Danish Energy Policy & Public Funding of Energy Technology R&D&D

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Danish Energy Policy – key targets

- **Long-term target is 100% renewable energy in all sectors by 2050**
- By 2035 all grids (electricity, gas and district heating) must be based renewable energy
- By 2030 coal is phased out of power and CHP plants
- By 2020 windpower will cover 50% of electricity production
- 40% reduction in Denmark's emissions of greenhouse gases by 2020 compared with the 1990 level

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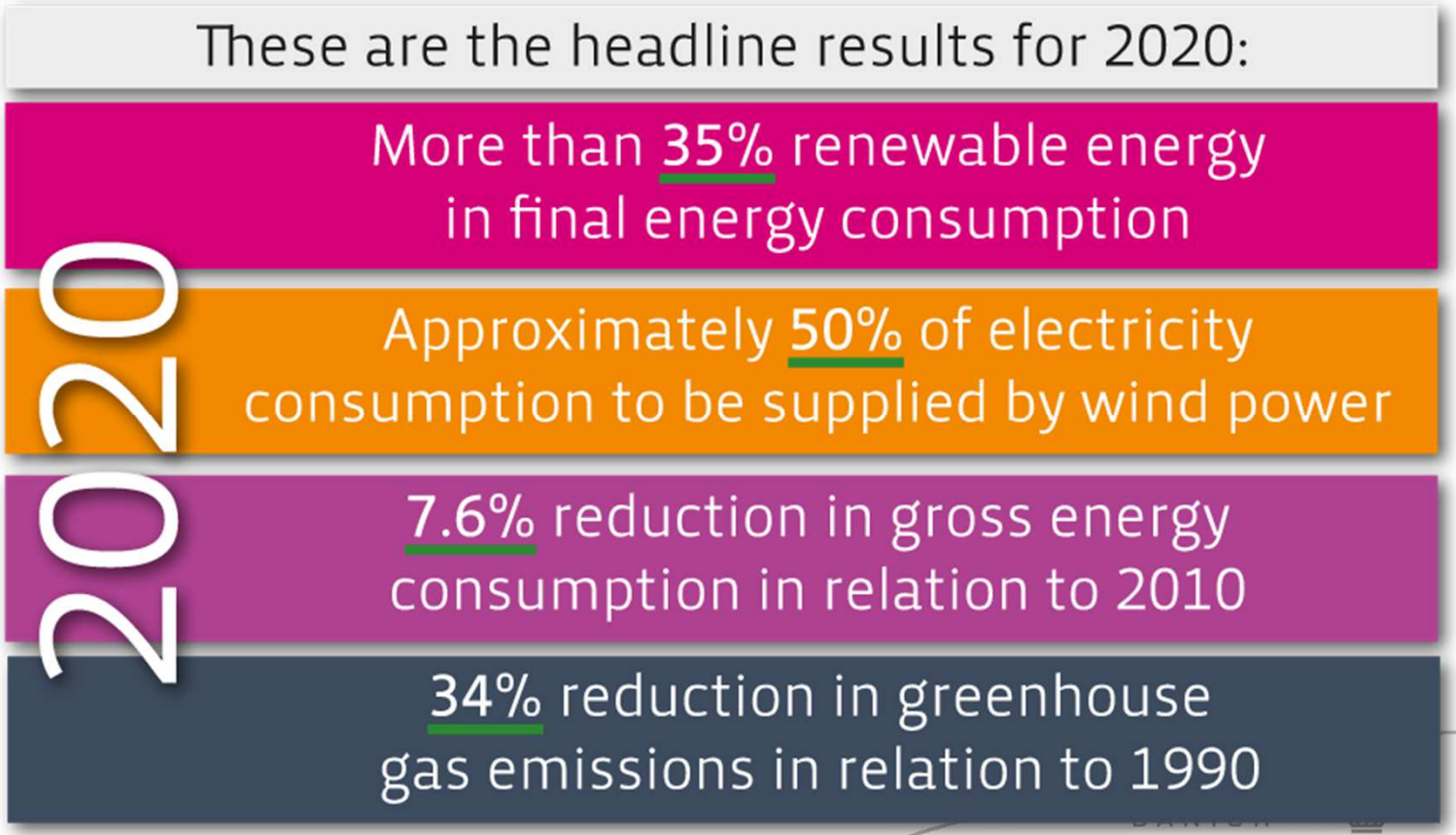
Ambitous Danish political energy agreement



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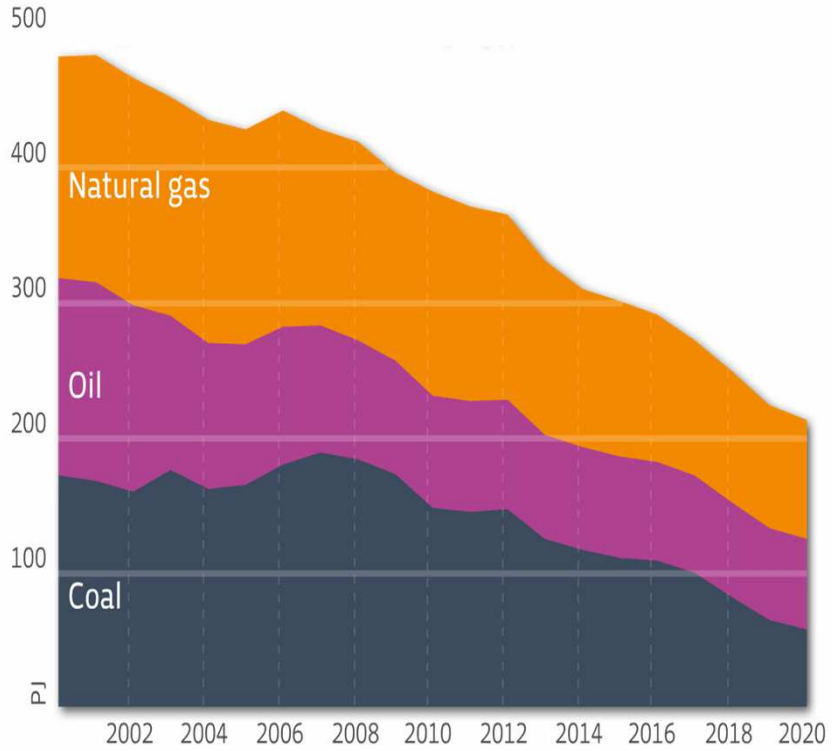
Key elements



- Energy efficiency
- Electrification, also in transport
- Renewable energy
- Research and development in new technologies

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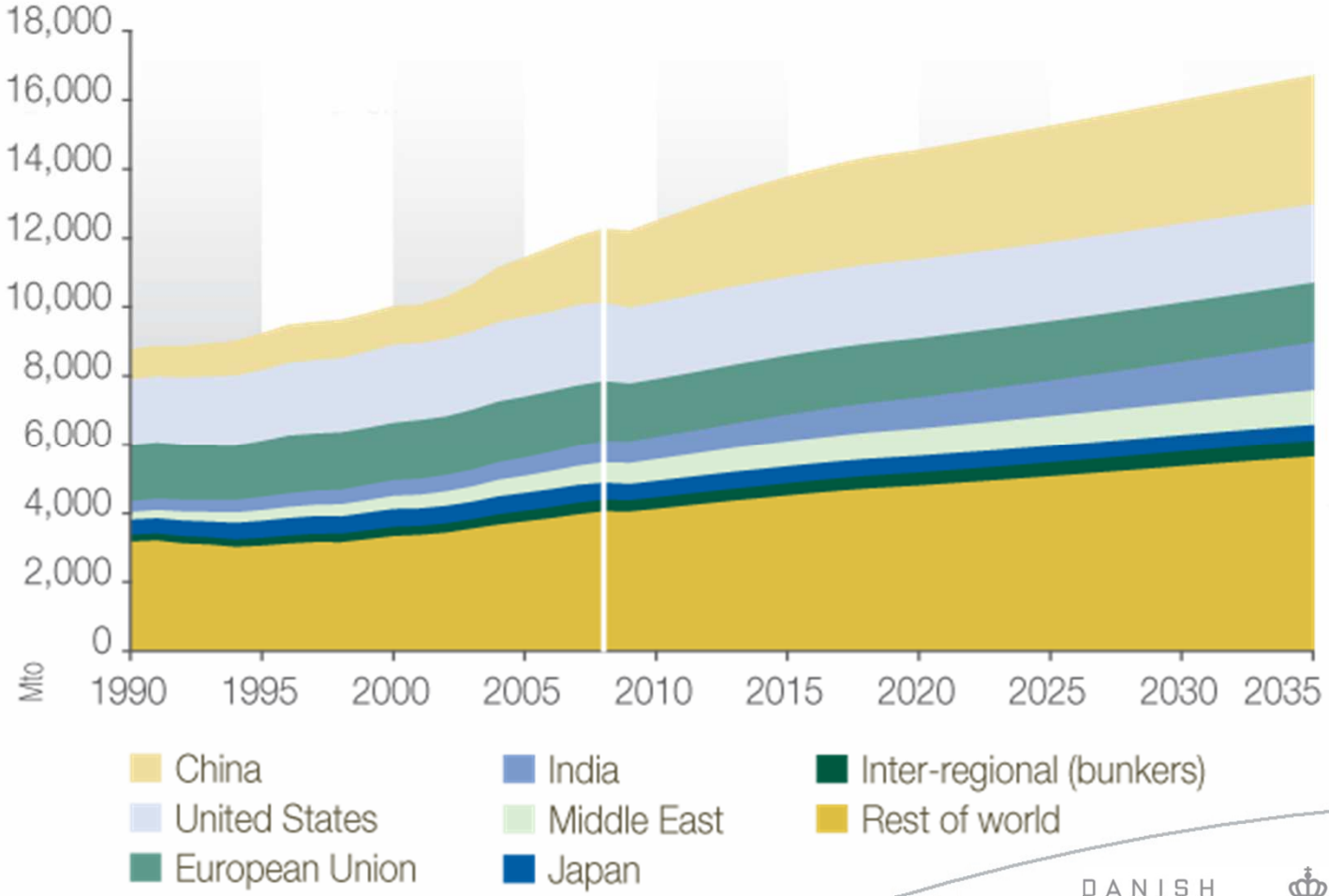
Why are we doing it?



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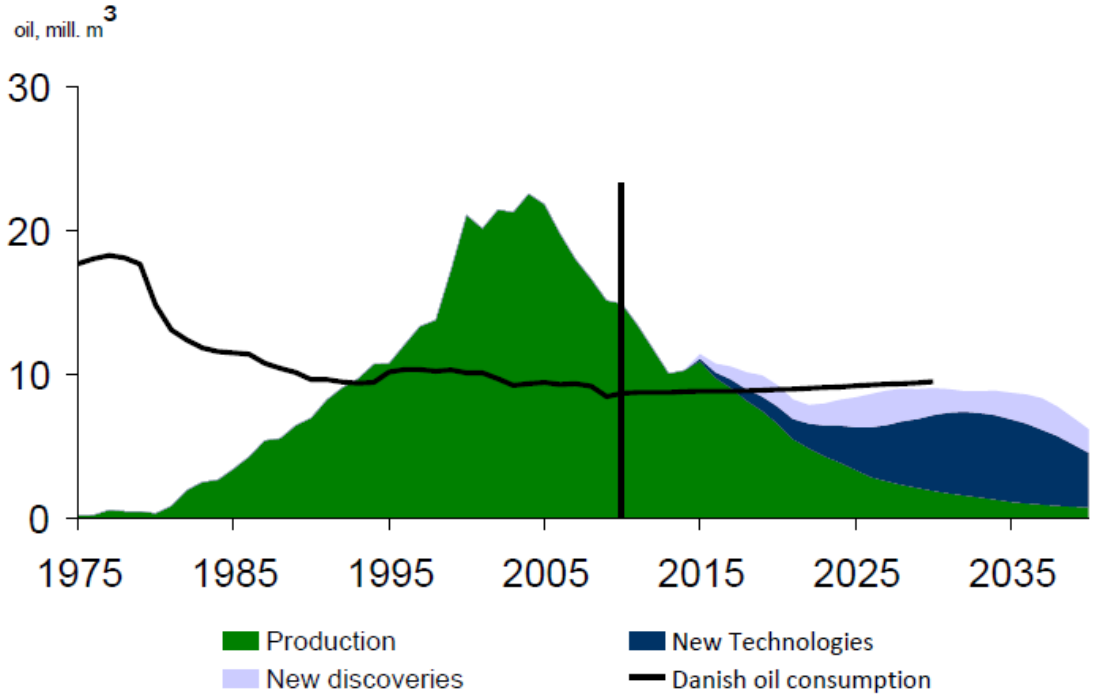
Denmark dependent on imported oil in the early 1970s

Figure 2 Danish oil production from 1975 to 2009 and projections for 2040



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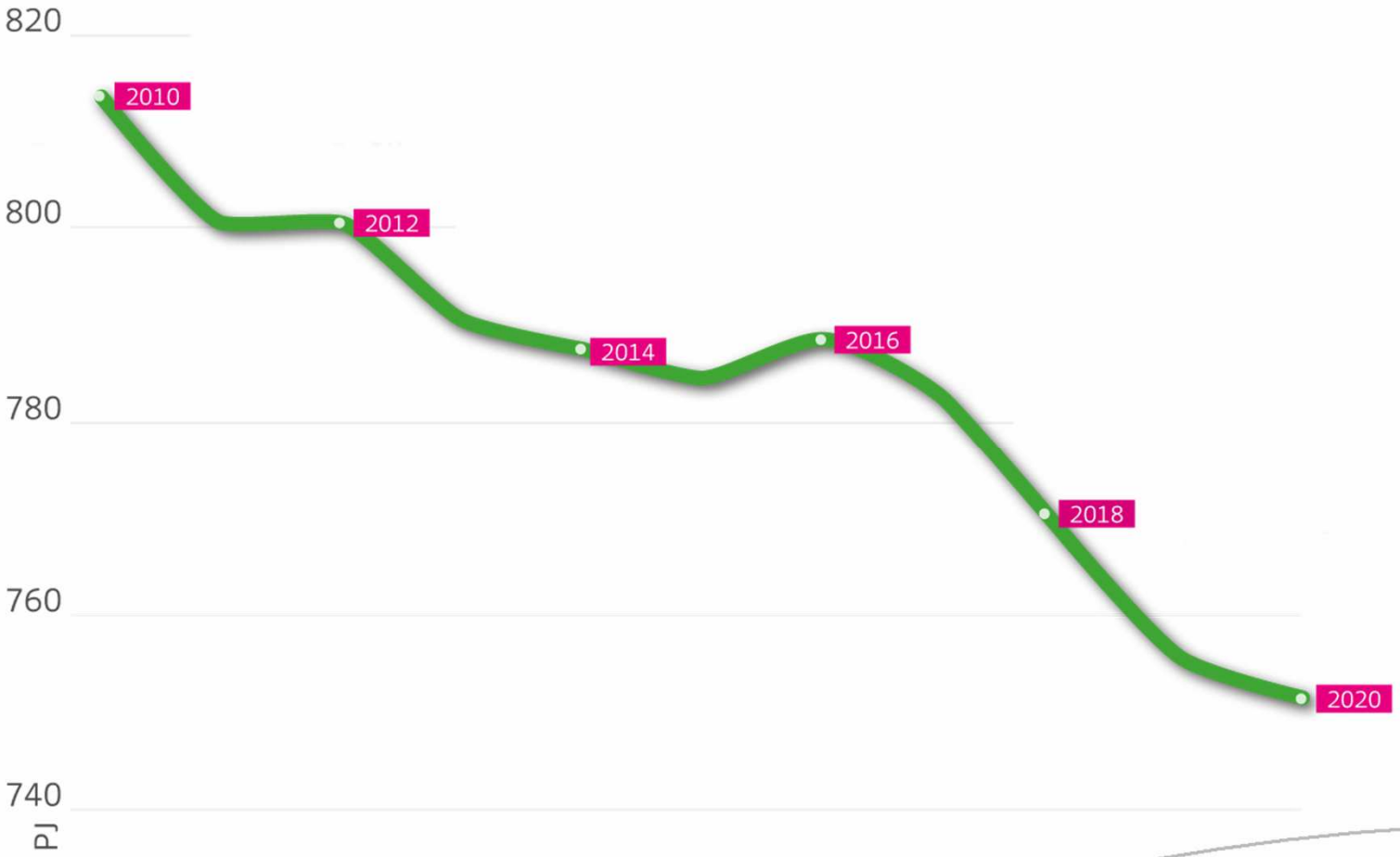
Reduction in gross energy consumption 2010-2020



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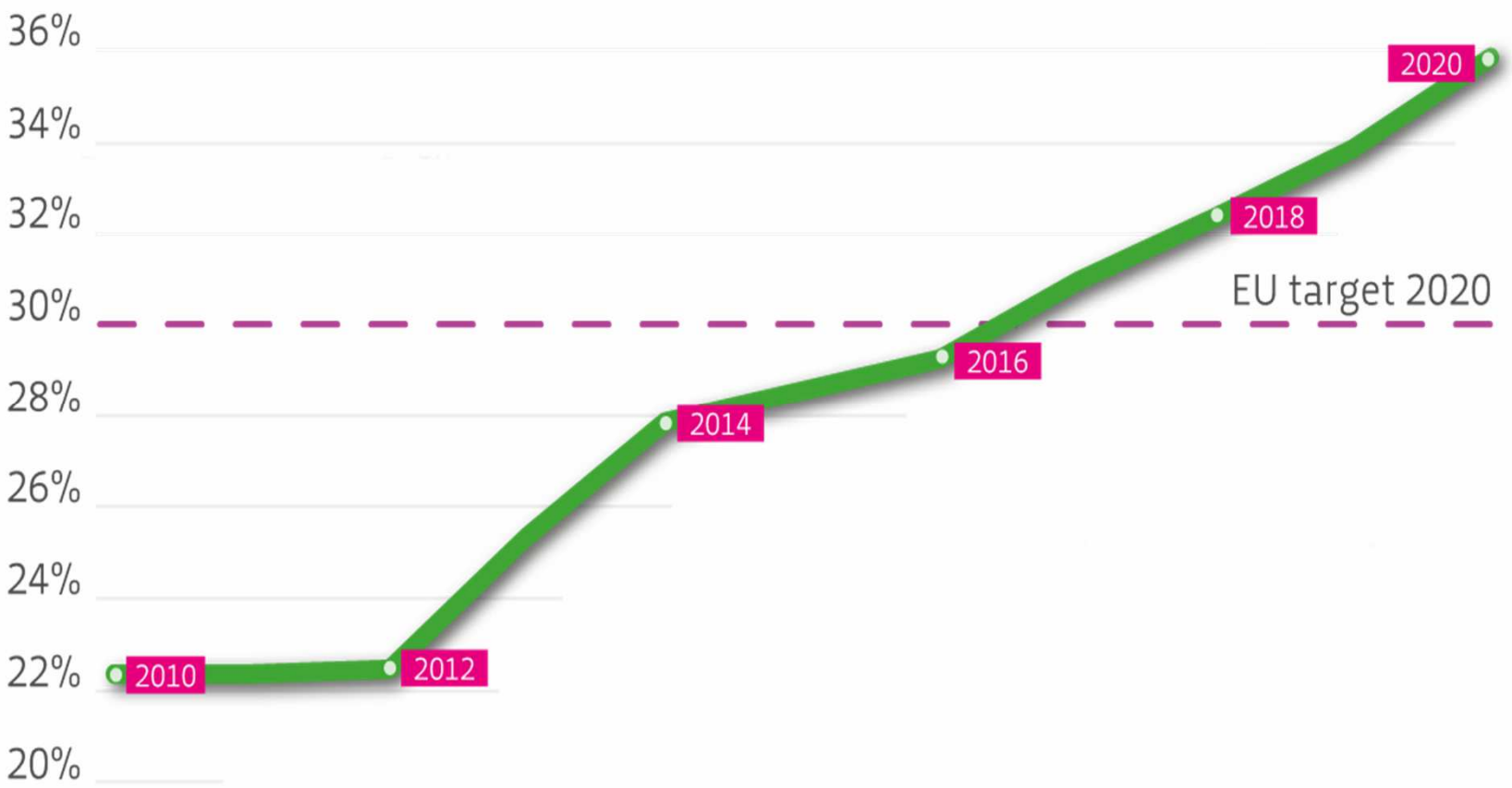
Renewable energy 2010-2020



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Share of wind in electricity

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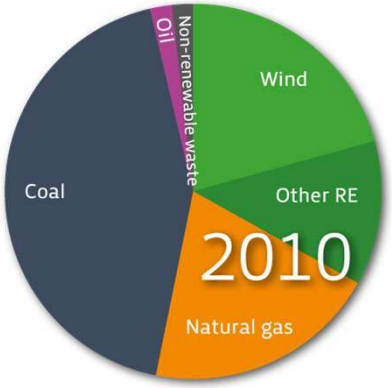
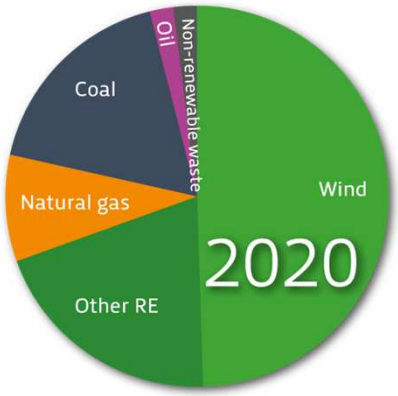
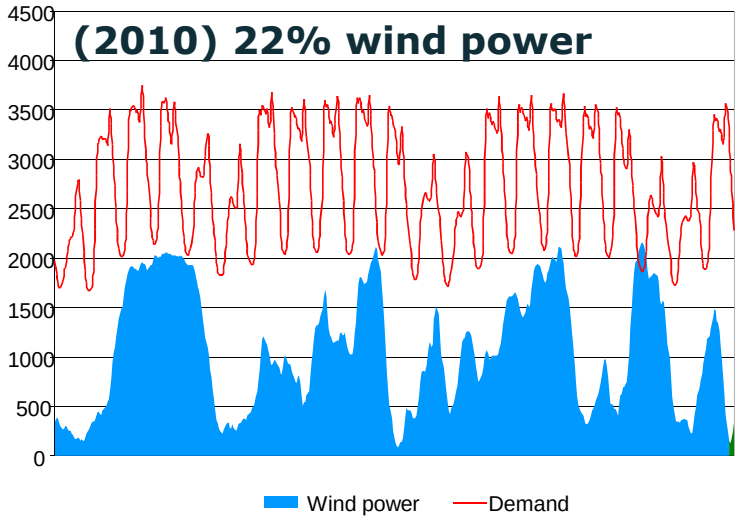
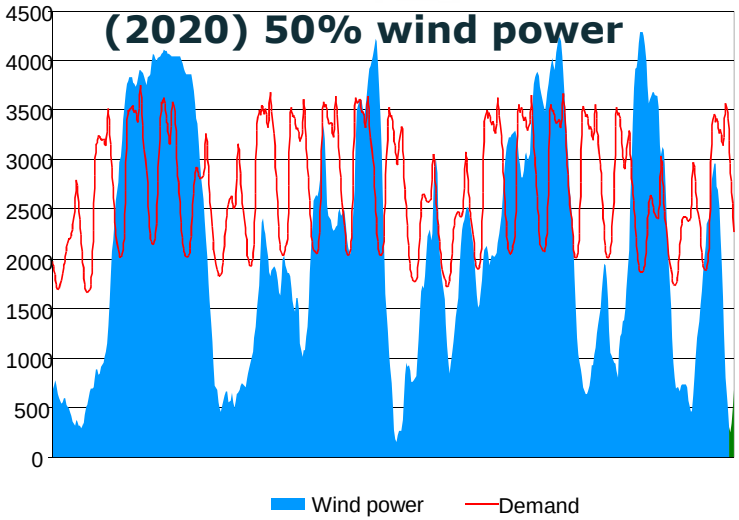
The Wind Power Challenge







Wind power may exceed demand in 200 hours (West DK)



Wind power may exceed demand in more than 1,000 hours

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Public funding of energy technology research and development

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Research and development in new technologies

New energy technologies should:

- Reduce dependency of fossil fuels through
  - Higher energy efficiency
  - Increased use of renewable energy
- Create Green Growth through
  - A more competitive energy system
  - Global commercial perspectives

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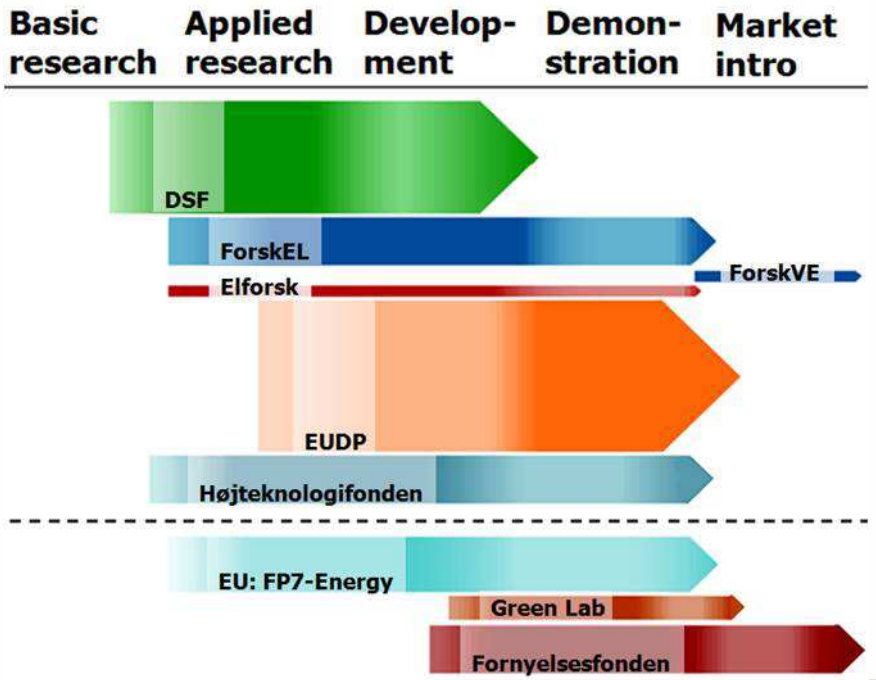
Public Funding of Energy Technology R&D&D in Denmark

- Public spending on R,D & D in energy technology has doubled from 2006 to 2010 – has stabilized after 2010
- Total public budget aprox. 150 million EUR on an annual basis



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Energy Technology Development and Demonstration Programme (EUDP)

- Subsidies for
  - Development and demonstration
  - Research supporting development and demonstration
  - Technology development in Denmark
- Encourage public private partnerships / cooperation
- Strengthen the interplay with other research programs and international activities

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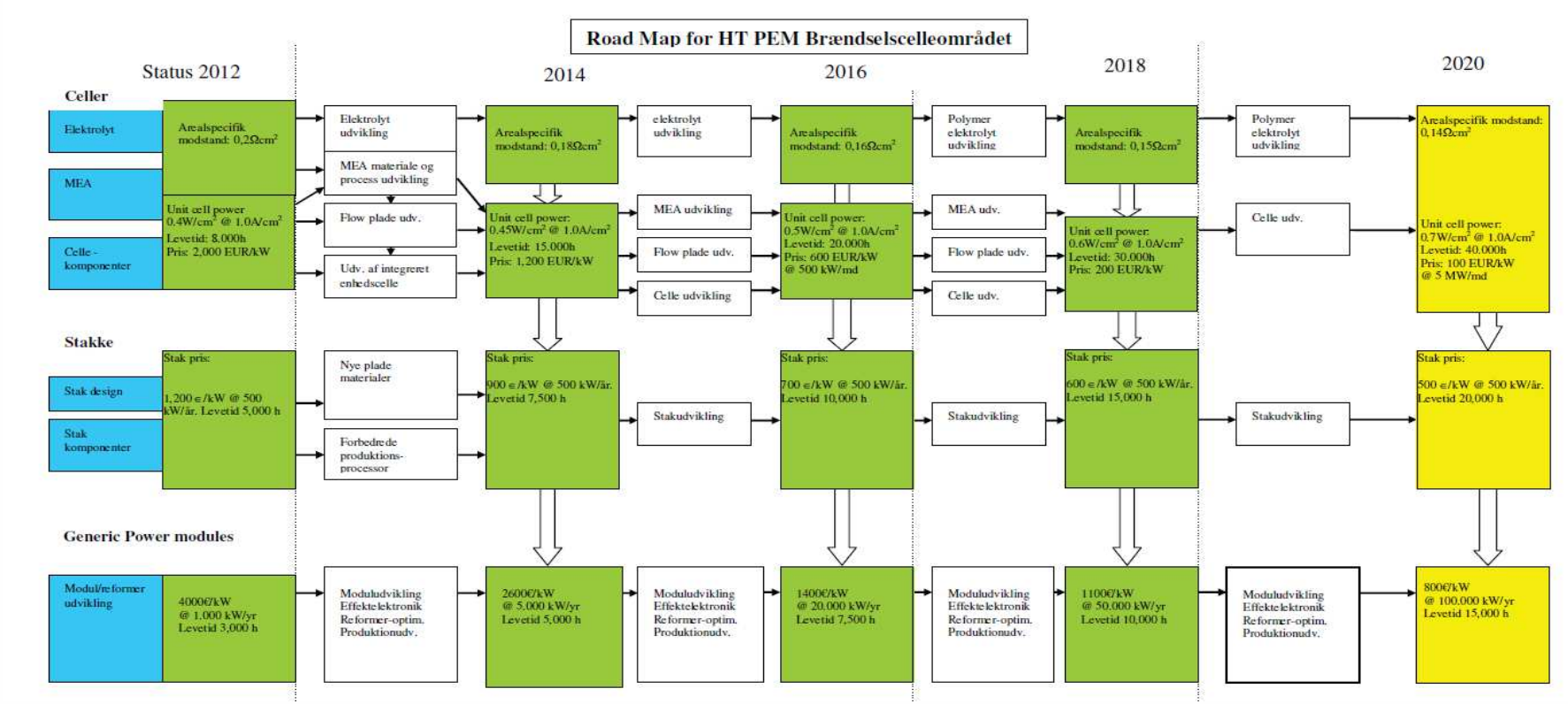
Roadmaps from Danish Partnership for Hydrogen and Fuel Cells



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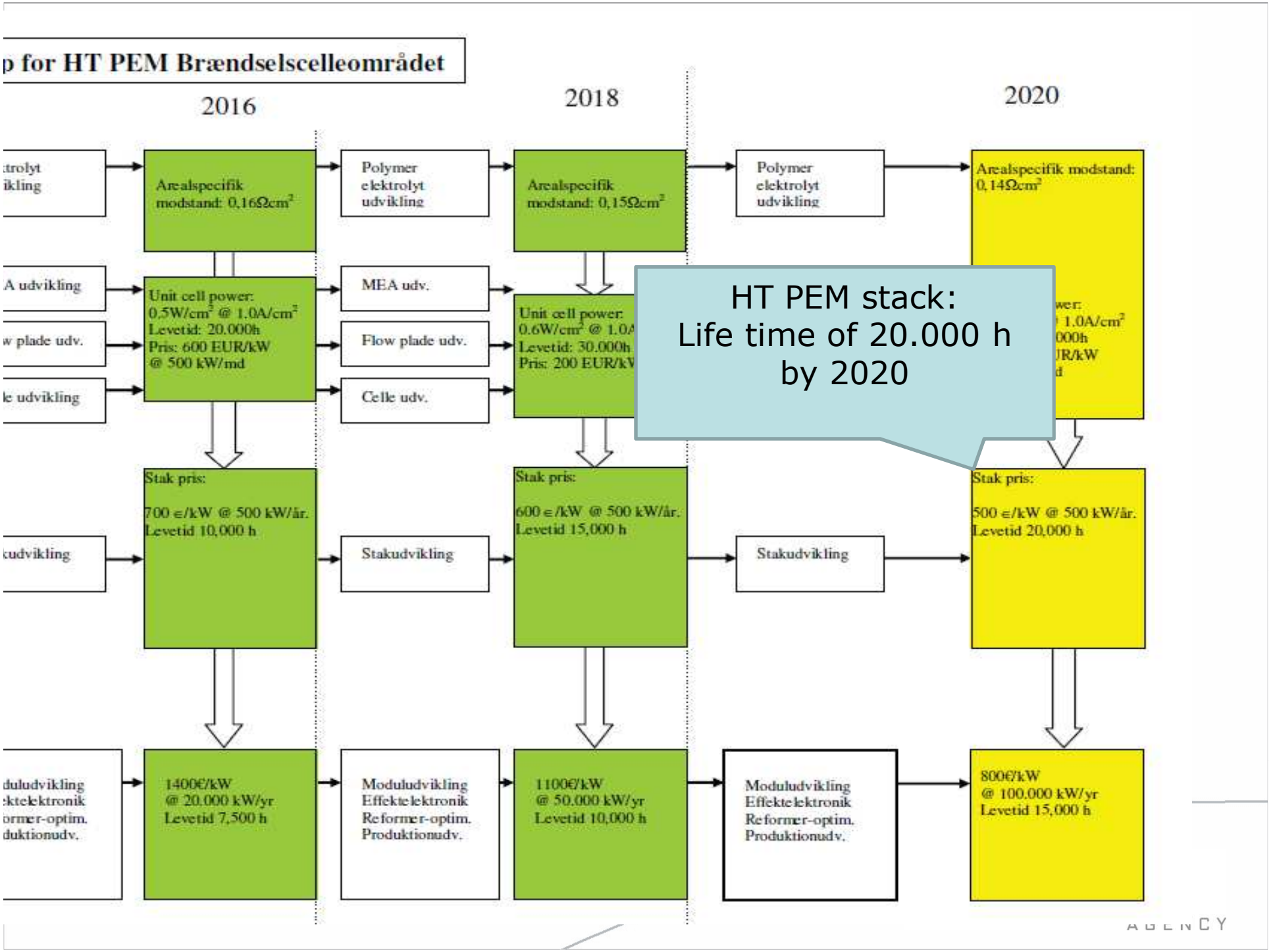
p for HT PEM Brændselscelleområdet
2016
2018
2020
Arealspecifik modstand: 0,16Ωcm²
Polymer elektrolyt udvikling
Arealspecifik modstand: 0,15Ωcm²
Polymer elektrolyt udvikling
Arealspecifik modstand: 0,14Ωcm²
Unit cell power: 0.5W/cm² @ 1.0A/cm² Levetid: 20.000h Pris: 600 EUR/kW @ 500 kW/md
MEA udv.
Flow plade udv.
Celle udv.
Unit cell power: 0.6W/cm² @ 1.0A
Levetid: 30.000h
Pris: 200 EUR/kW
HT PEM stack:
Life time of 20.000 h
by 2020
Stak pris: 700 €/kW @ 500 kW/år. Levetid 10,000 h
Stakudvikling
Stak pris: 600 €/kW @ 500 kW/år. Levetid 15,000 h
Stakudvikling
Stak pris: 500 €/kW @ 500 kW/år. Levetid 20,000 h
1400€/kW @ 20.000 kW/yr Levetid 7,500 h
Moduludvikling Effektelektronik Reformer-optim. Produktionudv.
1100€/kW @ 50.000 kW/yr Levetid 10,000 h
Moduludvikling Effektelektronik Reformer-optim. Produktionudv.
800€/kW @ 100.000 kW/yr Levetid 15,000 h

Project criteria

Energy and environment aspects

- Relevance regarding energy policy and strategies
- Sufficient content of technology development

Commercial aspects

- Market potential
- Business plan
- Project organization, financing arrangements etc.

"Aid rules"

- Ratio between own financing and subsidy ~ 50/50
- Enhancing technology development in Denmark, but now we can also support international partners

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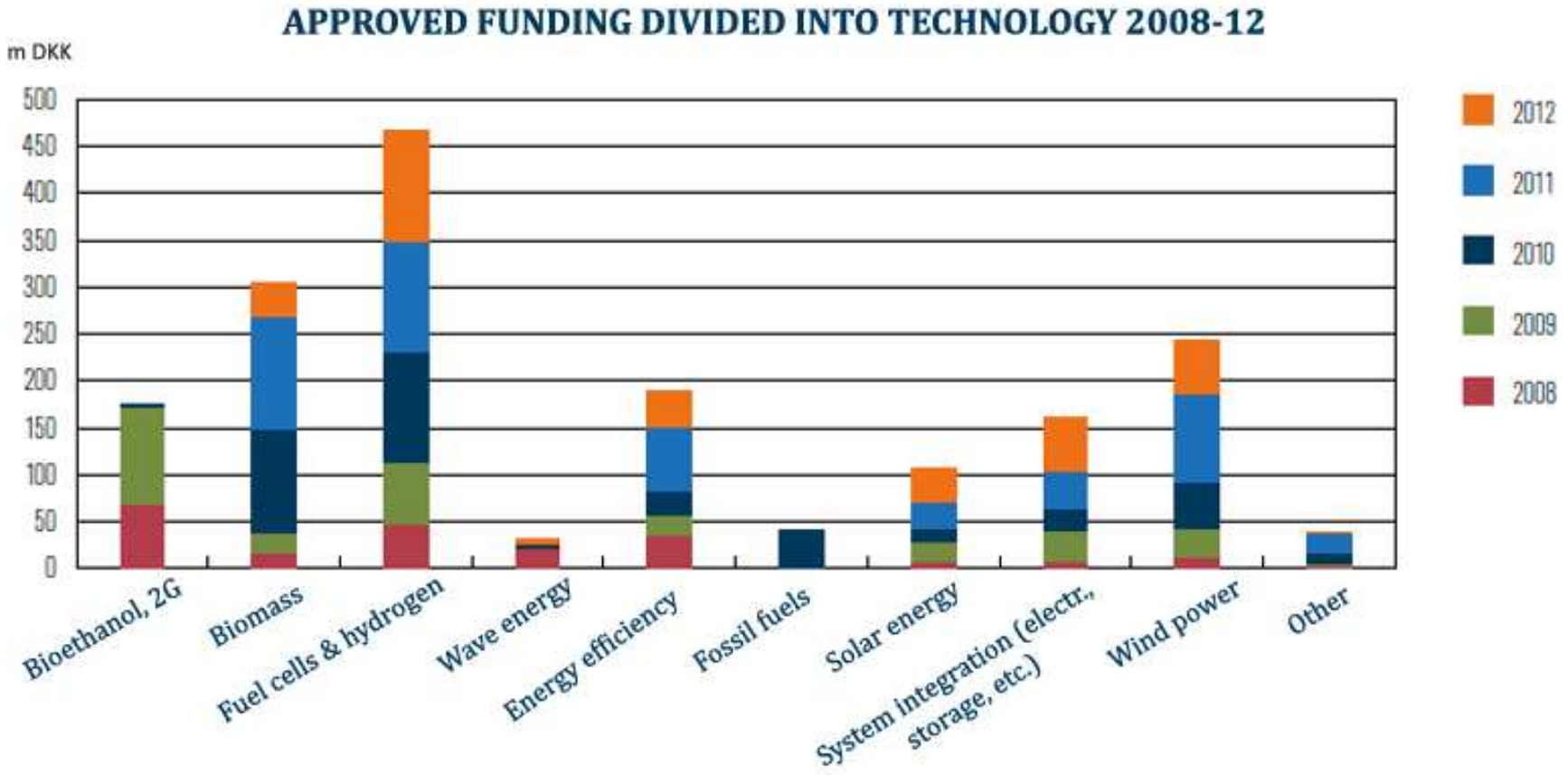
Funding from EUDP



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Cases …

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Danish Micro CHP based on Fuel Cells (Slide 1/3)

- 3 technology tracks + 3 phases of demonstration

1) LT-PEM (H2) – Demonstration in Vestenskov (32 units)

2) LT-PEM (NG) – Demonstration in Varde (20 units)

3) SOFC (NG) – Demonstration in Sønderborg (2 units)

Project period: 2007 – 2014

Project budget – aprox. 17 million EUR (Public funding aprox. 7 million EUR)

Phase 1

Phase 2

Phase 3

DANSK MIKRO KRAFT VARME

Boligenergi fra brændselsceller

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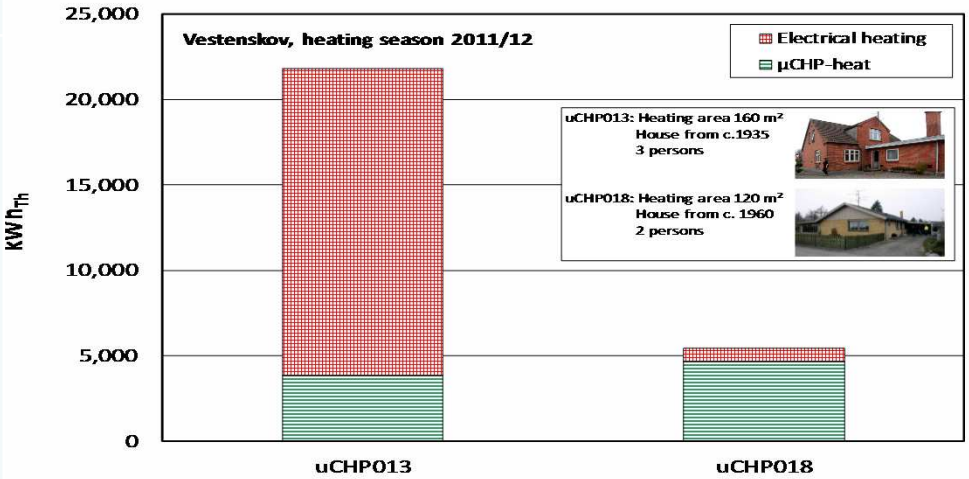
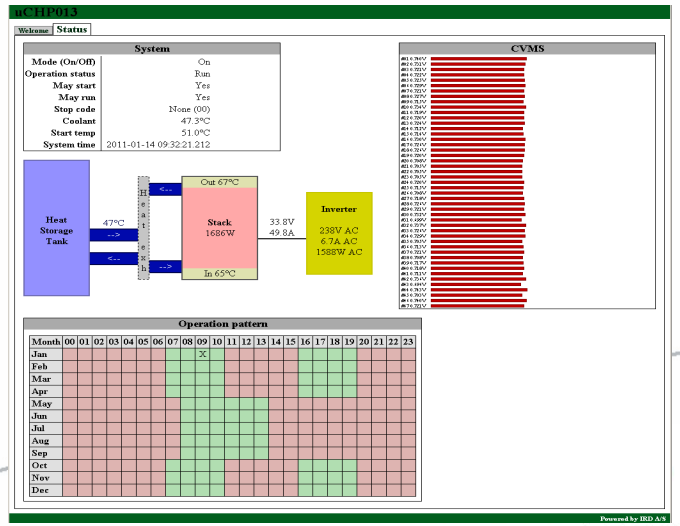
Track 1: Demonstration of LT-PEM (H2) in Vestenskov (Lolland) (Slide 2/3)

	Project targets	**Realized values (DGC & IRD)**
Fuel efficiencies	Power efficiencies (H2 - electricity) Phase 1 (2007): 40% Phase 2 (2008): 45% Phase 3 (2009): 50% Total el- and heat efficiencies (H_2) Phase 1 (2007): 75% + 10% by condensing operation Phase 2 (2008): 80% + 10% by condensing operation Phase 3 (2009): 85-90 % + 10% by condensing operation	Power efficiencies (H2 - electricity) Phase 1 (2007): 43% Phase 2 (2008): 47% **Phase 3 (2009): 44%** Total el- and heat efficiencies (H_2) Phase 1 (2007): 75% + 10% by condensing operation Phase 2 (2008): 94% **Phase 3 (2009): 94%**
Power output (AC) - BoL	1,5 kW_{AC}	1,5 kW_{AC}
Durability (stack)	Development target after 2012: 40.000 hours operation	Yet to be proven!!! The preliminary results are encouraging
Availability (CHP system)	Phase 2: 85% Phase 3: 95%	Phase 2: <<85% Phase 3: Overall 67% 81%/83% since improved PEM technology is implemented
Start-up time from cold	1 min	2.5 min.
Start-up time from standby, 0-100%	1 min	1.9 min.





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Danish Micro CHP based on Fuel Cells (slide 3/3)

Track 2 (LT PEM – NG) – latest results:

- One year test of 20 LTPEM µCHP units fueled by NG at private homes running stable for more than 125.000 hours, electrical efficiency > 32% and total efficiency > 95%.

Track 3 (SOFC – NG) – status:

- 2 µCHP units to be demonstrated in 2013 – 2014

- Next step:
  - continued R, D & D: lifetime, durability and cost
  - large scale demonstration (ene.field project)
  - µCHP unit combined with a PEM electrolyzer module

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Ecomotion

- Auxiliary vehicles drivetrain
- Battery/Reformed methanol fuel cell hybrid
- Range/performance as ICE based version
- Silent / no emission operation
- High Temperature PEM with integrated reforming
- Onboard power production for e.g. hedge trimmers
- 50% reduction in energy consumption

Project name: HyTEC-DK

Project no.: 64011-0331
Project partners: Hydrogen Link, City of Copenhagen and others
Project budget: 42 million DKK – 6,2 million DKK EUDP support - 15,6 million DKK FCH-JU support (total budget for entire FCH-JU project incl. London 226 million DKK)
Project purpose: Demonstration of FCEVs and HRSs in Copenhagen & London

Purpose

The Danish part of the FCH-JU HyTEC project

Demonstration of 10 FCEV's and a network of HRS' in Copenhagen

Status May 2013

15 Hyundai FCEV's delivered to the City of Copenhagen & 70MPa HRS in operation

Official hand-over event on June 3, 2013

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Product Portfolio (updated 2013)

Cells

- IRD A/S: PEM, DMFC & PEMEC electrodes & MEAs
- TOFC: SOFC cells
- IRD A/S: DMFC, LT & HT PEM graphite bipolar plates
- IRD A/S: PEM, DMFC & PEMEC electrodes & MEAs

Stacks

- IRD: DMFC/PEM/EC stacks
- TOFC: SOFC stacks
- SerEnergy: HT PEM liquid cooled
- Serenergy: HT PEM air cooled

Components

- IRD A/S: Humidifier, Inverter
- Danish Power Systems DPS: Improved MEAs
- Danish Power Systems MEAs
- TOFC: SOFC PowerCore and Stack Module
- SerEnergy: Serenus 25/65/120 Liquid
- Serenergy: Serenus 166 & 390 Air

Systems

- IRD A/S: PEMEC unit
- Leaneco: UpsEco G2
- IRD A/S: µCHP 1-1½ kW
- TOFC: SOFC system Convion
- Leaneco: UpsEco G1
- IRD A/S: DMFC 500/800W
- Serenergy: H3 350 methanol system
- Serenergy: H3 5000 methanol system
- H2 Logic A/S: H2Drive®
- H2 Logic A/S: H2Station®
- Serenergy: HC 700 methanol system
- Greenhydrogen:MW system
- Greenhydrogen: RME system, 1 nm3/h
- Greenhydrogen: RME system, 2-8 nm3/h
- Air Liquide: Hydrogen Refuelling Stations, cars & busses
- Dantherm Power: SOFC µCHP
- Dantherm Power: PEM µCHP
- Dantherm Power: DBX5000
- Dantherm Power: SINE project
- Dantherm Power: DBX2000
- Dantherm Power: 50 kW container
- Dantherm Power: UPS TETRA-net

Research and development	Sale for demonstration and field tests	Commercial sale

Source: Danish Partnership for Hydrogen and Fuel Cells

Thank you for your attention

For further information please contact:

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