Outline

• Recent US Government Developments

• Short term drivers of renewable energy

• The challenge of clean energy deployment in the industrial sector
Recent US Government Developments
First ever Federal Government report laying out how to achieve economy-wide 80% emissions reductions

- The MCS is not a political strategy or a new target – it’s a technical document illustrating pathways to achieve 80% economy-wide emission reductions
- Consistent both with the 2025 target in the U.S. NDC and the global ambition needed to meet the long-term Paris Agreement aim to limit increases in global average temperatures to well below 2°C above pre-industrial levels
Energy related emissions come from many different sources.
MCS lays out multiple pathways to achieve deep decarbonization

**FIGURE E1: U.S. NET GHG EMISSIONS UNDER THREE MCS SCENARIOS**

Multiple pathways to 80 percent GHG reductions by 2050 are achievable through large reductions in energy CO₂ emissions, smaller reductions in non-CO₂ emissions, and delivering negative emissions from land and CO₂ removal technologies. Note: “No CO₂ removal tech” assumes no availability of negative emissions technologies like BECCS.
Achieving these goals will require dramatic increases in the deployment of clean energy.

**FIGURE E2: AVERAGE ANNUAL CAPACITY ADDITIONS BY FUEL, HISTORICAL AND MCS BENCHMARK SCENARIO**

- **Historical & 2016**
- **MCS Benchmark Scenario**

*Note: 2016 data are AEO 2016 reference case projections (EIA 2016a; MCS analysis).*
Short-Term Drivers of Renewable Energy
The multi-year extension of the PTC and ITC for RE in December 2015 changed the short-term RE deployment trajectory.

Source: Mai et al, NREL, 2016
Low natural gas prices and RE tax extensions can lead to medium-term power sector emissions below CPP requirements.

RE tax credit extensions help drive even lower emissions and with longer lasting avoided emissions.

Source: Mai et al, NREL, 2016
Continued deployment of clean energy is also enabled by enormous cost reductions over recent years.

Notes: Land based wind costs are derived from levelized cost of energy from representative wind sites. Distributed PV cost is average residential installed cost. Utility-Scale PV cost is the median installed cost. Modeled battery costs are at high-volume production of battery systems, derived from DOE/UIS Advanced Battery Consortium PHEV Battery development projects. LED bulb costs are cost per lumen for A-type bulbs. See full report for full citations and details.

Source: Revolution... Now, DOE, 2016 Update
...As well as by increasing demand for voluntary renewable energy purchases

- Voluntary REC market grew ~10% from 2014-2015, and represented 25% of non-hydro renewables in 2015
- Other renewables – those built for purely economic reasons, represented 11% of non-hydro RE in 2015

Renewable Portfolio Standard Policies

www.dsireusa.org / August 2016

29 States + Washington DC + 3 territories have a Renewable Portfolio Standard
(8 states and 1 territories have renewable portfolio goals)

Extra credit for solar or customer-sited renewables
† Includes non-renewable alternative resources

State Policy has also been essential to increased RE deployment
There is substantial remaining growth in existing RPS demand

Under current state targets, total U.S. RPS demand will increase from 215 TWh in 2015 to 431 TWh in 2030 (though RE-portion in figure is slightly lower: 393 TWh in 2030)

California represents roughly 40% of that growth; most of the remainder associated with relatively large states

More aggressive RPS targets could drive significant growth in RE deployment

- **No RPS**: no further growth in RPS requirements beyond 2015 and limited economic growth in RE
- **Existing RPS**: RPS requirements continue to grow based on existing state RPS policies as of July 2016
- **High RE**: nearly all states adopt an RPS with relatively aggressive targets.

The challenge of clean energy deployment in the industrial sector
Deep energy transformation must include industry

Diversity of industrial energy use makes this sector especially challenging.

Generation and Use of Thermal Energy in the U.S. Industrial Sector and Opportunities to Remove its Carbon Emissions (McMillan, Boardman et al. INL-NREL, forthcoming)
Pulp & Paper: Current and R&D Energy Savings Bandwidths

- **Current Typical**
- **State of the Art**
- **Practical Minimum**
- **Thermodynamic Minimum**

**Current Savings Opportunity** and **R&D Savings Opportunity**

- **Paper Drying**: 37% Current, 22% R&D
- **Paper Machine Wet End**: 65% Current, 0% R&D
- **Liquor Evaporation**: 35% Current, 54% R&D
- **Wood Cooking**: 75% Current, 25% R&D
- **Pulping Chemical Prep**: 38% Current, 16% R&D
- **Bleaching**: 54% Current, 0% R&D
- **All Other Processes Including Env. & Utilities**: 75% Current, 25% R&D

*Shown in order of total TBtu opportunity, with Other Processes listed separately.*
Forthcoming project: Potential for Widespread Electrification to Reduce Unwanted Pollution (POWER-UP) Study – www.nrel.gov/analysis/power-up.html

**Goal:** Detailed system-wide exploration of the potential and impact of widespread electrification

1. What **end-use services** are the best candidates for **electrification** and how might adoption barriers be overcome?
2. How might mass electrification impact national and regional **electricity consumption and consumption patterns**?
3. How would the U.S. **electricity system transform** to meet the growing consumption needs from mass electrification and, at the same time, decarbonize?
4. How would a decarbonized grid operate to serve an electrified economy and what role might **demand-side flexibility** play to support reliable operations?
5. What impacts would this pathway have for GHG emissions, consumer costs, and other environmental, public health, and social implications?
But many industrial resources are hard to electrify

The largest source of industry GHGs is associated with fossil fuel combustion for process heating

Alternative heat supplies could include:
- Geothermal
- Solar industry process heat
- Small nuclear reactors
- Biomass
- Hydrogen

Conceptual $\text{H}_2$ at Scale Energy System

RE Grid plus battery storage

*Illustrative example, not comprehensive
Thank You!

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