How to electrify the industrial sector?

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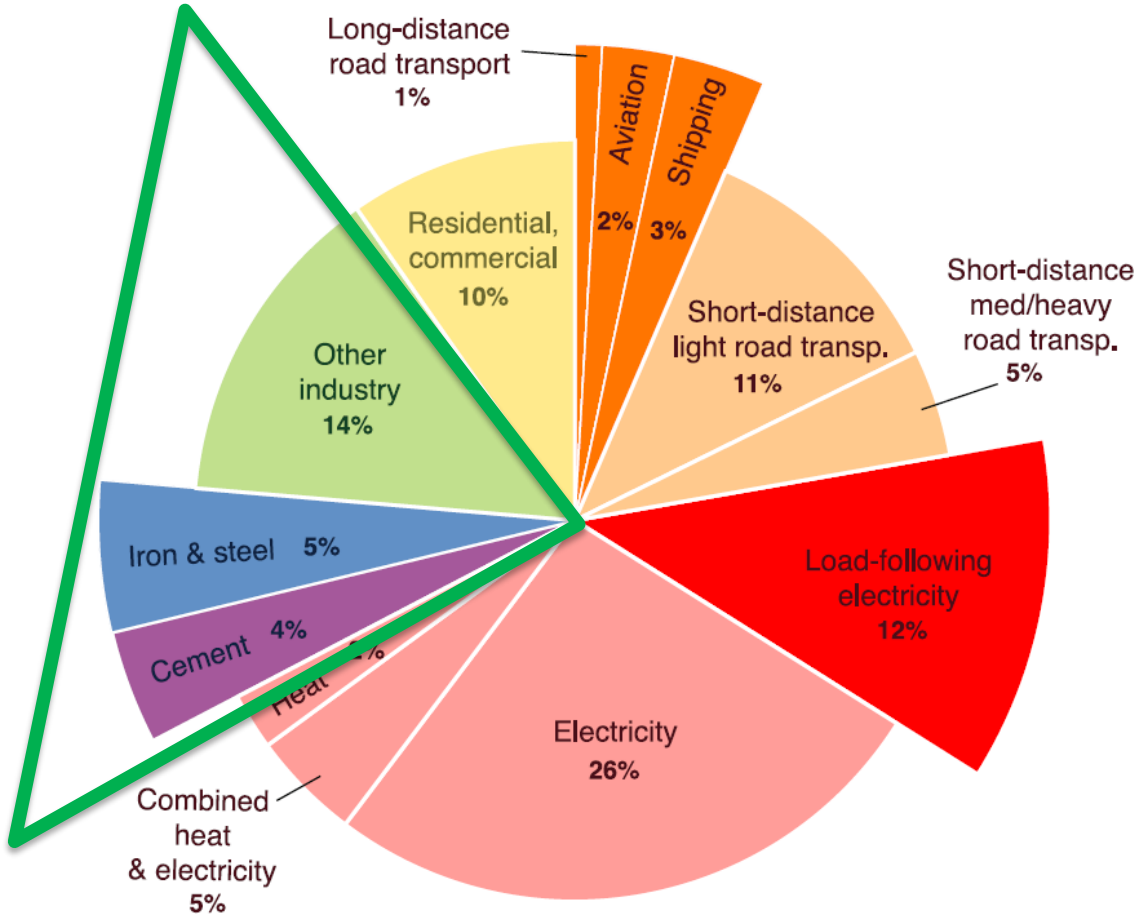
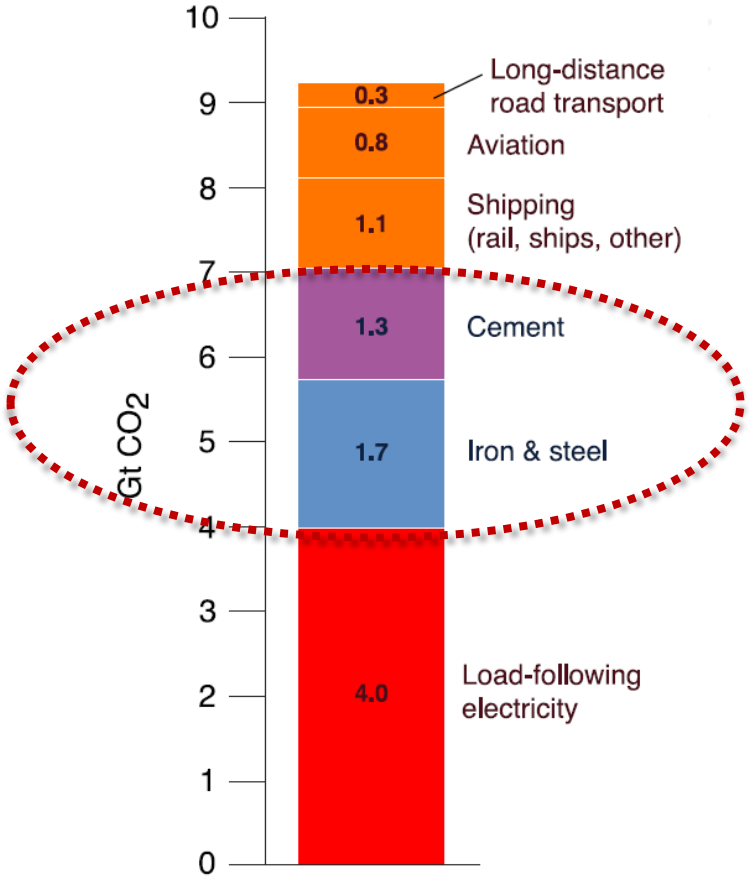
Industrial sector amounts to 23% of global CO_2 emissions… and it's hard to decarbonize



A **Global fossil fuel & industry emissions, 2014 (33.9 Gt CO_2)**



B **Difficult-to-eliminate emissions, 2014 (9.2 Gt CO_2)**

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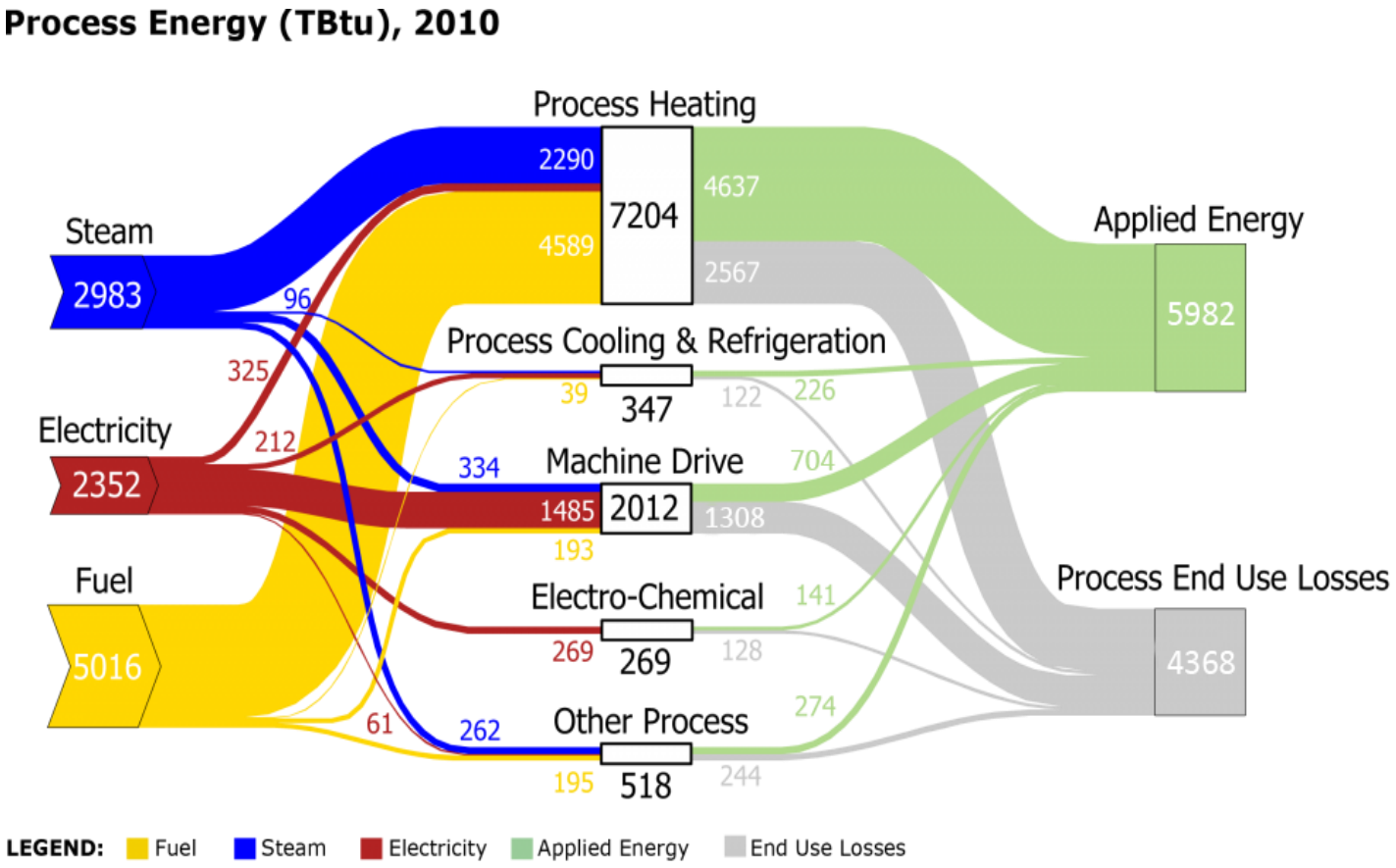
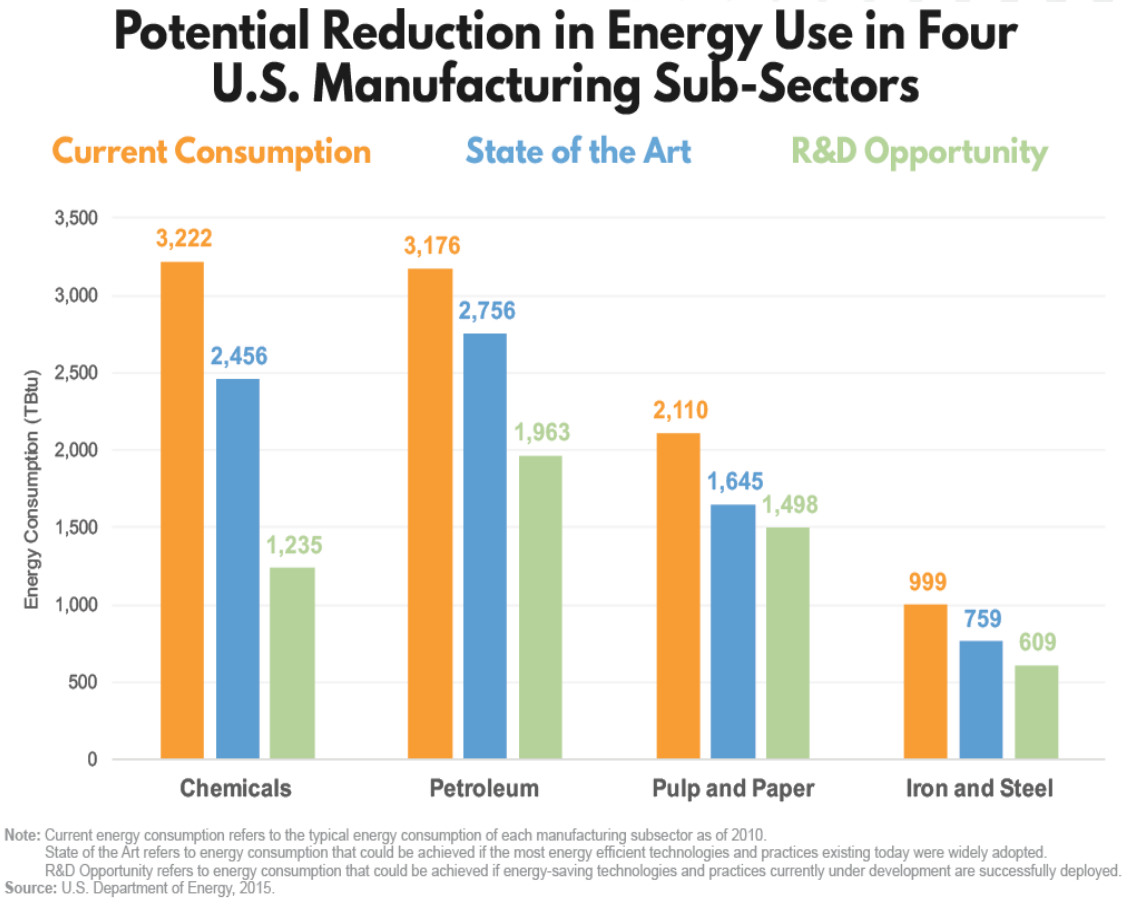
Process energy breakdown by sector

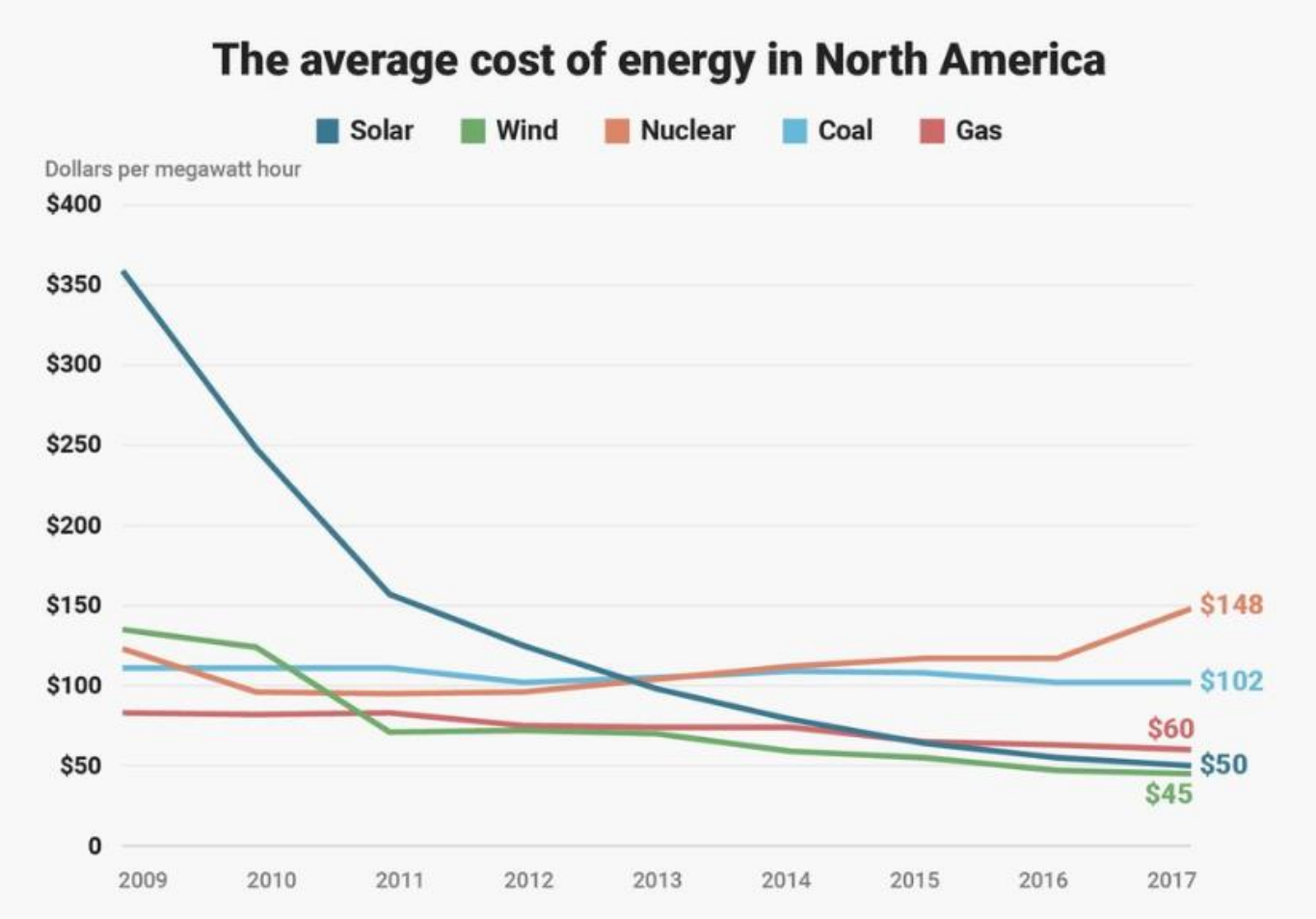




Note: Current energy consumption refers to the typical energy consumption of each manufacturing subsector as of 2010.
State of the Art refers to energy consumption that could be achieved if the most energy efficient technologies and practices existing today were widely adopted.
R&D Opportunity refers to energy consumption that could be achieved if energy-saving technologies and practices currently under development are successfully deployed.
Source: U.S. Department of Energy, 2015.

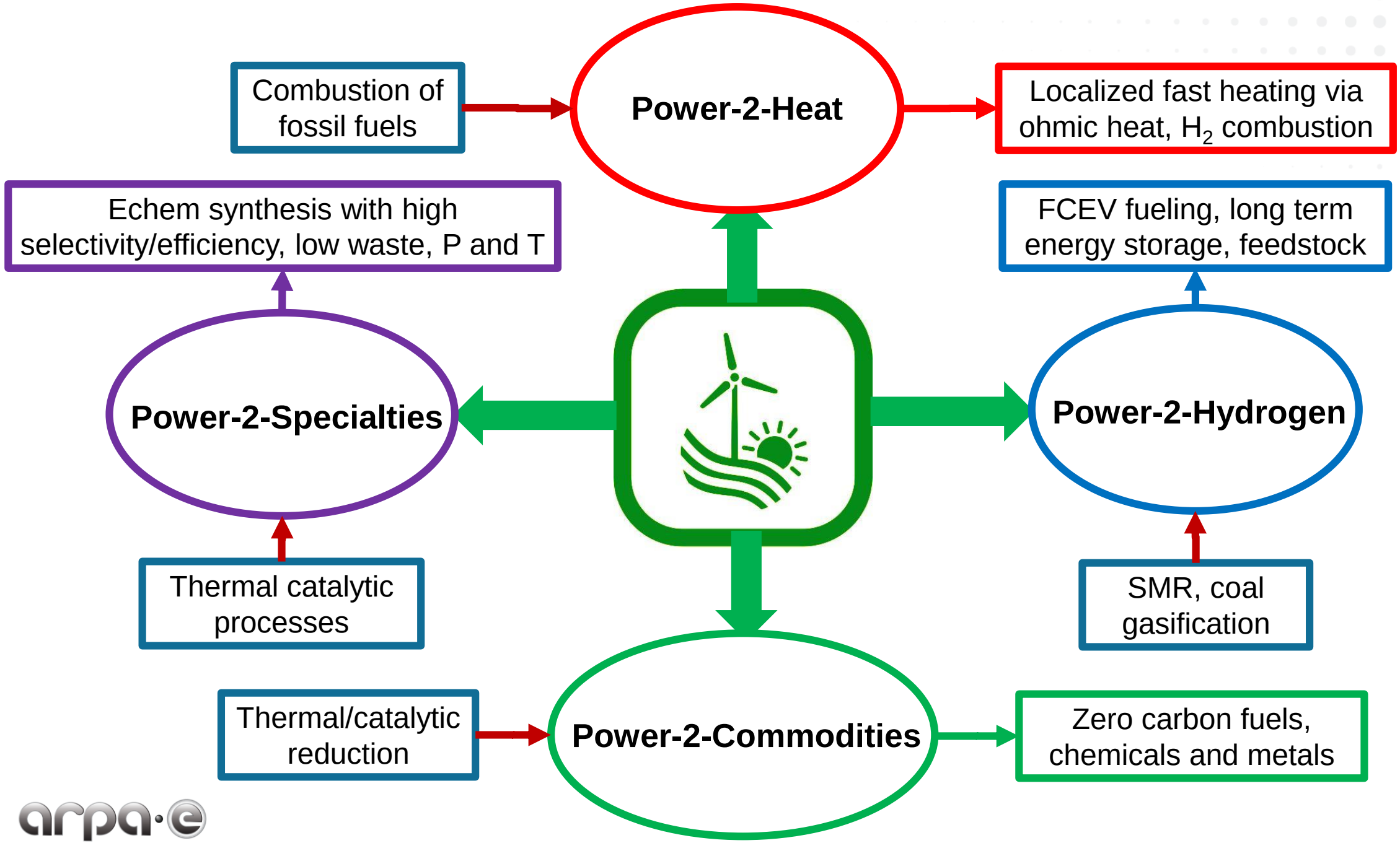
https://www.energy.gov/eere/amo/static-sankey-diagram-process-energy-us-manufacturing-sector

Use fossil fuels with CCS or renewable electricity?



"At zero-carbon electricity prices below ~$50/MWh, using zero-carbon electricity for heat or using hydrogen based on zero-carbon electricity becomes more economical than CCS"

https://www.lazard.com/perspective/levelized-cost-of-energy-2017/ , D. Pinner, McKinsey report 2018
https://www.mckinsey.com/industries/oil-and-gas/our-insights/decarbonization-of-industrial-sectors-the-next-frontier



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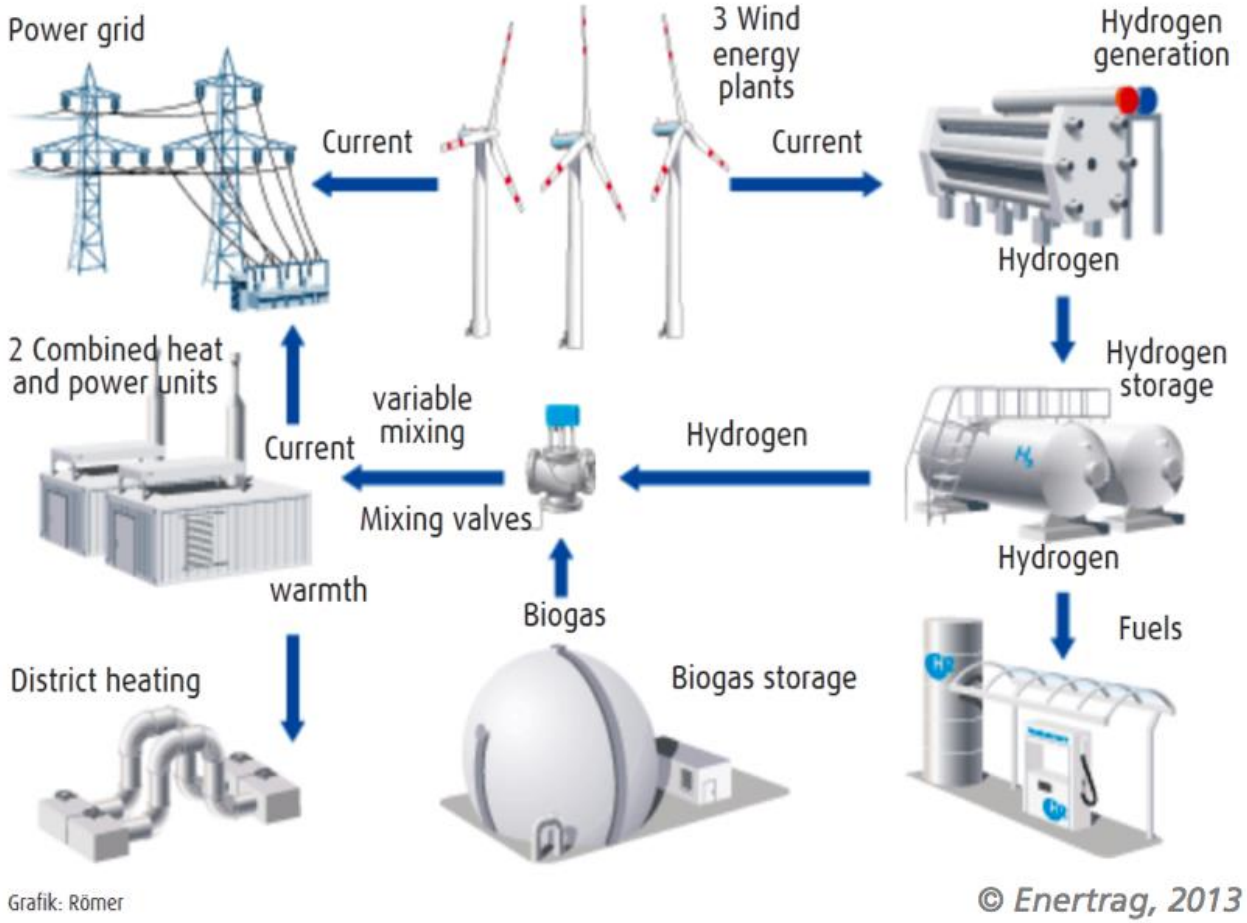
Example: Power-2-Hydrogen



Hydrogen produced through electrolysis or thermal splitting of water to be used for transportation, fuels, steel and chemicals manufacturing, and heating

T. Dillon "The Application of Electricity to Chemical Industry" https://www.jstor.org/stable/30093308

Use of renewable electricity in industrial sector - benefits

- **Increased industrial energy efficiency**
  - 40-60% less energy losses
- **Reduced fossil fuels consumption**
  - less CO_2 emissions
- **Effective use of renewable energy intermittent oversupply**
- **Reduced associated emissions due to cleaner processes**
- **Enable long-term energy storage**

Current and possible ARPA-E programs

- **Power-2-Commodities**
  - *Conversion of renewable electricity to fuels (REFUEL)*
  - Steel production using hydrogen and other fuels
- **Power-2-Hydrogen**
  - *Use of AEMs for hydrogen production and in fuel cells (IONICS)*
- **Power-2-Heat**
  - Develop technology for cement production
  - Develop thermal storage for building heating
- **Power-2-Specialties**
  - Develop new electrochemical manufacturing processes

The next frontier

“After breakthroughs in the power, transport, and buildings sectors, industrial decarbonization is the next frontier”

D. Pinner, McKinsey report 2018
https://www.mckinsey.com/industries/oil-and-gas/our-insights/decarbonization-of-industrial-sectors-the-next-frontier

Any suggestions?

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