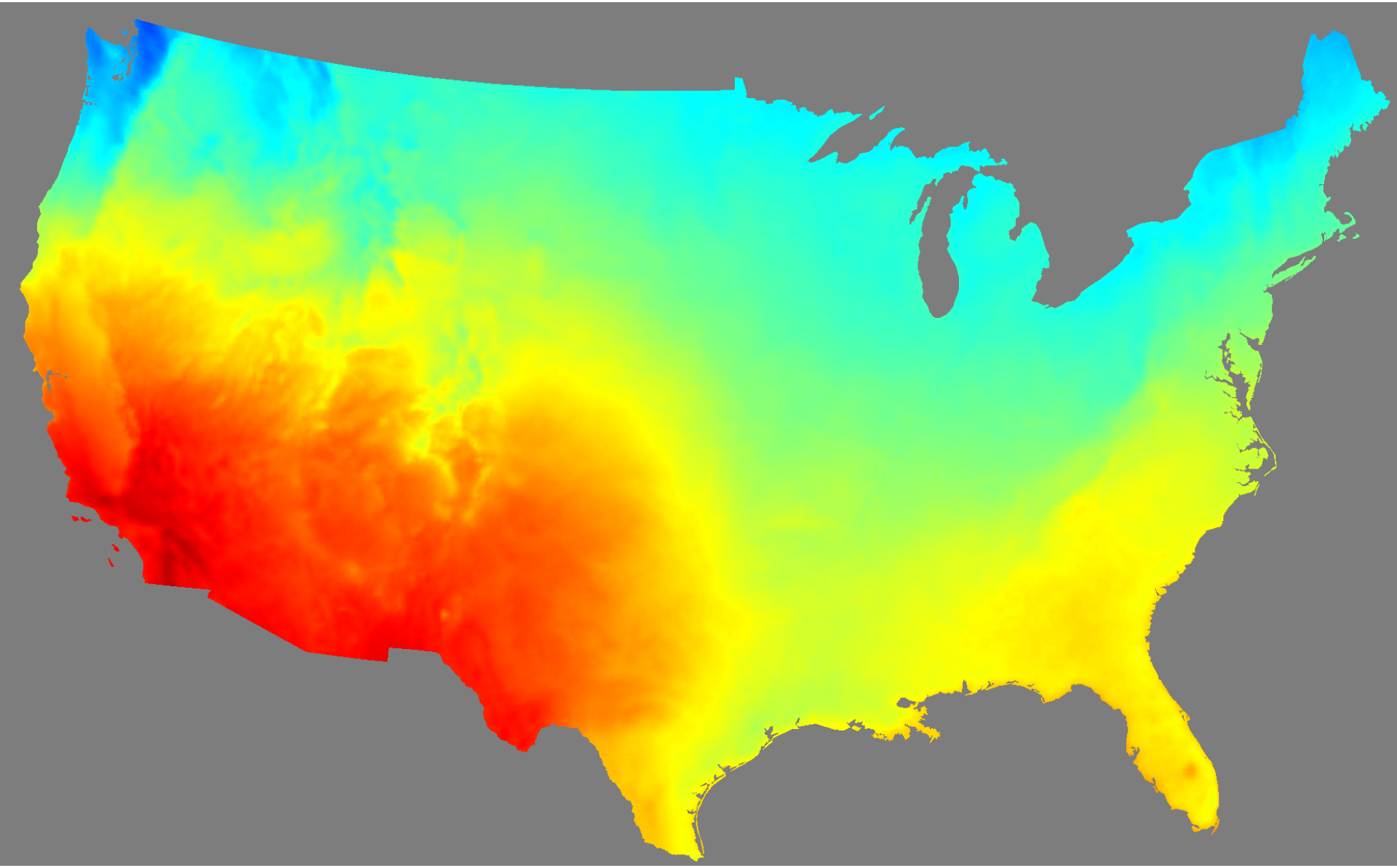
Electric Demand/Load



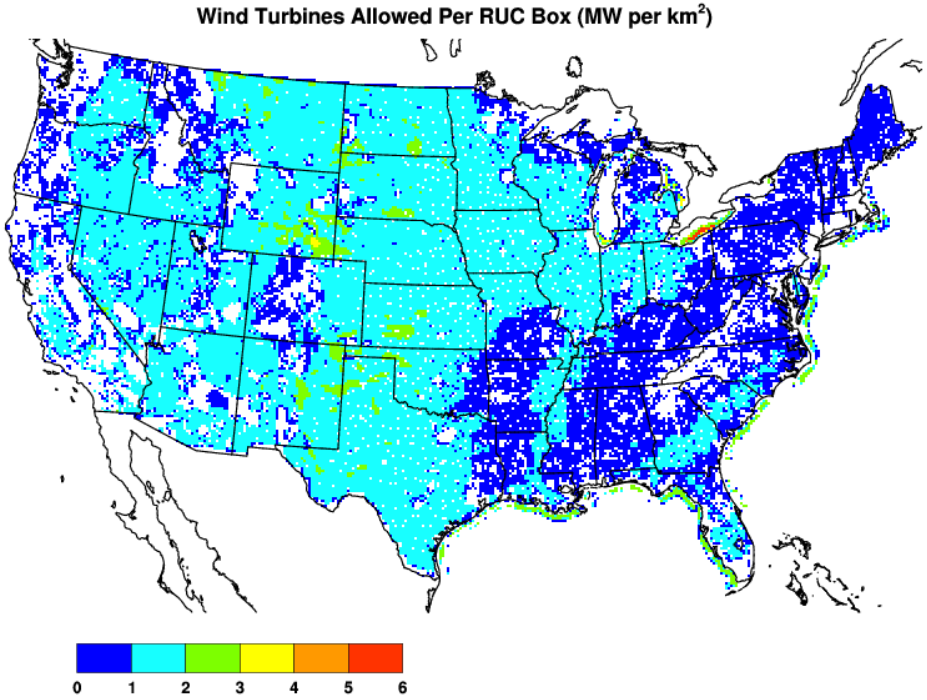
Average Wind Power

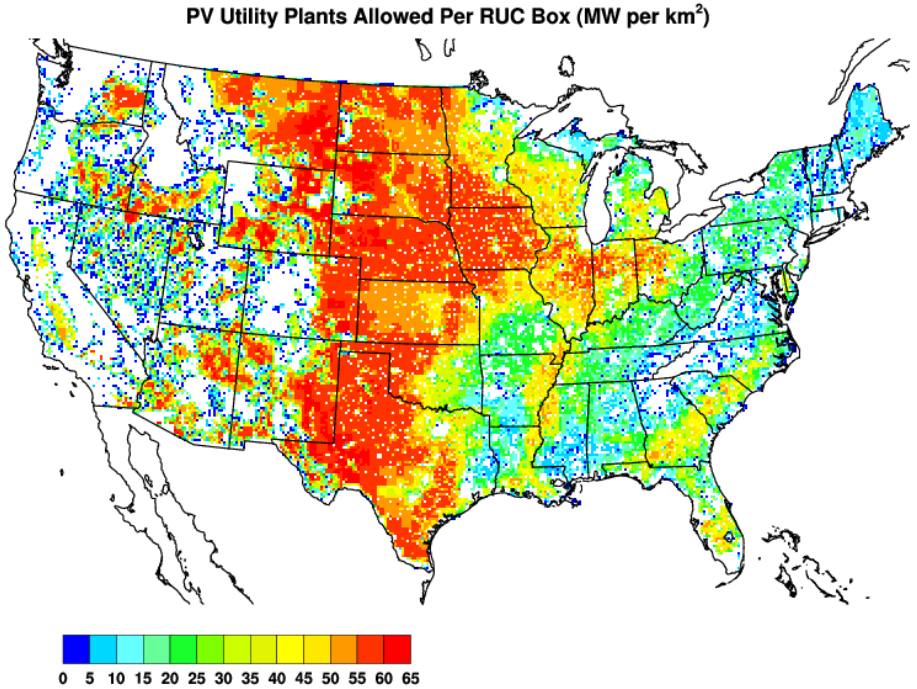


Average Solar PV Power



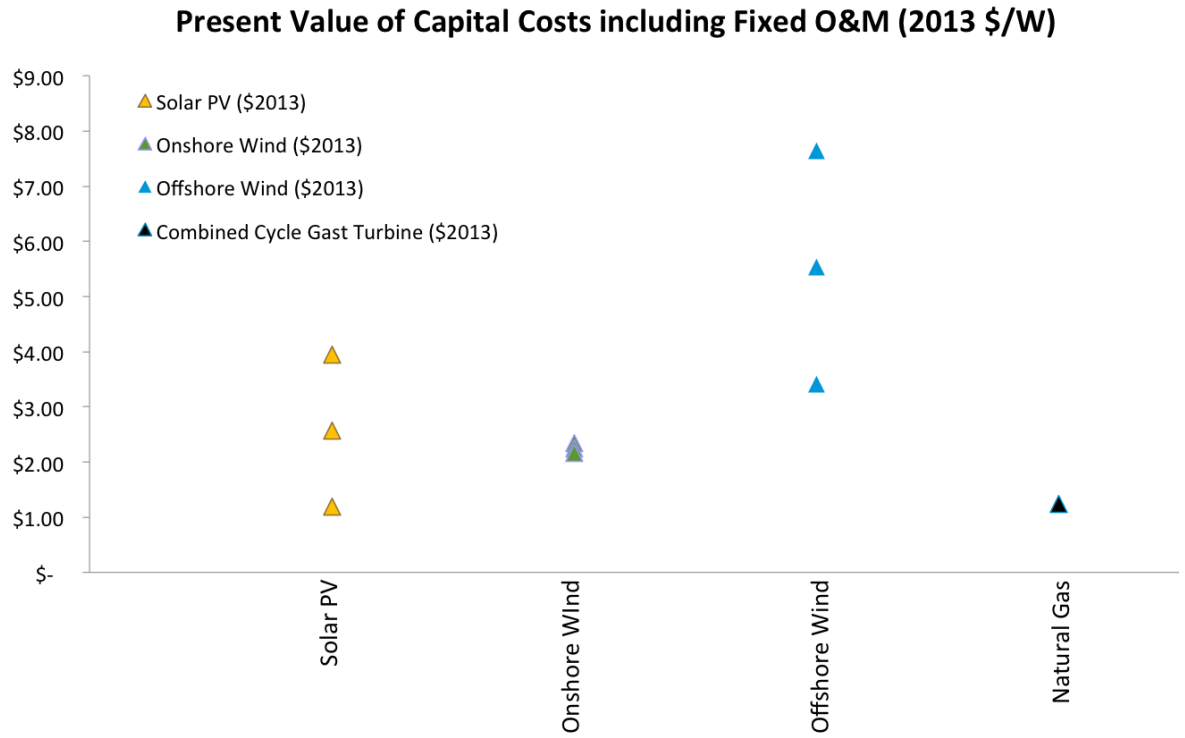
Land Use Constraints





- The type and amount of electricity generation installed in each RUC cell is constrained by:
  - **Spacing between facilities**
  - **Topography of the land**
  - **Land Use (residential, commercial, protected lands, etc…)**

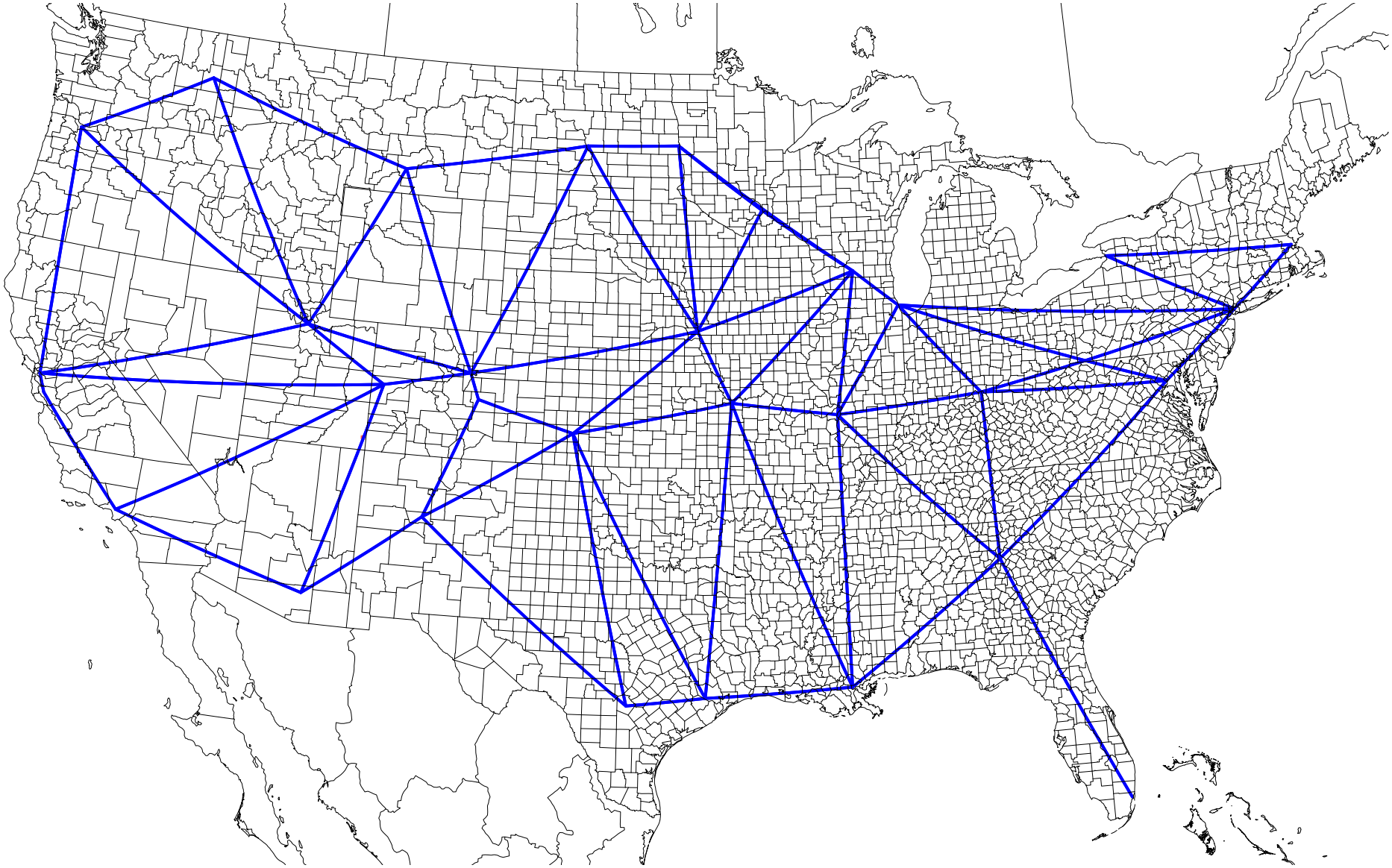
Cost Data



	Onshore	Offshore	PV	CCGT	NG Fuel	HVDC lines	HVDC Stations
Low W&S High NG	$2.16	$3.41	$1.19	$1.24	$11.10	$701.36	182,856.11
Mid W&S Mid NG	$2.25	$5.53	$2.57	$1.24	$8.82	$701.36	182,856.11
High W&S Low NG	$2.36	$7.64	$3.94	$1.24	$5.40	$701.36	182,856.11

Natural gas has a heat rate of 6430 Btu / kWh. Variable O&M is $3.11 / MWh

HVDC Transmission

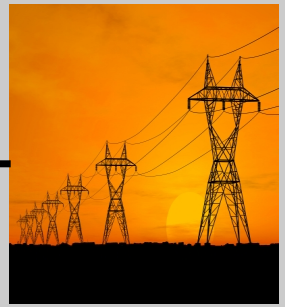


Mathematical Optimization

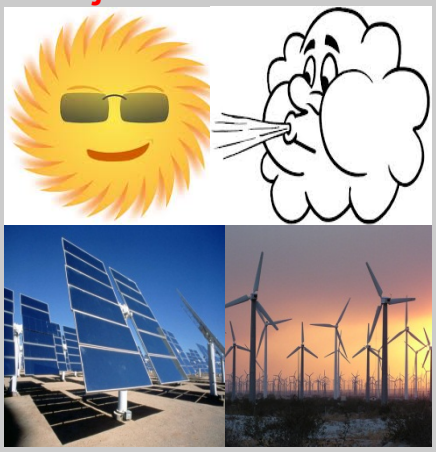
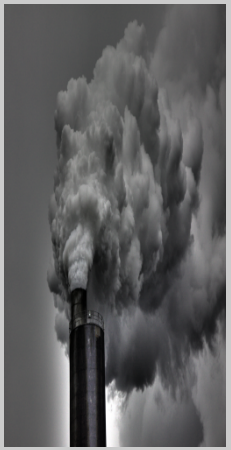
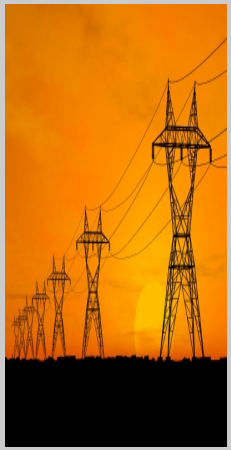
Minimize:





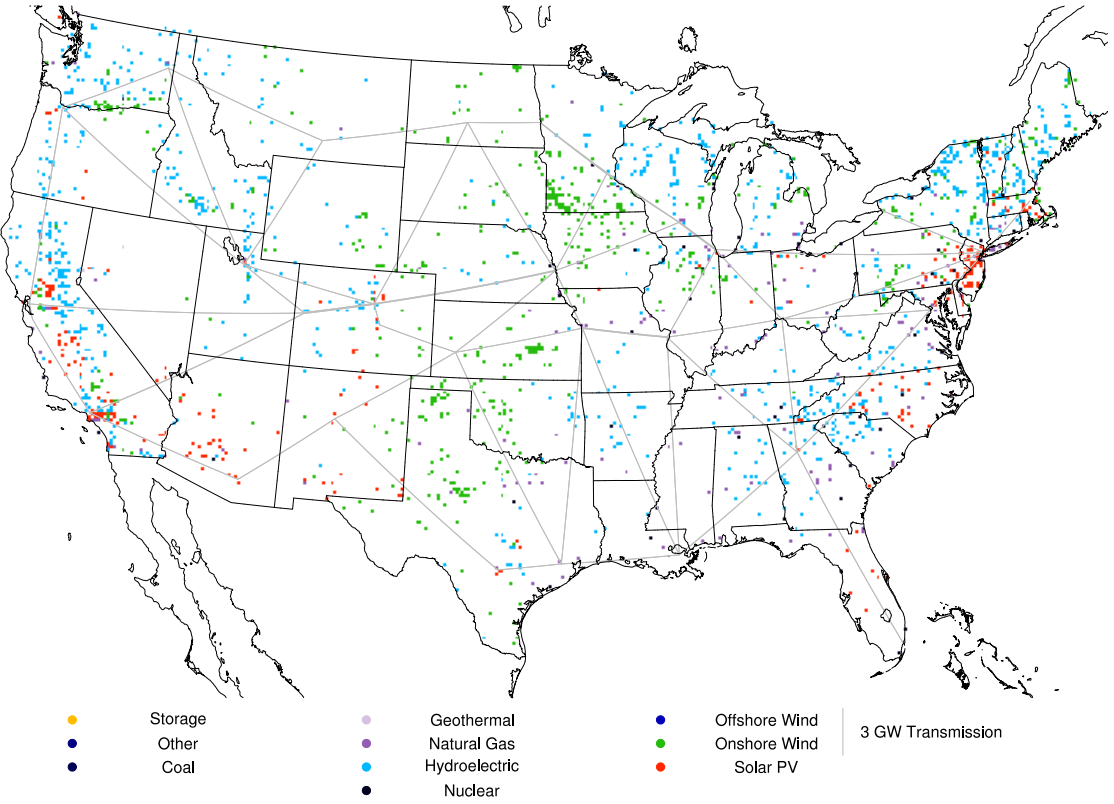
Subject to:

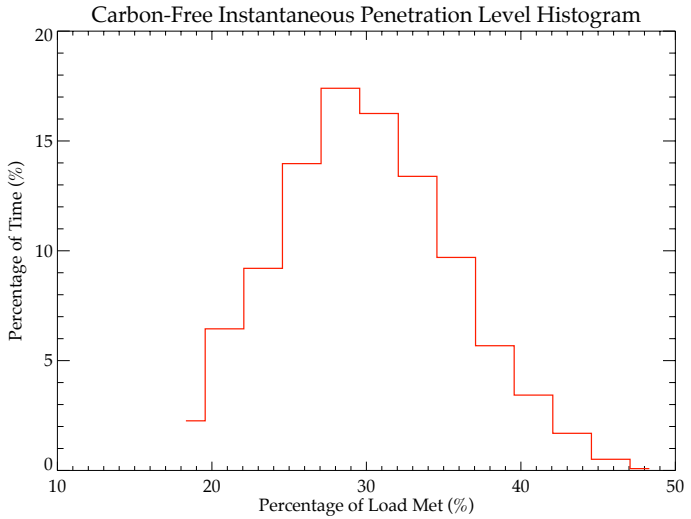




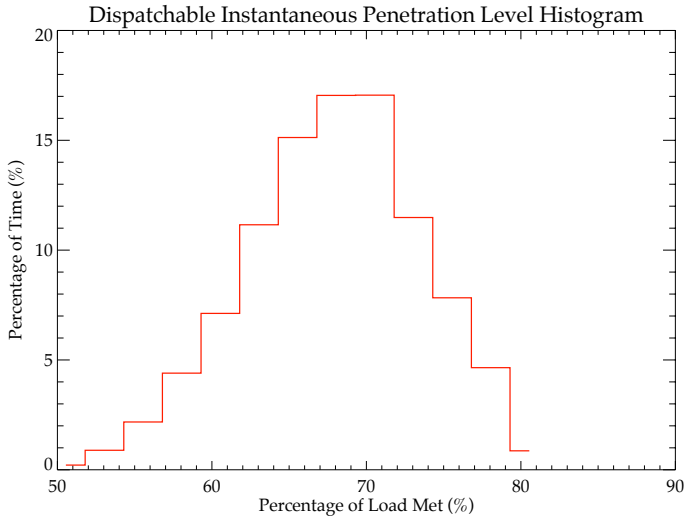

ALL OTHER EQUATIONS CONSTRAIN THE MAGNITUDE OF ANY OF THE TERMS

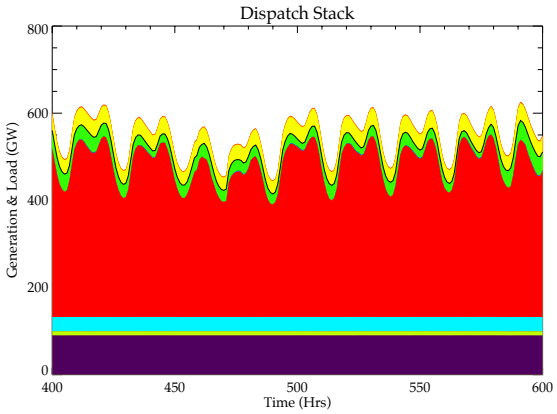
For details of the NEWS optimization see Clack *et al.*, IJEPES 2015.

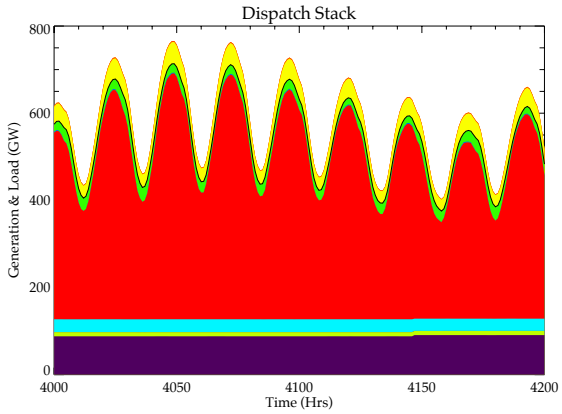
Today's Prices without Coal

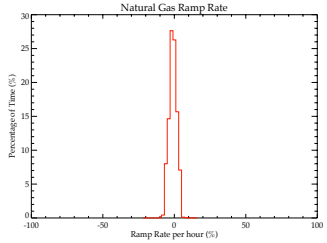


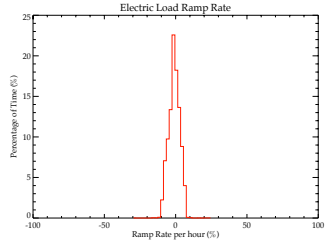




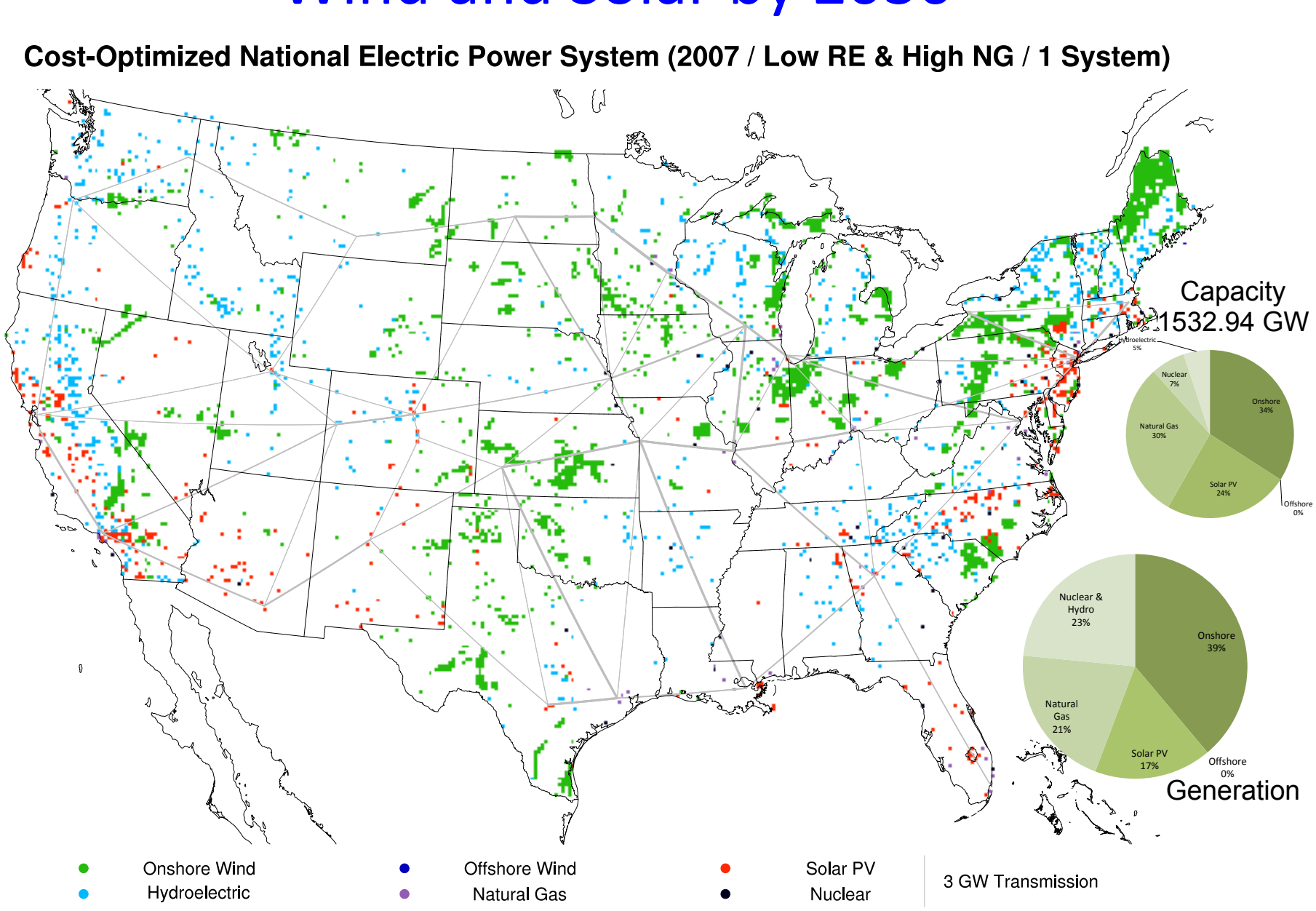




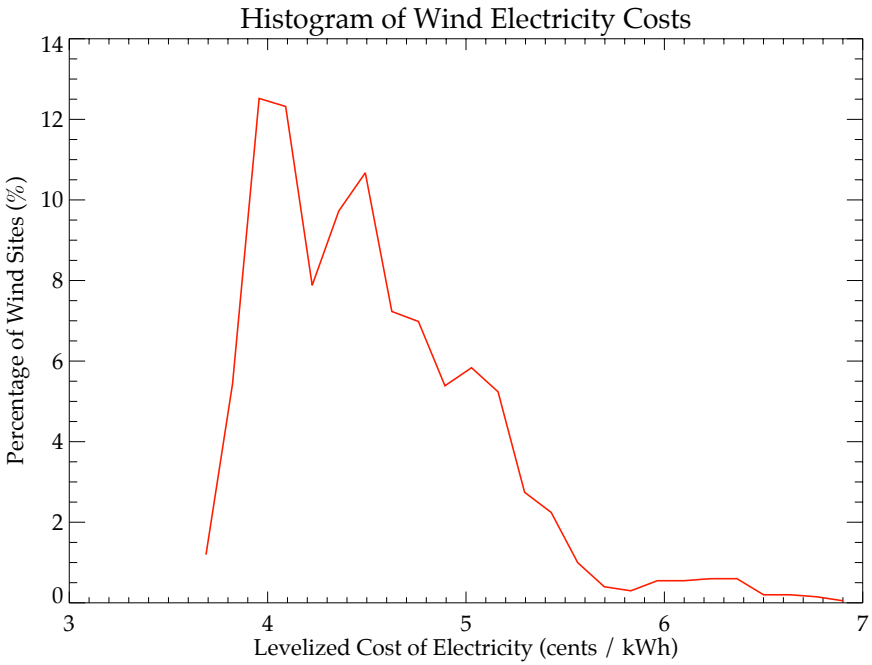




Wind and Solar by 2030

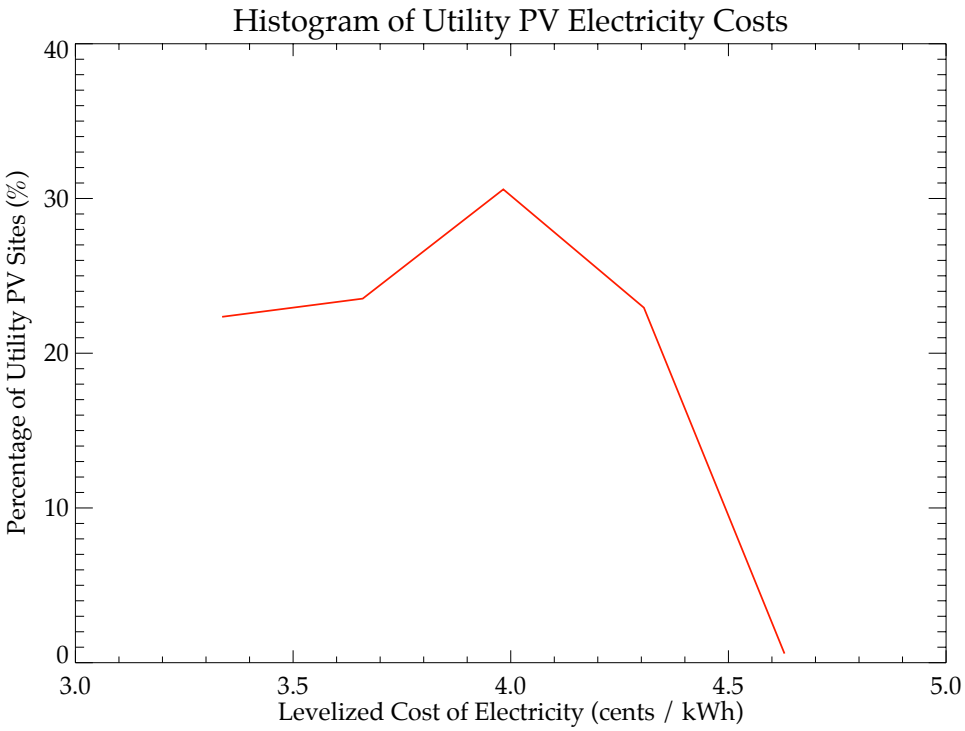


Wind and Solar by 2030

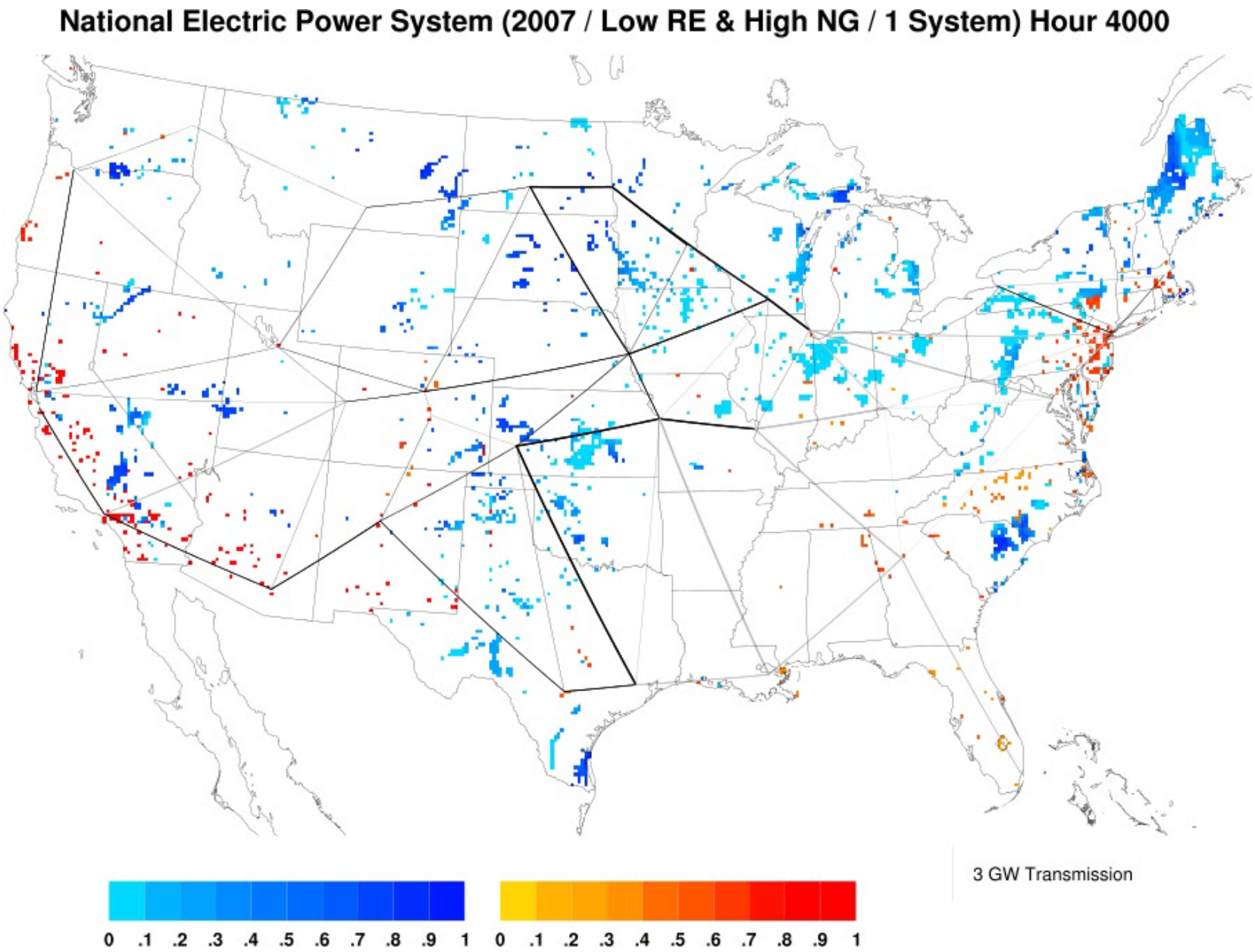


System uses only ~ 205,000 3MW wind turbines
~ 460 km^2 taken out of current use

System uses only ~ 18,500 20MW PV plants
~ 6,110 km^2 taken out of current use

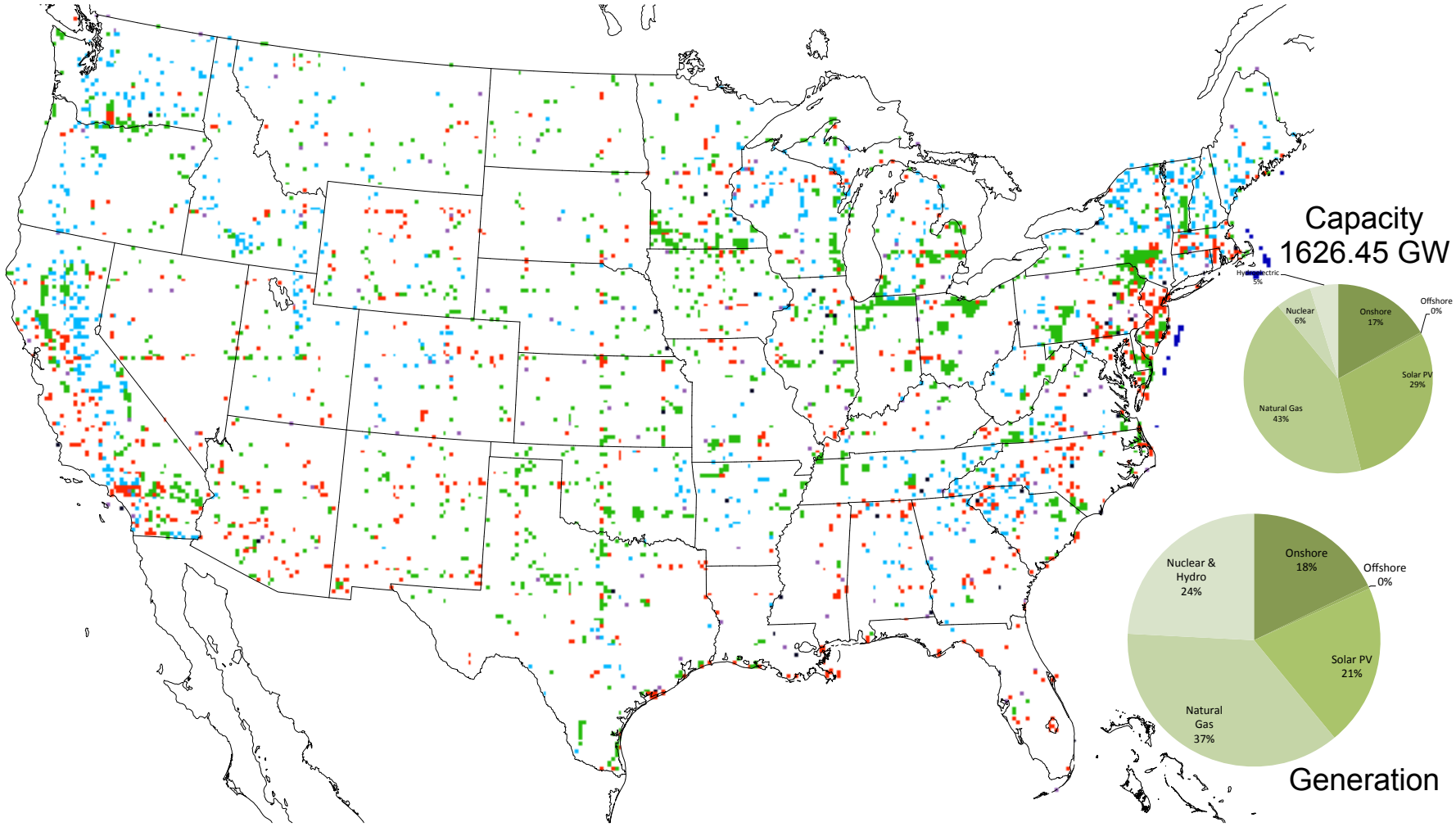


Wind and Solar Dispatch Display

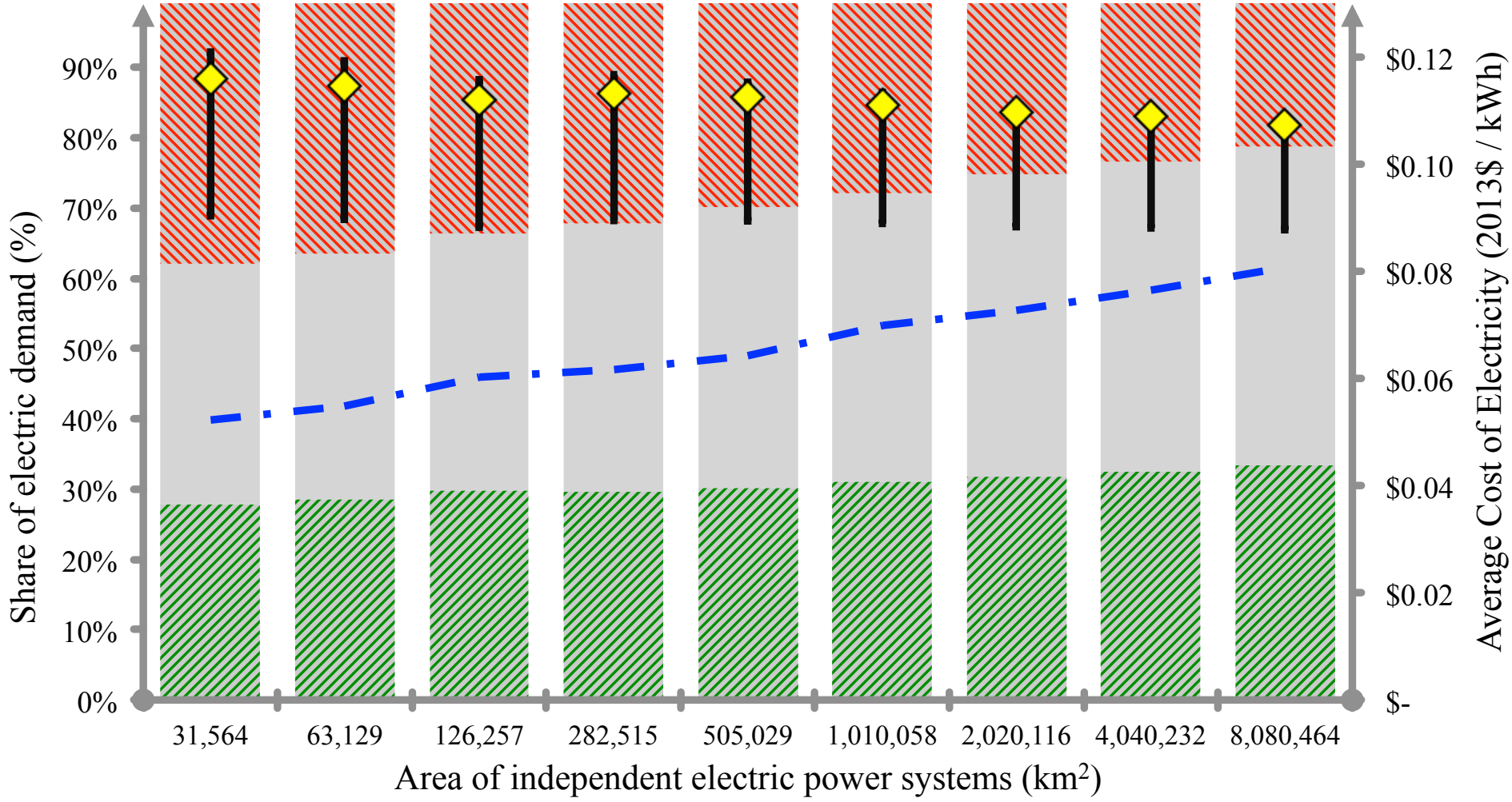


Geographic Scaling: 128th CONUS

Cost-Optimized National Electric Power System (2007 / Low RE & High NG Costs / 128 Systems)



What are the effects of Scaling and Cost?



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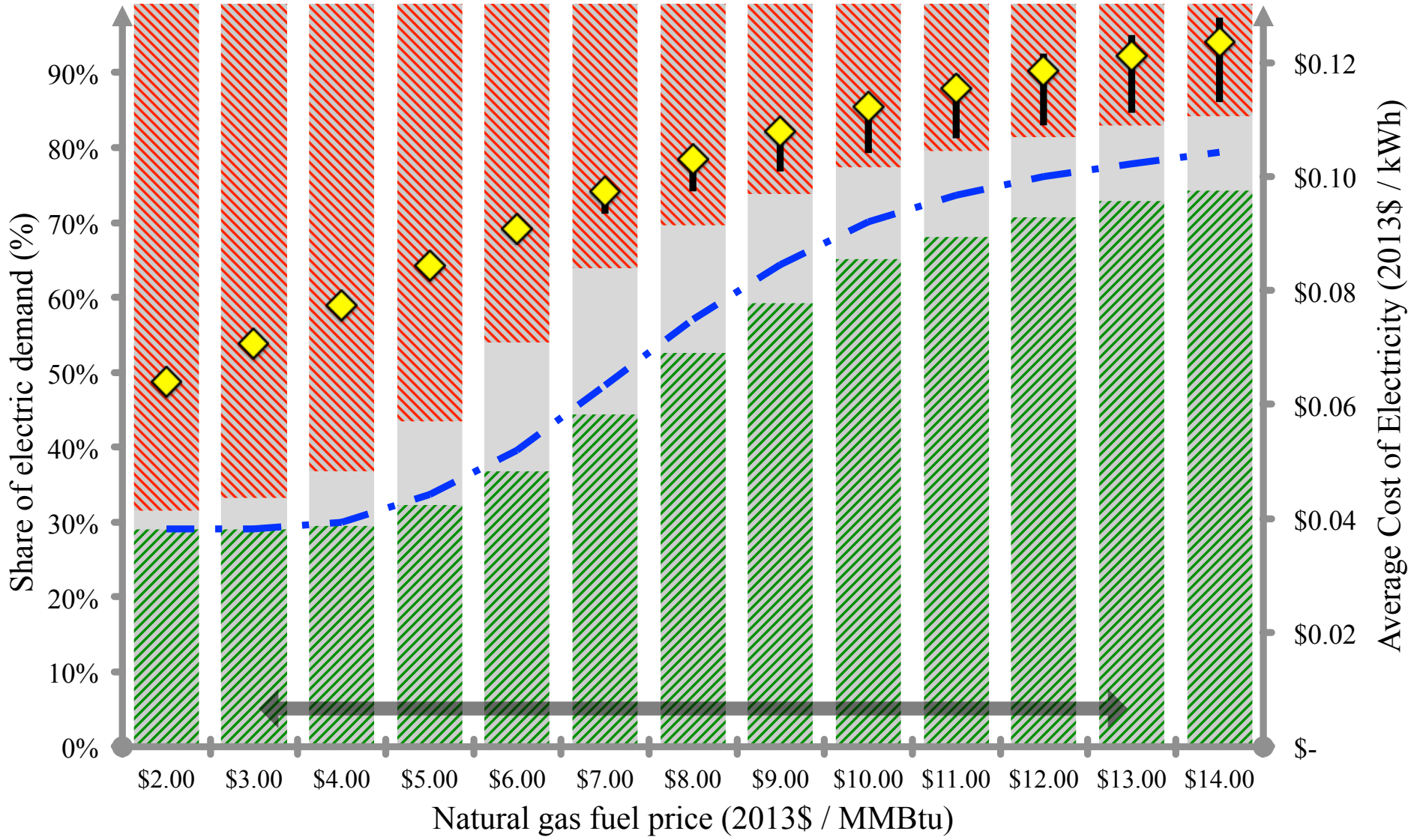
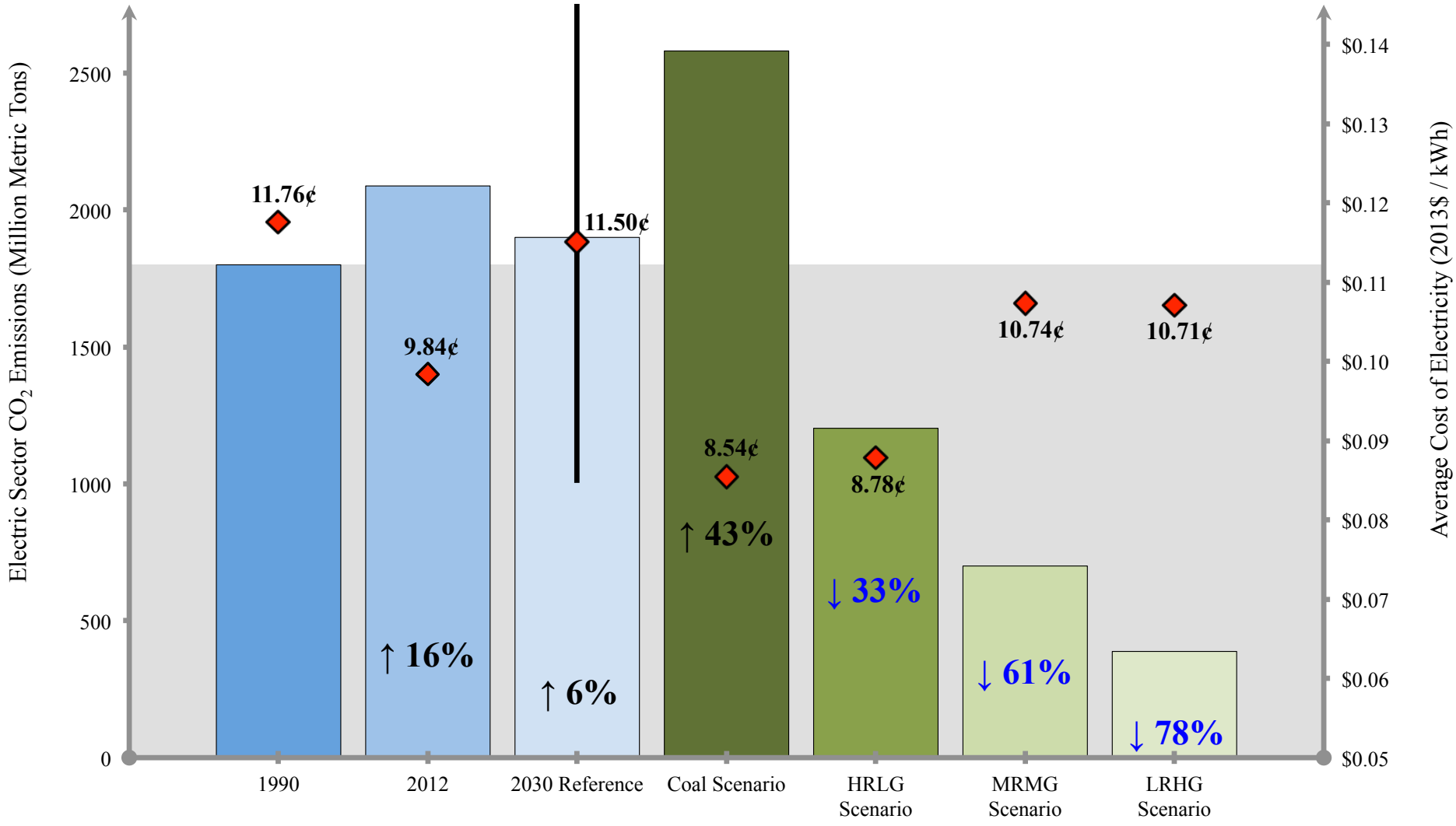


What can the US achieve and what will it cost?*



* Without storage and with current technologies

Conclusions and Future Work

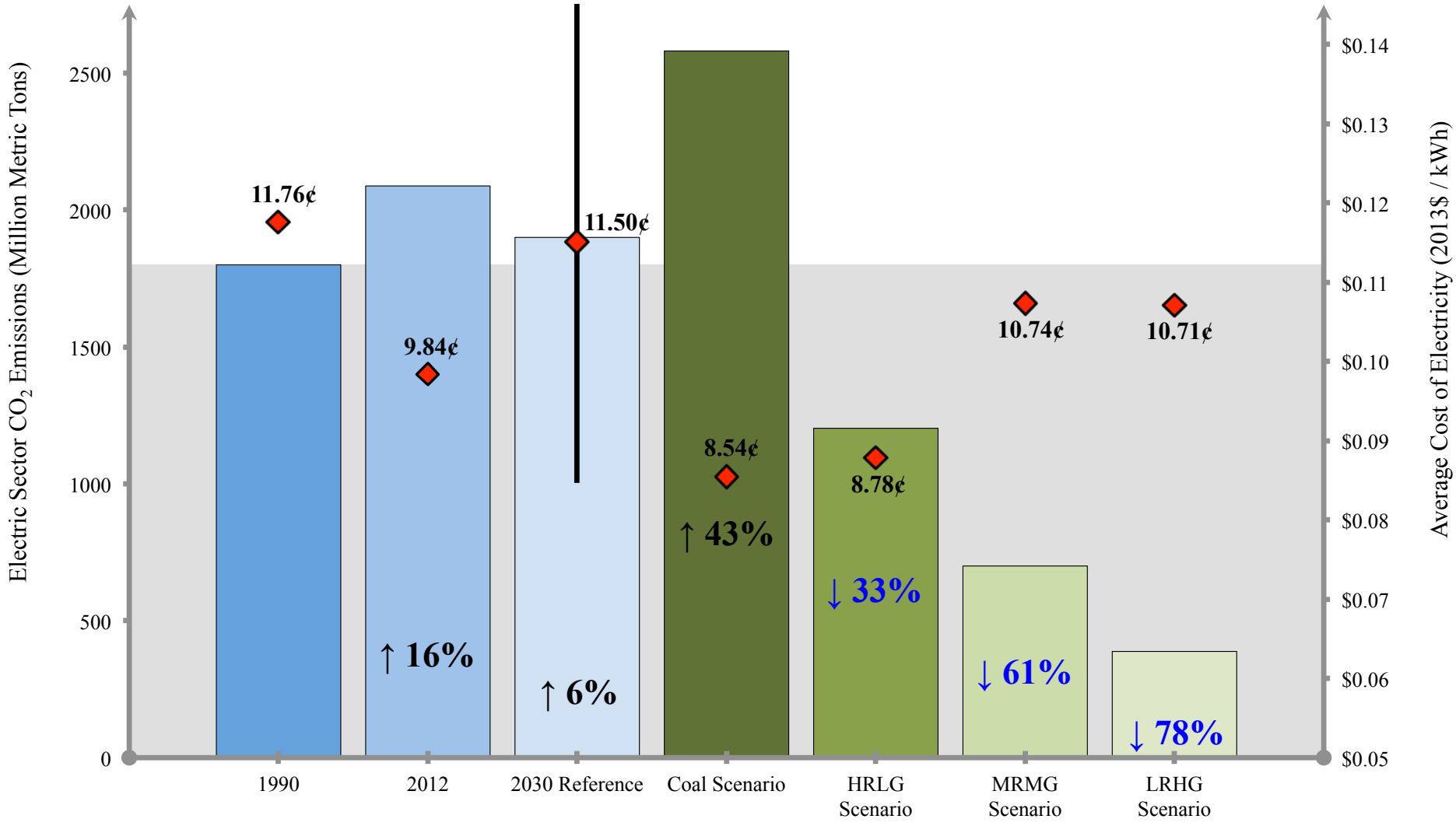
- The US can technically produce up to 80% of its electricity from wind and solar PV alone by 2030 at costs similar to those today:

  i. If national high-voltage direct-current transmission system is implemented.
  ii. If the US moves away from a localized system to a large-scale system.
  iii. If wind and solar PV reach the predicted by that time.
  iv. Without the use of electric storage or new technologies.

- Other technologies will play a role, but we show that the variability of the weather is not an over-riding limitation or resistance to a low carbon system.

- Further work:
  a) Stochastic Optimization with more years to optimize upon;
  b) Agent based modeling of the policies, utilities, consumers, etc. to produce a planning tool that factors in non-deterministic behavior;
  c) Sensitivity investigations into dynamic pricing within the optimization;
  d) More technologies included in the model (e.g. CSP, MHK, etc.);
  e) Produce a road map of investment periods to provide guidance of what are the first critical places to build transmission or power plants;
  f) And much more…

Questions?



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