2050 Electrification
Impact on Utilities & Transformers

Presented to

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By

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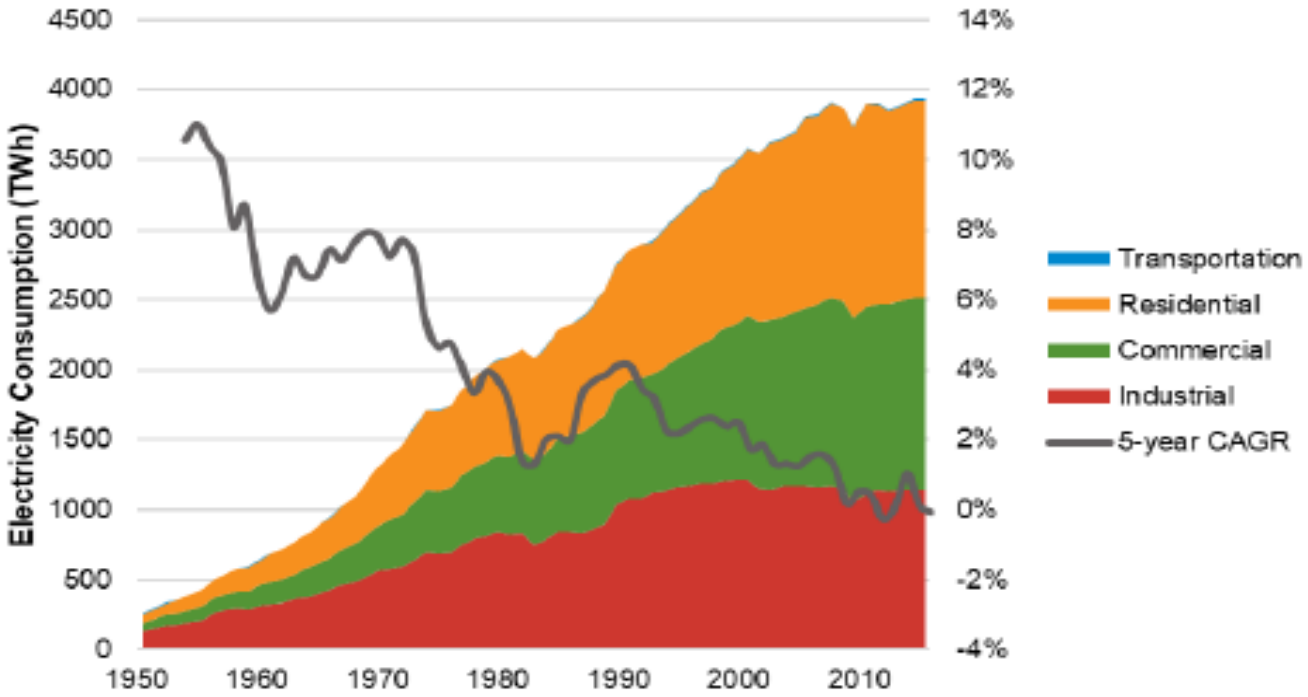
Topics

- **History - Where we have come from**
- **Future – Where we are going**
- **Some Math**
- **Impact**
  - **Utilities**
  - **Liquid-Filled Distribution Transformers**
- **Summary**
- **Discussion**

History

US Electricity usage by major sectors



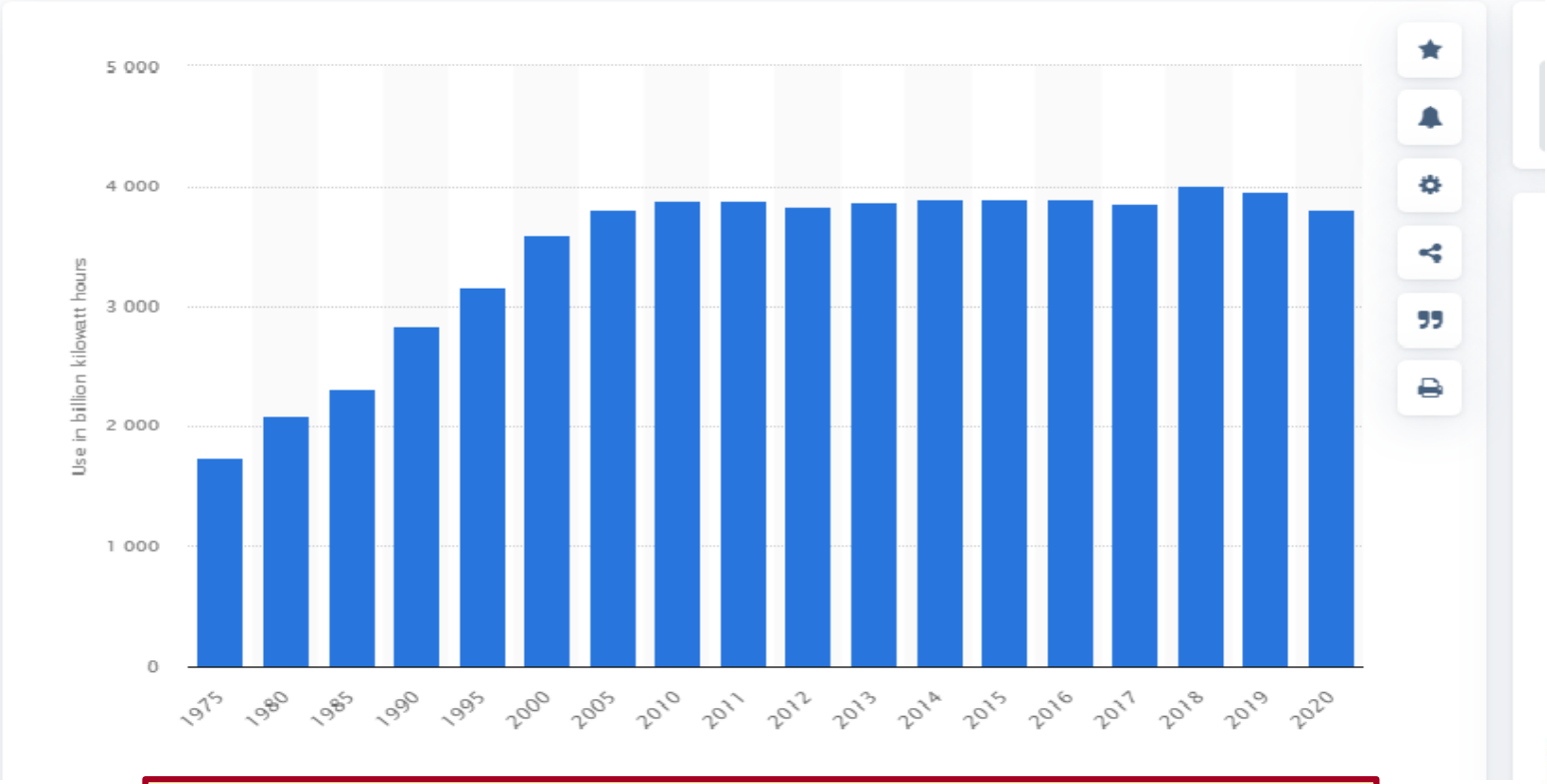
Very high growth in ‘50s – Decreasing since then

Total Electricity Usage in US

Energy & Environment › Energy

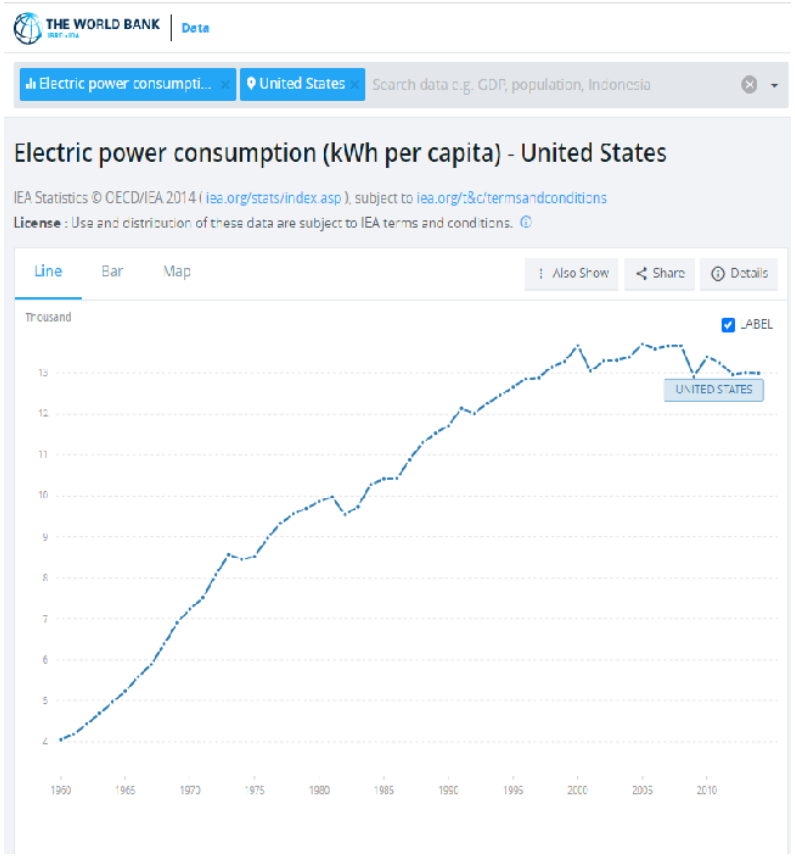
Total electricity end use in the United States from 1975 to 2020

(in billion kilowatt hours)



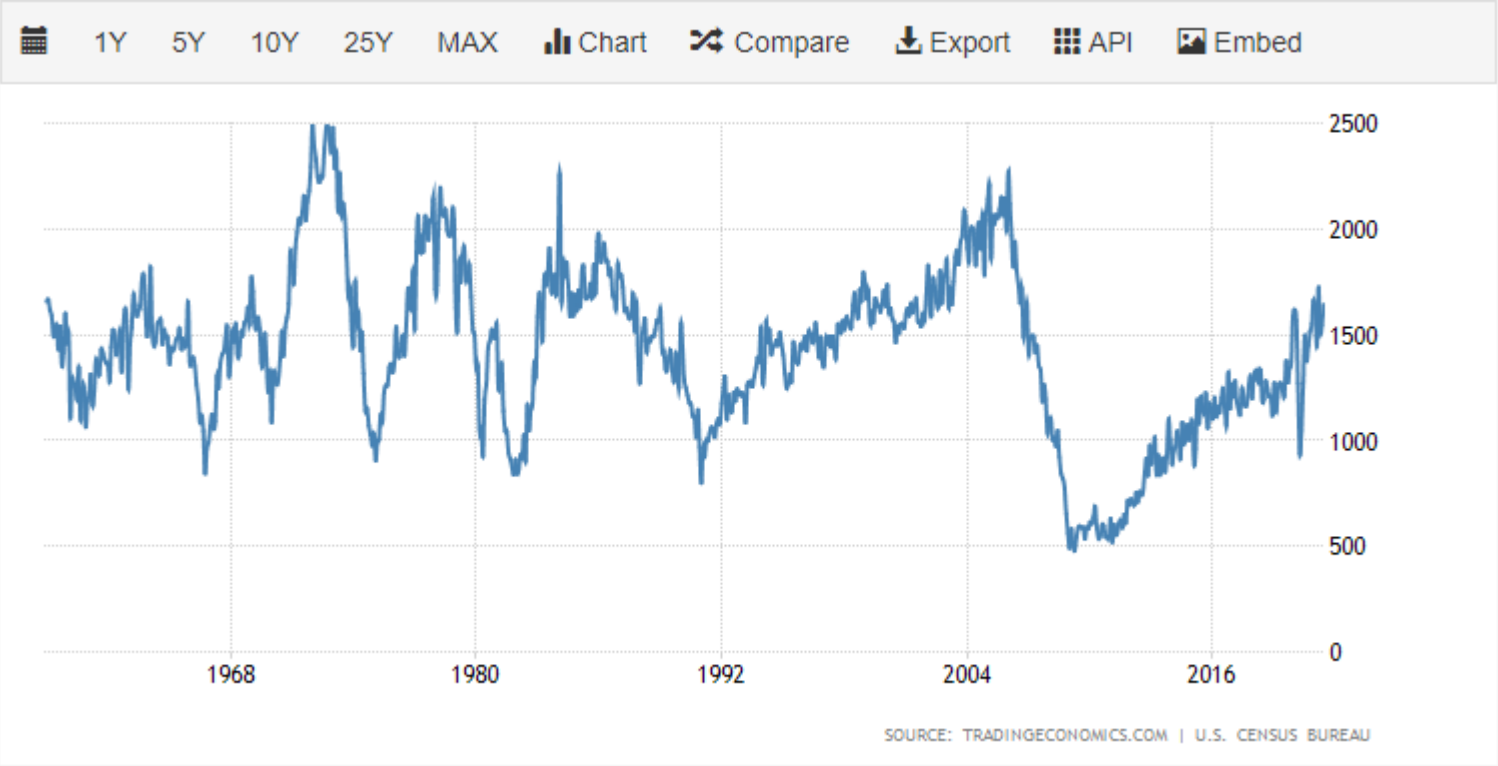
Electricity Usage in US has leveled off since 2005

Per Capita Electricity Consumption in US



- **Per capita electricity usage in USA has been going down since 2005**

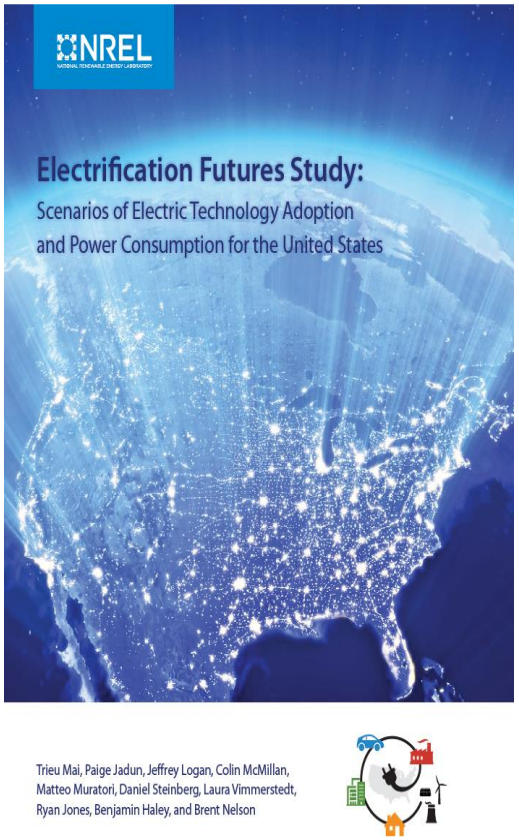
Housing Start in USA

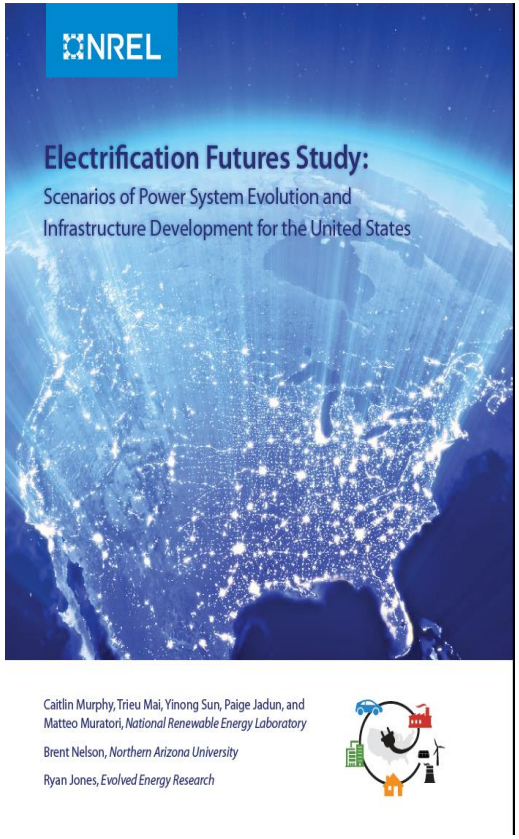


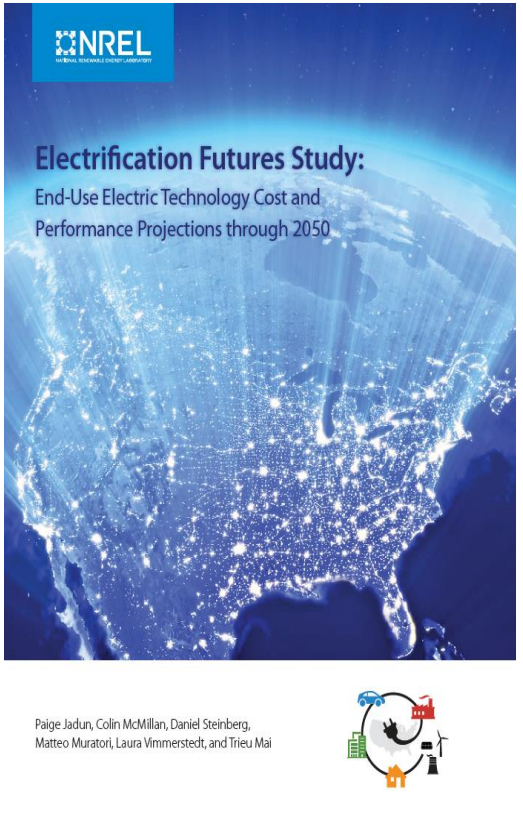
The Grid continues to expand due to new construction. needing Meters, Transformers etc.

Future

NREL Reports : 2050 Scenario

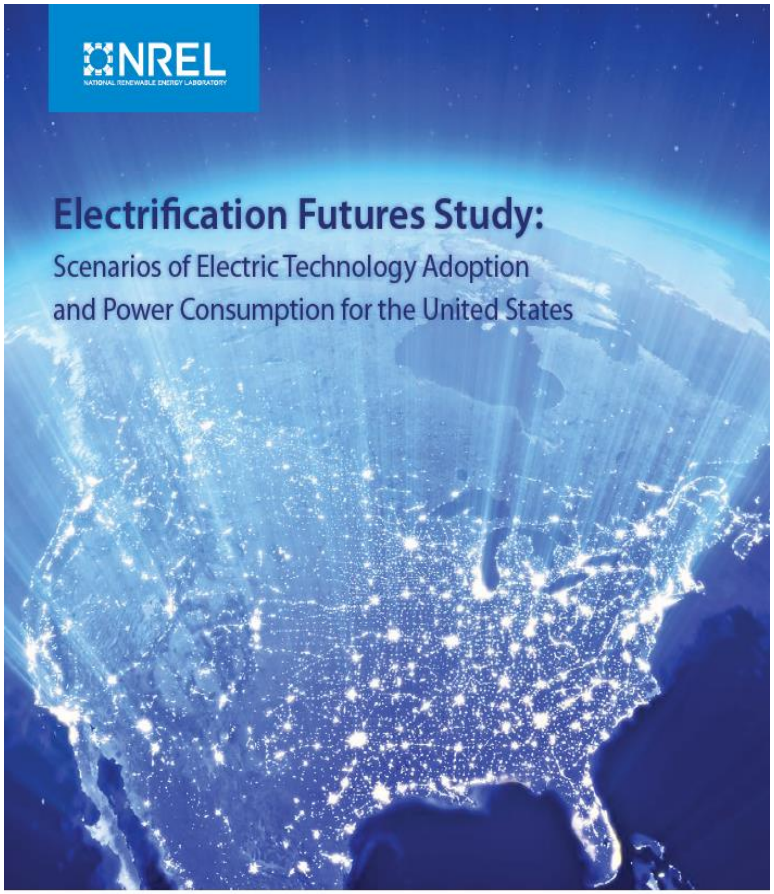






Three Reports: Bottom up analysis - Demand, Supply, Technology & Costs

NREL : Demand Report

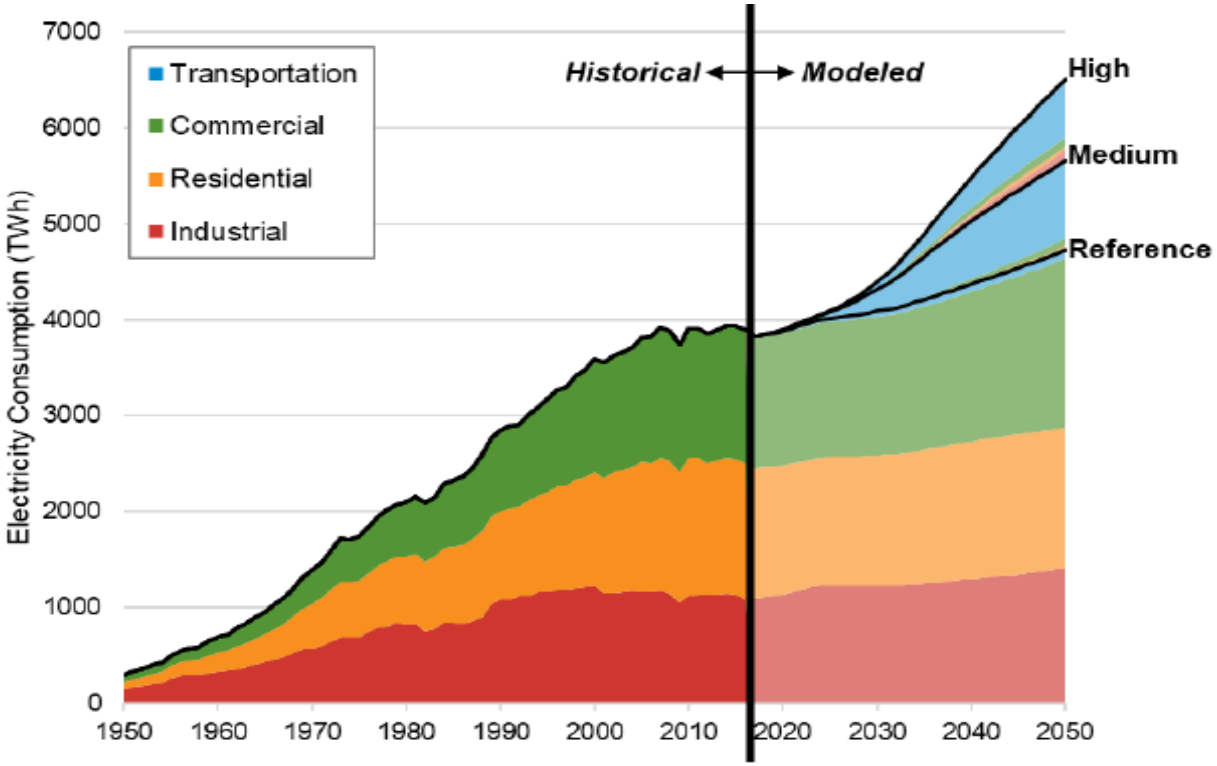


- **Reference scenario:** the least incremental change in electrification through 2050, which serves as a baseline of comparison to the other scenarios.[2]
- **Medium scenario:** a future with widespread electrification among the "low-hanging fruit" opportunities in electric vehicles, heat pumps and select industrial applications, but one that does not result in transformational change.
- **High scenario:** a combination of technology advancements, policy support and consumer enthusiasm that enables transformational change in electrification.

- **Reference:** No change in how electricity is consumed or provided (BAU).
- **Medium:** Widespread use of EVs, Heat Pump etc.
- **High:** "Aspirational" Will need advances etc.

Trieu Mai, Paige Jadun, Jeffrey Logan, Colin McMillan,
Matteo Muratori, Daniel Steinberg, Laura Vimmerstedt,
Ryan Jones, Benjamin Haley, and Brent Nelson

NREL : 2050 Projection



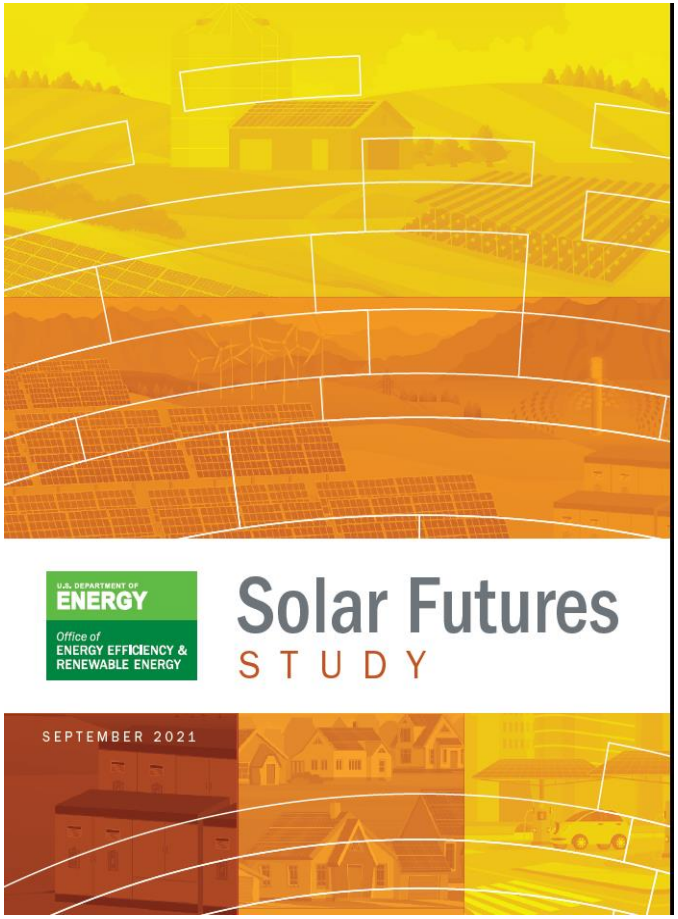
Greater electricity consumption

Reference case, minimal demand from electrification of transportation. Medium case is 20% over reference. High case is 38% over Reference.

EVs & Electrical Grid

- **EV Usage**
  - **Local (Commute)**
  - **Long Trips**
- **Average mile driven =14,000 annually**
  - **Long Trips miles ??**
- **Commute Charging will be at home & Office**
  - **Will Use existing grid, may need upgrades**
- **Long Trips Charging at “Fill-in” Stations**
  - **New addition to the Grid**
  - **Fast Charging requirement will need stiffer system**

Solar PVs & Electrical Grid



- **Roof Top PVs (Behind the meter) *reduce* grid supplied electricity**
- **Per NREL *2021 Solar Futures Report – by 2050***
  - **30% Of Building & 14% of Transportation energy need will be met by Solar**
  - **2020 Solar Production**
    - **28 GW DPV, 46 GW UPV**
    - **38% Local, 62% Utility**
    - **3 Million Rooftop PVs**
    - **Share of Local vs Utility in 2050?**

Load Factor vs Per Unit Load (PUL)

Load Factor (LF) = Average Load / Peak Load

Per Unit Load (PUL)* = $\frac{\text{Actual Power Supplied by a transformer}}{\text{Transformer's Rated Capacity}}$

Example: Electricity to a 100 Watt traffic light that is operating 24 x 365 is provided by a 10 kVA transformer.

- Average Load = 100 Watts
- Peak Load = 100 Watts

Load Factor = 100/100 = 1 (LF is Customer Specific value)

PUL = 100/10,000 = 0.01 (PUL is Transformer Specific value)

* PUL is DOE's Preferred Matrix

PUL of Transformer - Under three scenario

Average ***PUL*:**

From Past Task Force Presentations:		**DOE Estimate**
Dominion	- 0.1	
Duke	- 0.15	0.27 – 0.32
Con Ed	- 0.26 (Highly Urban)	
Toronto Hydro	- 0.24 (Urban)	

- **PUL Under Reference scenario: Minimal Transportation demand.** Demand from new construction (1.5 Million Houses, New Commercial and Industrial additions etc.) will be met by ***New*** additions to existing grid. BAU. ***Thus No change in PUL***
- **PUL Under Medium scenario: Assuming *all* "Charging" at home and *No* Residential PV,** PUL can go up by **1.2** over reference. Thus the 2050 PUL on the transformer can range from ***0.12 - 0.38*** (Ignores PV effect)
- **PUL Under High scenario: Similarly,** PUL can go up by **1.38.** Thus the 2050 PUL on the transformer can range from **0.138 – 0.44** (ignores PV effect)

Impact on Electric Utilities

- **Under Reference Scenario (BAU) Grid will continue to expand at the edges but there will be minimal impact to the load on the transformer.**
- **Under Medium and High Scenarios:**
  - **Per Unit Load (PUL) on the transformer will go up**
  - **Some part of the Grid will have to be upgraded**
  - **“Fill-In” stations will need strong (stiff) grid connection**
  - **Most likely additional Sales will be through existing infrastructure – Margin and Profit improvement opportunity**

Golden Era for the Industry???

Transportation: Competing Technology

Hydrogen:

- Fuel Cell Technology – Generates Electricity by combining Hydrogen & Oxygen.
- Electricity is used via motor for the mobility.
- Emission is H_2O (Water)
- Production of Hydrogen – Use renewable source of energy (solar, Wind) to generate Hydrogen via electrolysis
- Several countries are exploring such option

All Electrons for Transportation may not come from the Electric Grid

Summary

- Usage of Electricity has leveled off since 2005
- Per Capita usage of electricity has been going down since 2005
  - Shift in economy plus efficiency improvements
- To reach *Net* Zero CO_2 emission by 2050, significant Electrification of US economy is expected
  - Transportations
  - Building - Space Heating and Cooling Technology, etc.
- Per NREL Electrification Report
  - Demand for Electricity will be 20% higher under Medium scenario & 38% higher under High scenario over reference (BAU)
- Per Unit Load (PUL) on transformers can go up
  - *Without local solar*, up to 0.12 - 0.38 in medium scenario & up to 0.138 – 0.44 in high scenario
  - Local Solar (DPV) Production will lower above PULs
- Impact on Electric Utility will be *very* positive in any of above scenarios
  - However, Hydrogen for transportation could be a competing technology

Discussion

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