Flexibility from electrification of end-use sectors

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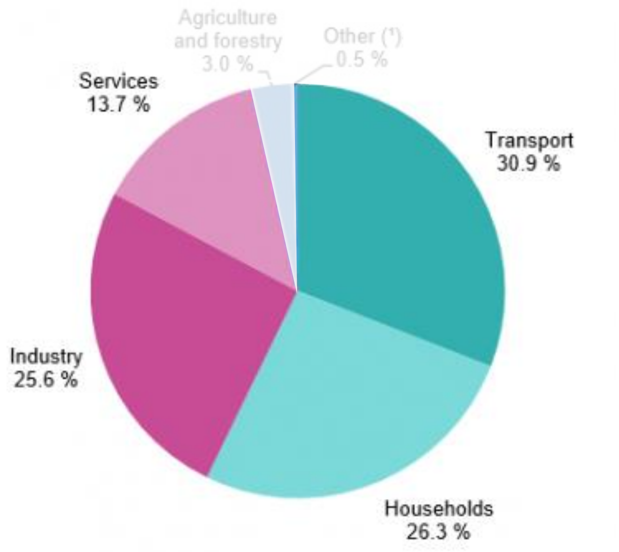
Transport, building heating and industry are electrifying. However, flexibility needs attention.

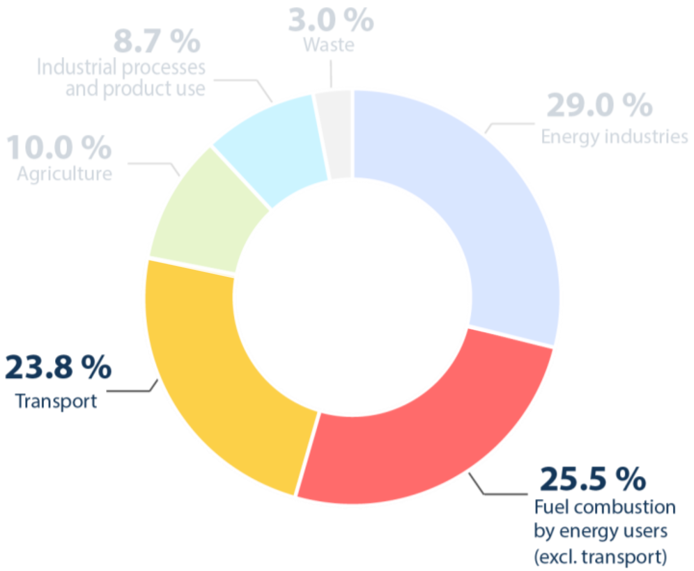
1. Why are end-use sectors important?
2. What are the drivers of electrification and flexibility?
3. In what order and how fast will they electrify?
4. What is the status of each sector: space heating, transport and industry?
5. How will electrification affect value of wind and PV?

Role of end-use sectors

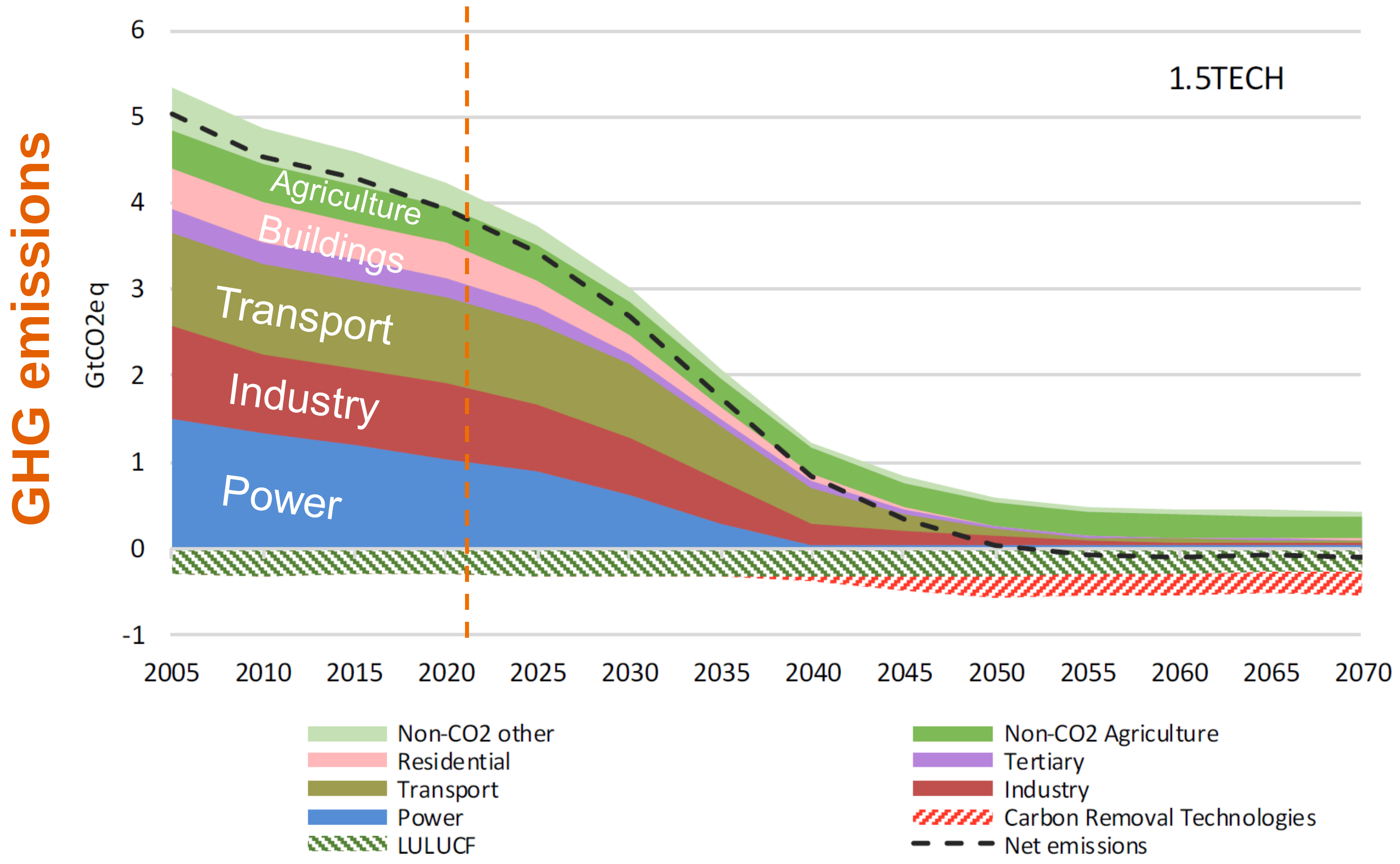
EU final energy consumption by sector 2019



EU GHG emissions by source 2017



Source: eurostat



CO_2 emissions in the energy sector

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Source: IN-DEPTH ANALYSIS IN SUPPORT OF THE COMMISSION COMMUNICATION (2018): A Clean Planet for all - A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy

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Drivers of electrification & flexibility

Eff ↑ VOM€ ↓ CO_2 ↓

Electrification

1. Climate driver
2. Technology cost and efficiency driver
   - Wind, solar, storage
   - Heat pumps, EVs

Flexibility

Sub-second (power quality)
Seconds to hours (power balance)
Hours to months (seasonal storage)

1. Power generation, including VRE
2. Electricity storages
3. Electricity transmission
4. Consumption from other sectors
   1. Interruptible processes
   2. Parallel energy sources
   3. Storages

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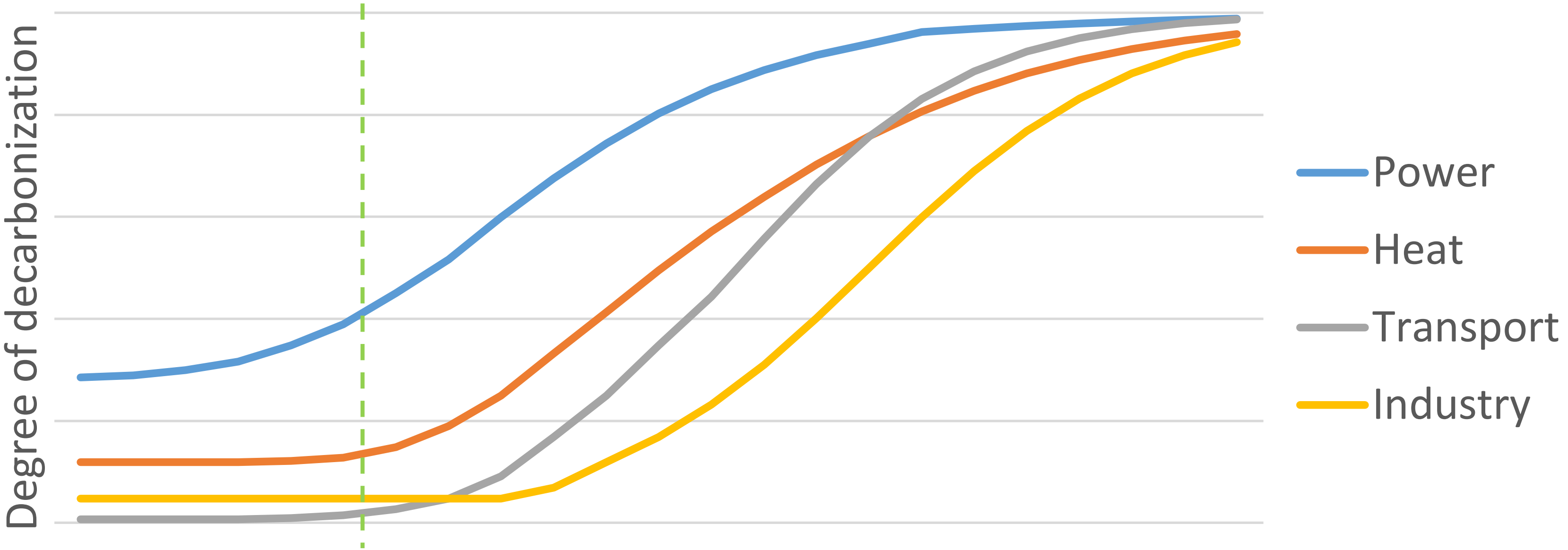
Conceptual decarbonization timeline of energy sectors



Flexibility in heating

- Main driver of electrification: **heat pumps**
- Opportunities:
  - Flexibility from heat storages (and building thermal inertia)
  - Flexibility from parallel heat sources
  - Providing short-term reserves with heat pumps only
- Problems:
  - Consumer acceptance of flexible operation (sufficient compensation?)
  - Installation of additional equipment (old buildings)
  - Time constant of storage may be short
  - Markets not fully supporting participation of small scale devices

Flexibility in transport

- Main driver of electrification: **li-ion battery development**
- Opportunities:
  - Smart charging
  - V2G
  - Fuels from electrolysis
- Problems:
  - Battery unexpected availability for charging and degrading
  - Everybody charging at the same time in the evening
  - Income vs. inconvenience
  - Controllable charging/discharging equipment
  - Markets not fully supporting participation

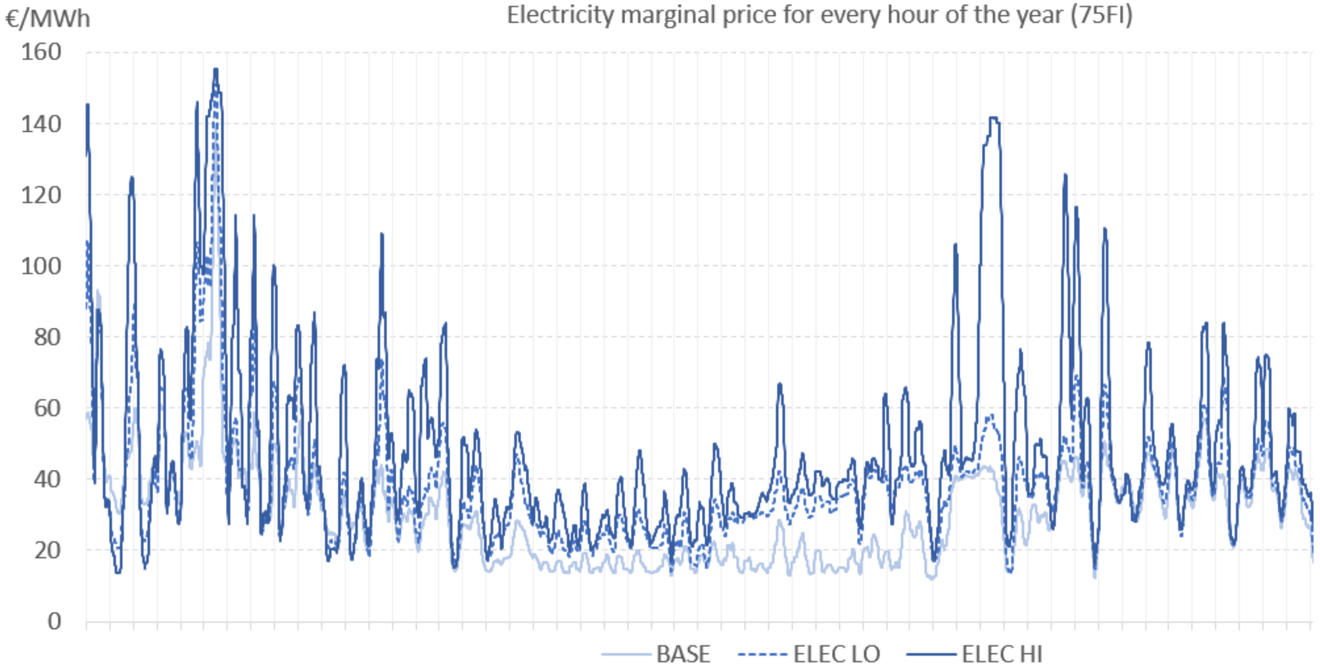
Flexibility in industry

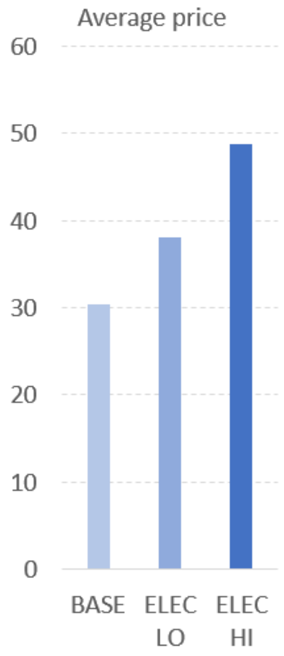
- Main driver of electrification: **cost of CO_2**
- Opportunities:
  - Low temperature heat can be stored
  - Some processes have internal storage opportunities
  - Electricity and fuel parallel systems can provide lot of flexibility
- Challenges:
  - Long investment cycles
  - Energy is secondary to the product – only proven solutions accepted
  - Fuels are competitive for producing high-temperature process heat (higher CO_2 prices required)

Indirect electrification

- H_2 (and NH_3 and CH_4), when direct electrification is impossible (materials, industrial processes) or impractical (shipping, aviation, long distances)
- Opportunities:
  - Electrolysis can be price responsive
  - Fuel storages can be cheap
  - Feeding back to power
- Problems:
  - High investment cost (at least currently)
  - Round-trip efficiency
  - Storage and transport of H_2

Wind & PV value with electrification





EV share: 12,5–25 %	25 –50 %	
Industry: 25 % of fossil fuels electrified	50 % of fossil fuels electrified	
Steel-making: 50 % by H_2	100 % by H_2	+ storages
Buildings: 25 % of demand electified	50 % of demand electified	+ parallel systems

Source: Pursiheimo & Kiviluoma: Analysing electrification scenarios for the northern European energy system

Electrified system with little flexibility

- More investments in transmission, distribution and peak power will be required
- More costly to remove final CO_2 emissions
- Increased price volatility
- Less options to support system stability

1 Electrification is a logical pathway to decarbonize. Stable carbon free power system requires current technology, new solutions and end-use participation.

2 Power generation is likely decarbonize first, followed by low-T heat and transport. High-T industrial heat and indirect electrification will take the longest.

3 Electrification will increase the value of wind and PV.

4 Flexibility will become increasingly valuable, but it needs attention already (long-term investments).

Acknowledgments

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