Green energy transition in Europe

– a 50 year project of reconstruction and learning

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Agenda

- **Big challenge:** From fossil energy to zero emissions
  - Transforming the energy system while serving society every day

- **The transition is a <u>PROJECT</u>** (think of building a house)
  - Many steps and measures are interconnected - we need a plan
  - Timing and sequence is important
  - Many components may require decades of development

- Costs are **<u>endogenous</u>** and also very **<u>uncertain</u>**

  ➔ Uncertainty for market players and authorities

- **Challenge to “conventional” economic thinking?**

The energy transition challenge

The Power Sector

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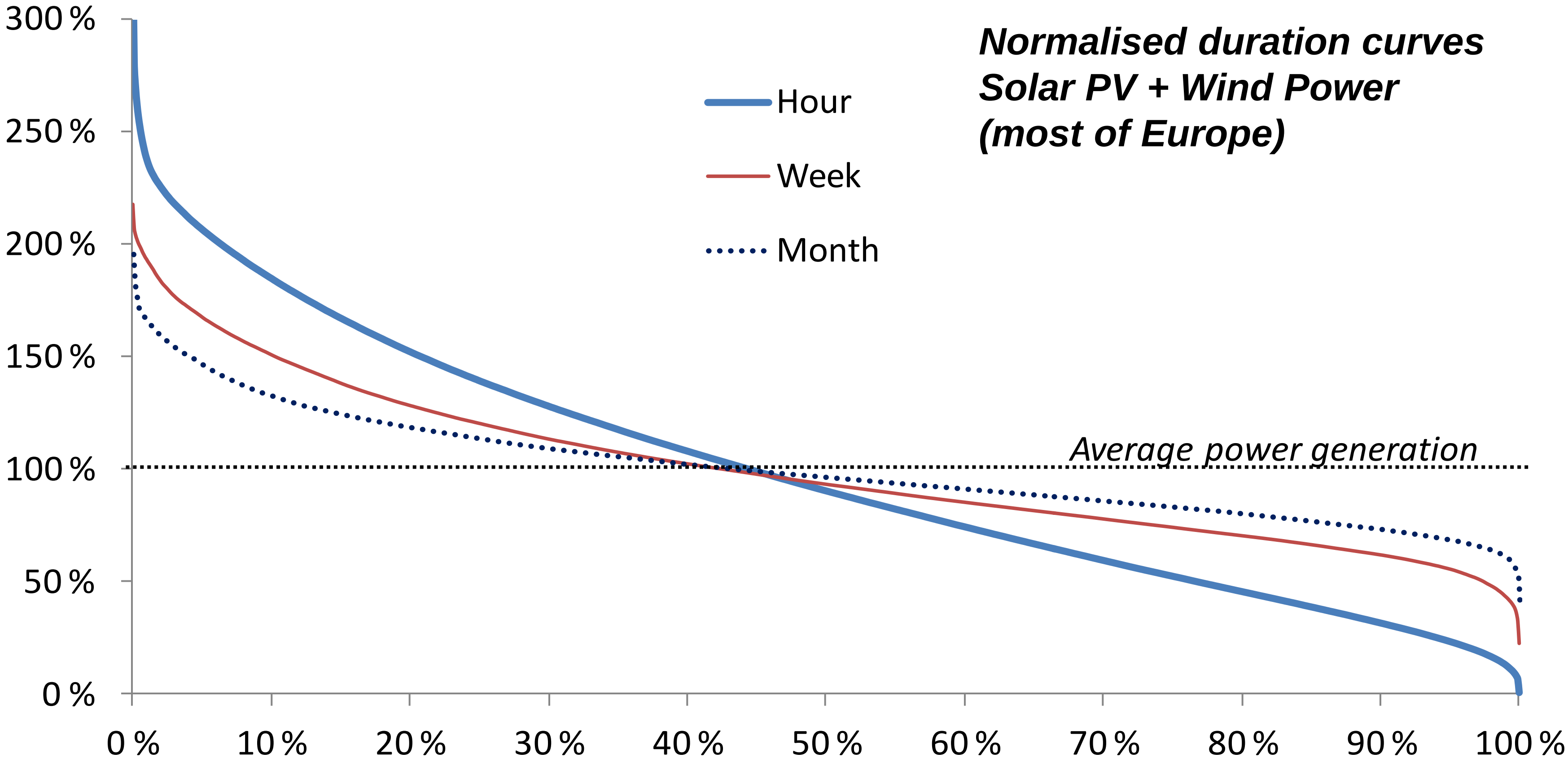
- **Replacing <u>flexible</u> fossil generation with less flexible and often intermittent renewable generation**
  - And to some extent also replacing nuclear power
- A stronger grid helps solving local variations ➔ better utilization of generation resources and flexibility
- But a stronger grid is not enough

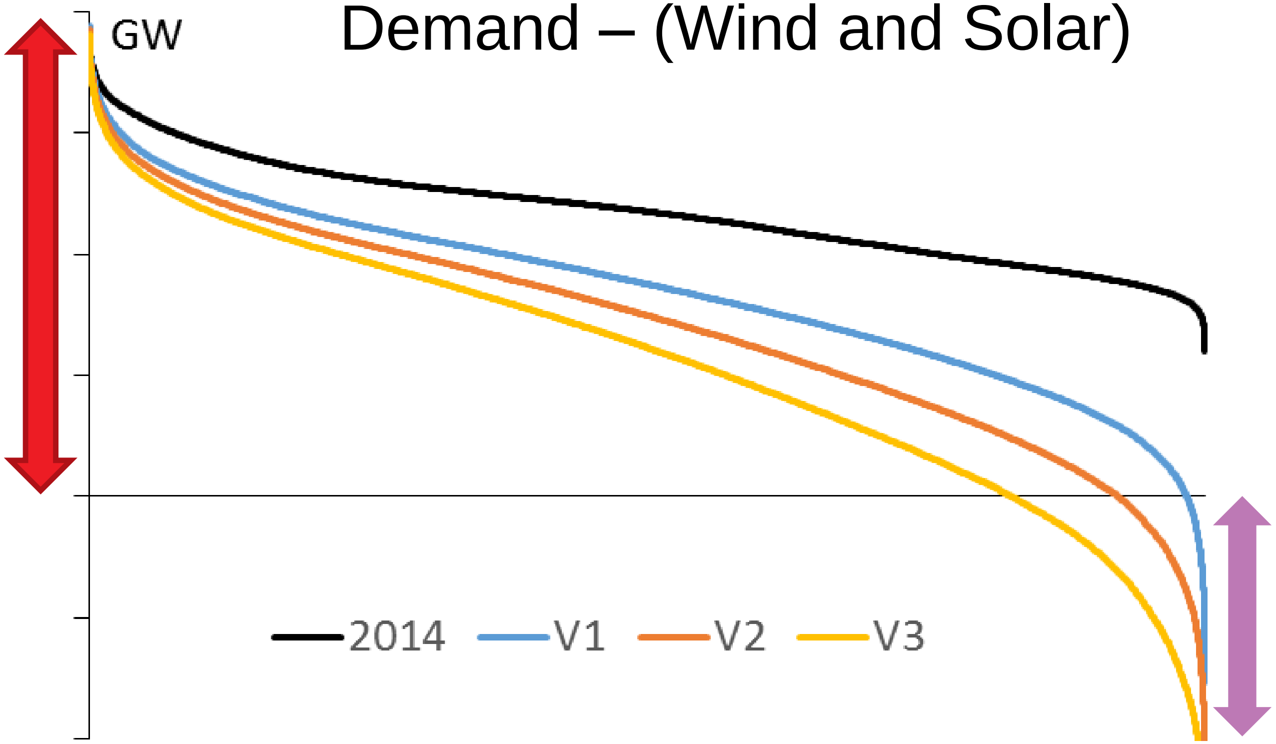
The Power Sector



Figurene bygger på en simulering som er gjort med utgangspunkt i værforholdene fra 1950 til og med 2012. Disse landene er inkludert: Polen, Tyskland, Østerrike, Sveits, Tsjekkia, Slovakia, Italia, Frankrike, Belgia, Nederland, Storbritannia, Norge, Sverige, Danmark, Finland, Estland, Latvia og Litauen. Simuleringen ser på samlet kraftproduksjon fra PV og vindkraft i 2030, totalt 443 GW installert kapasitet. I porteføljen inngår 42 GW gammel vindkraft, 142 GW ny vindkraft, 62 GW offshore vindkraft og 197 GW med PV. Ny vindkraft produserer jevnere enn gammel vindkraft, og offshore vind produserer enda jevnere, fordi vindforholdene offshore er mer stabile. Kilde: Statnett og Kjeller Vindteknikk.

The Power Sector

Residual demand =
Demand – (Wind and Solar)



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The challenge: All energy

EU: 20% RES by 2020

Norway: 67,5% RES onshore by 2020

Elec-
tricity

Heating and
cooling

Trans-
portation

Example: PV covers approx 7% of German power consumption ~ 2% of total energy

Electrification → Flexibility and decarbonisation

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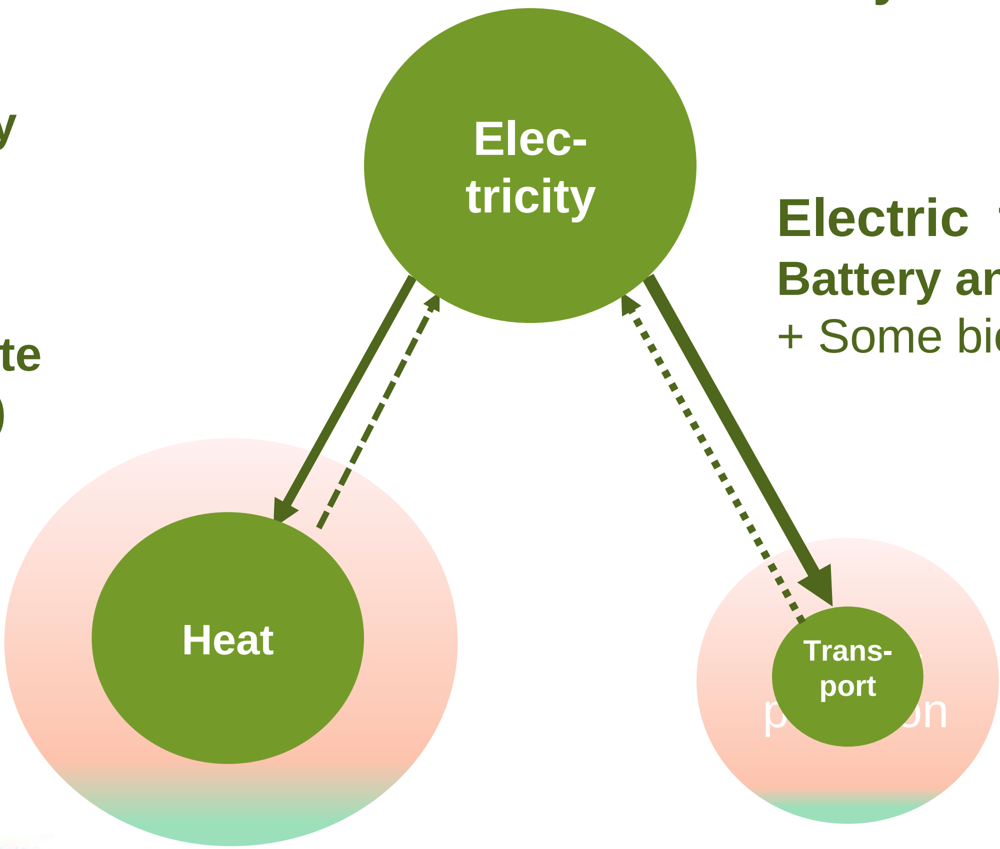
More zero emission electricity

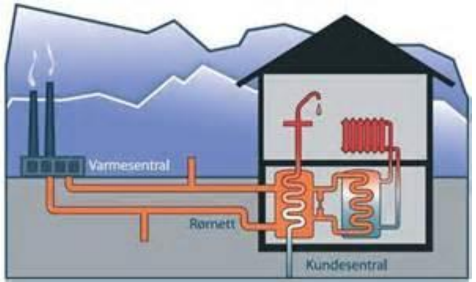
Energy efficiency

Solar heating
Geothermal
Bio fuel and waste (partly incl. CHP)
<u>Heat pumps</u>
<u>Electric heating</u> (e.g. boilers)

Heat storage



Electric transportation
Battery and hydrogen
+ Some bio fuel



We know the direction - roughly

- **Energy efficiency**
- **Bio energy when sustainable**
- **Power sector**
  - **More transmission capacity**
  - **Develop flexibility** in production and consumption
    - ✓ Help from the ICT-revolution (consumption)
  - **New generation technologies** with other production patterns
  - **More energy storage** – new and old technologies
    - Batteries, hydrogen, biogas, heat storage, hydro with reservoir (and pumped storage)
  - ➔ **Efficient markets to coordinate operation**

- **Integration of power sector with transportation and heating cuts emissions and gives flexibility**

The PROJECT perspective

The project perspective

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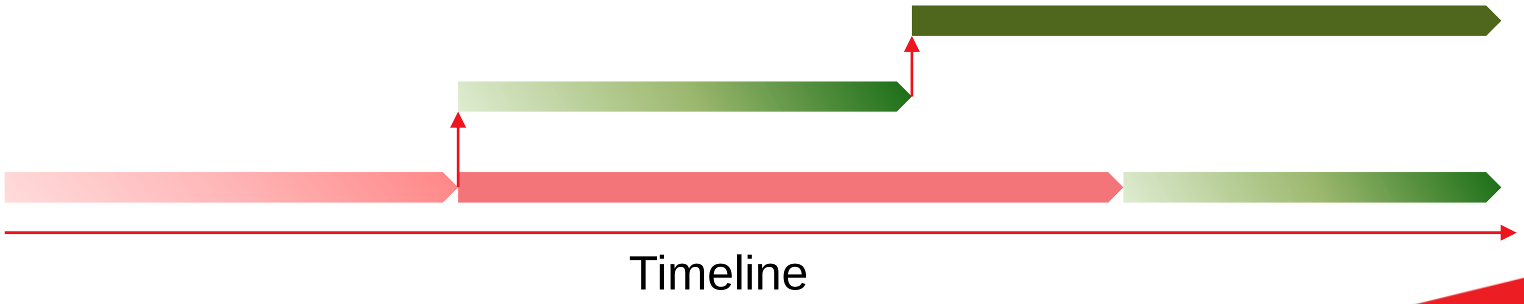
- **Each action must be understood in the context of the whole transformation project**
  - Building the foundation of a house only makes sense given the plan for the whole house
- Looking at the partial effect of one step today misleading
  - “We don’t need wind power”
  - “EVs don’t help, they run on coal fired power”
- We are changing (almost) everything – not marginally, but totally

Planning & timing cut costs

- **Exploiting investment cycles – crossroads**
  - Avoid lock in of emissions and of inefficient energy use
  - Life time perspective on abatement investments

- **Stable and predictable activity saves costs**
  - Uncertainty and on-and-off-policy increase cost and create delays
  - Economies of scale – investments in the supply chain

- **Early start and gradual expansion** to capture the benefits of **learning curves**
  - And to increase knowledge of the costs of different options



Example: Interconnectors

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- Big investment and long lead time (5-10 years)
- Limitations in the supply chain
- On shore grid constraint must be removed
- Incremental technology improvements needs testing
- Power system stability: market design and ICT-solutions must be developed and tested – need experience to reduce risk



Costs are endogenous and uncertain

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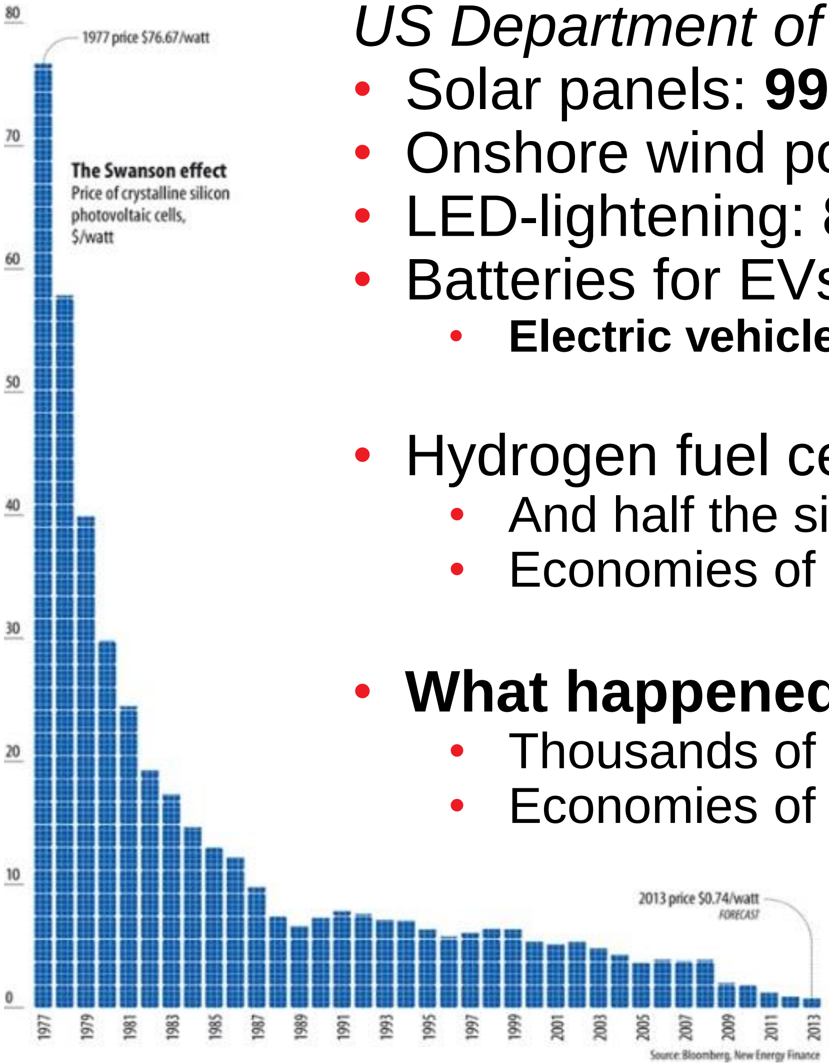
Research and deployment have given dramatic cost reductions



US Department of Energy, Revolution Now:

- Solar panels: **99 %** cost reduction in 35 years
- Onshore wind power: **90 %** cost reduction in 32 years
- LED-lightening: **85 %** cost reduction 2008 to 2012
- Batteries for EVs: **> 50 %** reduction 2008 to 2012
  - **Electric vehicles may be fully cost-competitive by 2022**

- Hydrogen fuel cells: **95%** cost reduction in 8 years
  - And half the size and weigh
  - Economies of scale may reduce cost by **75%** from now

- **What happened?**
  - Thousands of innovations in the whole value chain
  - Economies of scale

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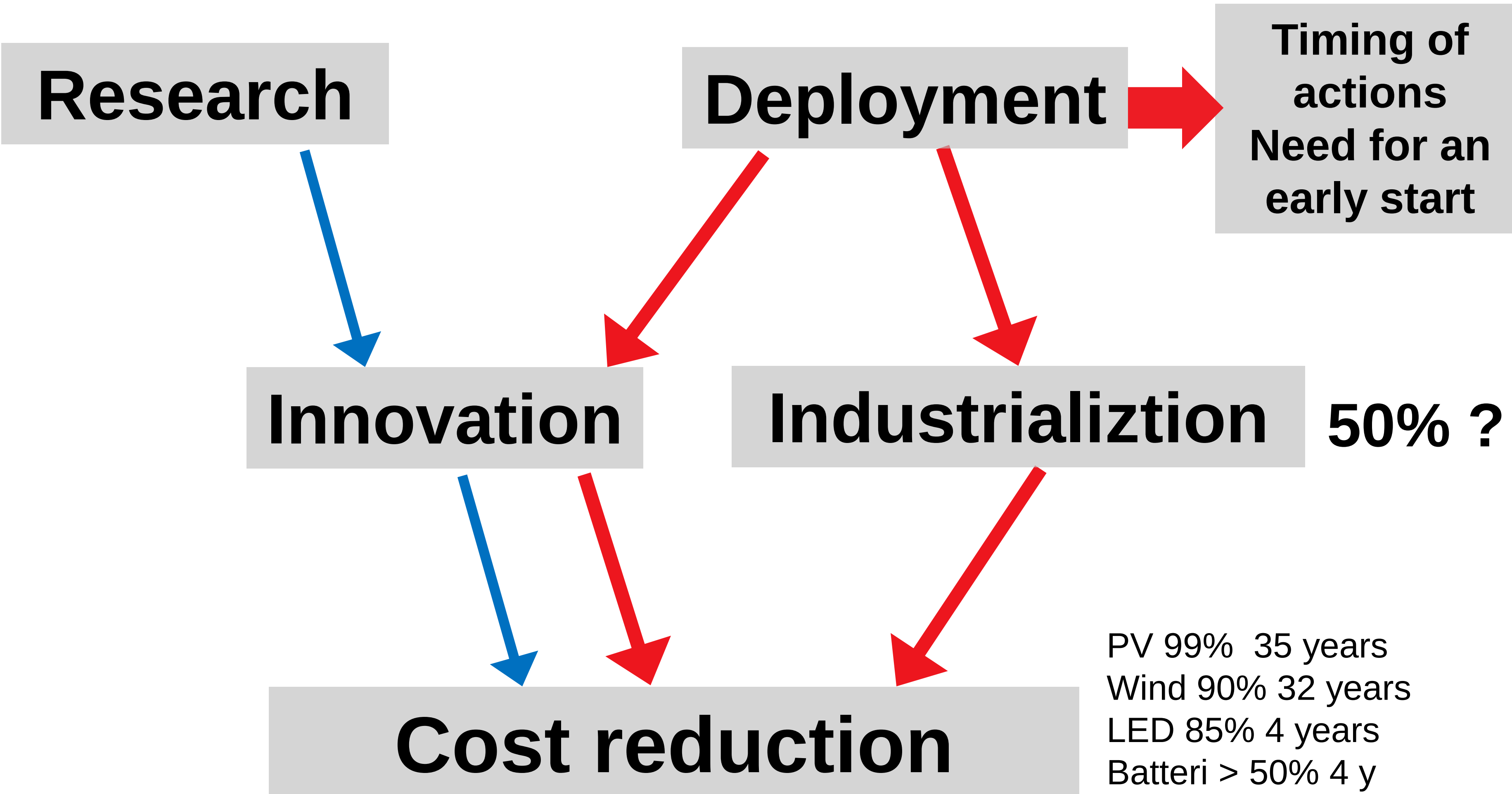
Research and deployment have given dramatic cost reductions



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The technology optimists were <u>wrong!</u>

- ***They were far too pessimistic!***
- ***Research and deployment can create miracles***
  - But how fast and how much?
  - Difficult to predict
- ***We will need to adjust the plan***
- ***And try to predict technology improvements***

Challenge to “conventional” economic thinking?

Why does it take five economists to change a light bulb?

You only need one economist to change the bulb, but you need four to keep everything else constant

The *marginal* and *partial* approach misses the target

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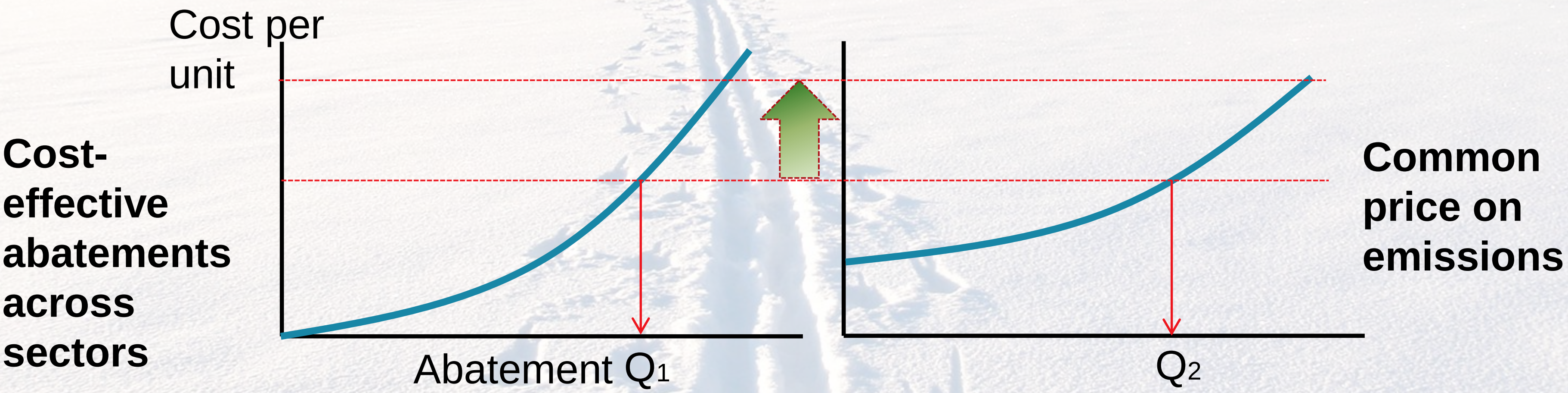
- **Typical approach: analyze marginal changes – often changes in only one parameter**
  - "Does it help to promote EVs?"
- **Climate policy: energy system <u>transformation</u>**
  - **Every action plays a part** in the of total transformation
  - **Learning is essential**: Costs and even preferences are endogenous
    - Technology development – <u>game changer</u>
    - Societal learning – e.g. the development of adequate markets

A beautiful economic model



How can this be wrong?

The simplified merit order curve does not represent reality well

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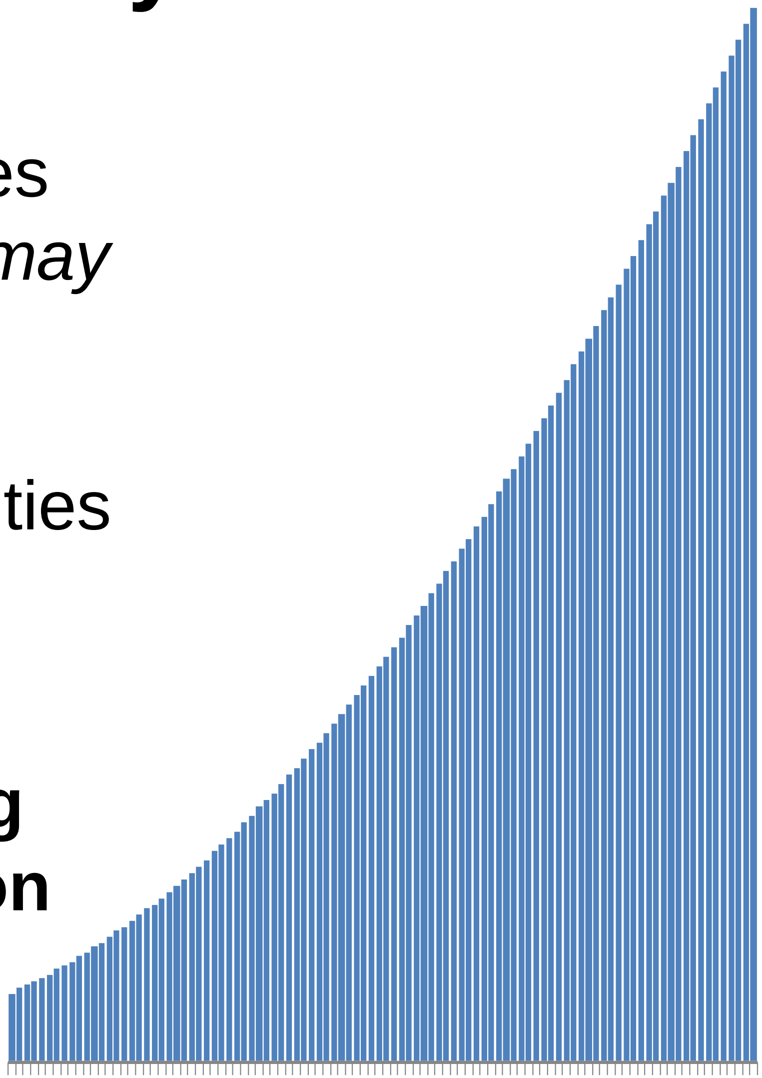
- Interdependencies of measures
- Learning curves – *expensive may become cheap!*
- Economies of scale
- Timing – investment opportunities
- Exploring options for later use
  - ➔ Better investment decisions

➔ Better objective: Minimizing the cost of the total transition




Thank you
Fremtiden er **elektrisk**