A market design integrating the view of stochastic producers

Antonio J. Conejo, Ramteen Sioshansi

THE OHIO STATE UNIVERSITY

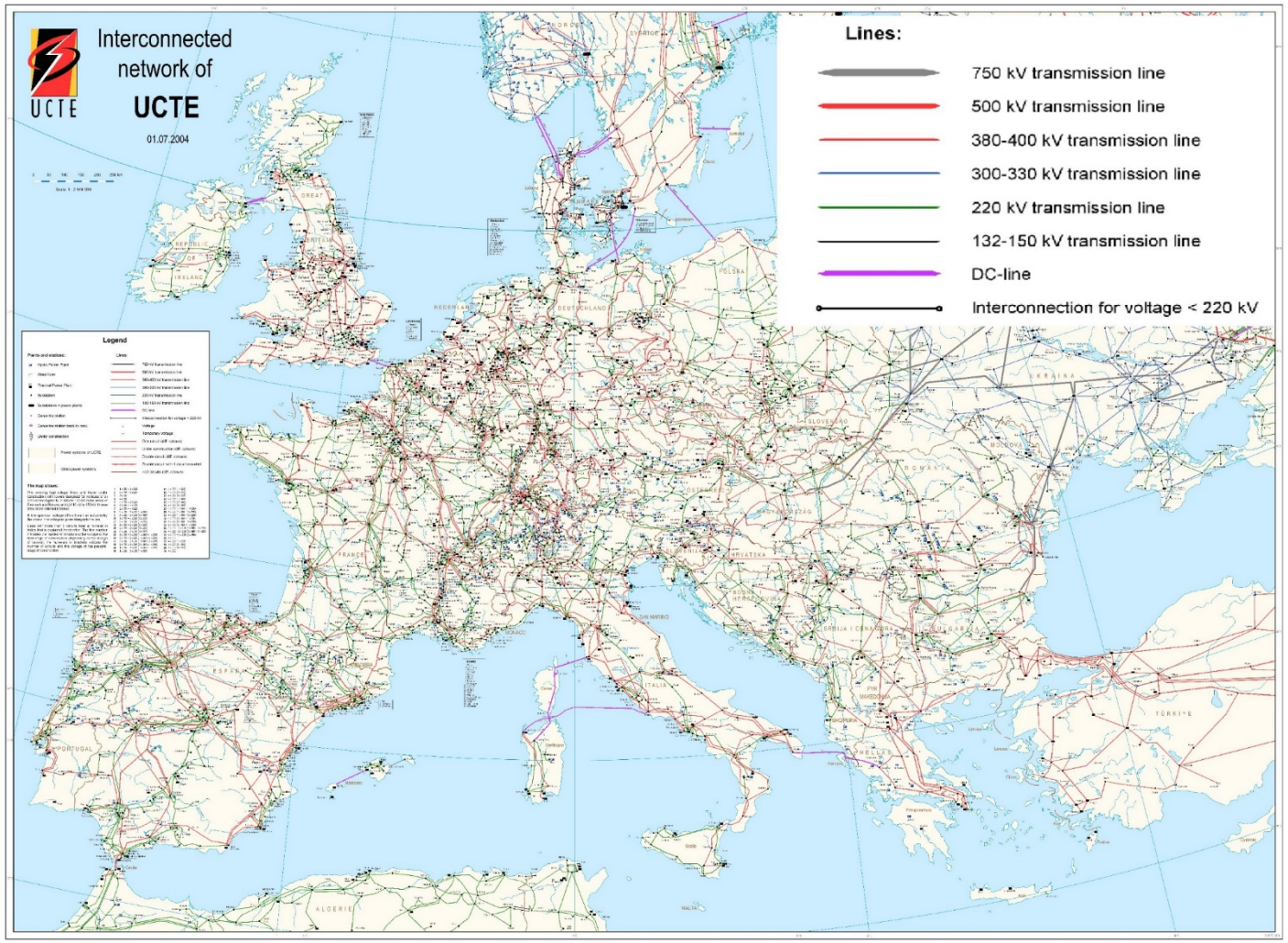
A market design integrating the view of stochastic producers

- History
- Wester European view
- US view
- Issues
- Proposal
- Conclusions

History

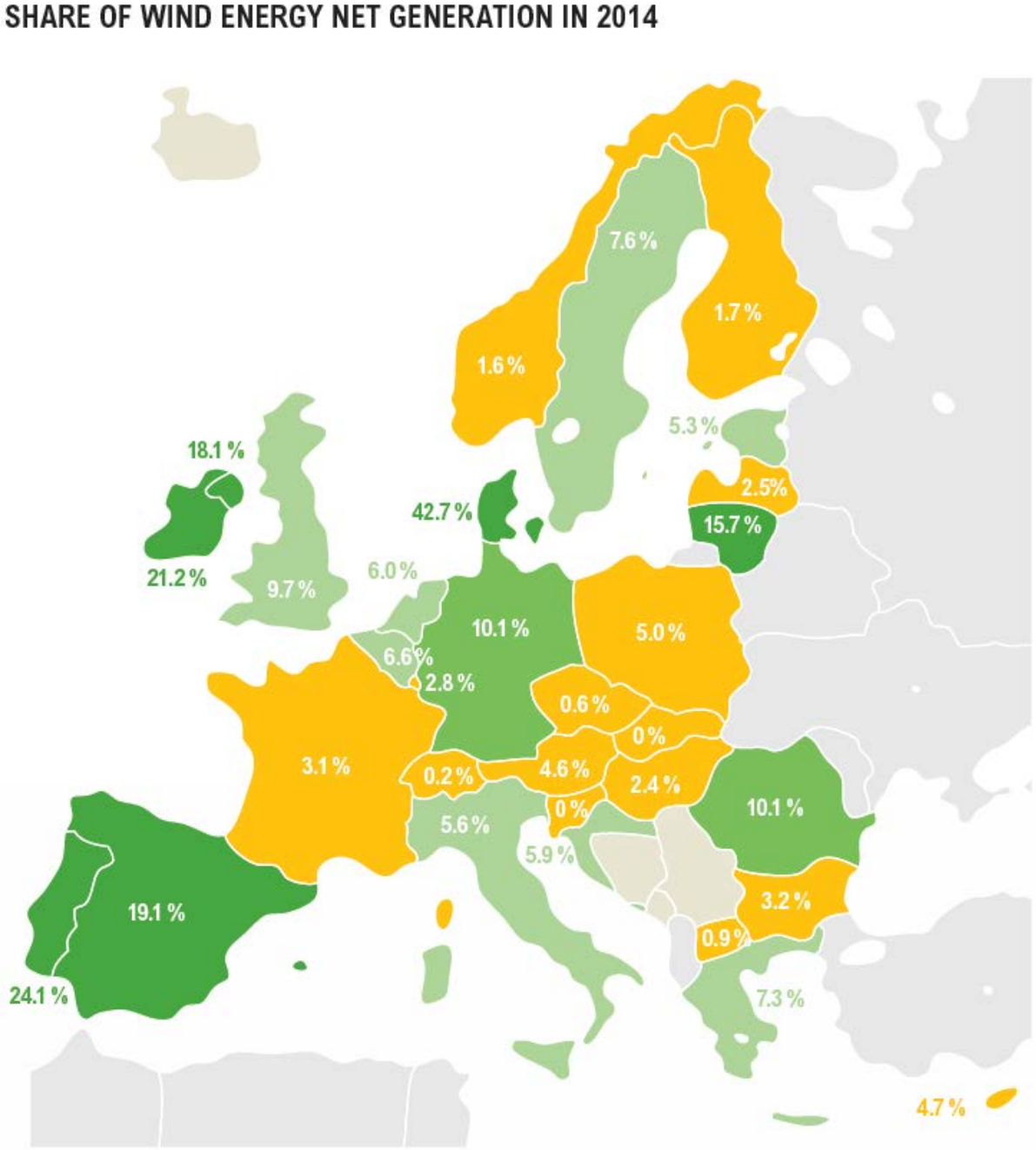
- Most electricity markets in US and Western Europe (WE) realized in the late 90s
- No relevant stochastic (wind- or solar-based) producer operated at the time
- Thus, the *stochastic producer view* was not incorporated in the market design
- Do we need to update the current market design?
- Updating may correct previous design flaws

Wester European view

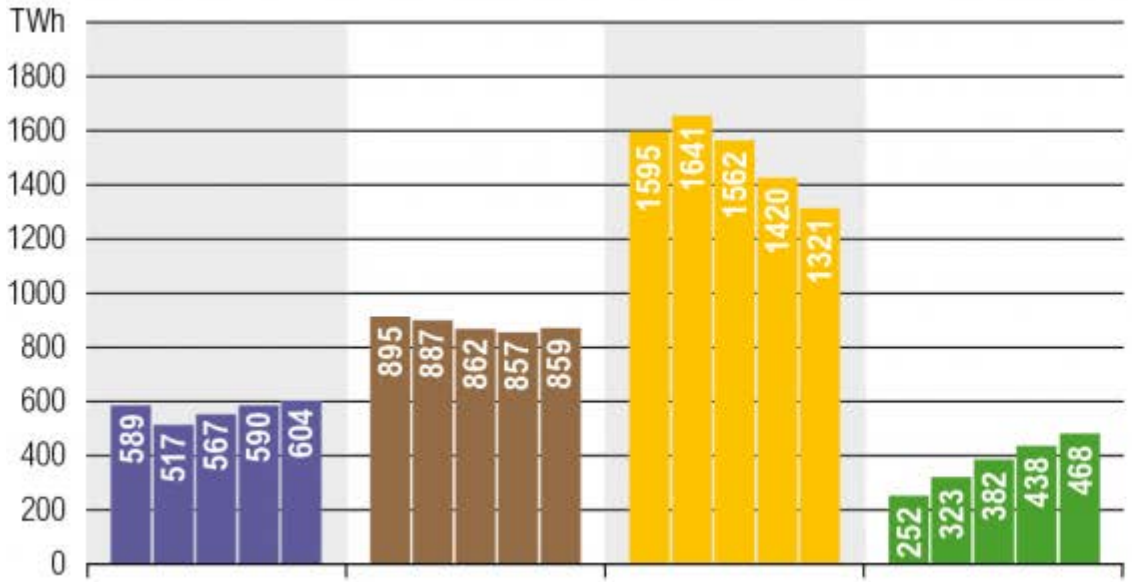


ENTSO-E

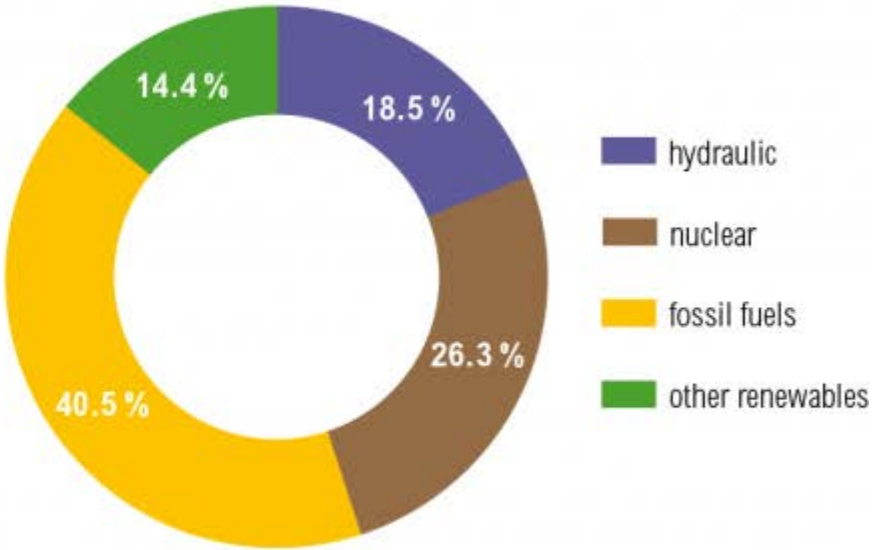
Wind power in Europe



ENTSO-E: Energy

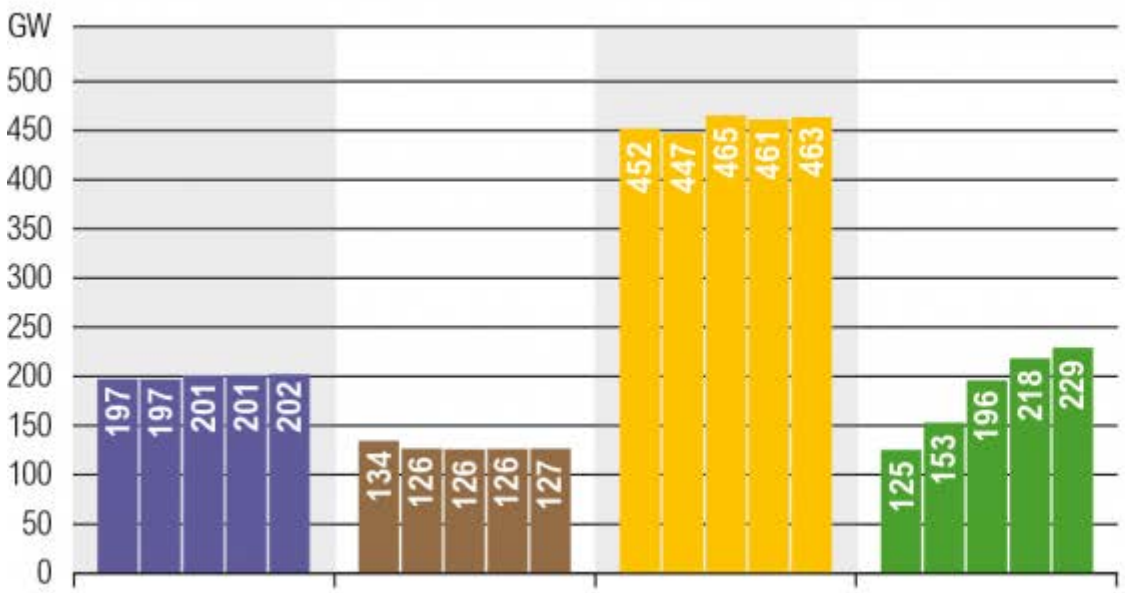


Energy net generation form 2010 to 2014

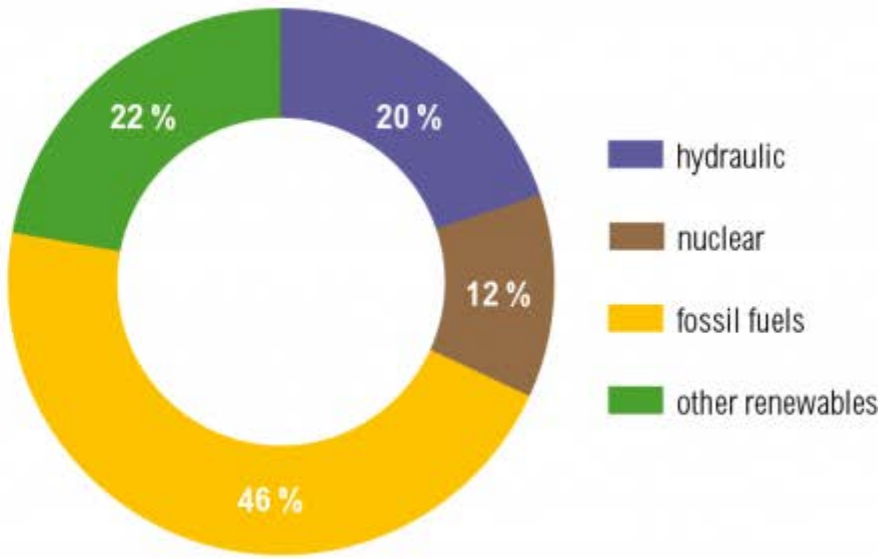


Energy net generation in 2014

ENTSO-E: Capacity



Net generating capacity from 2010 to 2014

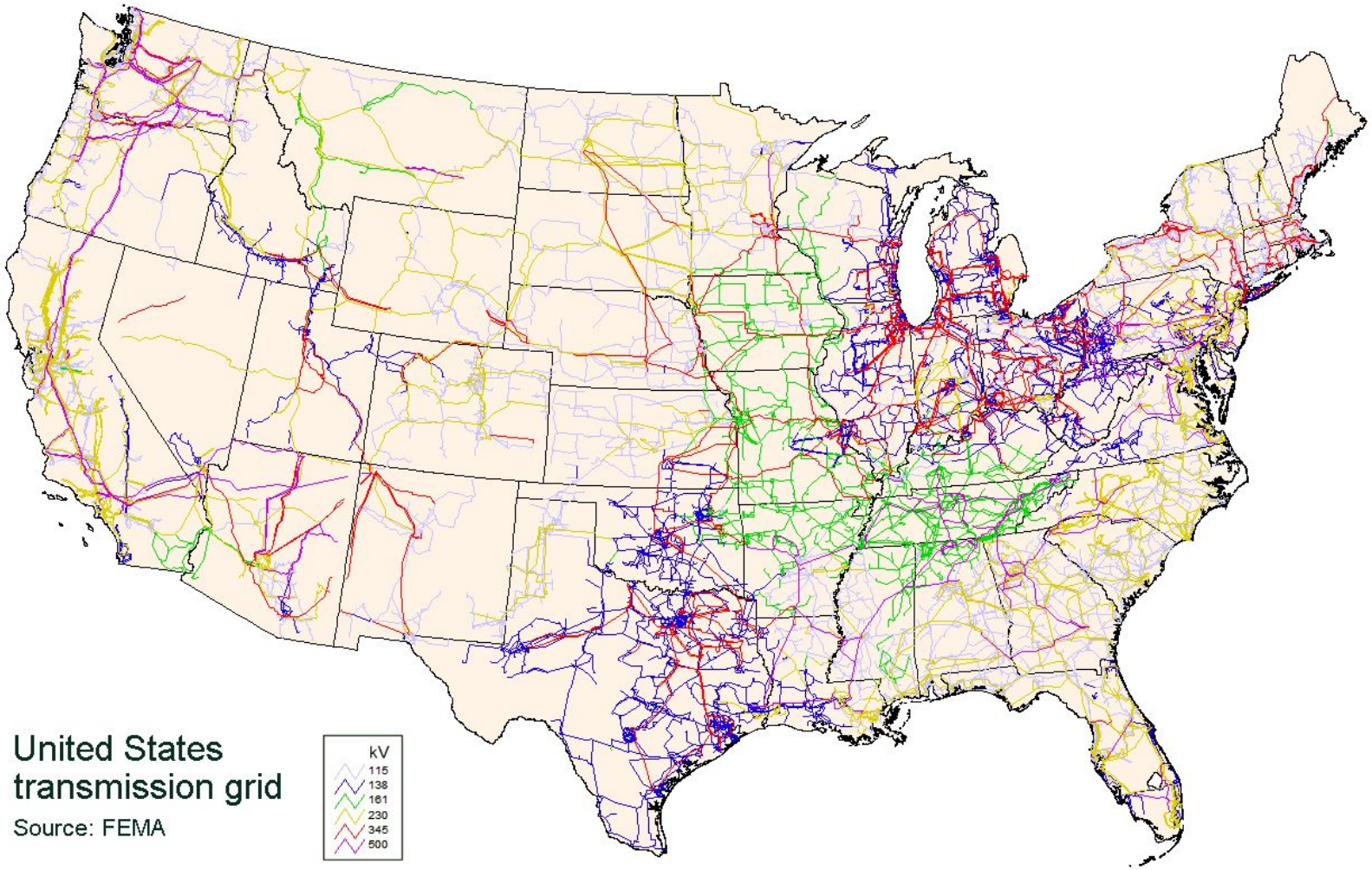


Net generating capacity in 2014

Wester European view

1. Dedicated futures market
2. Continuous day-ahead market (no unit commitment)
3. Reserve market
4. Real-time market
5. No network representation (or very simple representation)
6. Simple price generation

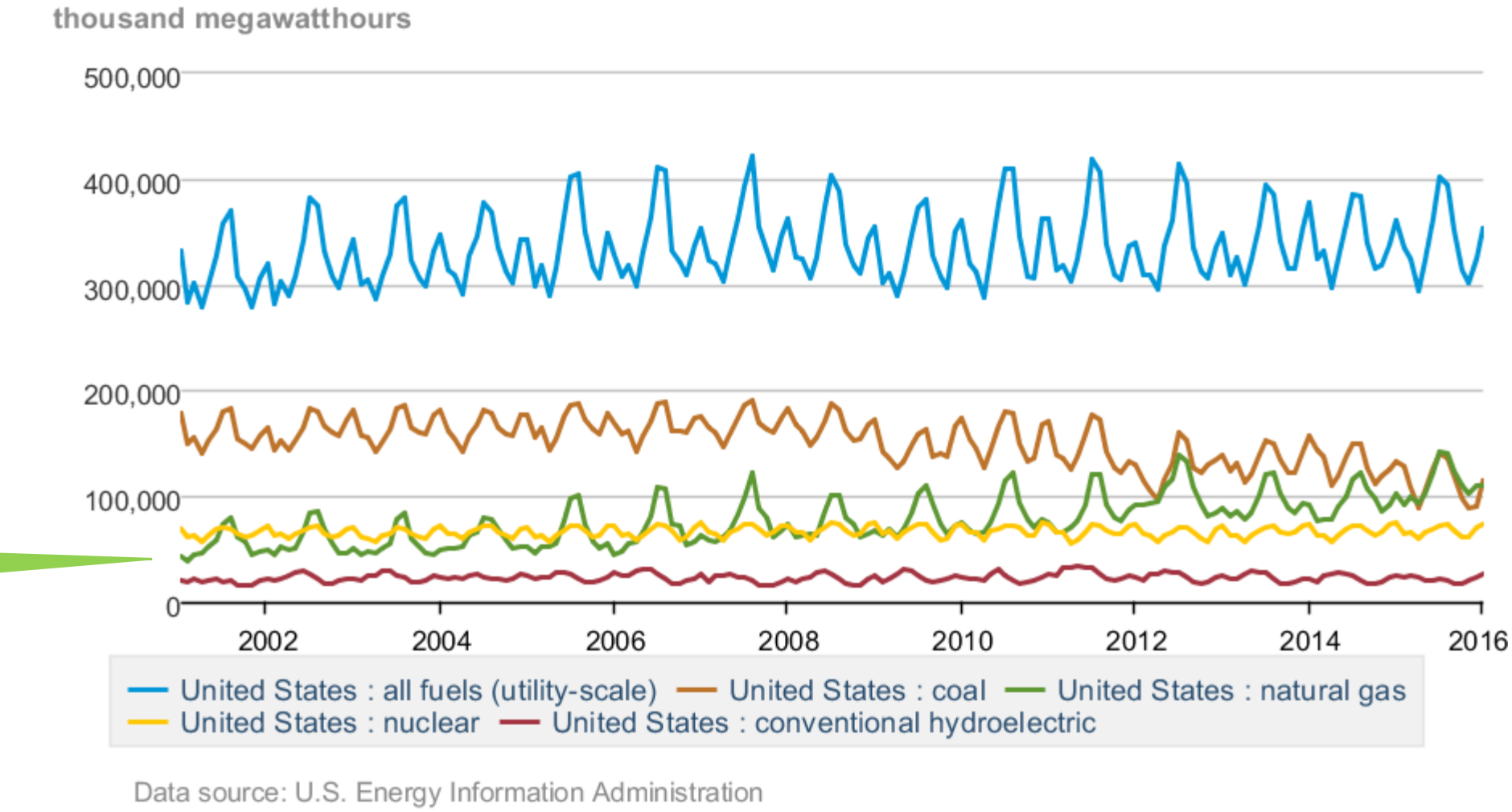
US view


United States
transmission grid
Source: FEMA
kV
115
138
161
230
345
500

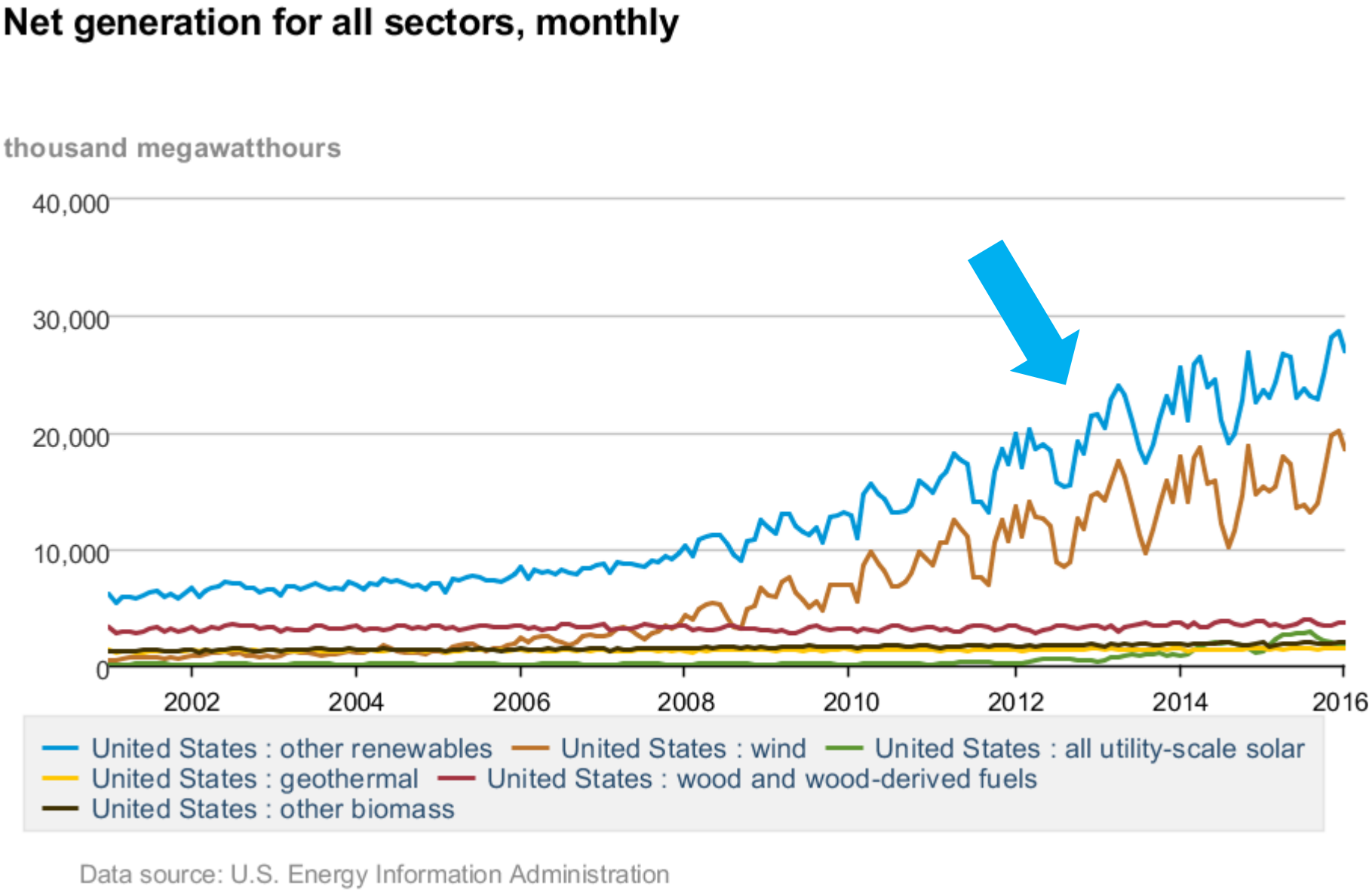
US view

EIA

Natural gas (green)



US view


Net generation for all sectors, monthly
thousand megawatthours
40,000
30,000
20,000
10,000
0
2002
2004
2006
2008
2010
2012
2014
2016
United States : other renewables
United States : wind
United States : all utility-scale solar
United States : geothermal
United States : wood and wood-derived fuels
United States : other biomass
Data source: U.S. Energy Information Administration

US view

1. Generic futures market
2. Non-continuous day-ahead market (unit commitment). Special case of Texas
3. Co-optimization of energy and reserve
4. Reliability unit commitment (non-continuous)
5. Real time market
6. Detailed network representation
7. Complex or *impossible* price generation

Issues

Challenges
Issues

Issues

- Not representing the network (WE view) is ignoring the physical layer and generally results in ex-post complications, often solved using arbitrary rules
- A discontinuous market clearing formulation (US view) prevents generating meaningful prices
- One-day ahead (WE & US views) is "too far away" in time for stochastic producers, as they don't know their actual productions until minutes of power delivery

Proposal

Proposal

1. Continuous day-ahead market clearing: to get prices that are prices
2. Detailed network representation: the physical layer cannot be ignored
3. Energy and reserve co-optimization: two commodities produced by the same facilities
4. Stochastic market clearing: stochastic producers play an increasingly important role
5. A number of intra-day markets: to correct errors
6. AC real-time market: the physical layer cannot be ignored

Continuous day-ahead market clearing

- A non-continuous / non-convex market clearing algorithm does not allow the derivation of marginal prices that “clear the market”
- Ex-post price adjustments: uplifts are both arbitrary and discriminatory
- Convexification is not unique
- A continuous market-clearing algorithm is desirable (à la WE)

Detailed network representation

- The network is an integral and fundamental part of the physical layer
- Ignoring the network requires arbitrary ex-post adjustments
- No computational reason for not-representing the network
- Network representation leads to LMPs
- A detailed network representation is desirable (à la US)

Energy and reserve co-optimization

- The same facilities – power plants – provide both energy and reserve
- Decoupling the provision of energy and of reserve results is suboptimality
- No computational reason for decoupling the provision of these two commodities
- Co-optimizing energy and reserve is desirable (à la US)

Stochastic market clearing

- Not representing the uncertainty involved results in either insecure or very expensive (overly secure) market outcomes
- Stochastic production uncertainty is not very different than demand uncertainty
- The computational challenge is moderate
- Appropriate prices are needed and their properties need to be further studied
- A stochastic market clearing algorithm is desirable (perhaps a 3-stage one)

Intra-day markets

- They allow correcting mistakes
- They are attractive for stochastic produces as they clear closer to power delivery than the day-ahead market does
- They are not complicated to implement once the day-ahead infrastructure is in place
- Markets closing closer to power delivery are desirable

AC real time market

- Voltage may play a role
- The real-time market clearing algorithm may incorporate AC constraints
- Incorporating an AC network representation might be advisable

Concluding remarks

- Continuous day-ahead market clearing… to get prices that clear
- Network representation… required by physical laws
- Intra-day markets… to correct mistakes
- Stochastic market clearing… to balance risk vs. cost
- Detailed real-time market clearing… to comply with physical laws


Thank
you