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# The big picture: Achieving very low CO2 futures

#### The Nordic perspective for a carbon neutral society

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#### GDP vs. GHG emissions: California and Sweden







#### Nordic primary energy supply, 2013





#### Nordic vs. California primary energy use, 2013



# Nordic electricity trade

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#### **Opportunities for efficient integration of wind & solar**

Shifting	Absorbing	Complementing
<ul> <li>Electricity ⇒ Electricity</li> <li>Reduce curtailment and peak power</li> <li>More even costs on diurnal basis</li> </ul>	<ul> <li>Electricity ⇒ Fuel and heat</li> <li>Reduce curtailment</li> <li>Fewer low cost events</li> </ul>	<ul> <li>Fuel ⇒ Electricity</li> <li>Reduce peak power</li> <li>More even costs on yearly basis</li> </ul>
Batteries	Power-to-heat	Flexible thermal generation
Load shifting	Electrofuels	Reservoir hydropower
Pumped hydro	Power to gas (hydrogen)	









Göransson, L., Johnsson, F. (Wind Energy, in-press)





- Transport accounts for the largest share of additional cumulative investments (USD 200 billion), but this is less than a 10% increase on 4DS levels
- 90% additional investment in buildings goes to drastically reduce space heating demand. The remainder goes to more efficient space and water heating equipment, appliances and lighting

Industry is the most difficult sector to decarbonise, requires innovation in technology and policy



Nordic Energy Technology Perspective 2016

CCS plays an increasingly important role in industrial sectors with high shares of process-related CO2, as no current alternative prospects exist for cost-competitive CO2 mitigation.

#### Example - Nordic basic material industry (Cement & Steel)

## Measures to comply with Year 2050 targets ~100€/ton CO<sub>2</sub> EU-ETS<sup>1</sup> < 10 €/ton CO<sub>2</sub>

<sup>1</sup>So far, but has recently increased somewhat and will increase further due to the recent revision of the EU-ETS system (up to some  $35\ell$ /ton CO<sub>2</sub>). Yet, unlikely to initiate transformative investments in processes and practices in the value chains of cement and iron and steel.

# CARBON



#### Example - Nordic basic material industry (Cement & Steel)

Measures to comply with Year 2050 targets ~100 $\notin$ /ton CO<sub>2</sub> EU-ETS < 10  $\notin$ /ton CO<sub>2</sub>

Rootzén and Johnsson Energy Policy 98 (2016) 459–469 Climate Policy 17, 6, (2017) 781-800 See also (in Swedish) <u>http://www.dn.se/debatt/plan-saknas-for-att-minska-basindustrins-klimatpaverkan/</u>

# CARBON



### Sweden's carbon policy

- EU ETS (electricity & industry, **13.9** €/ton CO<sub>2</sub>)
- EU Vehicle efficiency standard
- Swedish carbon tax (135\$/ton CO<sub>2</sub>)
- Bonus-malus
  - "New vehicles emitting more than 95 g CO<sub>2</sub> per km will pay a tax of 77 SEK (~8€) per gram CO<sub>2</sub> above 95 g during the first three years after registration. That tax increases to 100 SEK per gram above 140 g CO<sub>2</sub> per km.
  - After the three years the tax will go down to 22 SEK per g CO<sub>2</sub>, which is the level paid by new cars emitting less than 95 g per km.
  - New cars with emissions below 60 g CO<sub>2</sub>per km will get a one-off bonus of up to 45 000 SEK (zero-emission vehicles) six months after registration."
- Aviation tax proposed
  - EU flight (\$9 per person per trip), outside EU (\$30), long intercontinental (\$50)
- Meat tax?
- Industry are actively engaged and oftentimes take voluntary actions



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