

# Review of Initial Markets for Fusion Energy

Or any new heat source

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# Hiring for T2M for fusion

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- ▶ Work with Scott and Colleen!
- ▶ Help make fusion real!



## Tech-to-market introduction

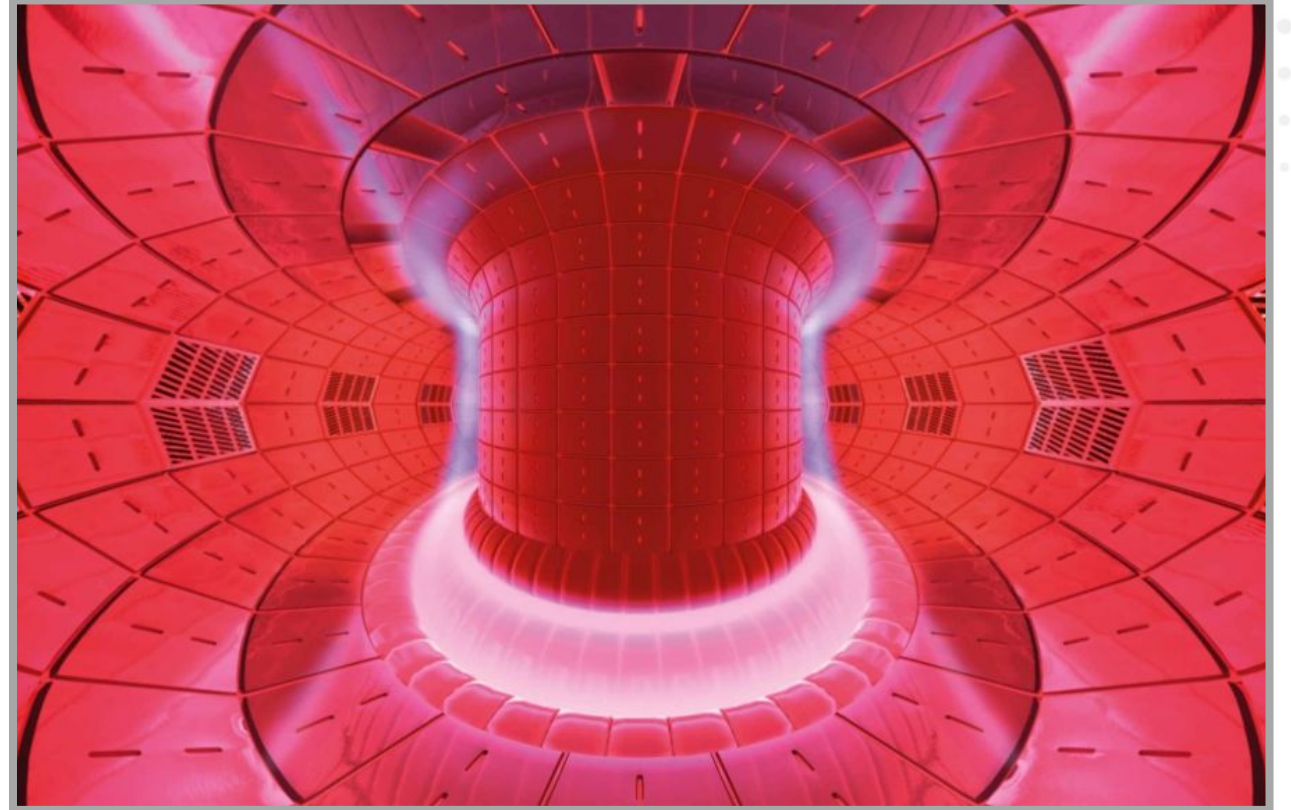
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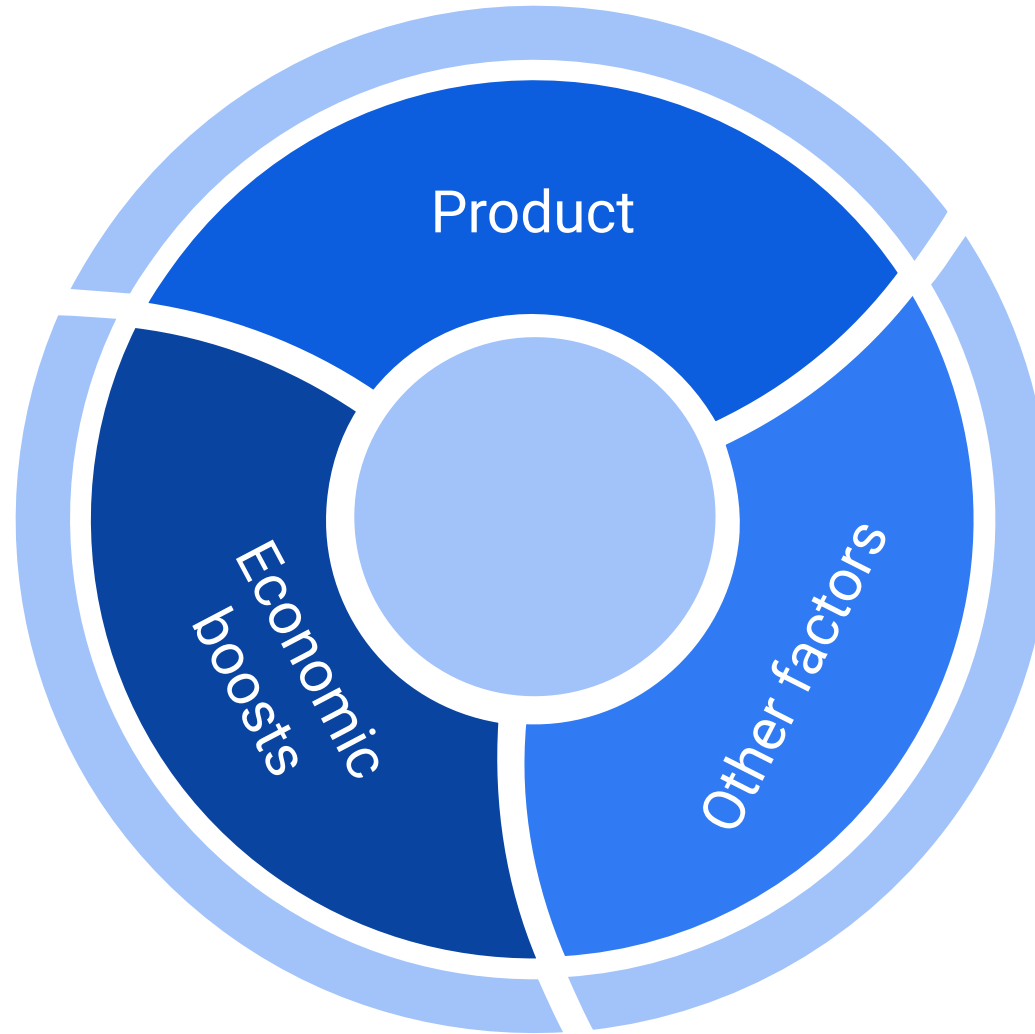
# Goals for the market study

- ▶ Suggest initial markets
  - 2035
  - Carbon tax up to 100 \$/tCO<sub>2</sub>
  - Looking for existing markets
- ▶ Audience:
  - Companies
  - Investors
  - Larger fusion community
- ▶ Suggest market requirements and price enhancements



# Factors to consider for selecting initial markets

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# Results are in $\$/MWh_e$

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# Electricity: Consider early markets where prices are high



## Other factors:

- Renewable capacity
- Population density
- Nuclear technological capabilities
- Capacity payments

# Electricity: Thermal storage fills out the duck curve

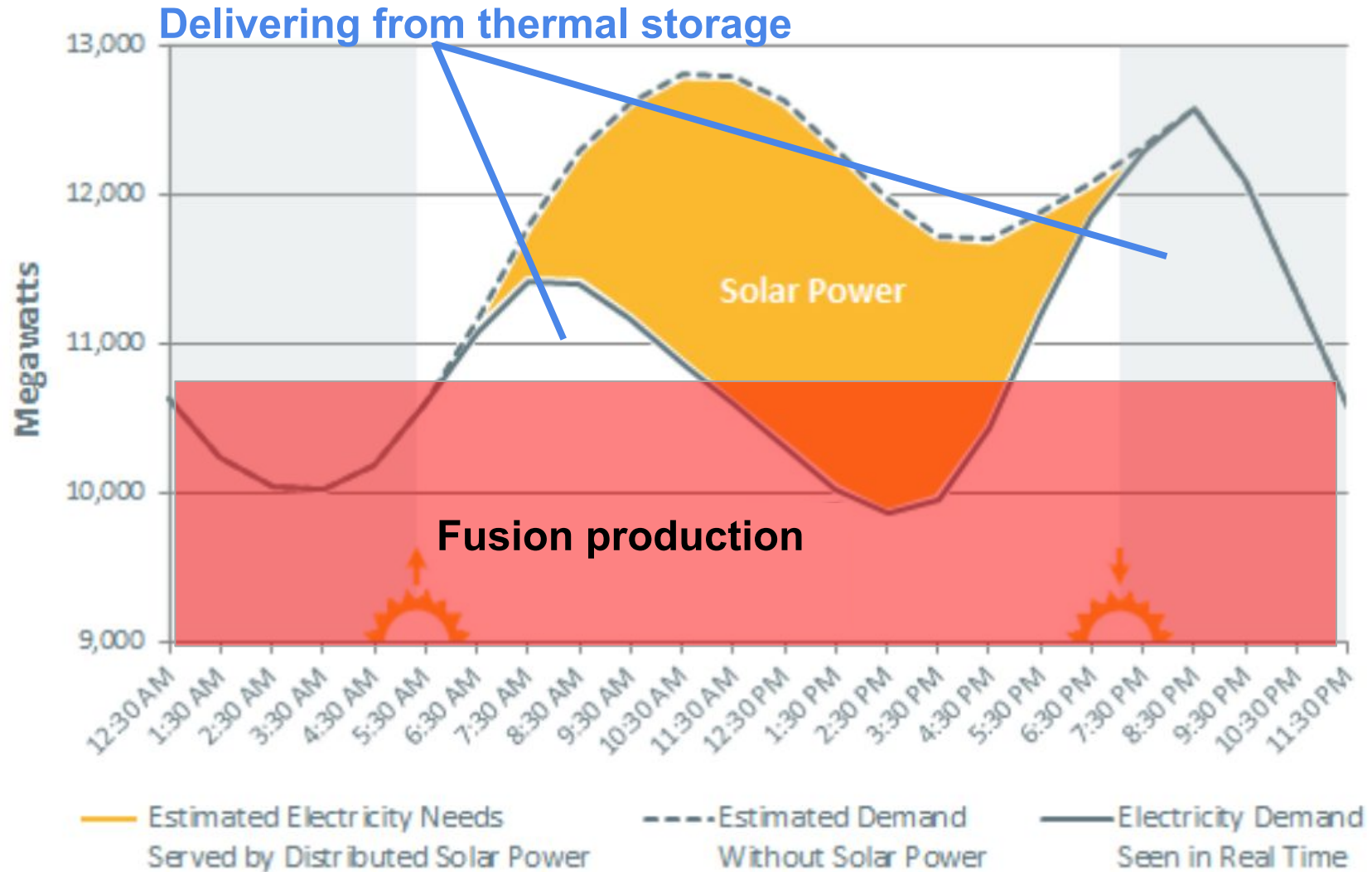
High renewables lower the capacity factor for firm power



Big increase in LCOE for fusion



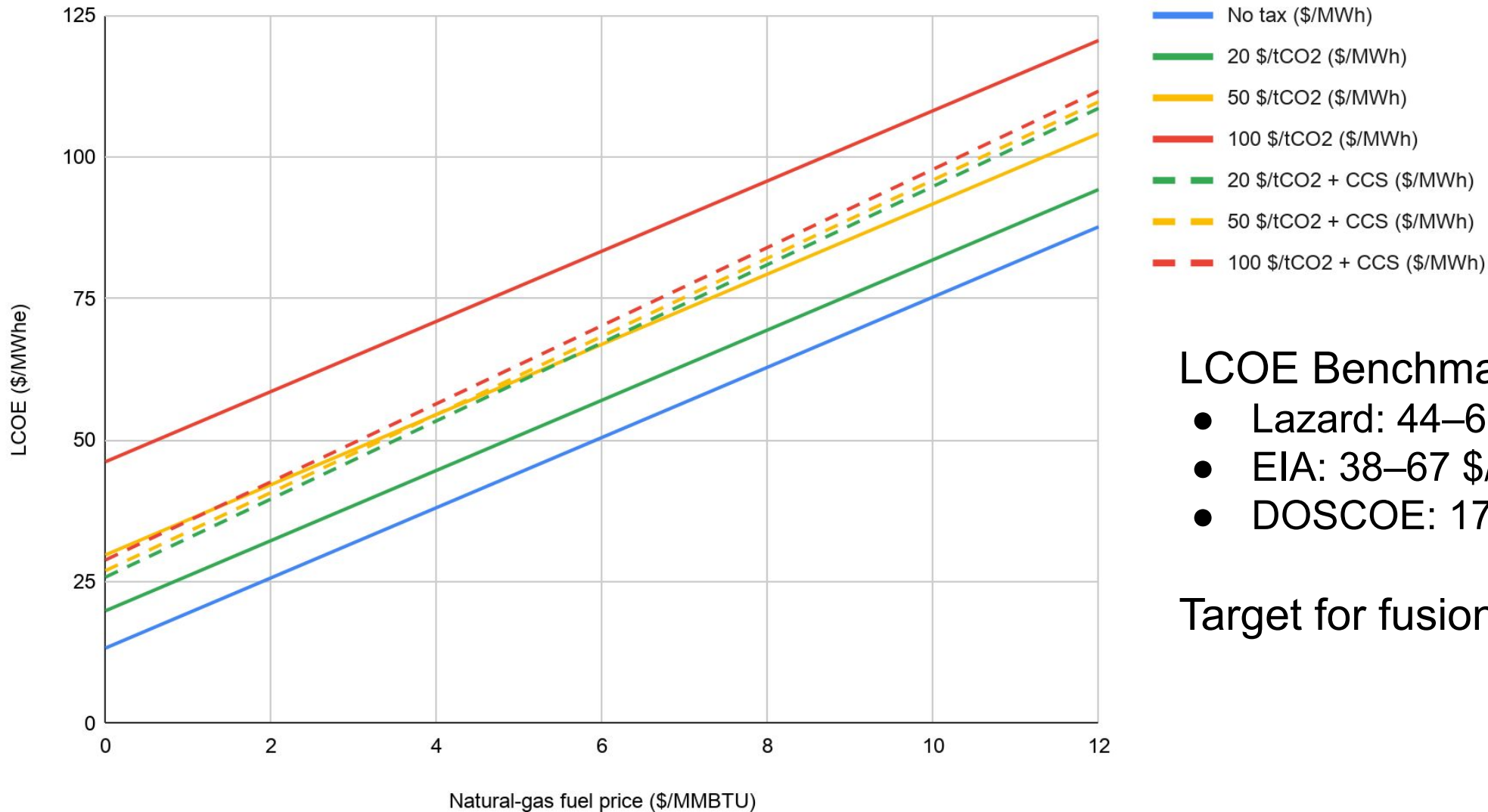
Integrated thermal storage might reduce LCOE by ~40%



Source: ISO New England

# Electricity: Must compete with natural gas in the long term

LCOE for NGCC by carbon tax and gas price



## LCOE Benchmarks

- Lazard: 44–68 \$/MWh<sub>e</sub>
- EIA: 38–67 \$/MWh<sub>e</sub>
- DOSCOE: 17–28 \$/MWh<sub>e</sub>

Target for fusion: 50 \$/MWh<sub>e</sub>?



# Process heat market will mostly be inaccessible to fusion

Tough market in general:

- ▶ Dependent on local customer
- ▶ Competing against free fuel
- ▶ Needs high temps

But: some promising markets, including remote mines:

- ▶ Repeat customers
- ▶ High price
- ▶ Tolerant of downtime



# Hydrogen could provide a small early market

## Heating:

- ▶ Japan: 78 \$/MWh<sub>e</sub> (3.5 \$/kgH<sub>2</sub>)
- ▶ Europe: 66 \$/MWh<sub>e</sub> (3.0 \$/kgH<sub>2</sub>)

Energy companies ready to build hydrogen plant if fusion is “the right price”

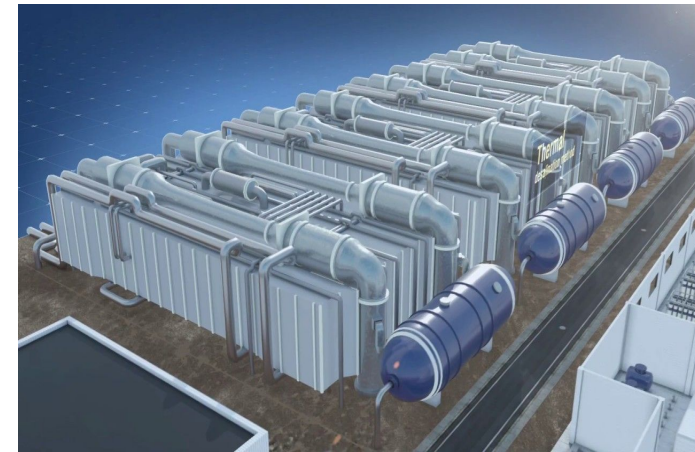
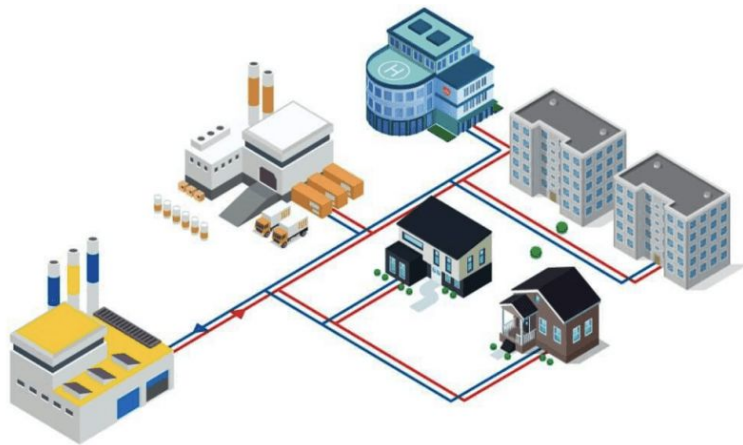
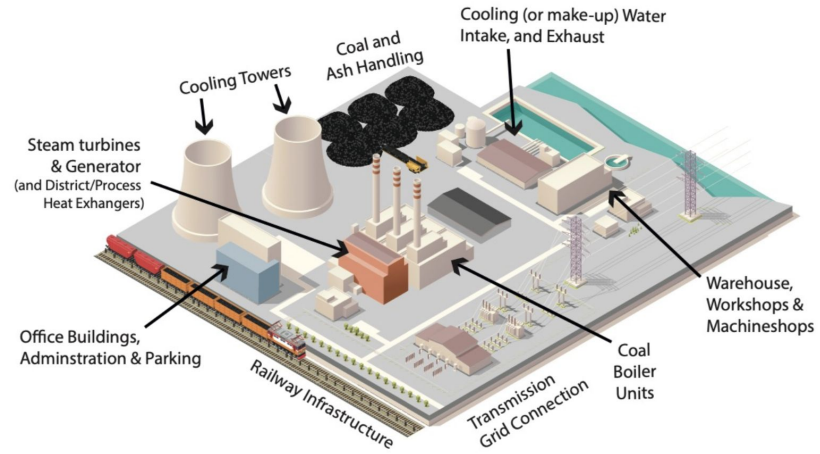
Firm power is less important than for electricity—more competition from renewables

## No obvious early markets in:

- ▶ Ammonia, Methanol
- ▶ Oil refining
- ▶ Steel refining



# Economic boosts

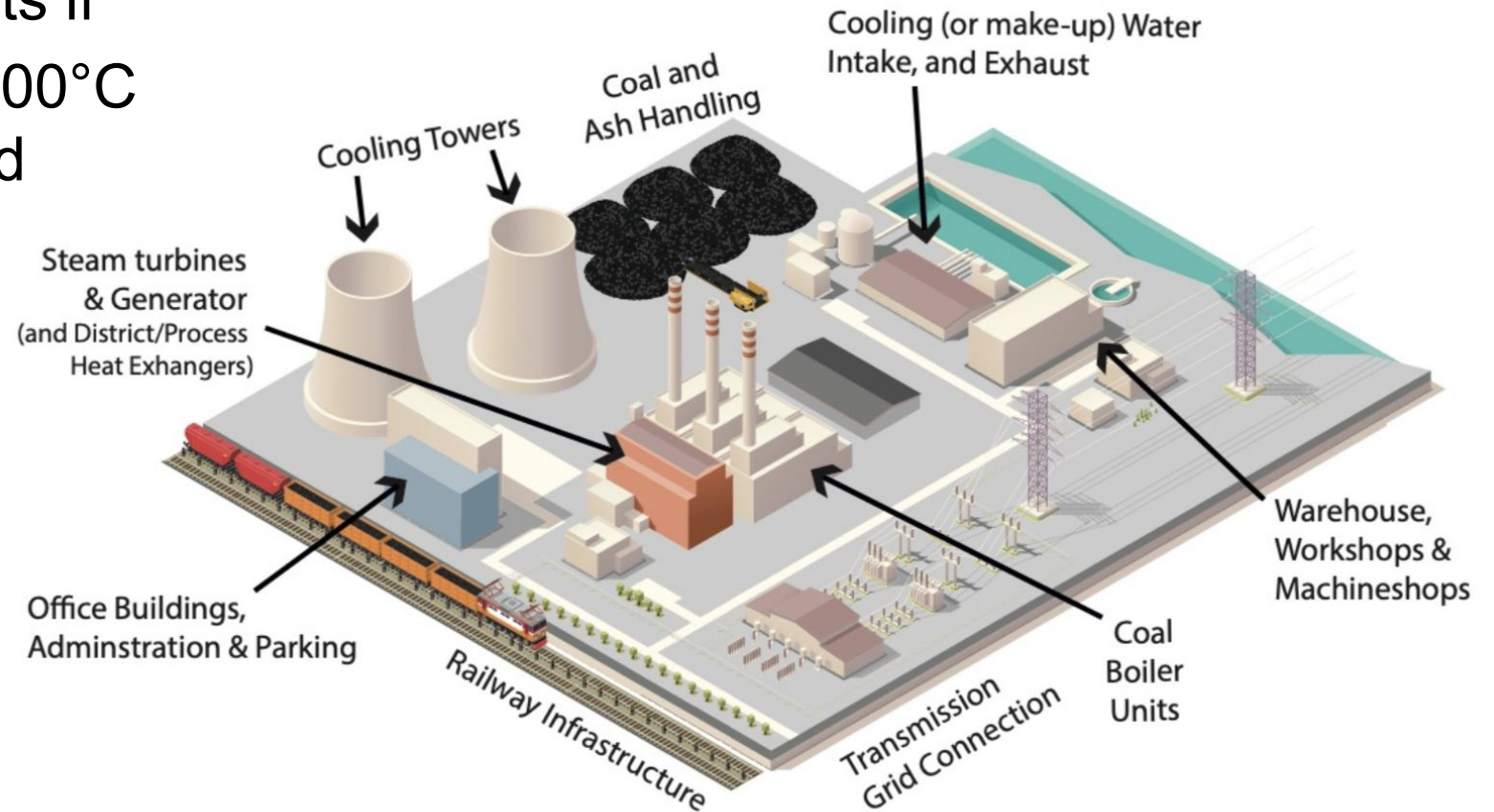


# Retrofitting coal plants could significantly reduce capex

Save up to 30% of capital costs if

- ▶ Fusion delivers steam at 500°C
- ▶ Coal plant is < 20 years old

Fusion and fission are the best fits for repowering most coal plants



Based on unpublished work by Staffan Qvist

# Direct Air Capture provides opportunity to reduce cost

Potential to reduce fusion LCOE by 35% through cogeneration

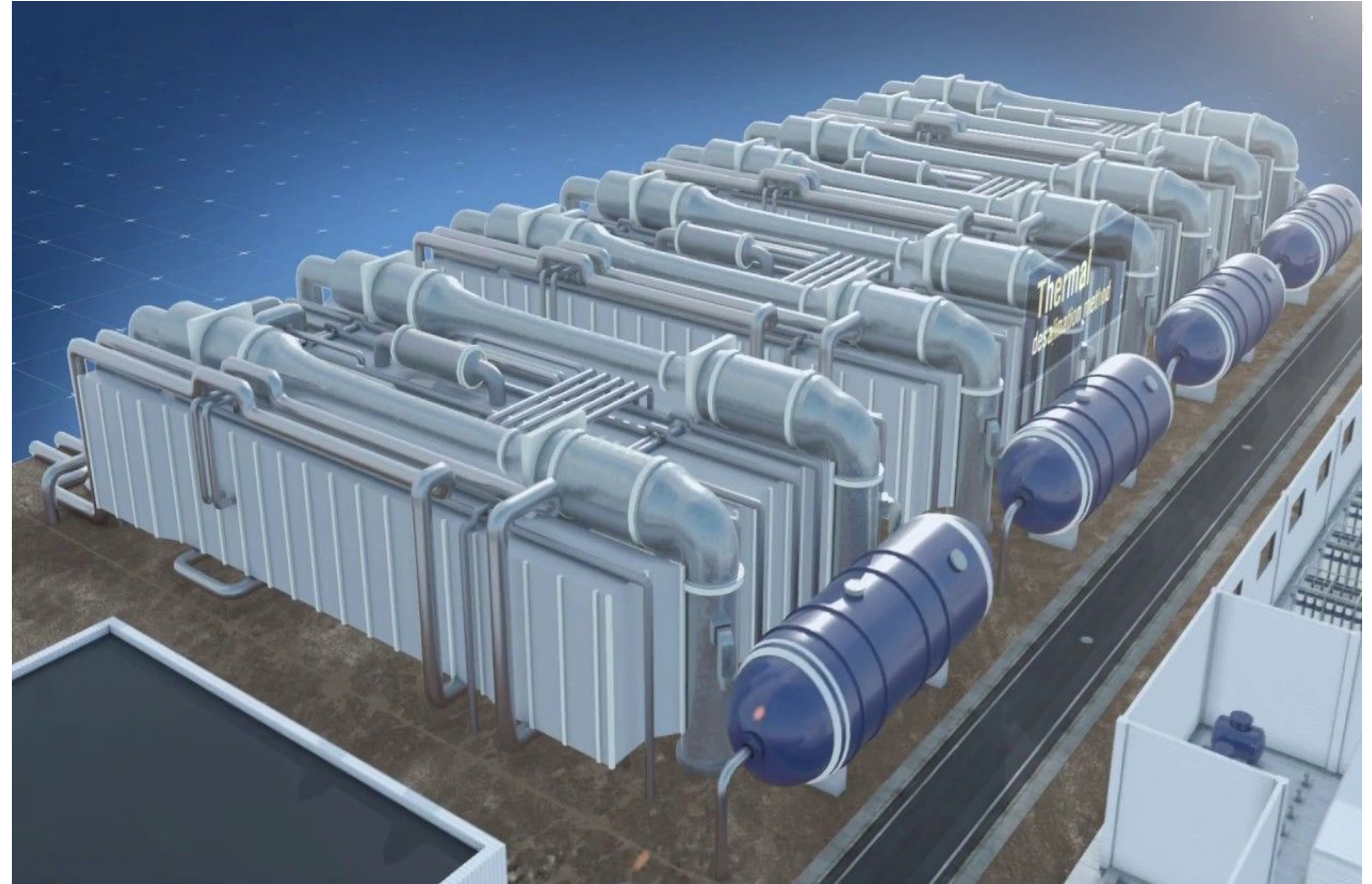
- ▶ Fusion supplies DAC plant free heat and electricity
- ▶ DAC plant generates revenue equal to cost per ton of CO<sub>2</sub>



# Desalination is cheaper with fusion

Thermal desalination methods require heat at about 100°C

Providing waste heat from fusion could cut O&M for desalination by about half

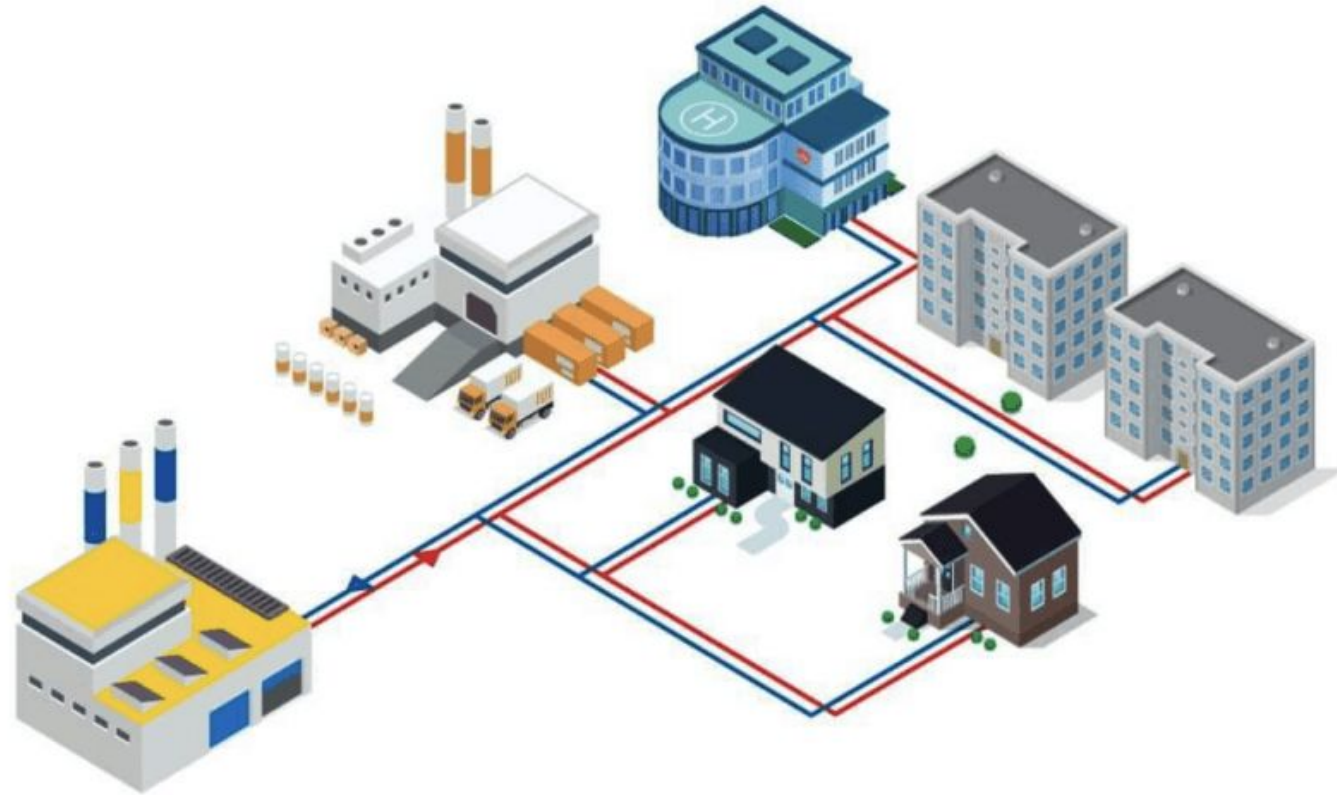


# District heating could provide a unique market for fusion

Individual cities can use multiple  
 $\text{GW}_t$

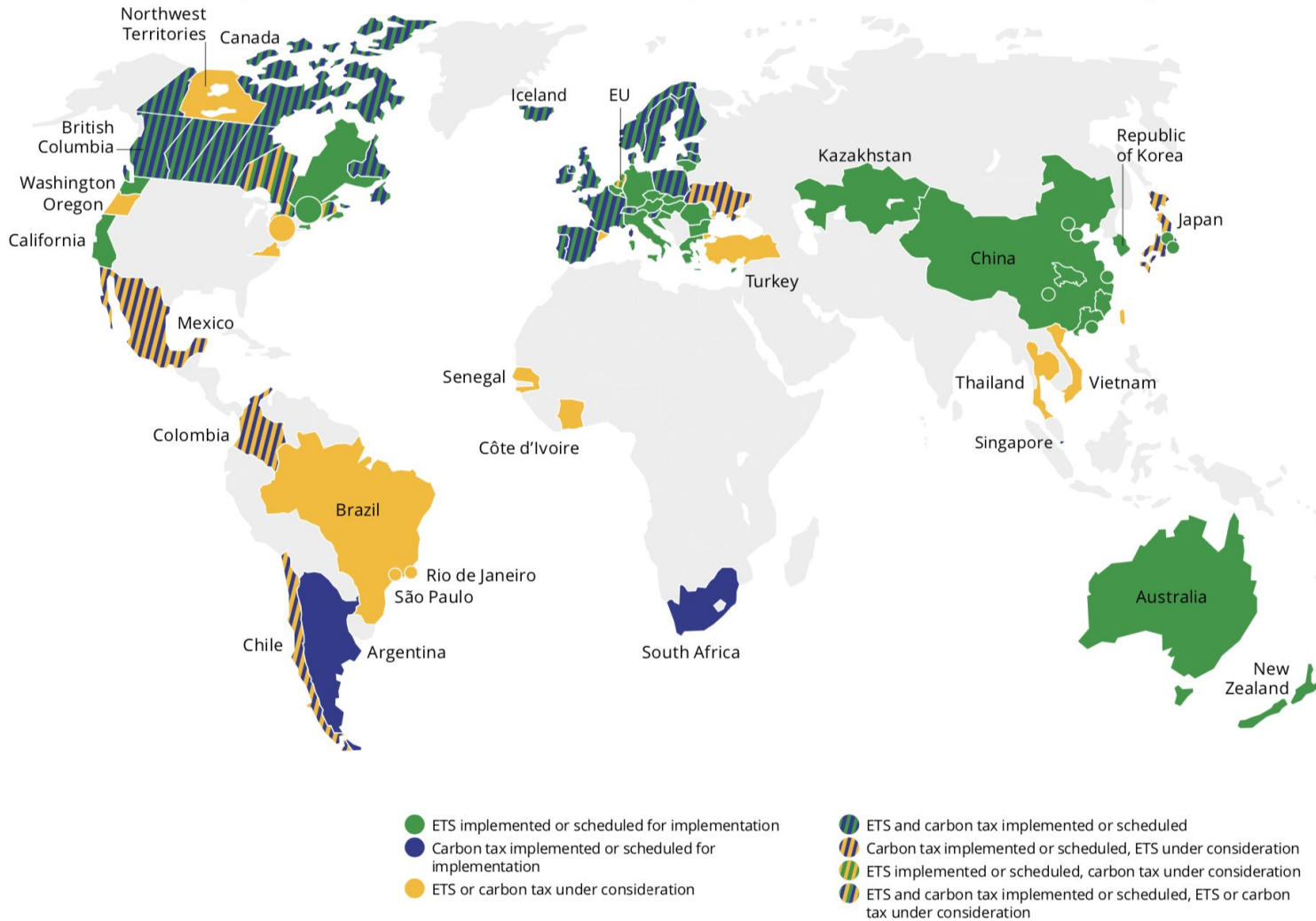
Fusion plants might be closer to  
demand than fission

Early market requires finding a  
large heat network to supply



# Carbon taxes will affect analysis

## CARBON PRICING INITIATIVES AROUND THE WORLD



implemented or scheduled for implementation



46 NATIONAL  
28 SUBNATIONAL  
jurisdictions



11 GtCO<sub>2</sub>e = 20%  
of GHG emissions covered



Range of prices in existing initiatives

US\$1 - 127/tCO<sub>2</sub>e

51% of the emissions covered are priced < US\$10/tCO<sub>2</sub>e



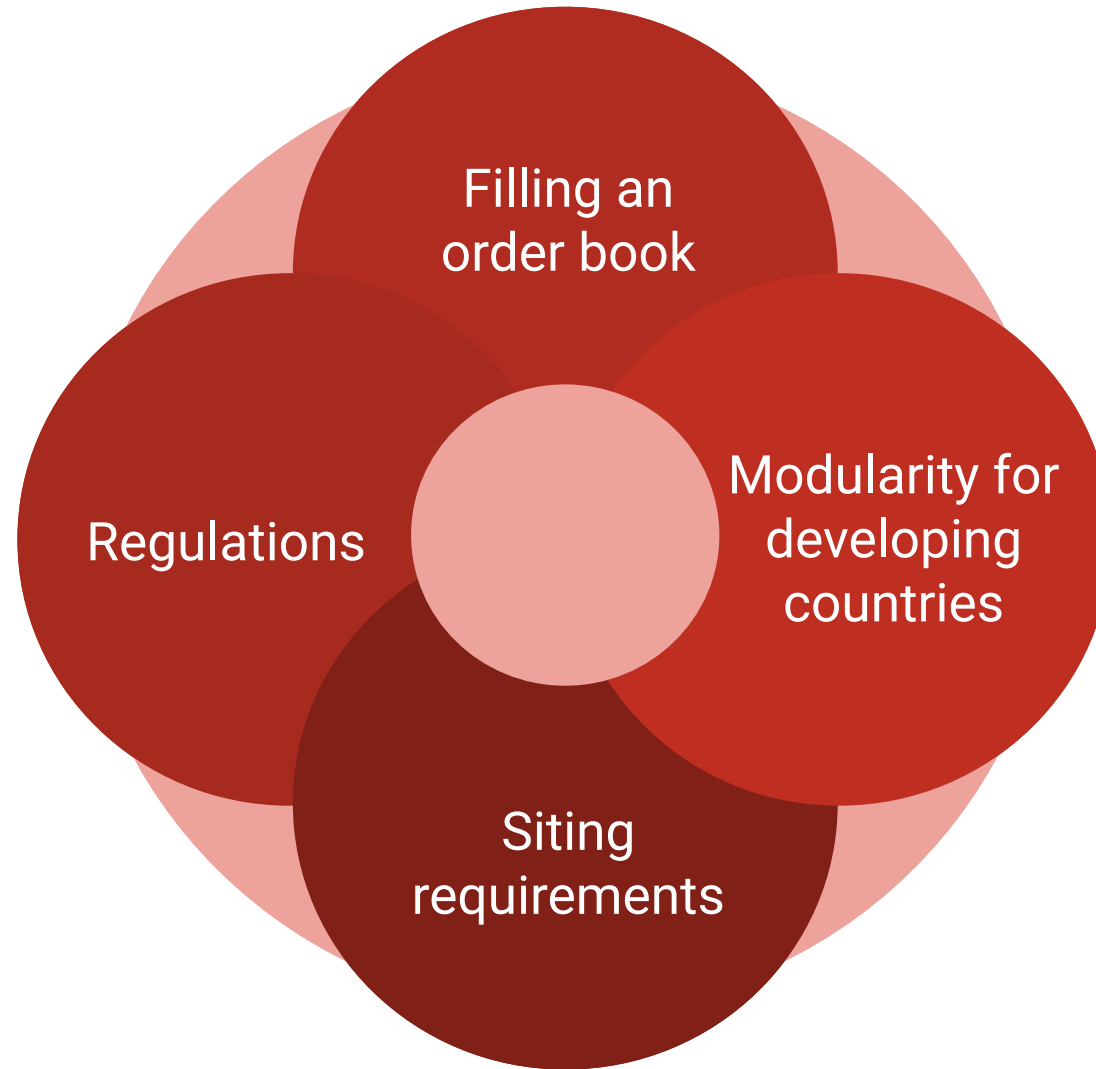
US\$44 BILLION

raised in carbon pricing revenues in 2018.



# Other factors

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# Conclusions

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- ▶ Grid **electricity** presents the most promising early market
  - For early development, look to countries with high costs of electricity
  - For longer term, 50 \$/MWh is a good benchmark that opens up most markets
  - Integrated thermal storage will be needed to compete in markets with high renewables
- ▶ The **process heat** market will be challenging in the short term and long term
  - There may be special circumstances where fusion could work well
- ▶ In areas where **hydrogen** is expensive, fusion could be a good fit
  - A market would be available in Japan if fusion can cost 78 \$/MWh
  - To reach larger markets worldwide, fusion would need to be half that cost
- ▶ Various **economic boosts** could help initial fusion deployment
- ▶ **Carbon taxes** will benefit fusion in all scenarios

Questions?