Is 100% Renewable Energy Possible?

Marin Environmental Forum

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About PSE Healthy Energy

Generate, translate, and disseminate

Scientific research, analysis, synthesis and communication to inform energy policy decisions

Primary focus areas

- Clean energy transition
- Unconventional oil and gas
- Health and environment

Who we work with/for:

Academics, advocacy groups, regulators, policymakers, media, and the public

Is 100% renewable energy possible?

The quick answer:

100% is hard, but we can get close

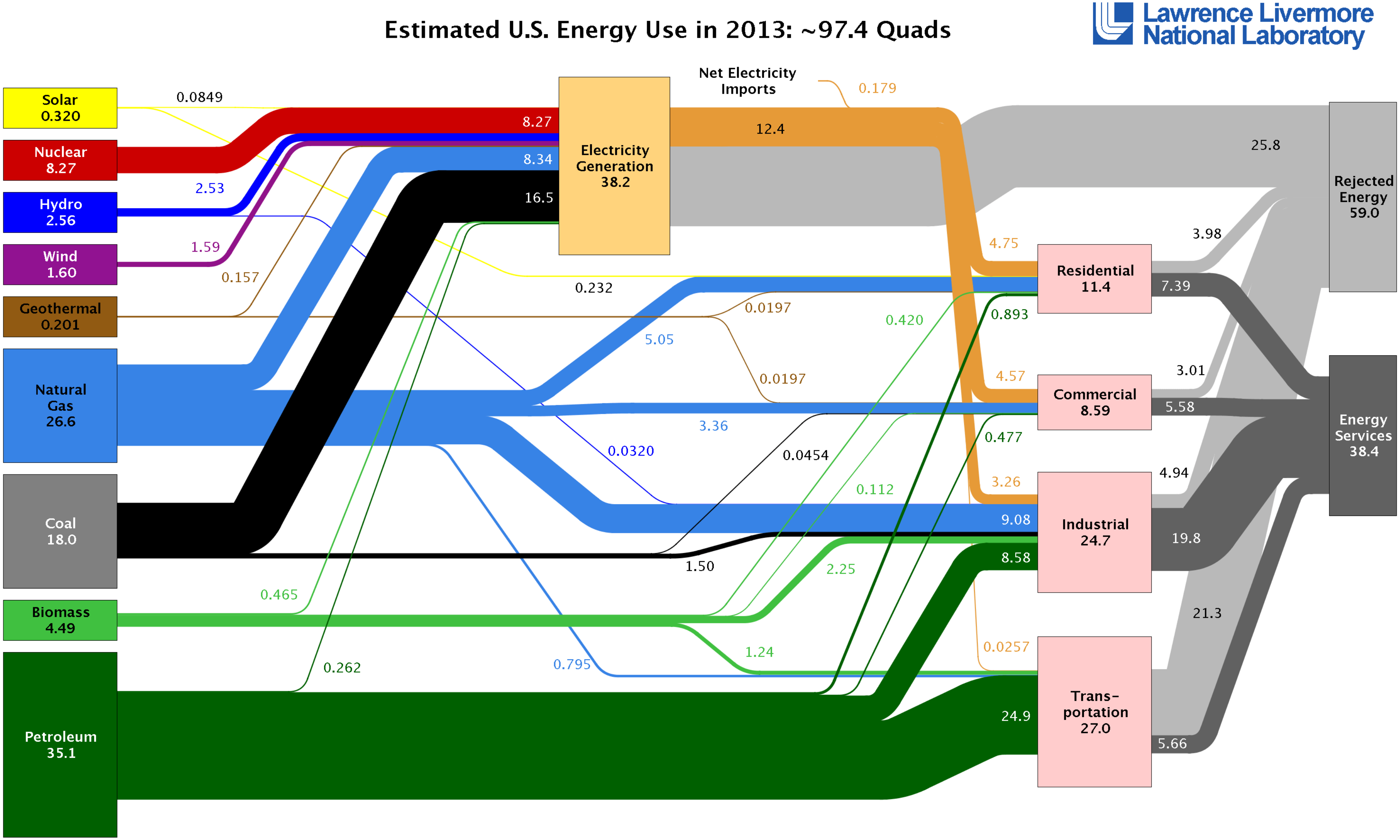
How do we get there?

1. Deploy what we’ve got
2. Test and scale mid-range technologies
3. R&D for end-game technologies

Outline

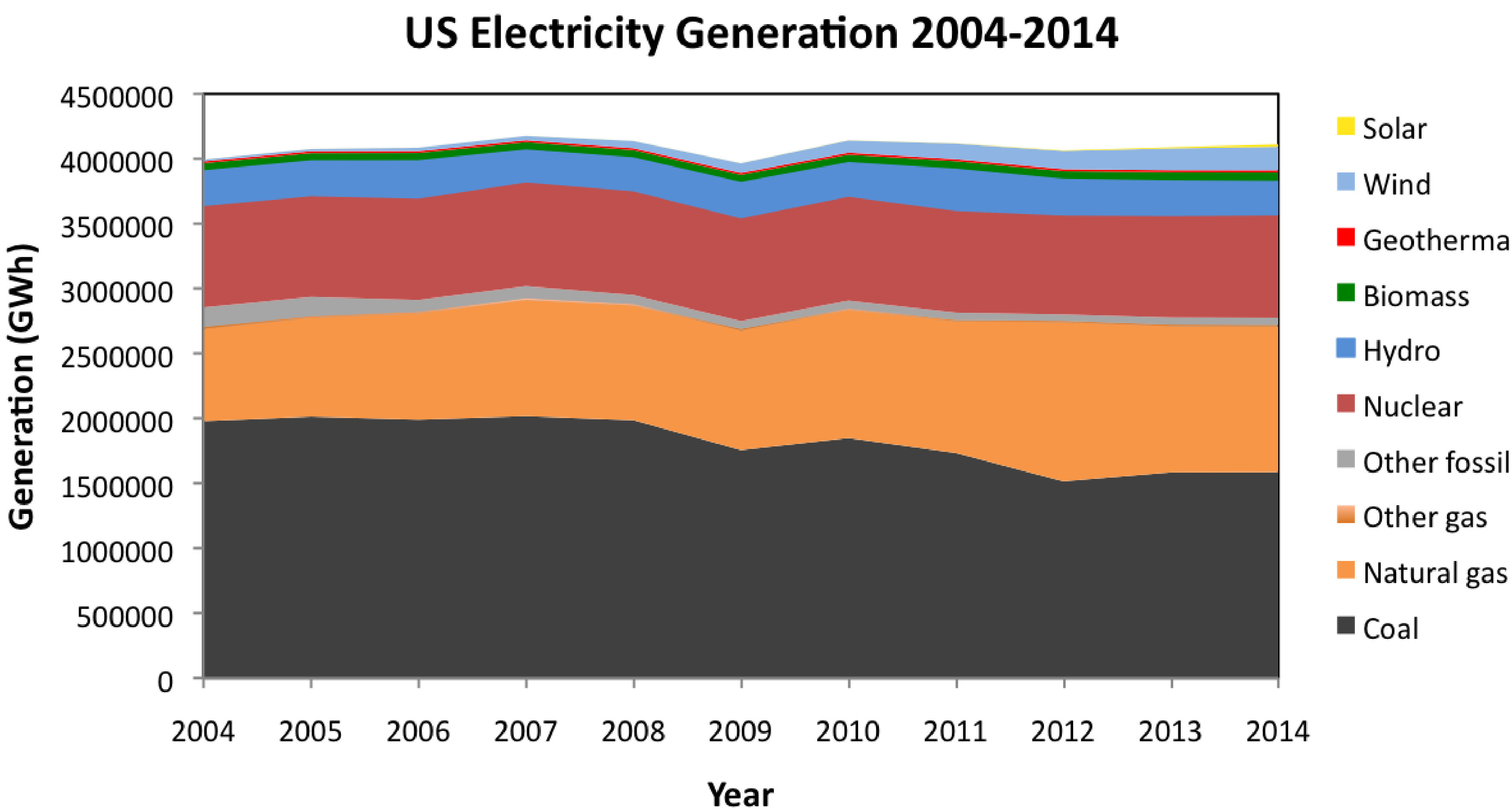
1. Background: energy today
2. The clean energy transition
   i. Renewable resources
   ii. Demand & integration
3. Remaining technical hurdles
4. Moving forward
   i. Next steps
   ii. Health, environment, justice

1. Where are we now?



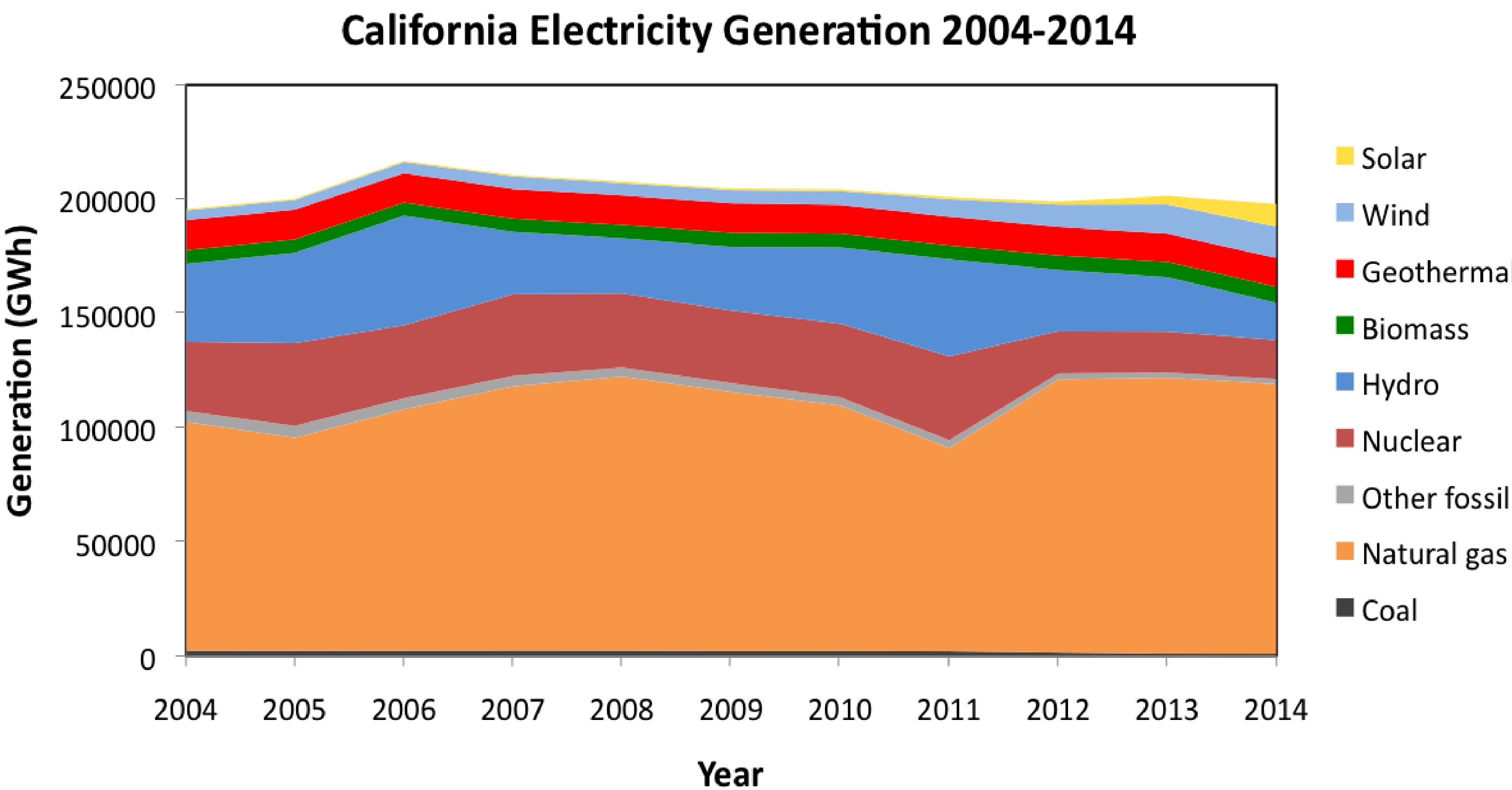
Source: LLNL 2014. Data is based on DOE/EIA-0035(2014-03), March, 2014. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Ten years of electricity: US



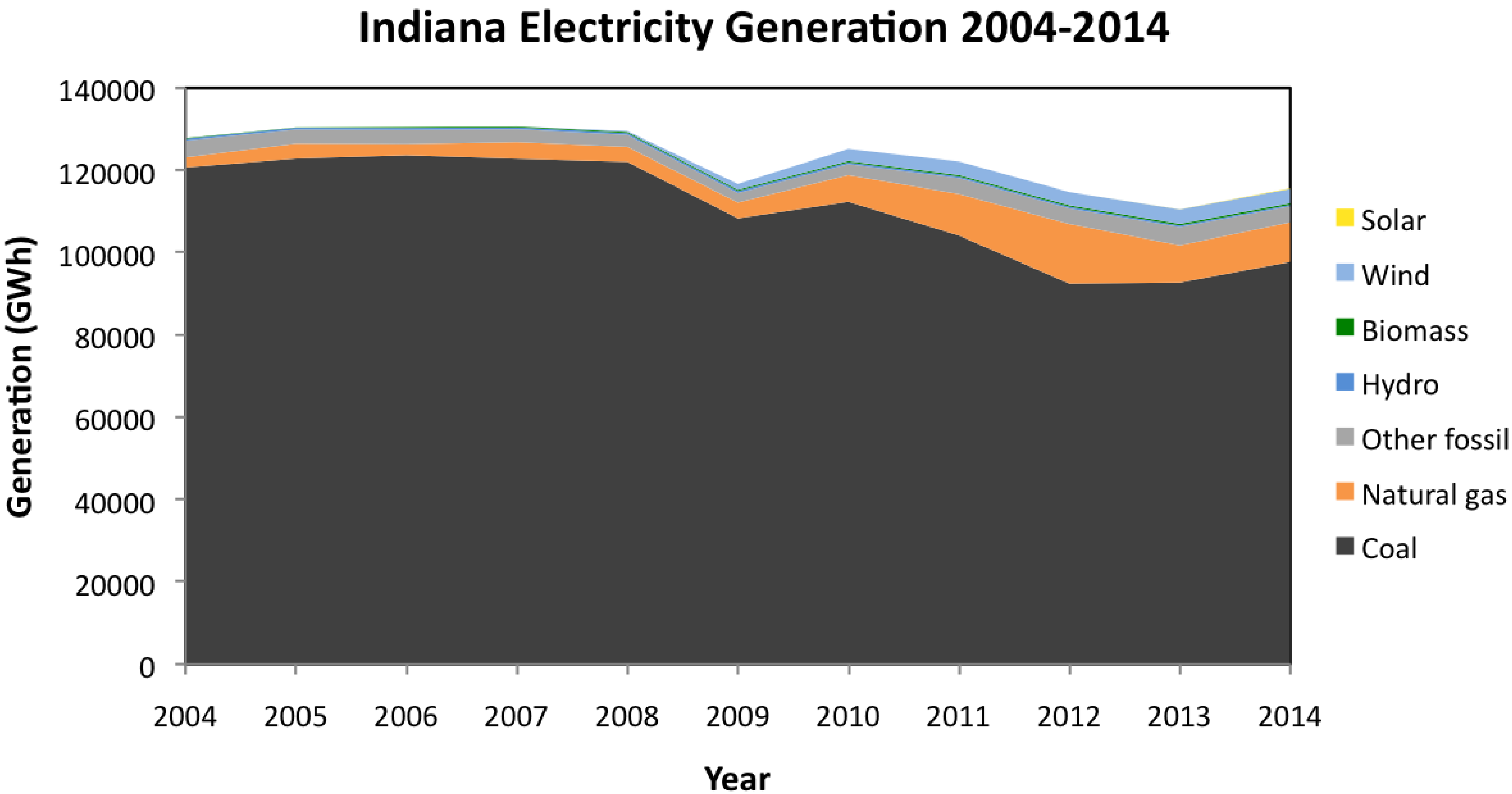
Data source: US EIA, 2015

Ten years of electricity: CA



Data source: US EIA, 2015

Ten years of electricity: IN



Data source: US EIA, 2015

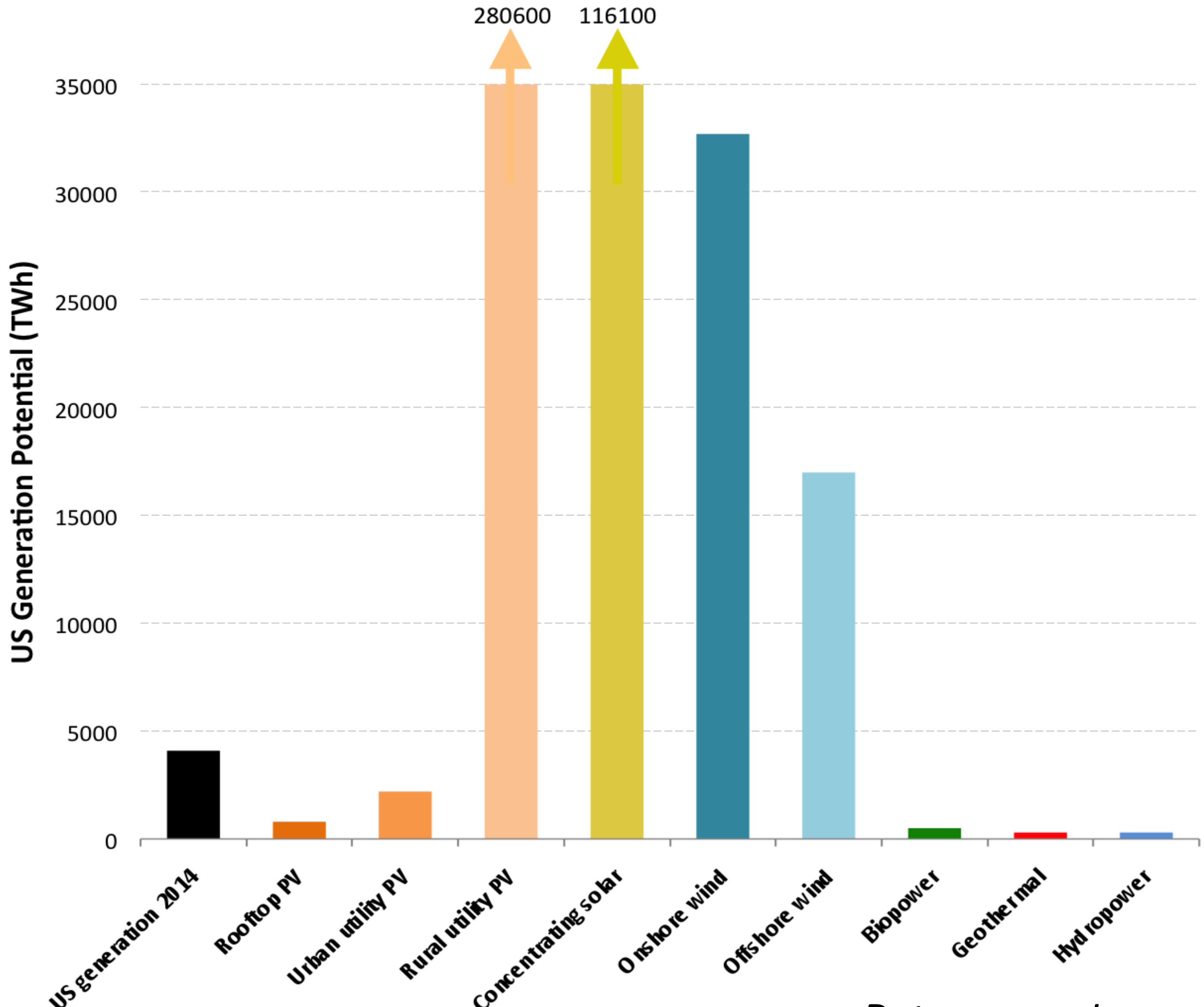
2. The clean energy transition

Getting to 80-100% renewables

1. Switch power sector to renewables
2. Electrify current fuel users
   i. Transportation
   ii. Industry
3. Change how we use electricity
   i. Efficiency
   ii. Flexible demand
   iii. Use less: electricity, stuff
   iv. Integrate across sectors: transportation, industry, residential

We need to change *where* our energy comes from and *how* we use it

Do we have enough renewables?

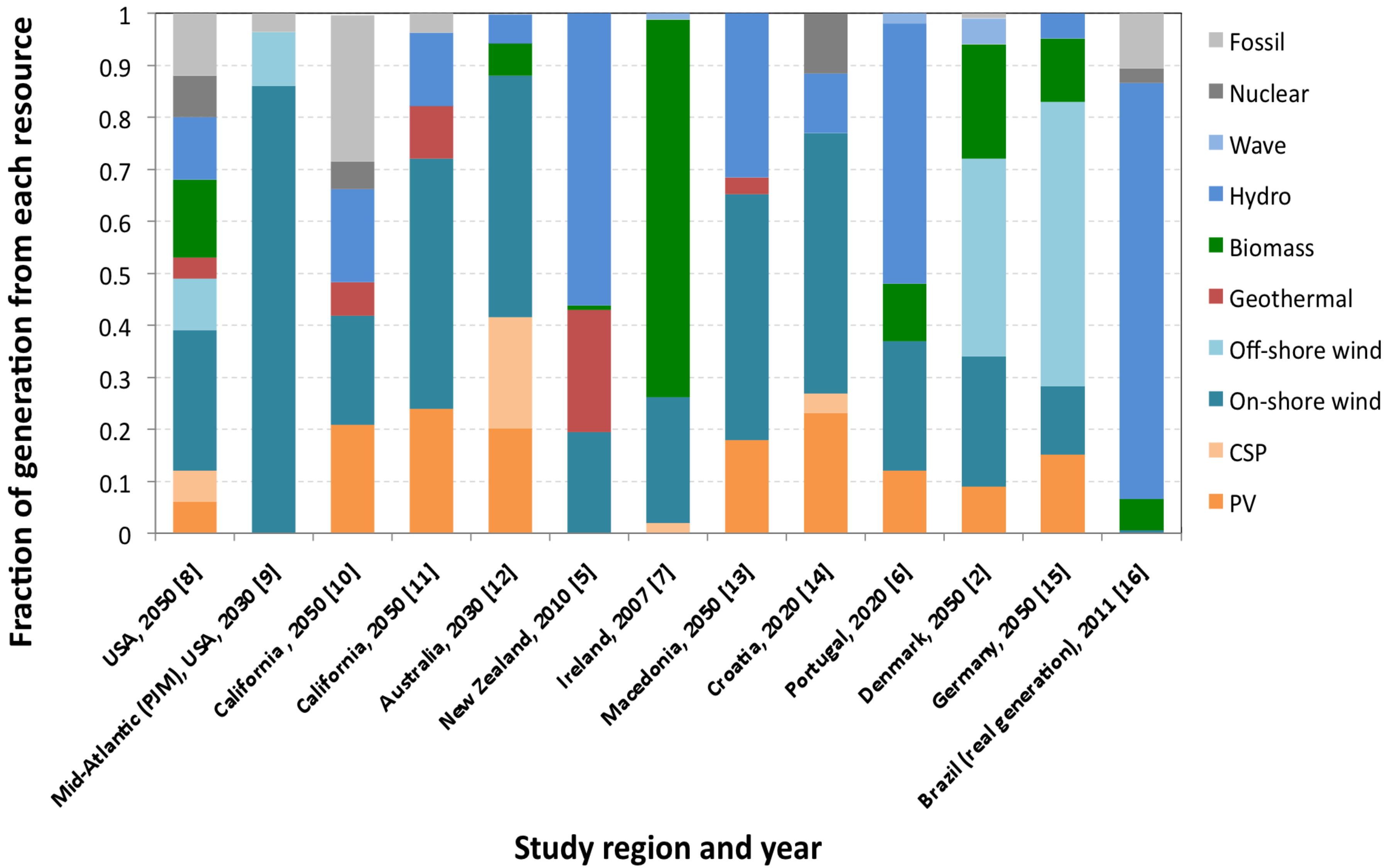


Data source: Lopez, NREL, 2012

Integration challenges

- Can't *dispatch* wind or PV generation
- Wind and solar generation output *varies* on both short and long timescales
- Location of resources doesn't always match location of demand

Many ways of reaching 80-100%



Strategies for integration

- Efficiency
- Energy storage
- Transmission
- Transportation
- Integrate across technologies, regions
- Flexible, responsive electric grid (smart grid)

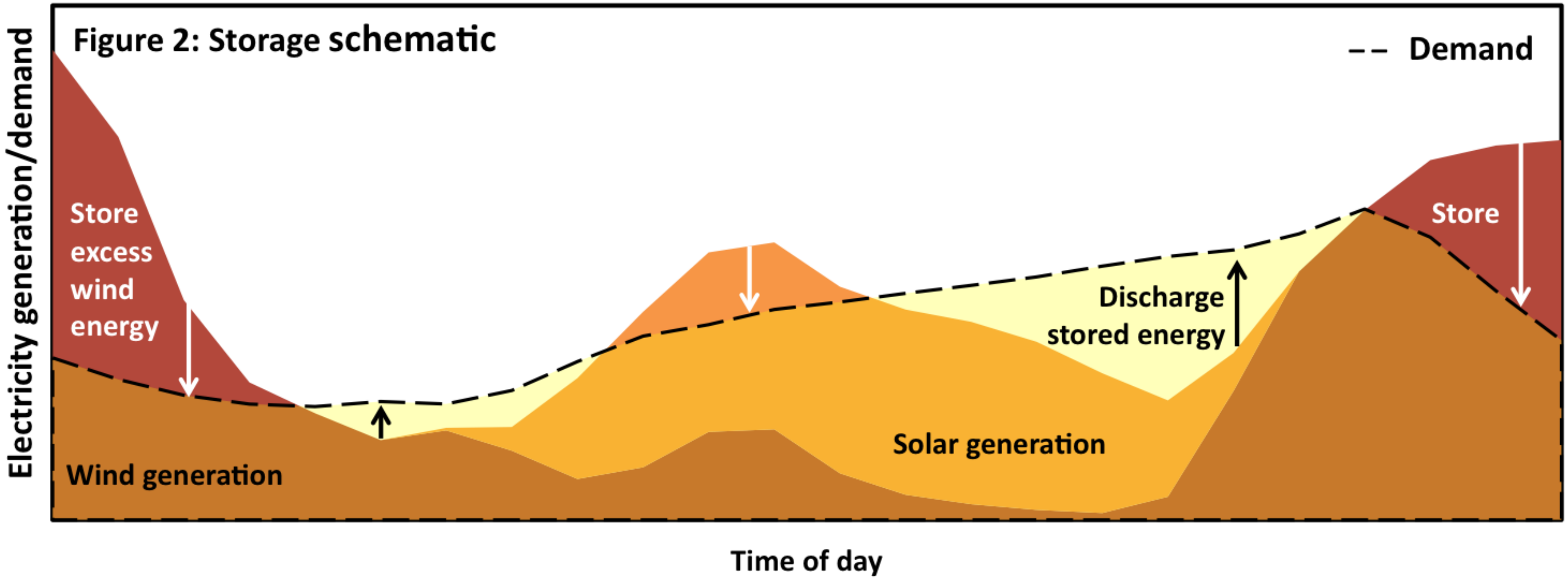
Efficiency

- Efficient appliances
- Efficient behavior
  - *Use less & consume less*
- Efficiency in generation + grid
  - *Combined heat & power*
  - *Lower peak demand*
  - *Decentralized generation*
- Electrification of industry, transport

Reduce "rejected energy"

***Example**: Danish model assumes 50% drop in residential consumption [Mathiesen, 2014]*

Energy storage



- Smoothes out intermittent renewables
- More efficient grid operation
- Grid support – power quality, deferred upgrades

***Example**: New Zealand model relies on 15% capacity matched in pumped hydro storage [Mason, 2010]*

Transmission upgrades

- Bring wind, solar in to meet urban demand
- Reduce variability by integrating over large regions
- Reduce curtailment

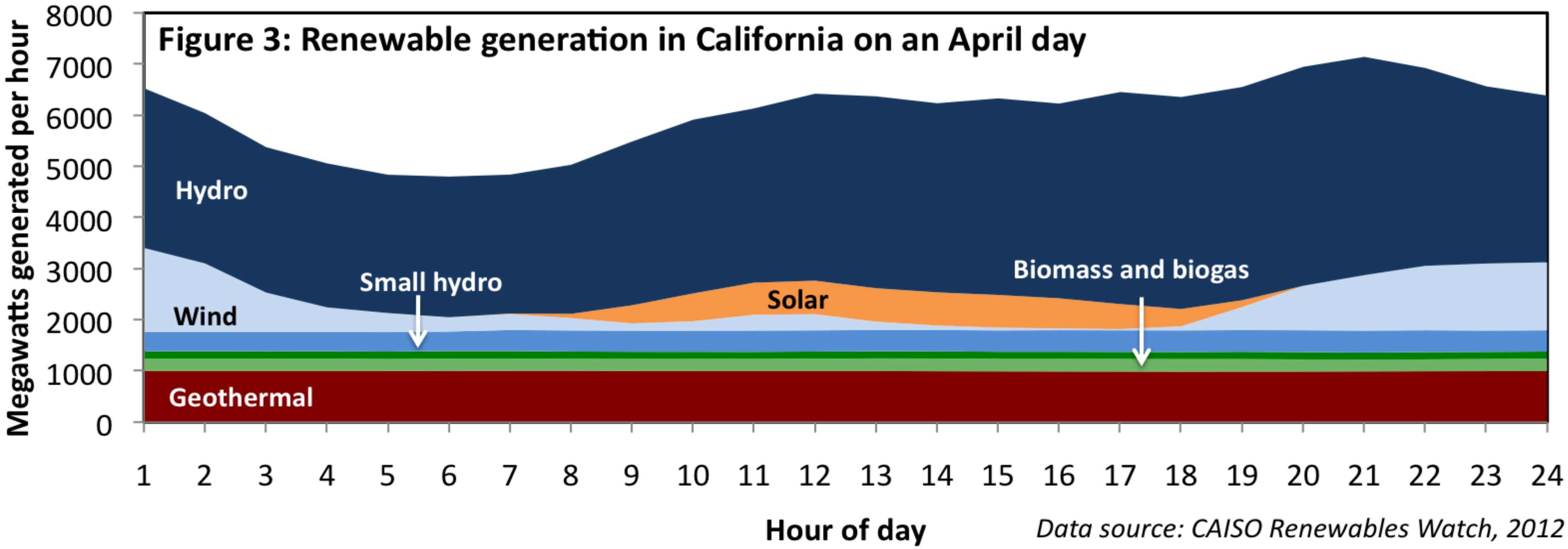
***Example**: US model estimates need for 100 million MW-miles of transmission [Hand, 2012]*

Transportation

- Electric vehicles
  - Demand response
  - Distributed storage
  - Reduced air pollution
  - Increased total power demand

- Expand alternatives: *mass transit, walking, biking*
- Other options:
  - Hydrogen fuel cells
  - Biofuels

Integrate across technologies, regions

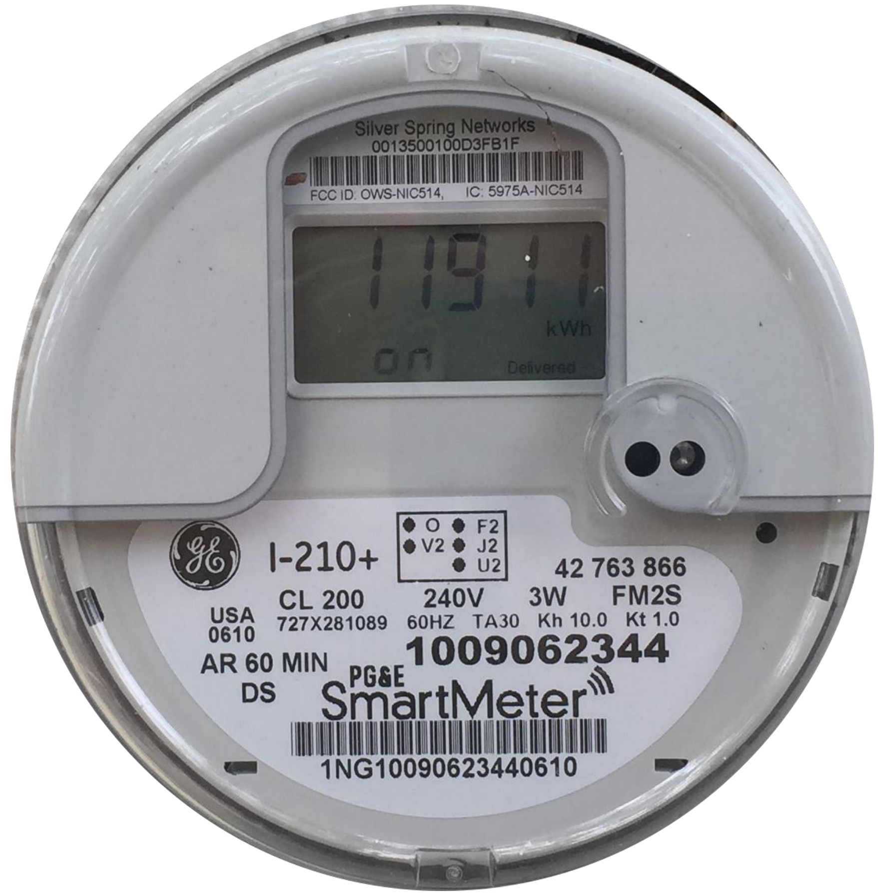


- Mix resources to reduce variability
- Integrate over large regional areas (transmission)
- Over-generate and curtail

***Example**: PJM model integrates wind over large area but curtails up to 50% with no storage [Budischak, 2013]*

Grid flexibility

- Demand response
- Load shifting
- Smart appliances
- Real-time analysis
- Flexible EV storage and charging
- Smart grid



3. Technical hurdles

- Heavy-duty transport
  - Ships
  - Trucks
  - Planes
- Intensive industry demands
- Big data challenges
  - Real-time analytics and optimization
  - Privacy and security

4. Moving forward: near term

Scale up commercial technologies a.s.a.p.

- Renewables: 50% capacity added in 2014
- Efficiency

Stop building out fossil infrastructure

- Hard to retire a new power plant
- Locks into decades of emissions

Lots of headroom to add renewables in most regions before variability becomes an issue


Image source: PNNL

Moving forward: mid-term

Large-scale pilots of non-commercial technology

- Learn to operate, optimize
- Adapt markets, regulations
- Identify scalable technologies

Example: 1.325 GW energy storage pilot in CA

Ensure technologies are ready to integrate when we need them

Moving forward: long-term

Ongoing R&D

- Heavy transportation, big data, heavy industry
- Inverters, optimization, storage, etc.

We can do a lot now, but better technologies will make it ***cheaper and easier***

Ongoing R&D means when we get to 80%, we'll know how to keep moving towards 100%

Keeping the bigger picture in mind

- Health benefits
- Environmental impacts and benefits
- Environmental justice
- Jobs and local economy
- Technology transfer & energy access
- Resiliency & energy security

Thank You

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