Welcome to State of Green

Presenter: Maria Lind Arlaud
Project Manager, Energy Efficiency in Industry & District Energy

STATE OF GREEN

Video: Vestas

Agenda

8.15: Arrival and welcome by State-of-Green

8.35: Welcome by DEA: Deputy Director General, Iben Møller Søndergaard

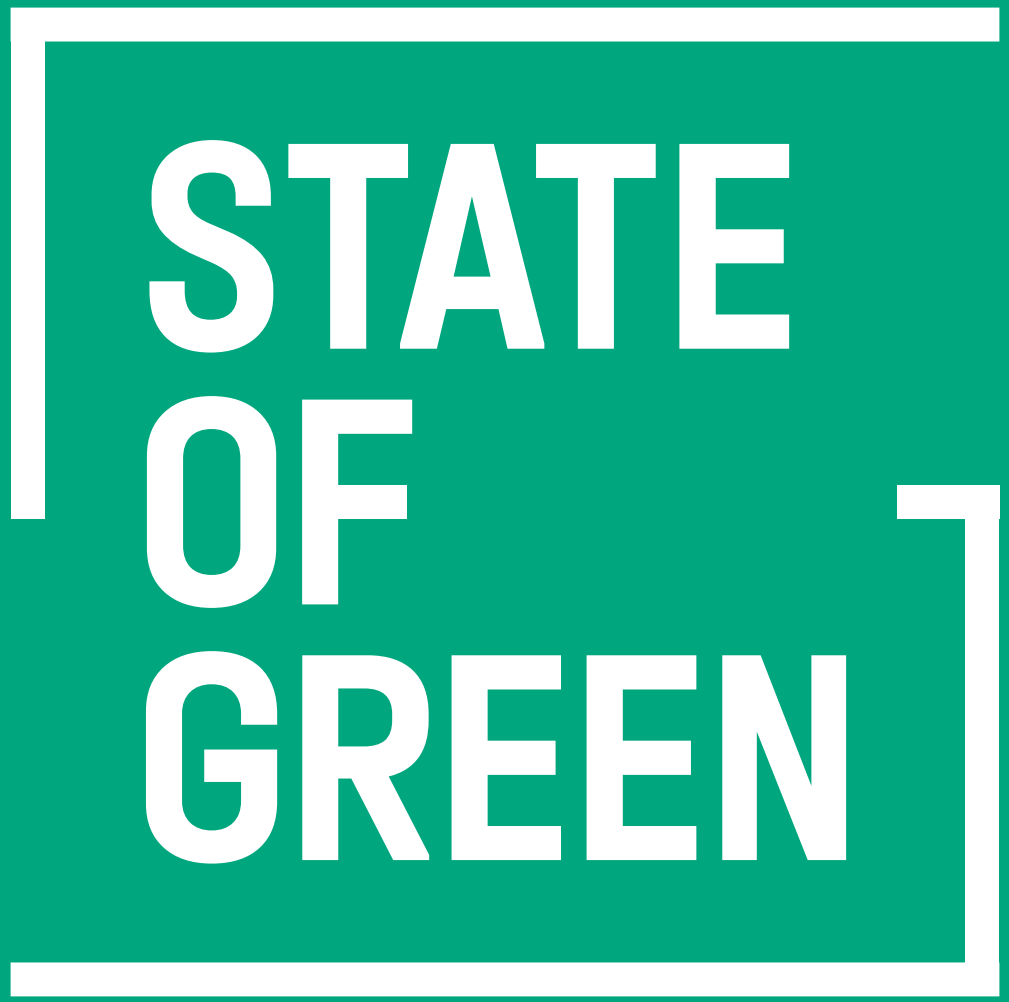
8.50: Regulatory perspective: Peter Bach from DEA

9.40: Break

10.00: Industrial Perspective: Peter Maagøe from Viegand&Maagøe

10.50: Review and next steps (+ lunch)

13.30 – departures


STATE
OF
GREEN


Like many countries, Denmark was once entirely dependent on imported fossil fuels. Today, many consider Denmark a global green frontrunner. We want to share our experiences and help others towards a more sustainable society.


State of Green is your one-stop shop to 600+ Danish solution providers. We connect international decision makers with Danish players driving the global transition to a sustainable, low-carbon, resource-efficient society

How we create value

Who we work with

- Public decision makers
- Private decision makers

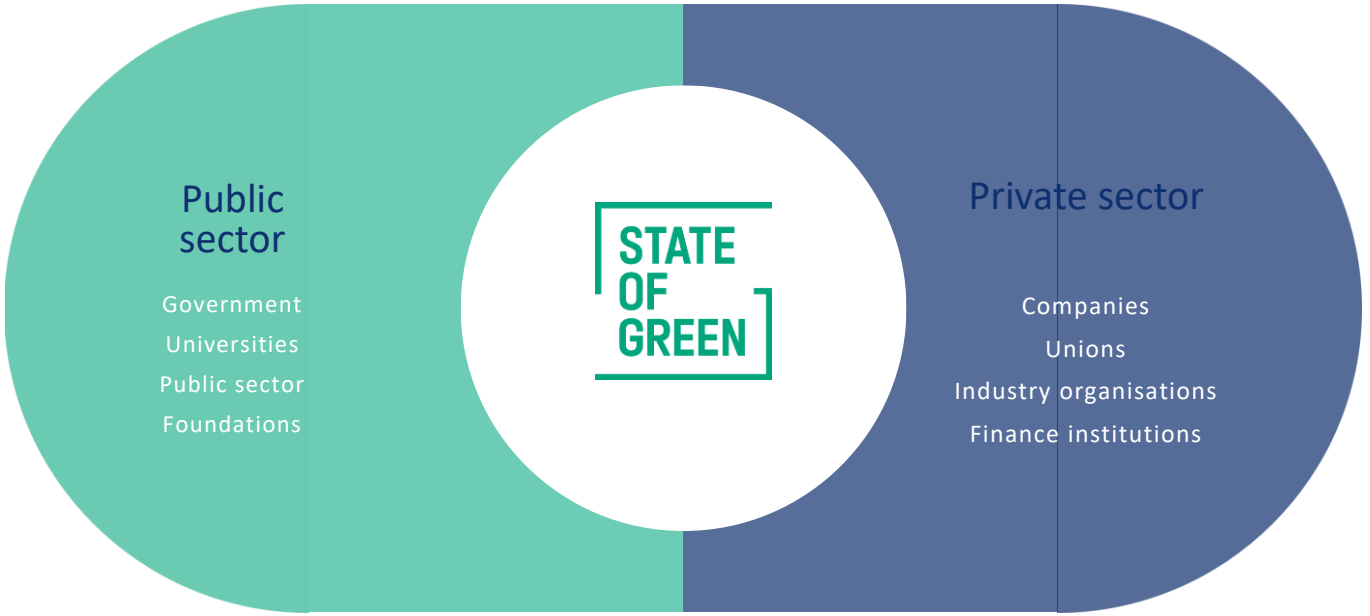
What we do

How we do it

- **Inspire**
  Branding, communication, marketing & press-related activities
- **Engage**
  International and national events (online & in-person), expos, conferences, round tables
- **Connect**
  Delegation visits, partnerships, workshops

Bridging the green gap between the public and private sector

We are the only one-point entry to both the public and the private sector, gathering state-of-the-art green knowledge and solutions from Denmark.



Public-private partnership

Public | **Private**

Government

- Ministry of Foreign Affairs of Denmark
- Danish Ministry of Climate, Energy and Utilities
- Ministry of Environment of Denmark
- Ministry of Industry, Business and Financial Affairs

Business organisations

- Danish Industry
- Green Power Denmark
- Danish Agriculture & Food Council

Strategic partners

- Grundfos
- Topsoe
- Ramboll
- DanishShipping
- Rockwool
- Ørsted
- Velux
- COWI
- andel

Associate partners

- PensionDanmark
- Industri
- FLSmidth
- CIP Copenhagen Infrastructure Partners
- Danfoss
- NKT
- Hempel

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HM King Frederik of Denmark

Green business is good business (2022)

00%

of total Danish exports come from green technologies alone

76,000

green jobs

3.4%

of GDP

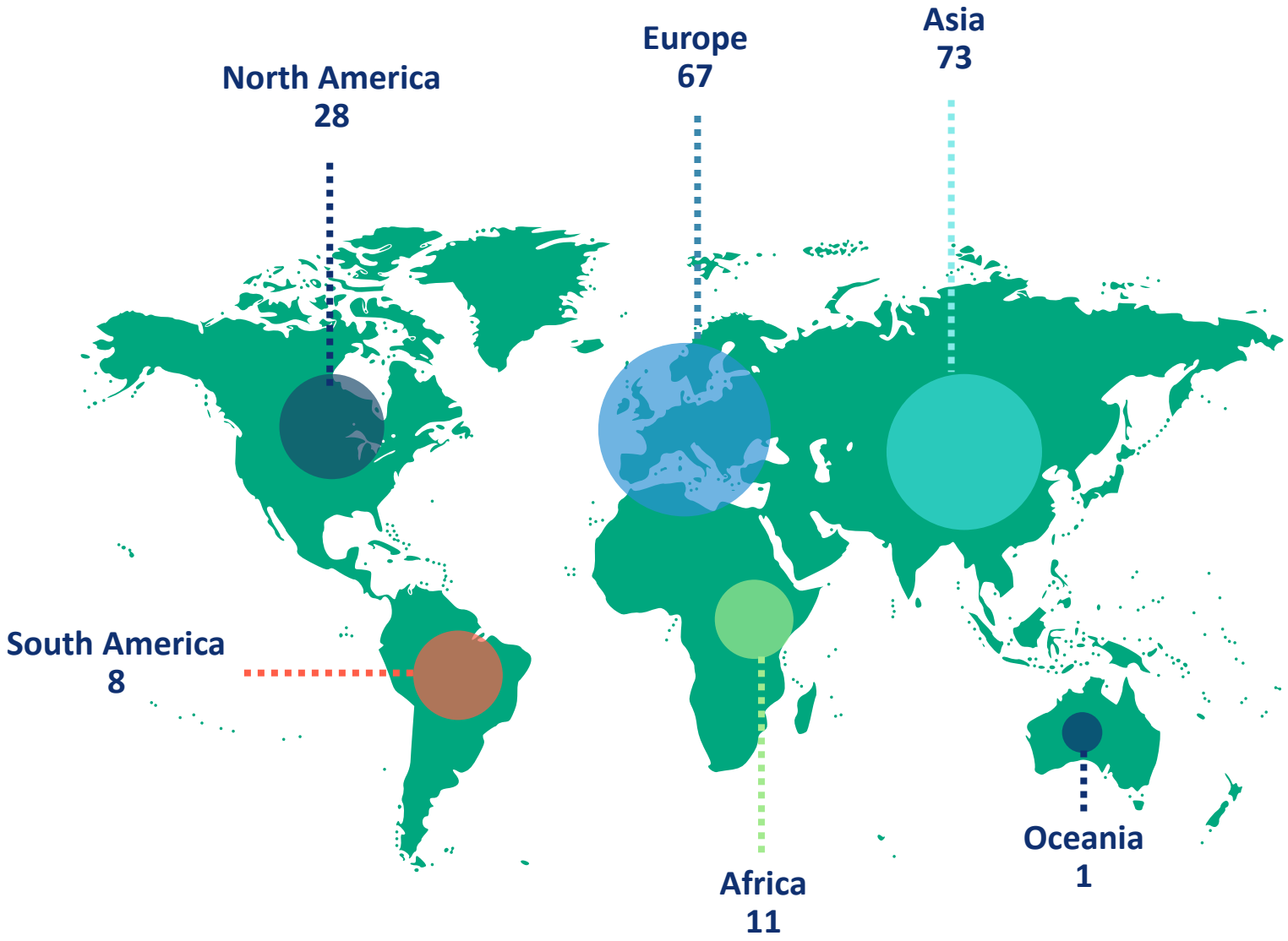
33 billion

euro in turnover

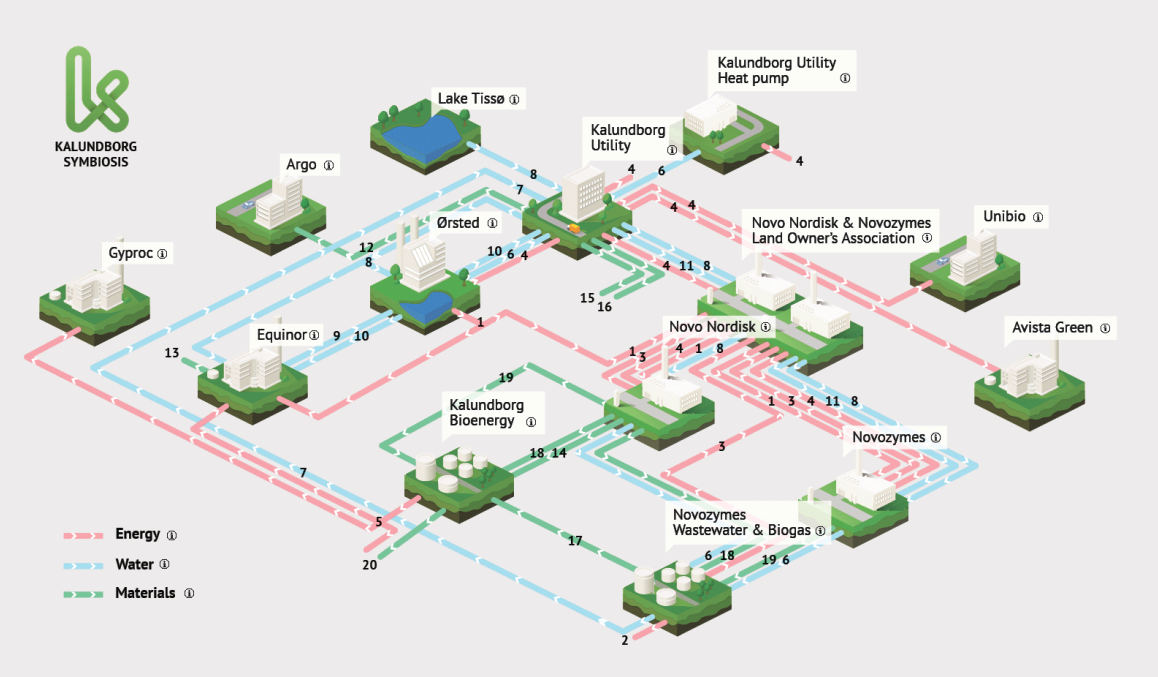
Our global impact

Every year, State of Green welcomes hundreds of delegations from all over the world at House of Green and engages international decision makers through online and in-person events.

In 2023, State of Green welcomed more than 175 delegations at House of Green.



Case: Center for Sustainable Infrastructure (CSI) and industrial symbiosis



- CSI is a Pacific Northwest-based non-profit with a mission to catalyze state-of-the-art sustainable infrastructure solutions that help communities of every kind thrive economically, socially and environmentally.
- Industrial symbiosis (IS), pioneered in Denmark, is a triple-bottom-line approach to infrastructure and economic development, where one sector's wastes – energy, water, materials – become valuable resources for other businesses.
- Since 2017, the Center for Sustainable Infrastructure (CSI) has joined three dozen Washington state legislators – evenly distributed between Republicans and Democrats -- on study tours in Denmark where they observed IS in action.

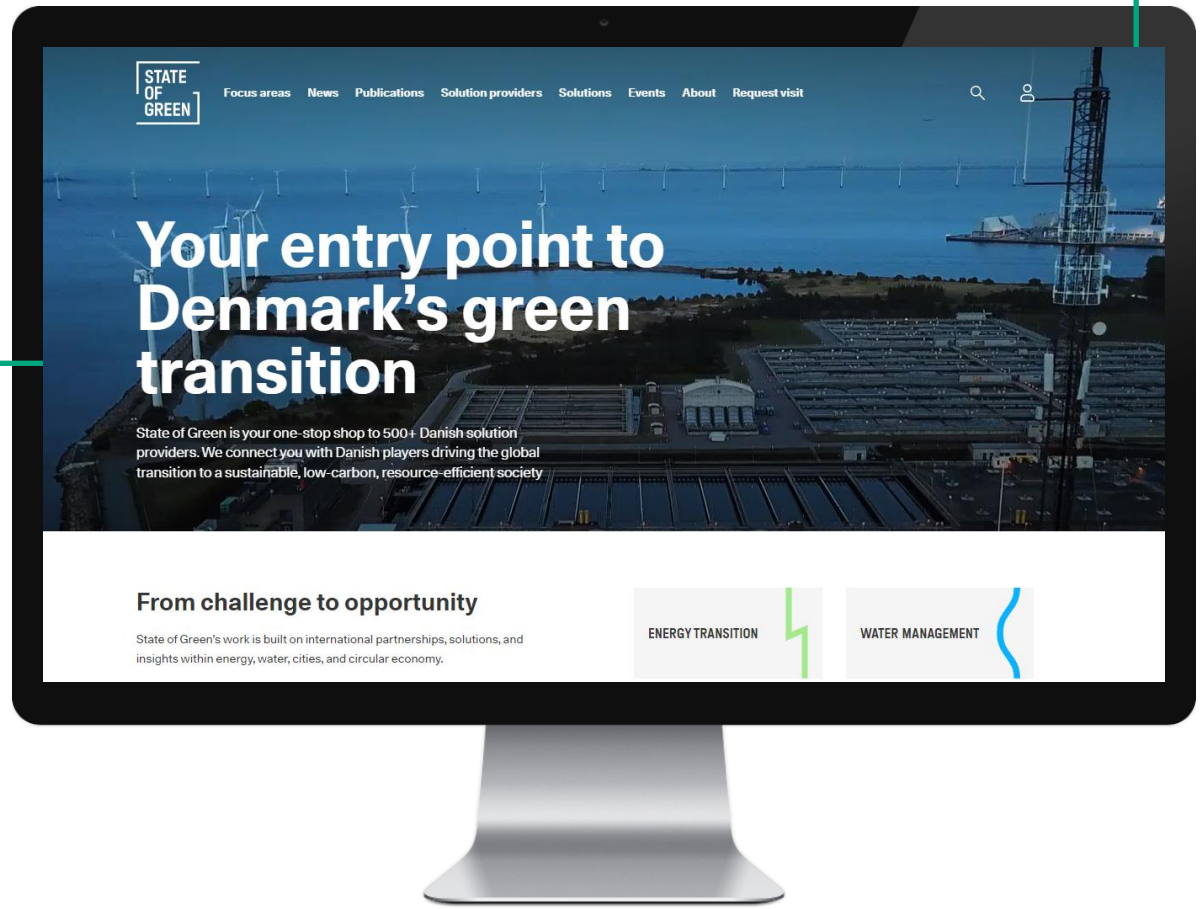
Case: Center for Sustainable Infrastructure (CSI) and

- Six consecutive legislative sessions supporting IS initiatives. →
- 2021: Launched the nation's first statewide IS program at the Department of Commerce.
- 2022-2023: Secured over $9 million for IS programs and projects.
- 2024: $300,000 secured for industrial symbiosis parks in Pasco and Longview. CSI partnering with Denmark's GreenLab for these pilot projects.
- Currently hoping to achieve similar success in Oregon

Your one-point entry to Danish green solutions

+600
solution providers

+1,700
sustainable solutions



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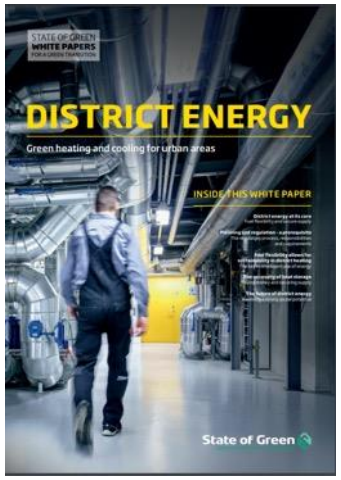
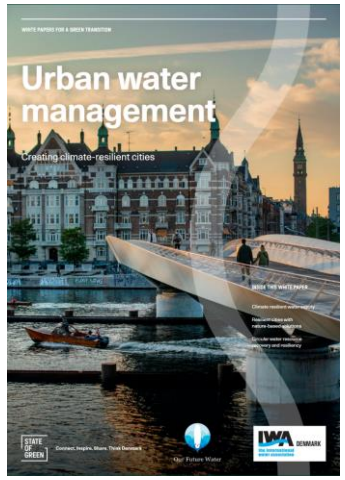
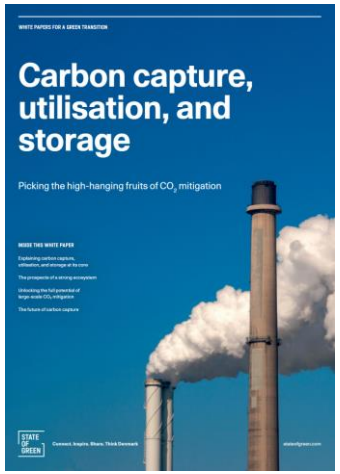
White papers for a green transition







stateofgreen.com/publications

Industries moving towards Green Transition

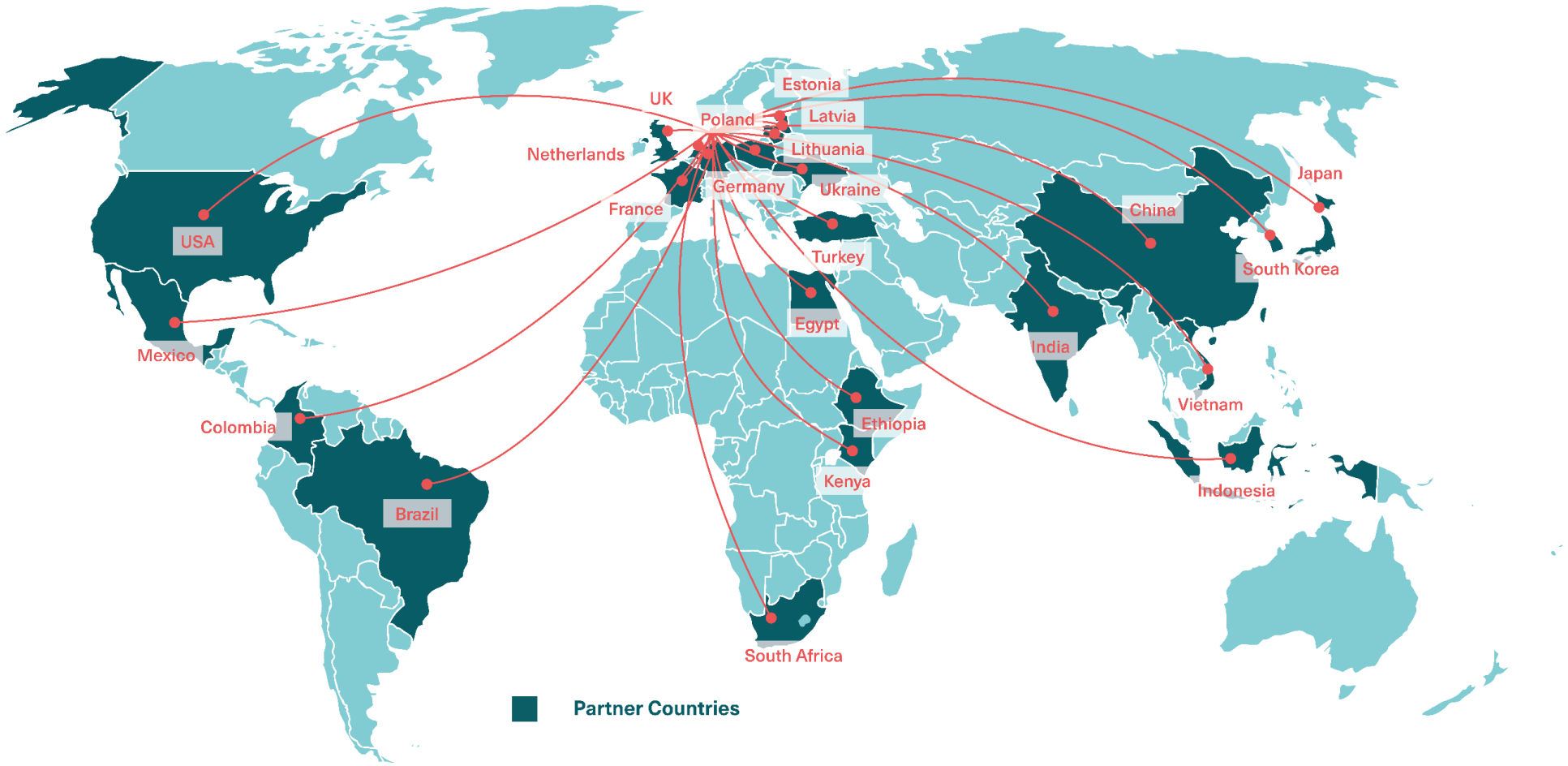
Iben Møller Søndergård, Deputy Director General
Danish Energy Agency

June 28th 2024

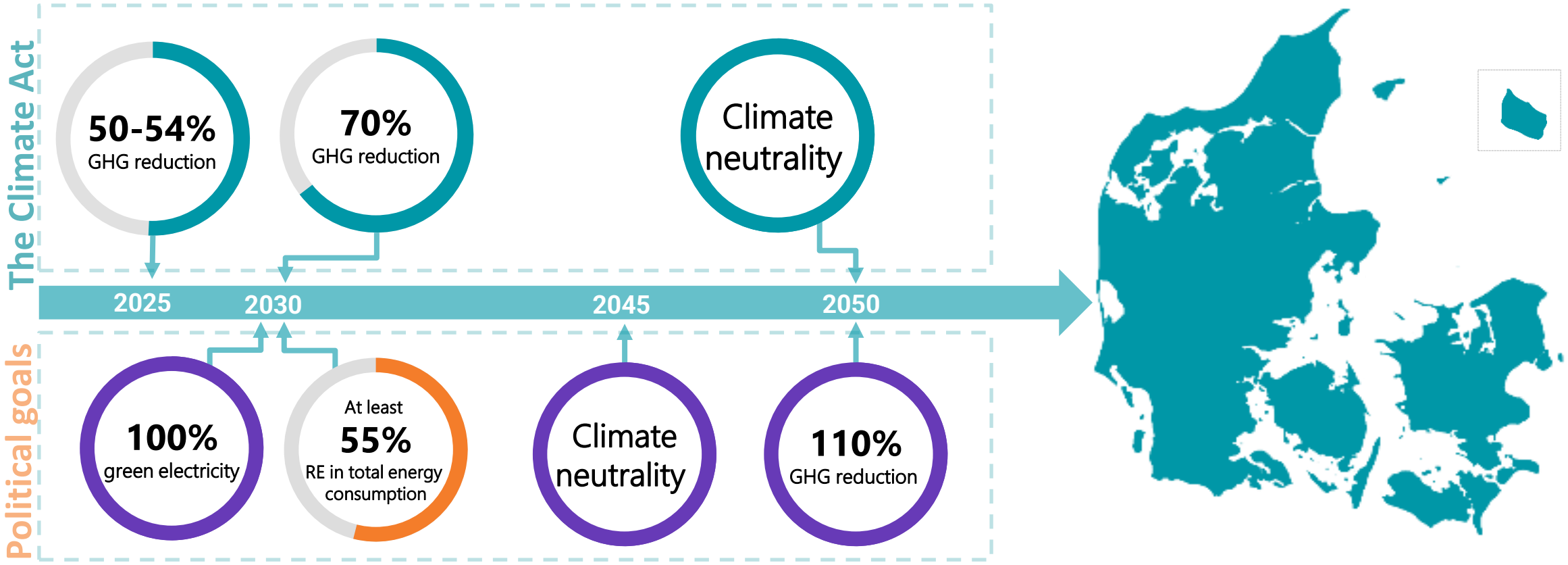
Energistyrelsen


Danish Energy Agency

WE COORPERATE WITH 24 PARTNER COUNTRIES



Climate goals



Showcase Denmark


Danish Energy Agency

Energistyrelsen

Decarbonizing Danish industry – a regulatory perspective

Peter Bach, High-level Delegation from US, 28 June 2024

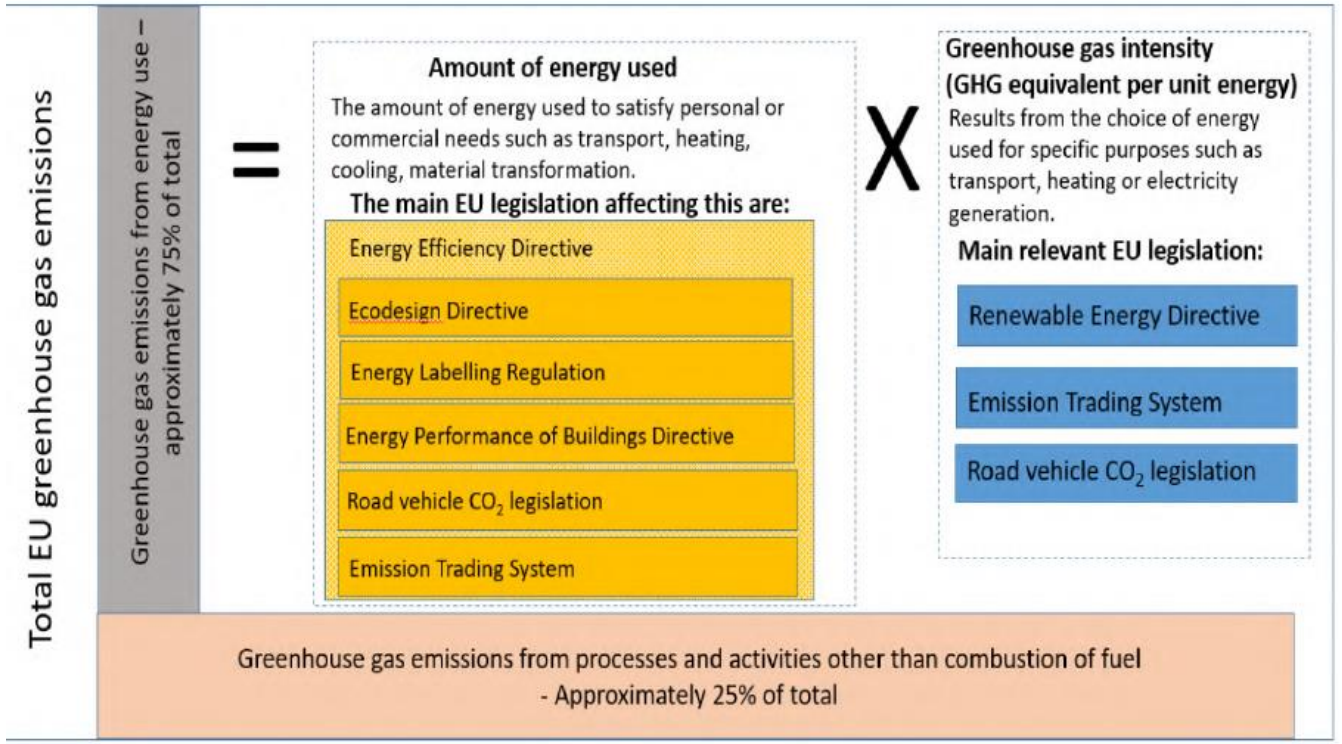
Danish Energy Agency

Decarbonisation

- Reduce energy use
- Reduce GHG intensity - Electrification

Importance of reducing energy use

- 75% of EU GHG emissions are from energy use;
- To reduce these emissions we must both use less energy and reduce the GHG intensity;
- Illustrated graphically below:

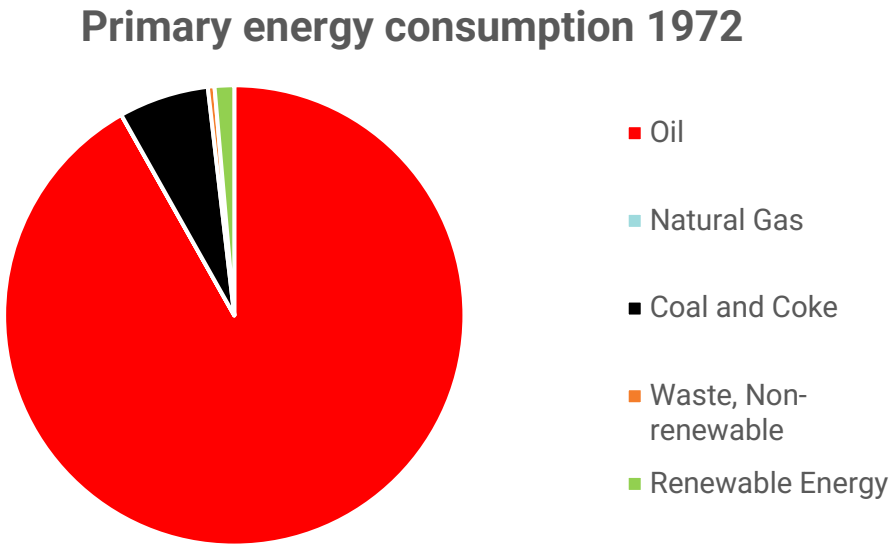


Agenda

- A short historical view on Danish Energy Policy
  - With focus on energy efficiency
- Development in energy consumption and energy intensity in industry
  - Main policy measures
- Development in the use of different energy sources
  - Electrification
- Decarbonisation
- Lessons learned

DANISH EXPERIENCES

- The oil cries in 1973-74 set the scene for Danish Energy Policy in many years
- Denmark was one the countries most dependent on imported oil – and one of the countries most influence by the oil embargo
- Important reason for the broad support for an active energy policy
  - In the population
  - Across parties - Stability



Danish Energy Agency

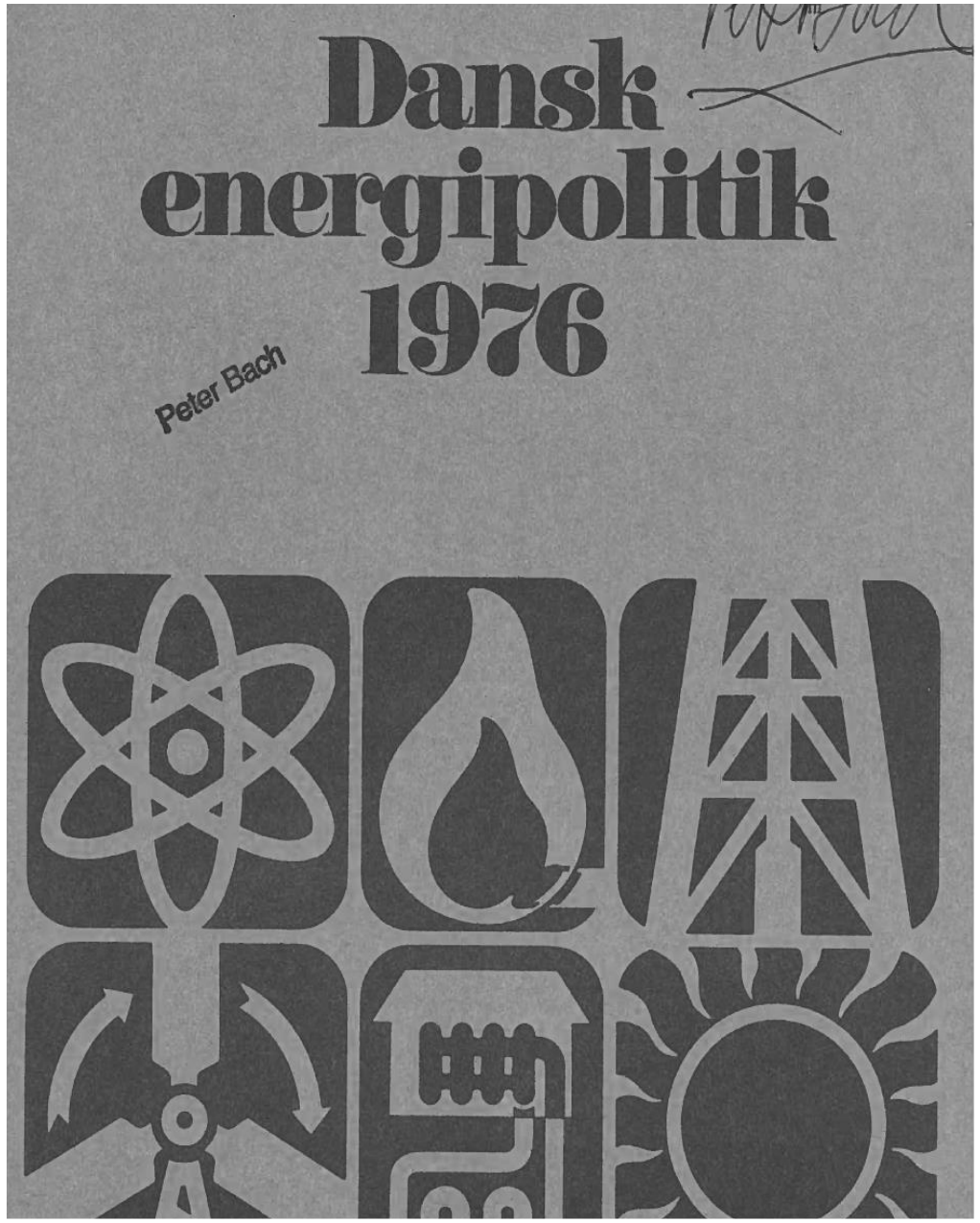
DANISH ENERGY POLICY 1976

Objective:

- Reduction of the dependency of oil

Policies – actions:

- Energy savings especial in buildings
  - 18 pct. reduction of consumption for heating from 1975 to 1985
- Expansion of district heating and use of CHP
- Introduction of natural gas
- Change of power plans from oil to coal
- Introduction of nuclear power plants
- Establishing a comprehensive heat planning



ENERGY PLAN AFTER THE SECOND OIL CRISES

The focus was the high energy prices and the economic impact

- Energy to the lowest possible cost – strong focus on coal

Energy efficiency still important

- More information on EE
- Taxes and energy prices
- Subsidy schemes incl. subsidies for more efficient industrial processes
- Stronger targets for new buildings

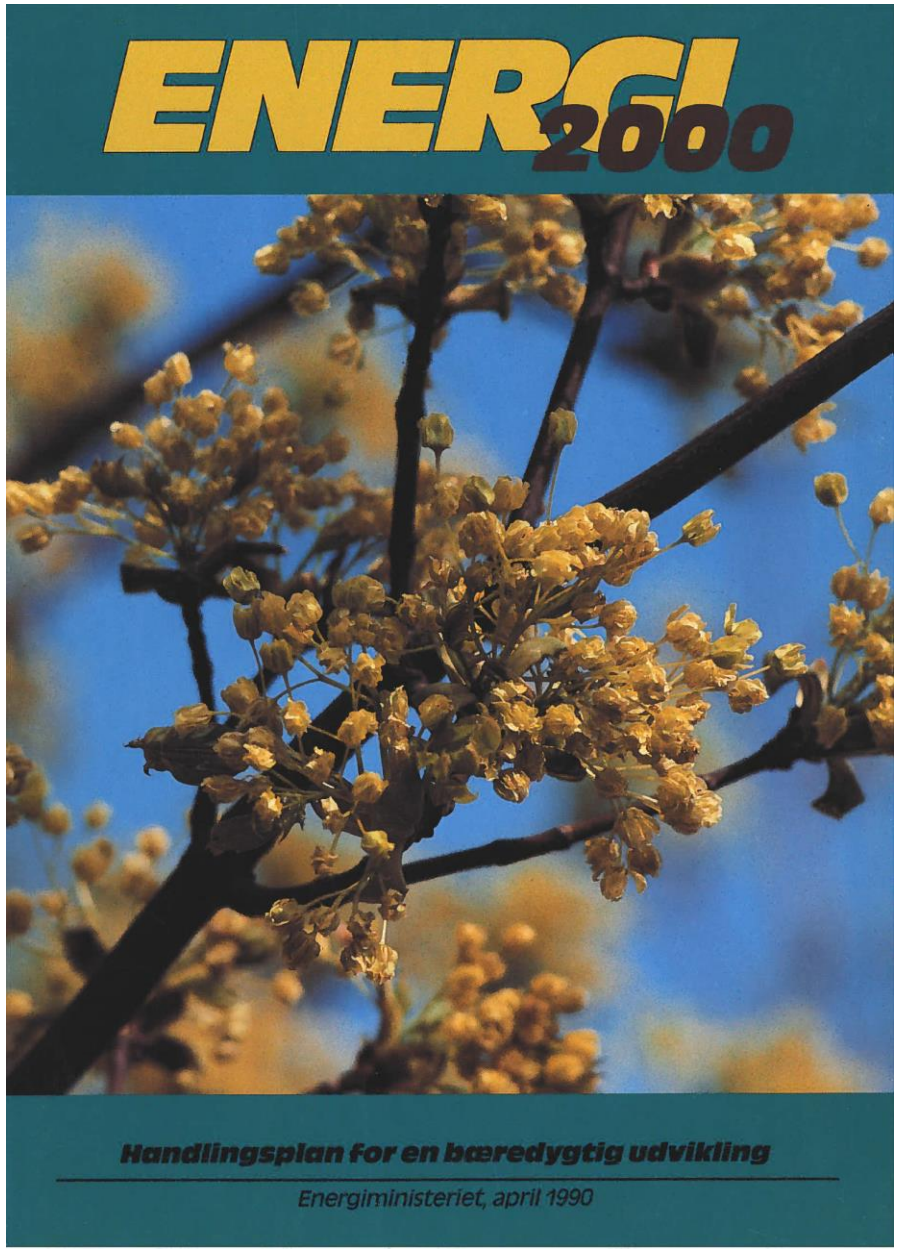
“ENERGY 2000” IN 1990

The first Danish Energy Plans with focus on climate change and reduction of CO2 emission

- 20 pct. reduction of CO2 in 2005 compared to 1988
- This target was reached!

Actions on energy efficiency:

- Lower energy consumption for new building
- Focus on renovation of existing buildings
- Labelling and standards for appliances and products
- Focus on commercial sector and industries/manufacturing



PHASES IN ENERGY EFFICIENCY POLICIES IN DENMARK

Period	Priority	Special focus areas
1979-1983	Security of supply	Reduction of oil consumption Heat savings in existing buildings
1983-1992	Economy	Cost-effective savings
1993-1995	Environment and Climate	New buildings Saving of electricity Energy efficiency in industries
1995-2001	Marked and climate	Saving of electricity Reduction of consumption in buildings Demand Side Management
2001-2019	Marked, climate and reduction of fossil fuels	Energy saving obligations for energy companies (EEO) Stronger EU-regulations – buildings, targets, etc. Reduction of consumption of fossil fuels
2019-	70% reduction of GHG in 2030 Zero carbon in 2050	EE in all sectors, decarbonisation, flexibility Strong focus on fuels shifting - Electrification

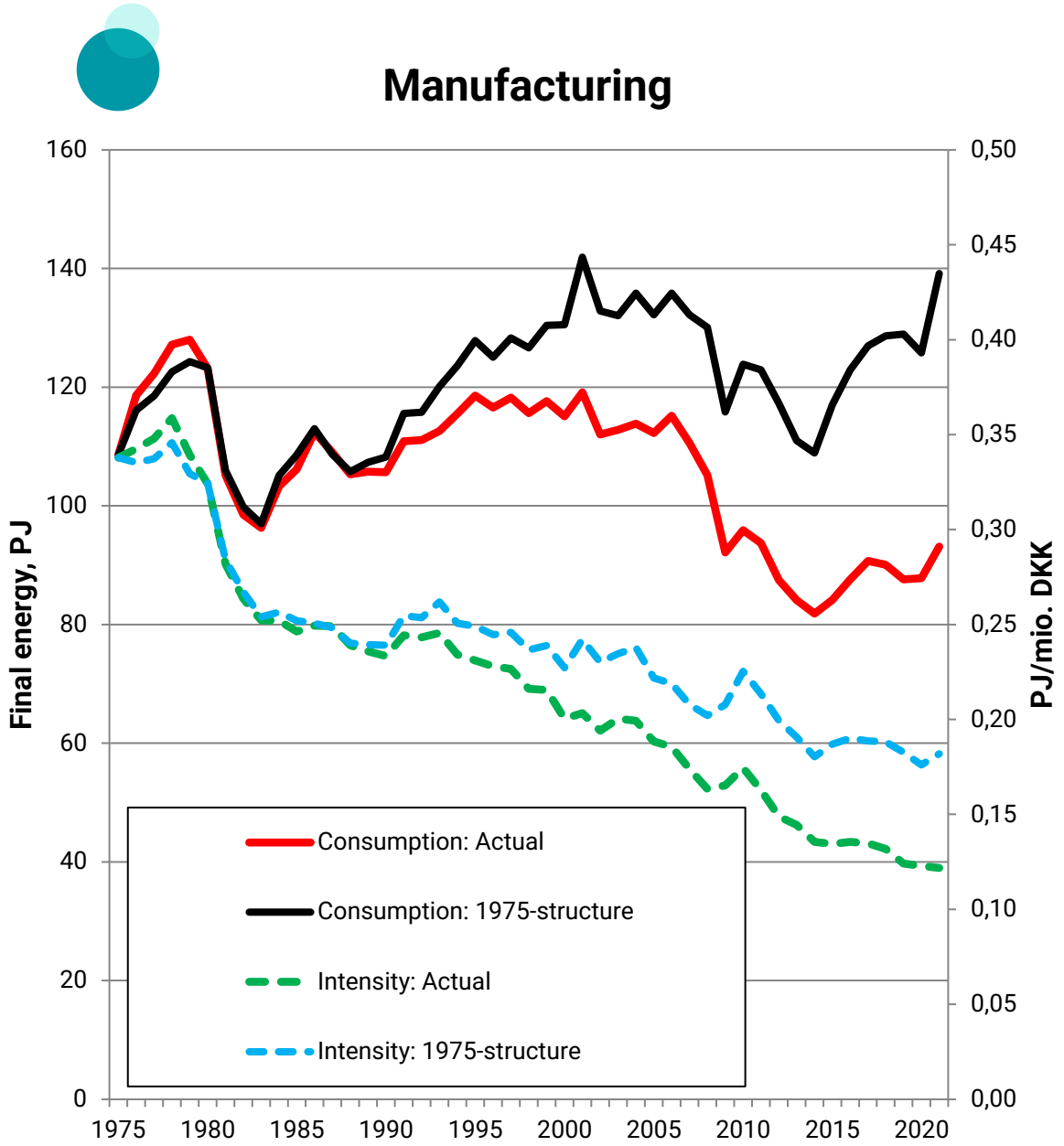
EE IN MANUFACTURING

Final energy consumption lower today then in 1975

- Energy efficiency improvements
- But a part is linked to structural change

Massive decrease in energy-intensity since 1975

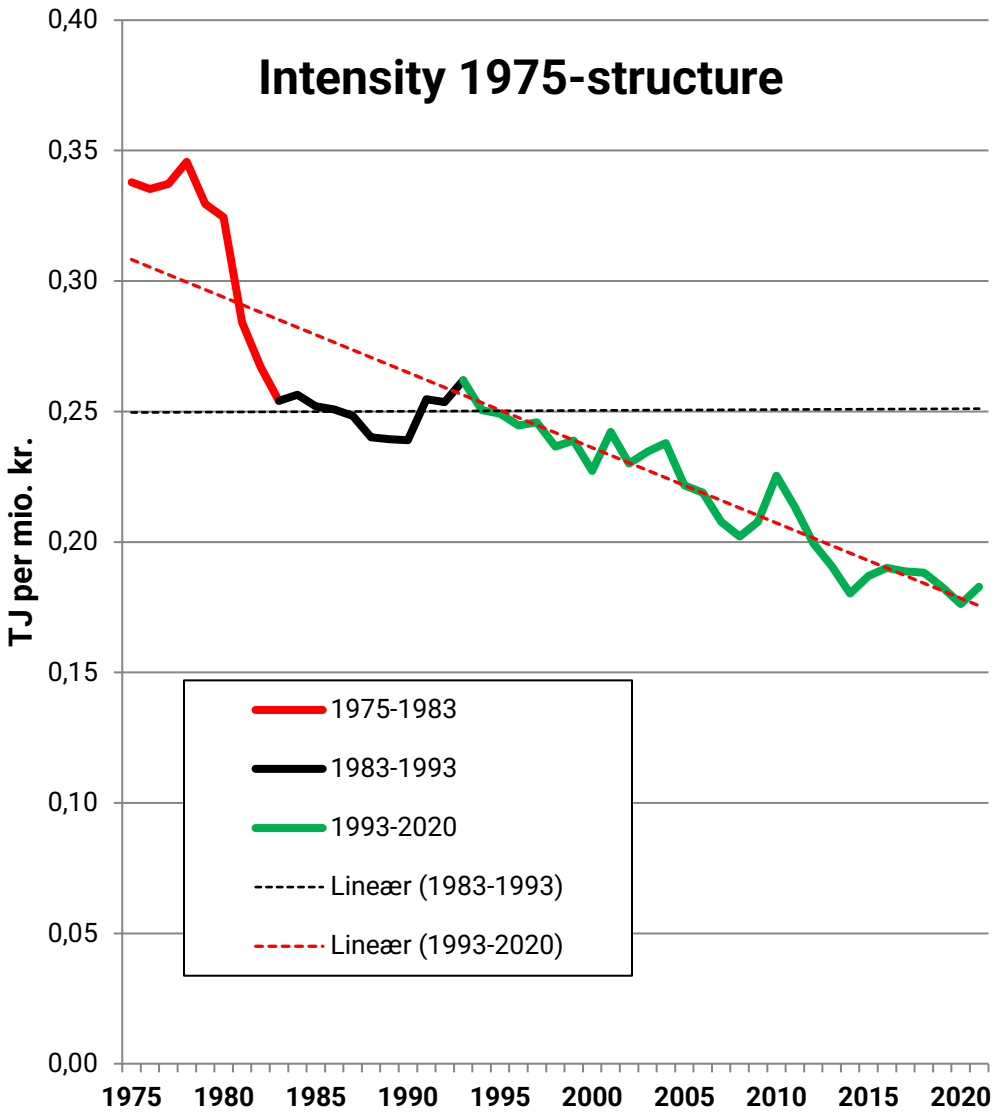
Delivered by a combination of measures



INTENSITY IMPROVEMENTS SINCE 1975

1979-1983	Effect of the second oil crises – higher prices on energy
1983-1993	Lower prices. Very few new measures
1993-2021	First CO2-tax and several other measures

Average annual	Actual	1975-structure
1979-1983	-7,1%	-6,4%
1983-1993	-0,3%	+0,3%
1993-2021	-2,5%	-1,3%



STRONG IMPROVEMENT SINCE 1993

1) The first CO2-packets was introduced in 1993:

- A CO2-tax
- A voluntary agreement scheme
- A subsidy scheme

The rest of the income from the CO2-tax was given back as a reduction of labor cost.

2) The first DSM obligation for electricity companies was introduced in 1993

- Information and advice – no target

The voluntary agreement scheme

Was active in different forms from1993 to 2000

- Linked to tax or tariff reduction

Mail elements:

- Mandatory to implement all projects with af payback time up to 3/5 years
- Energy management system -. ISO 50001 (energy audit the first period)
- Special investigations

Several evaluations have shown that it was a cost-effective measure with a clear effect

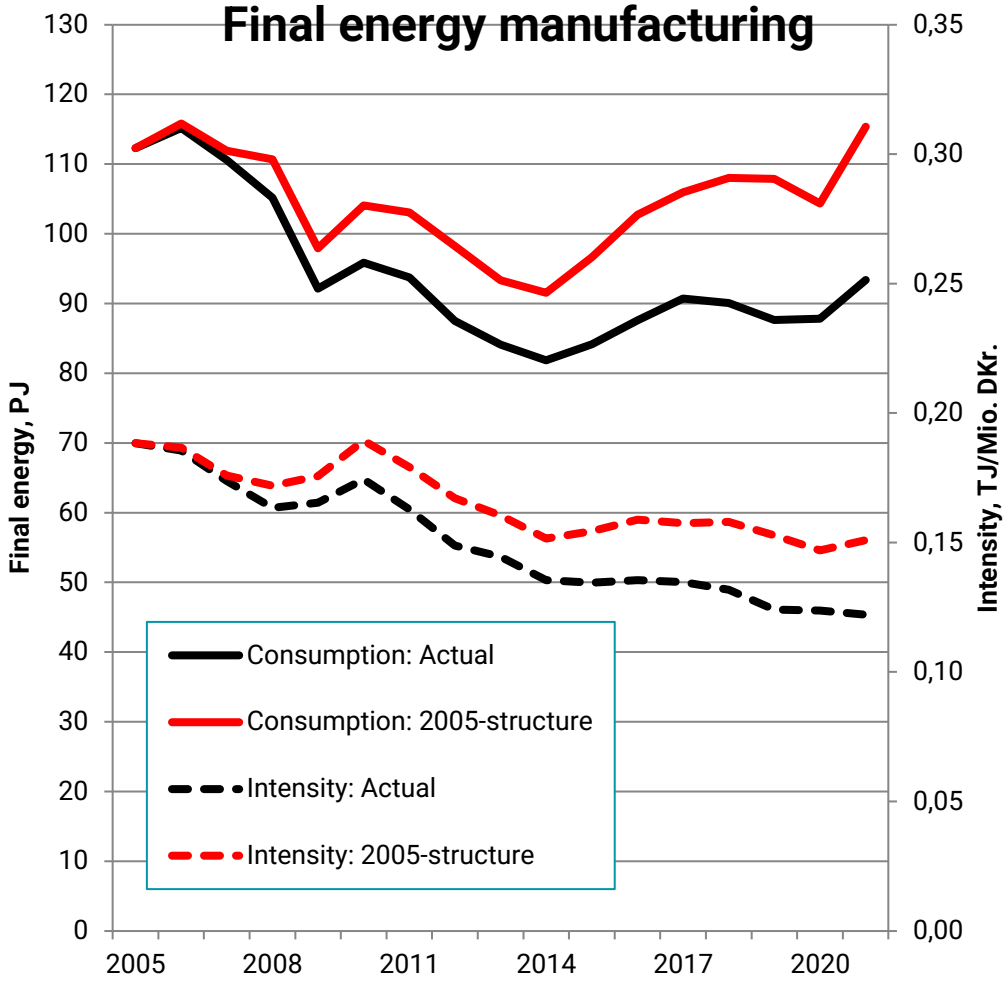
A CLOSER LOOK AT 2005-2021

Structural change still important

Energy Efficiency Obligations

- The main energy efficiency measure from 2006 to 2020
- Annual saving targets for electricity, natural gas, district heating and oil companies
- The targets was increased several times – especial from 2010

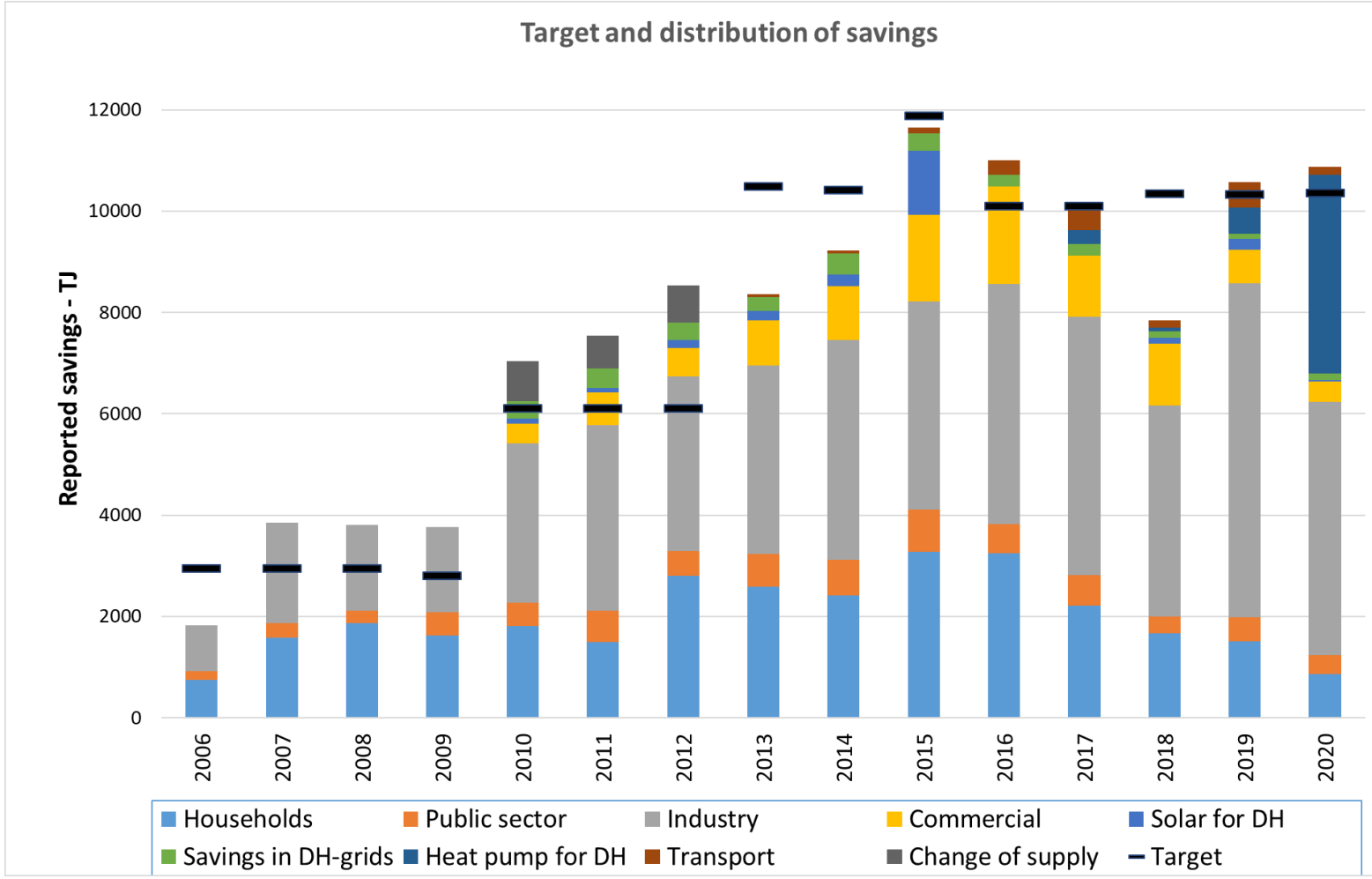
Work well in combination with the agreement scheme and the energy audit scheme



EEO – Reported savings

A big part of the savings was in industries (more then 50% the last years)

- Help to identify and implement the savings very important
- Several evaluations show that the activities in industry was very cost-effective

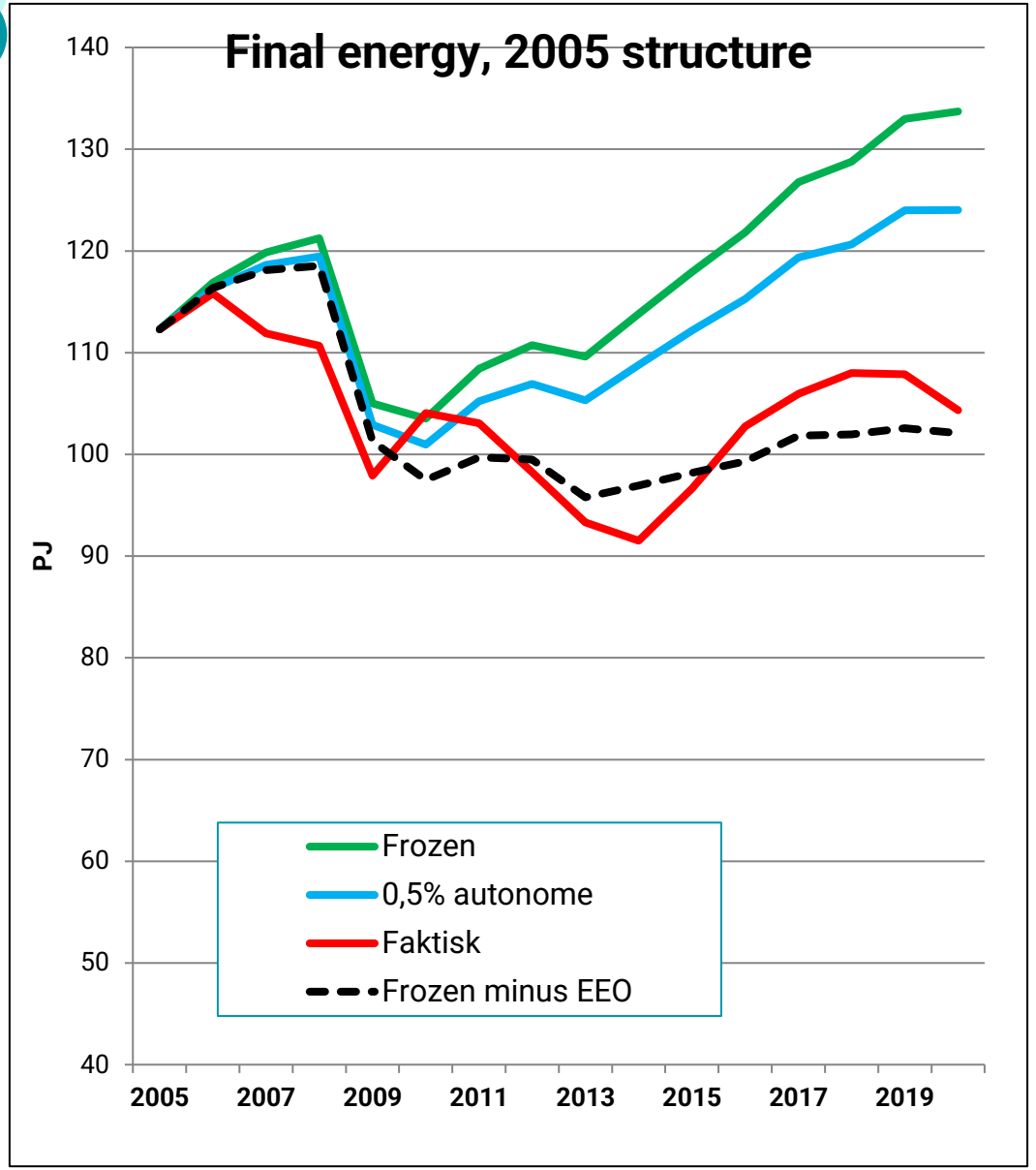


EFFECT OF EEO

The was a clear relation between the cumulative reported savings in manufacturing and the development of the actual consumption

- The effect is first clear from 2010, when the targets was increased

The additionally in industry was around 50%



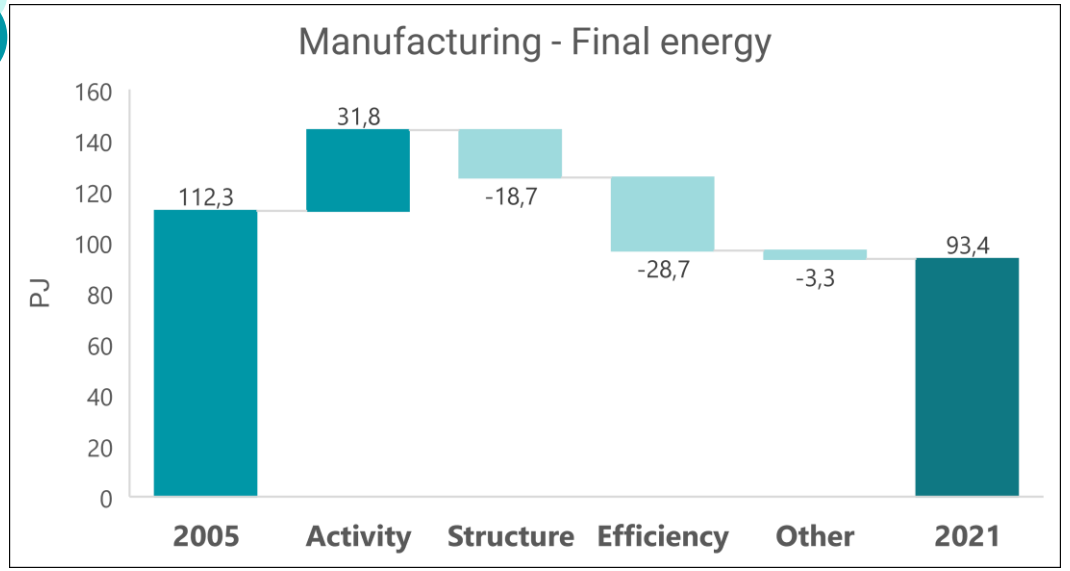
DECOMPOSITION

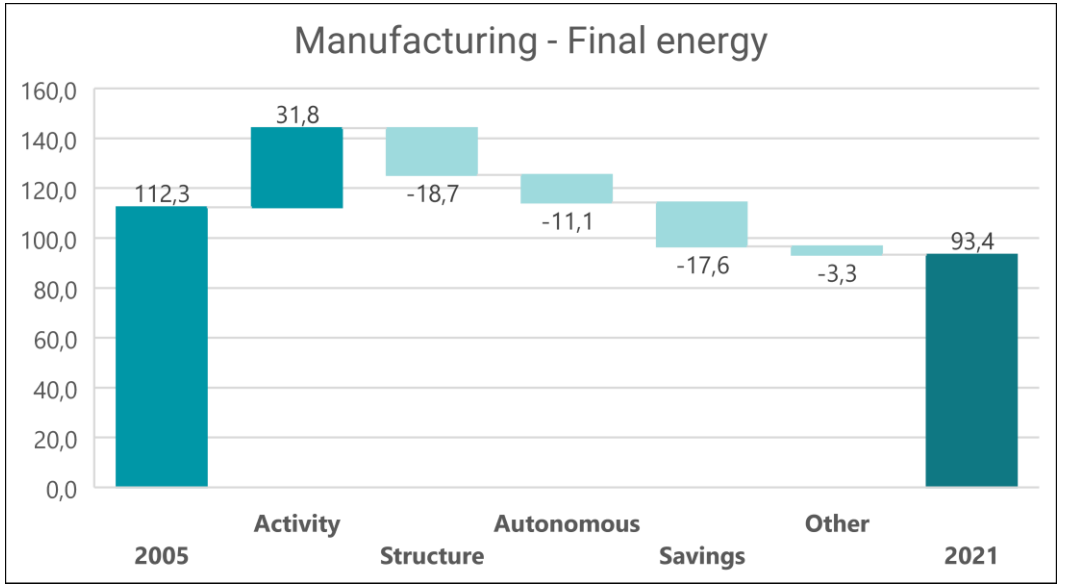
The increase in activity is more the outweighed by

- Structure change and
- Energy efficiency

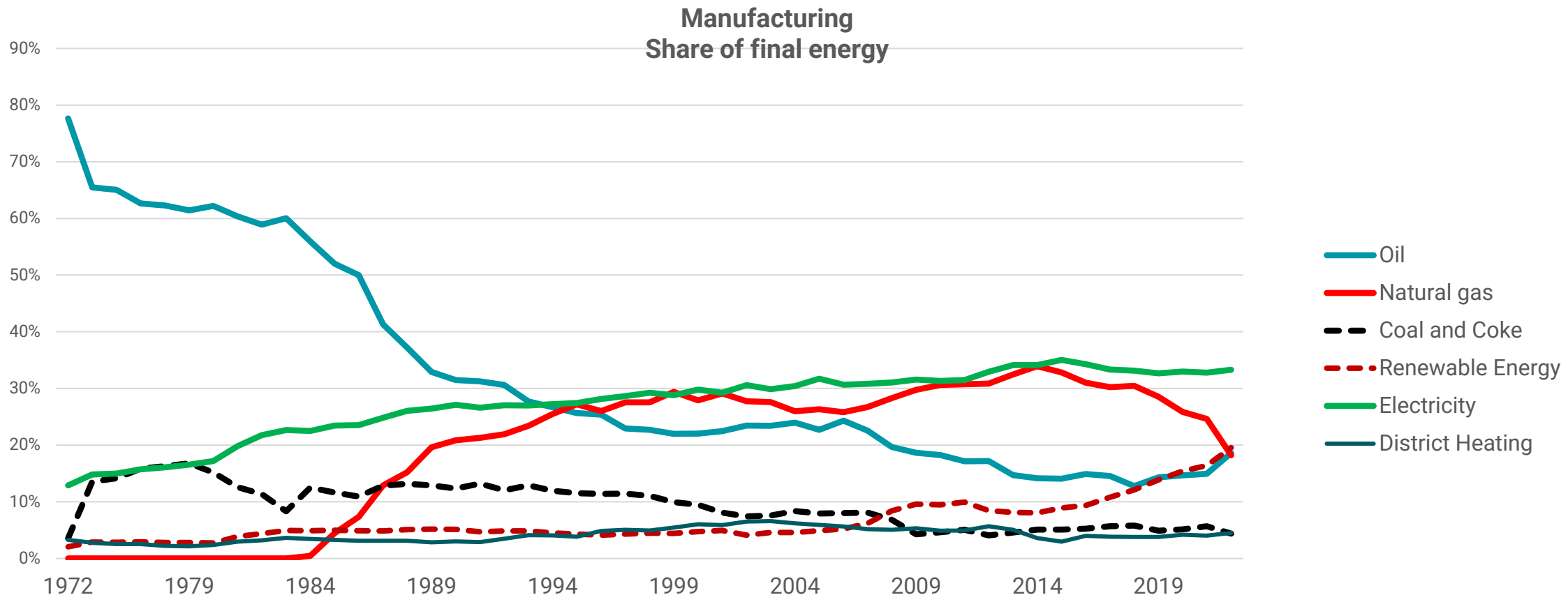
Not all energy efficiency improvement are a result of policies and measures!

- Here is the autonomous EE improvements set to 0,5%/year

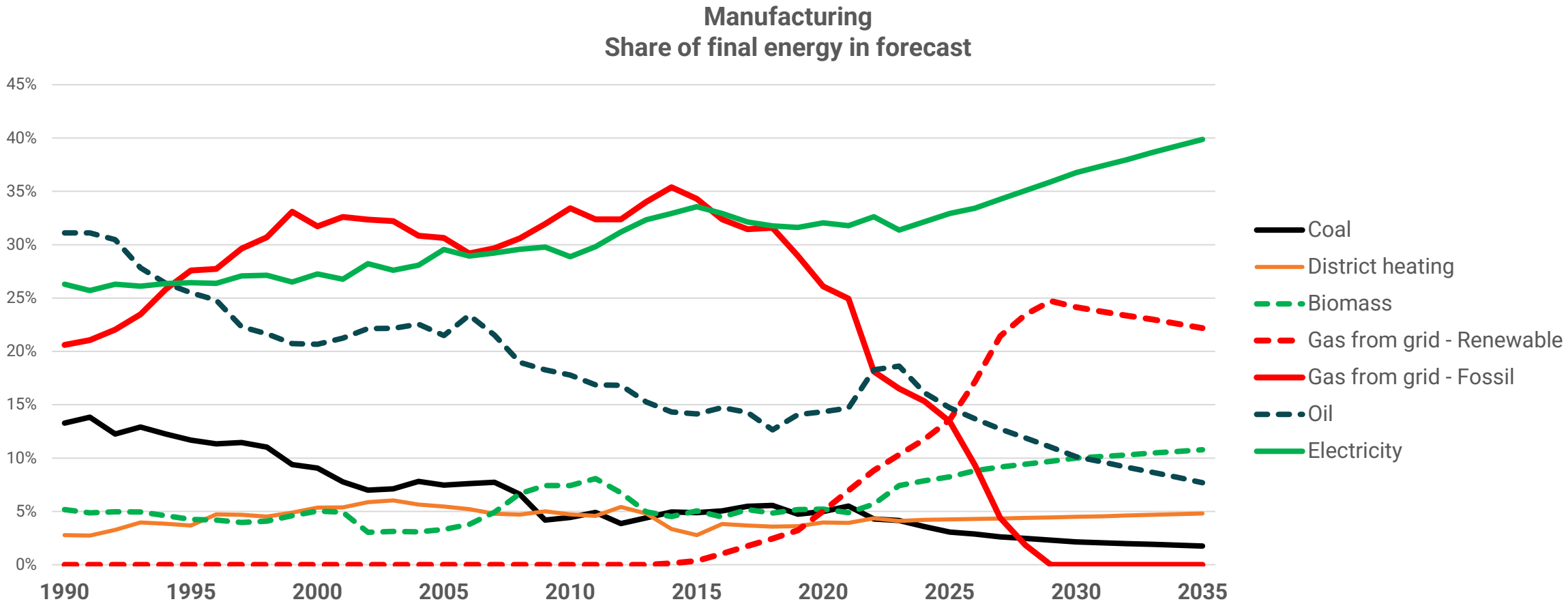




Historical change in use of energy sources



Electrification and facing out fossil gas

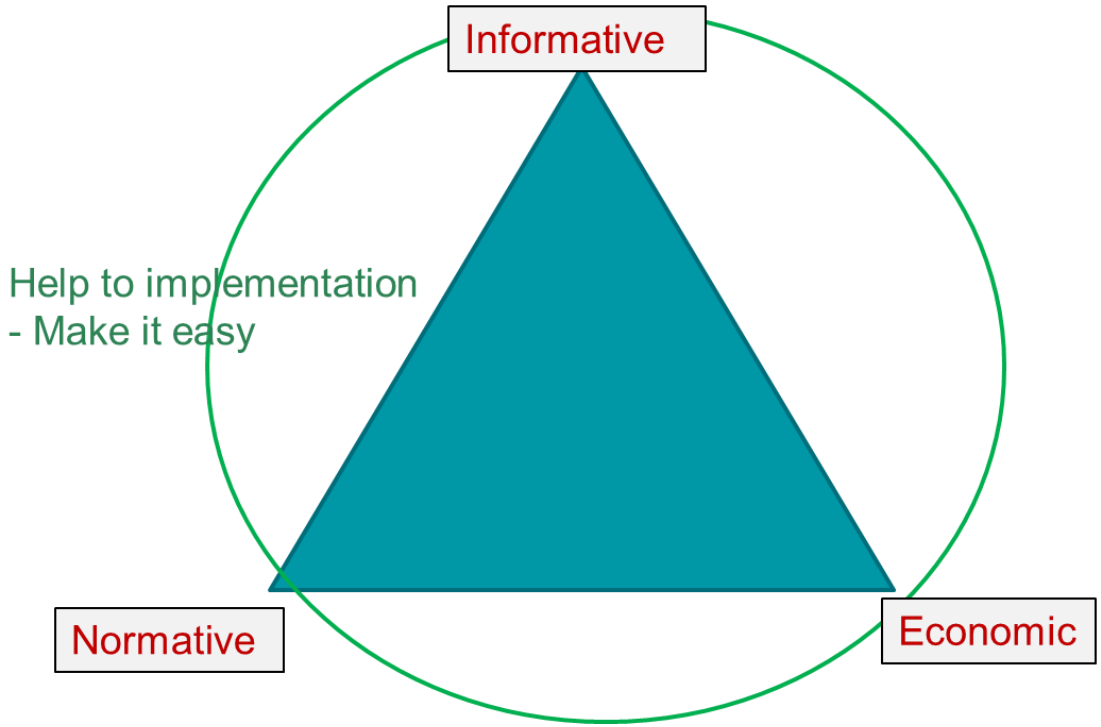


LESSONS LEARNED

Stability in policies and strategies are important

An effective strategy shall include:

- **Combinations of measures**
  - Economic
  - Normative (regulation)
  - Informative
- **Combination of target groups**
  - Not only end-user – also supplier of products, etc.
- **Combination of actors**
  - EU, national, local, construction companies, plumbers, etc.



SUMMARY

Decarbonisation is a combination of

- Reduction of energy consumption by energy efficiency
- Use of fuels/energy sources with low GHG intensity

Until today mostly energy efficiency

In the future will electrification also be very important

Thank you for your attention!

Viegand Maagøe

Decarbonizing Danish Industry

An industrial perspective

State of Green

28’th of June 2024

My background

- Certified energy consultant under Danish auditor scheme
- 30+ years of experience from large industries (LEGO, Novo Nordisk, Arla Foods etc.)
- 10+ years of experience within electrification and ”deep” sustainability roadmaps
- International projects in Ireland, Mexico, Vietnam and US etc.
  - For governments as well as private industries
  - Recent US-experiences from Leprino, Saputo, Wrigley, Eli Lilly etc.
- Meeting and site visit with Andrew McAllister in Copenhagen in 2016
- Co-founder of Viegand Maagøe (2006) with now 130 employees

Outline

- A historic view on energy efficiency efforts in Danish industry
- Current sustainability developments in Danish industry
- Some experiences from US-industries
- Future challenges and opportunities

A historic view on energy efficiency efforts in Danish industry

Danish policy measures in brief – a little history

- In 1992, an energy audit scheme for large industries was launched by the Danish Energy Agency as an element under the CO2-legislation
- The audit scheme was mandatory to comply with to get a tax relief (CO2-tax)
- The audit scheme was quite prescriptive defining specific energy efficiency measures to investigate
- However partly with an ”old-fashioned” approach to energy saving potentials:
  - Boilers efficiency
  - Insulation materials
  - Light
  - Etc.

- A first evaluation of the scheme in mid-90’ties showed low rate of implemented savings

Viegand Maagøe

Evaluation of energy audit scheme mid-90'ties

- No management commitment to energy efficiency-projects
- No understanding of real energy saving potentials

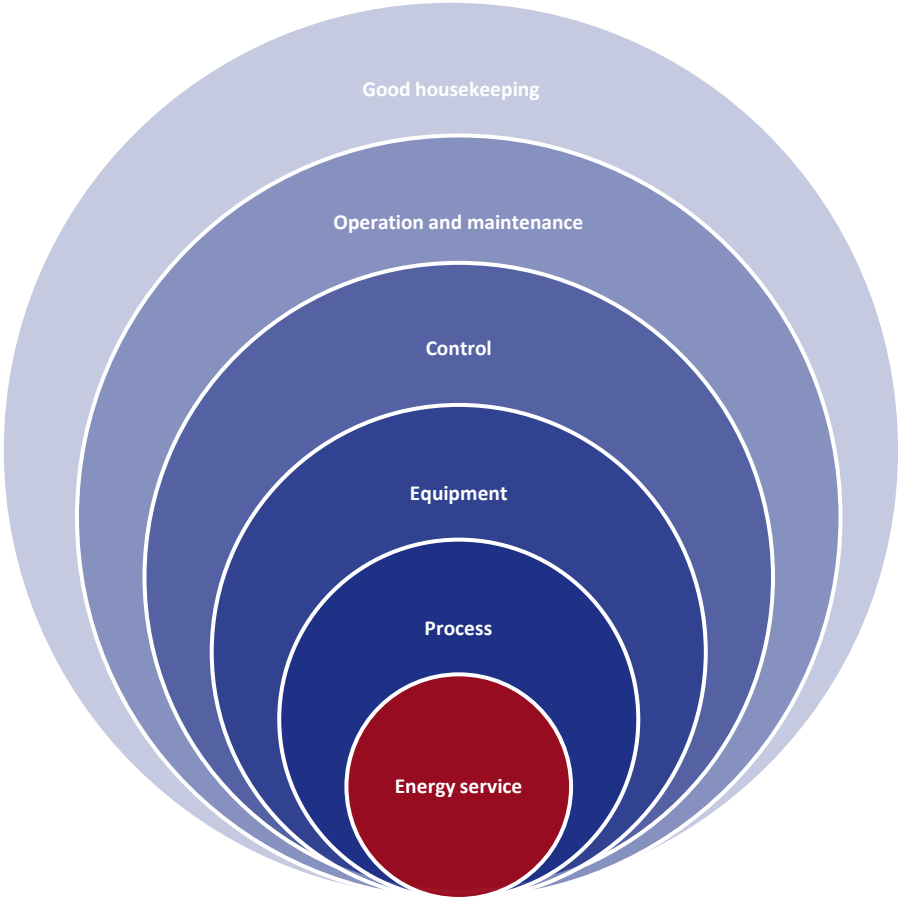
- The following decade, the Danish Energy Agency led important developments:
  - The concept of energy management systems (DS2403 -> EN16001 -> ISO50001)
  - Introduction of a voluntary agreement (VA) scheme (with CO2-tax relief):
    - A 3 year-agreement period
    - "Special investigations" as a new element for complicated technical assessments
    - An obligation to implement energy efficiency investments with payback < 4 years
    - Mandatory "energy efficient design" (EED) for CAPEX-projects
  - Compliance with scheme was to be verified by an independent verifier (DNV etc.)
  - Methodology development for "deep" energy efficiency
  - Information activities and demonstration projects
  - Grant schemes

Industry was positive - even though initial sceptisism

- The voluntary agreement scheme was succesfull:
  - The 3-year time horizon is much more in line with industrial thinking than audits
  - ”Special investigations” a good approach for most complicated saving intiative
  - The request for investments with payback up to 4 years stimulates results
  - Good demonstration projects supported new ways of working

- Danish industries have been considered ”best in class” in terms of energy usage
- An advanced understanding of industrial energy efficiency has been gained
  - The current EU-energy audit scheme is not effective (for large industries)
- Grant schemes works well – minimize risks and uncertainties for investments
- Today, many industries ask for guidance on future efforts
  - Clear statements about policy, focus areas and boundary conditions

The ”onion” for deep energy efficiency (©Viegand Maagøe)



4 categories of EE potentials:

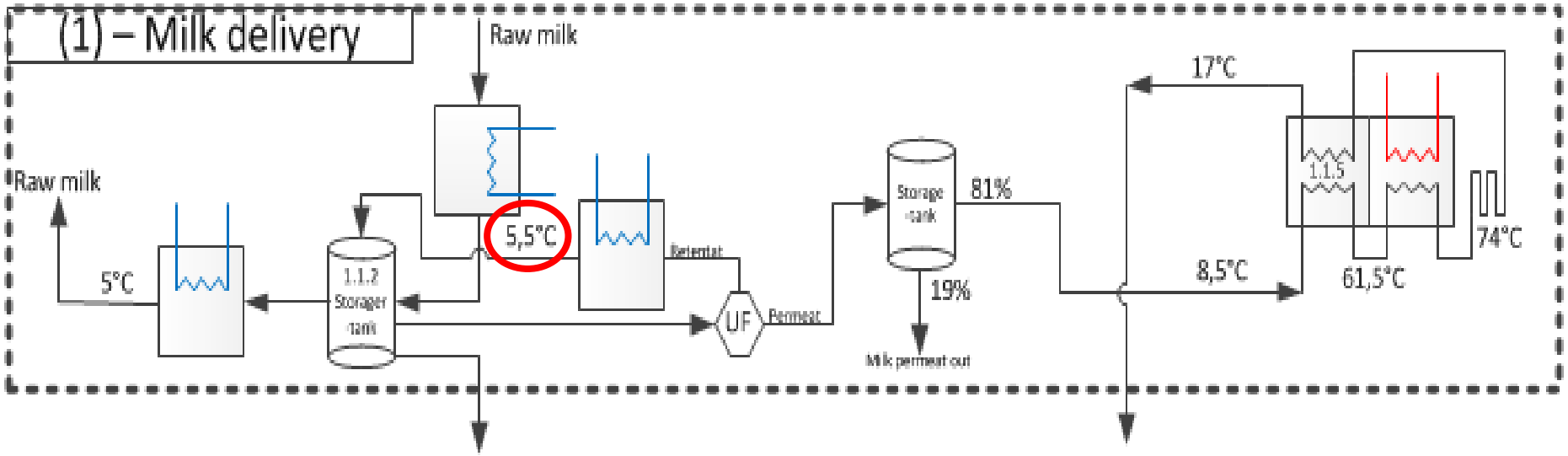
KPIs and operational control identify faults in operation and maintenance

Utility structures and efficiency of components to be assessed

Heat recovery systems, process optimization and electrification have huge impact on energy efficiency

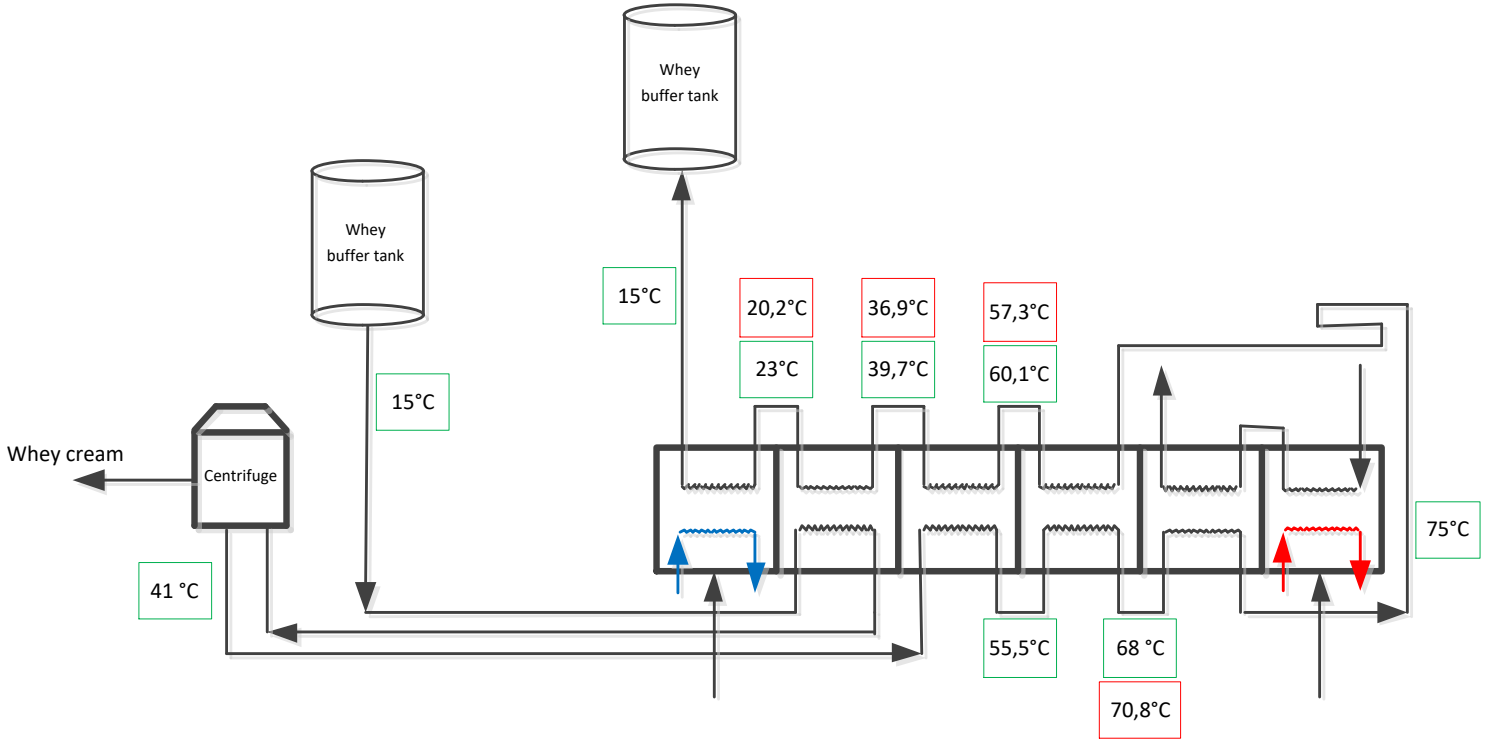
Deep process rehabilitation reduces demand for energy with important links to “non-energy-benefits”

Challenge energy demand



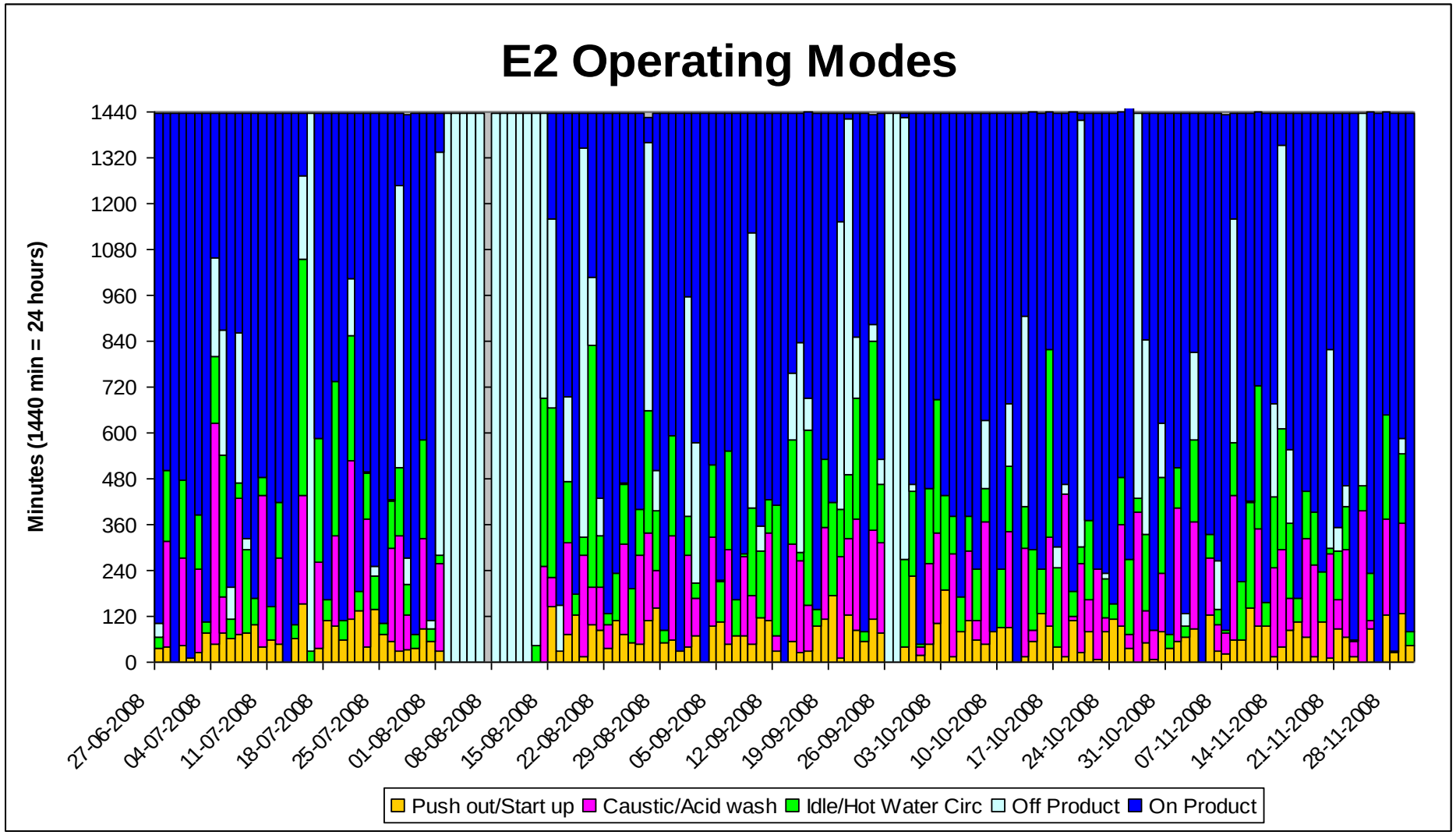
- What is target temperature for received milk/whey/raw material? - 6ºC? - 10ºC? - 14ºC?
- Is the target temperature the same for all products and raw materials
- When is deviation-reports prepared - at 8ºC? - 12ºC? - 16ºC?
- 2ºC has a significant impact on cooling demand

Optimize process



Before modification:			After modification:		
	Heat demand (kWh):	Cooling demand (kWh):		Heat demand (kWh):	Cooling demand (kWh):
Whey HEX	1.000.541	1.000.541		627.205	627.205

Monitor operations



Idle load of evaporator consumes > 30% of annual steam consumption

Current sustainability developments in Danish industry

Viegand Maagøe

Current legislation targetting the industrial sector

- Mandatory audit schemes for SMEs and large industries (EU) every 4 year
  - Energy audits
  - ISO50001
- EU-CTS to control CO2-emissions in large industries
  - Free allowances are gradually reduced
- CO2-tax imposed for fossil energy usage in industry
  - Approx. 100 USD/ton CO2 in 2030 for industries outside EU-ETS
  - Approx. 50 USD/ton CO2 in 2030 for industries inside EU-ETS
- Grant scheme for industry – approx 25-30% CAPEX-support
  - Energy efficiency
  - CO2-projects (electrification)
- EU-CSRD and ESRD (Corporate/Environmental Sustainability Reporting Directive)
  - Calls for ESG-action in all industries from 2025 and forward

Viegand Maagøe

Current trends we see in Danish industry

- Strong focus on sustainability questions in most sectors – stimulated by:
  - Customer focus B2B ad B2C
  - CSRD- and ESRD-legislation
- Many industries look into reduction of Scope 1- and 2-emissions (GHG-protocol)
  - To phase out use of fossil fuels
- Electrification is a preferred solution in most sectors
  - To phase out use of natural gas (from Russia)
  - Because grid electricity is about to be carbon neutral (wind and solar)
- Important discussion on which role energy efficiency will play in the future
  - Will we have a lot of excess electricity in the Danish grid?
- Early discussions on flexible consumption and importance of back-up/storage
  - Security of supply expected to decrease from 99.95% -> ?

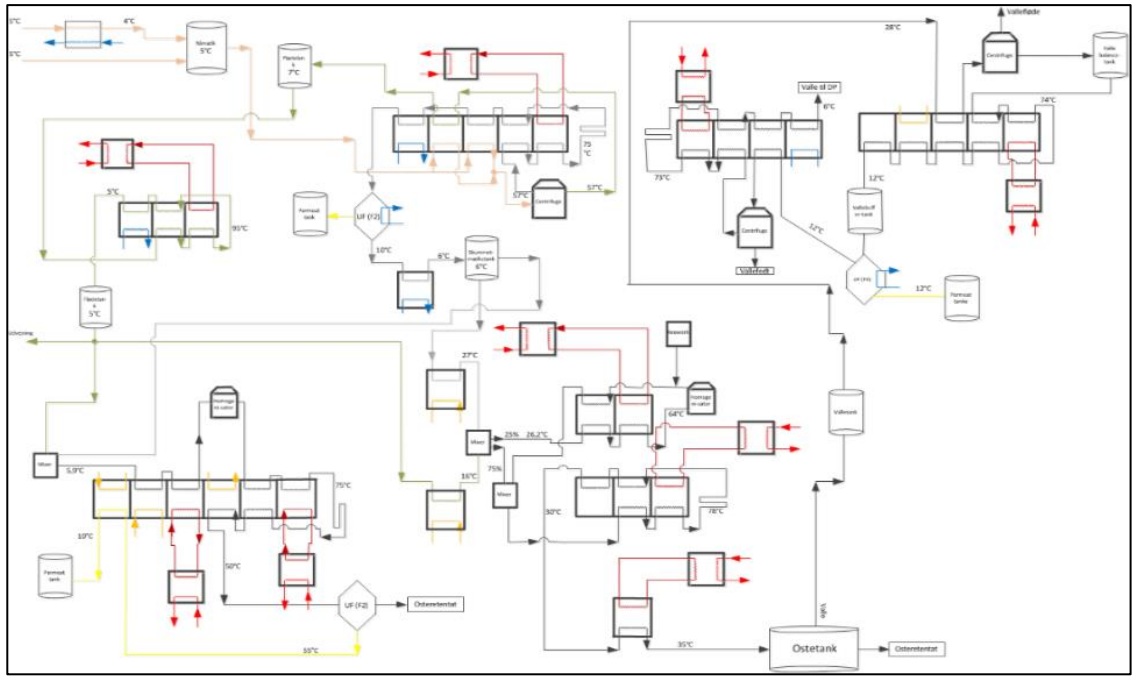
Viegand Maagøe

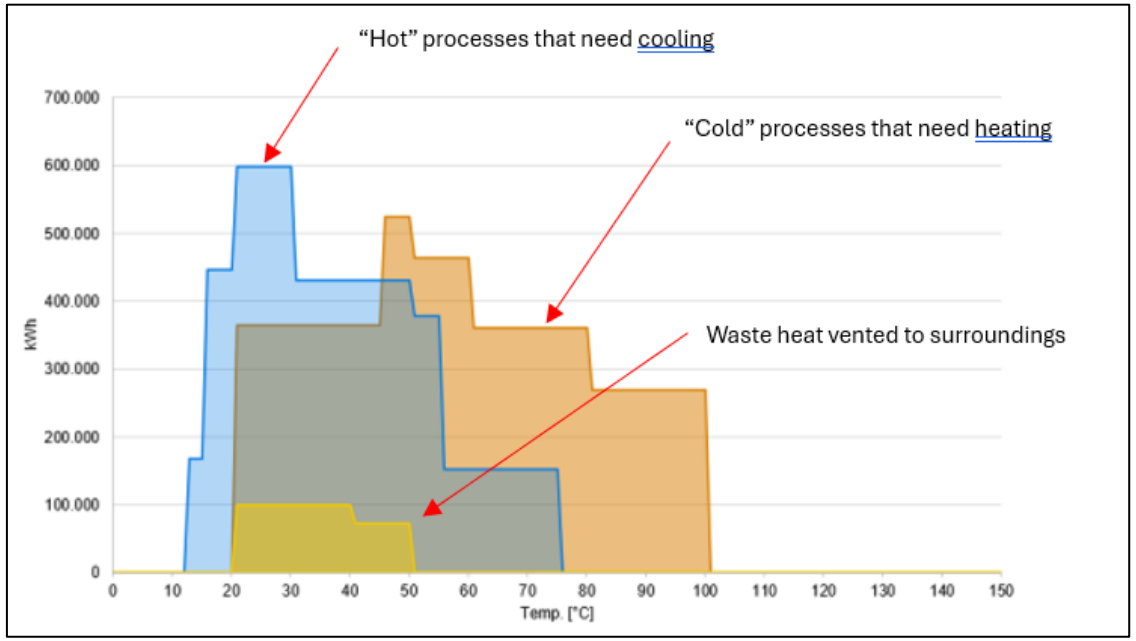
Current solution paths we experience

- The approach and level of ambition is very different:
  - Some companies prefer simple electrification, i.e. simply to build electric boilers (1:1)
  - Some companies look into ”deep” electrification applying heat pumps
- Heat pump strategies can achieve significant energy saving savings
  - We see strategies that reach 50-70% reduction of primary energy usage…
  - …if you dare to go for ”deep” electrification and de-centralized solutions
- Other companies need other solution paths
  - Biogas and/or hydrogen are to be used for high. temp. processes (cement, tiles etc.)
  - Hydrogen will however most likely be an expensive and scarce energy source
- Many companies don’t have a clue:
  - Are waiting for the ”silver bullet”
  - Are waiting for steam producing heat pumps (that Viegand Maagøe not really believe in)
  - Or will use hydrogen for any purpose

An important experience!

- In average, 45% of the heat demand in Danish industry* occurs < 100°C
- Flowsheeting analysis are needed to construct composite curves identifying heat recovery potentials

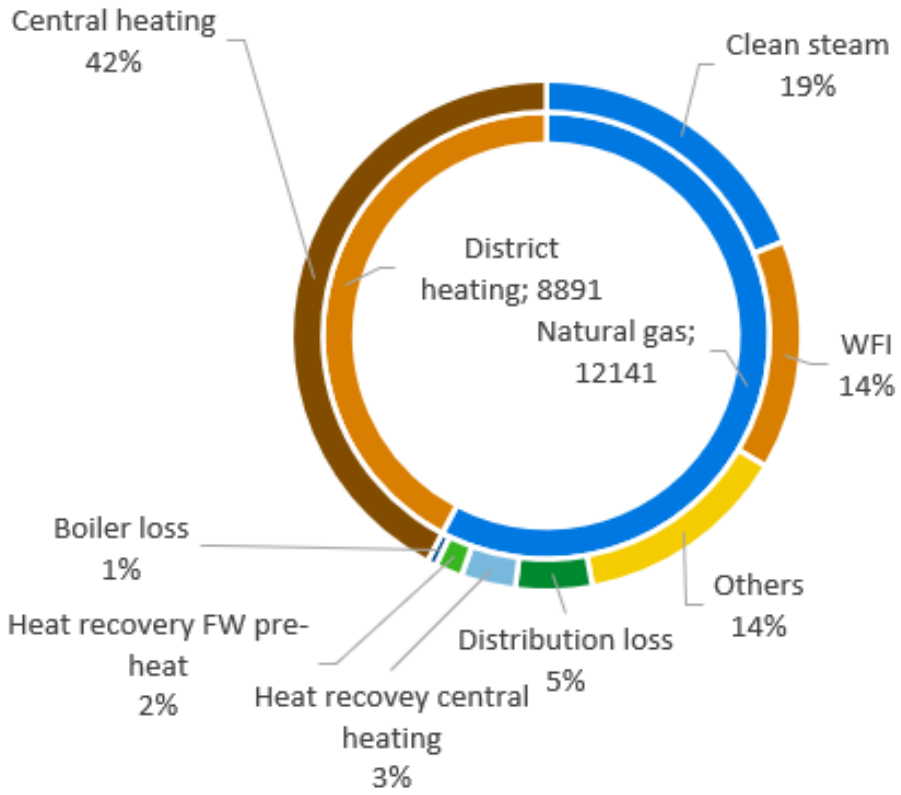




**Manufacturing industry and agriculture but not including service industry*

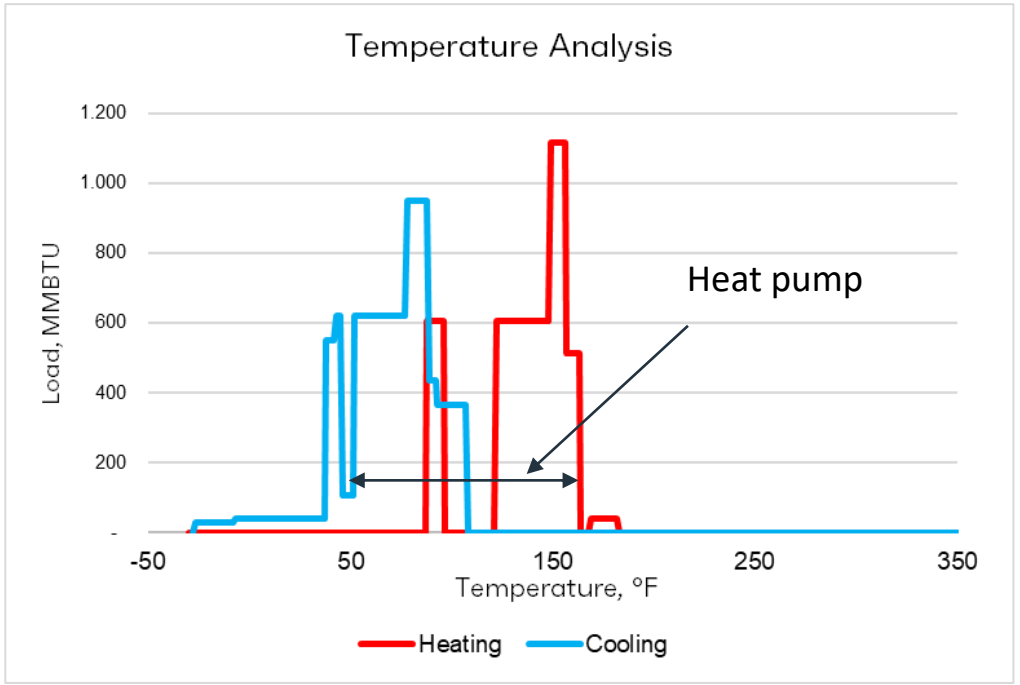
Case: electrification of a pharmaceutical company

- Two electrification strategies have been investigated at a pharmaceutical industry close to Copenhagen
- A detailed data-mapping has been undertaken:
  - Heat demand vs. end-use and temperature
  - Forecasting of 2030-demands
- In conclusion, most of heat demand is:
  - At low temperatures
  - Possible to cover via decentral solutions
- Two strategy paths are to be considered:
  1. Electric boilers (1:1)
  2. De-centralized solutions (“deep” electrification)



Case: electrification of a pharmaceutical company

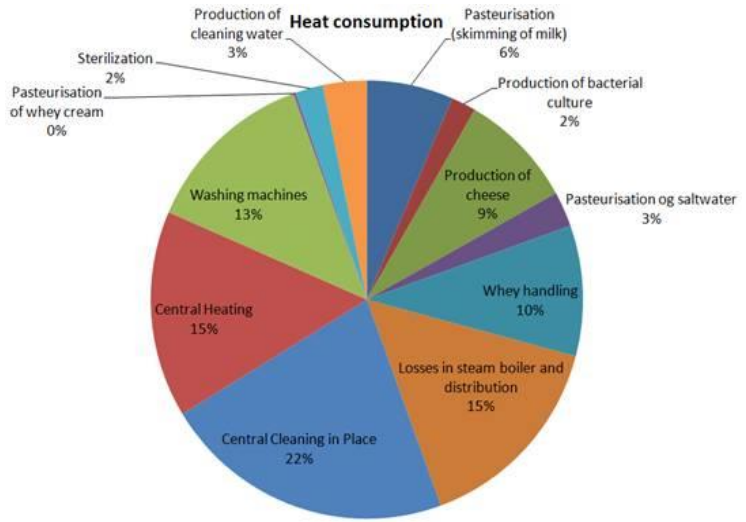
- The 2 strategy paths comprise:
  - New central electric boilers to replace existing gas boilers 1:1
  - De-centralized heat pump-solutions at major end-users
- The de-centralized strategy comprise:
  - Mechanical Vapour Recompression (MVR) for WFI
  - High pres. heat pump for clean steam
  - Heat recovery for buildings and WFI-reheat
    - Combined heating and cooling
  - Storage, batteries and generators as back-up
- The decentral strategy achieves:
  - 60% saving in primary energy demand

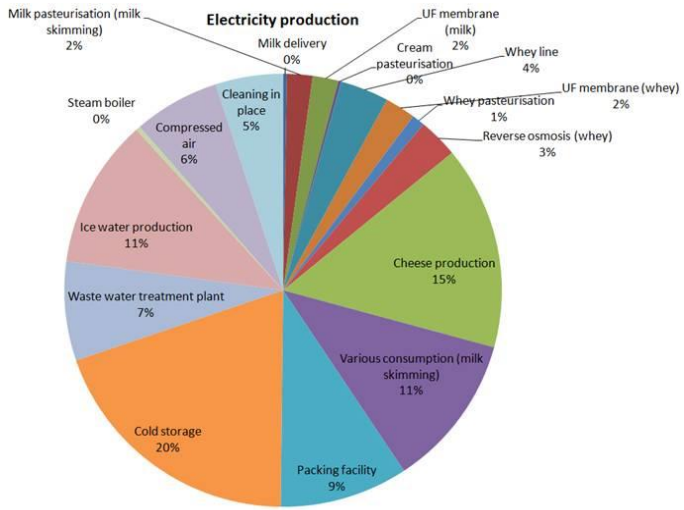


The question about flexible consumption

- Most industries consider flexibility is only acceptable for energy demand related to non-critical usage with large ”thermal capacity”, i.e. building heating or building cooling
- Such energy usage is however limited in manufacturing industry (<10%), why flexibility potential is low
- What do we look into:
  - Either we have to accept small benefits from flexibility
  - Alternatively we must install batteries and storage solutions
  - Or look into ”deep” flexibility (i.e. ”process”)

- The challenges and opportunities regarding ”deep” flexibility are the same as for electrification – when we move close to individual processes we find many new solutions





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Best in class approach to green transition

The most advanced Danish industries build their sustainability strategies on the following pillars:

- Electrification (deep)
- Energy efficiency is key
- Flexible consumer (deep and/or batteries and storage)
- Generators (e-methanol) for back-up operation when brown-outs
- Grid support from generators during periods with no wind and solar
- Waste heat exported to support public district heating grid
- Solar PV on own buildings
- Advanced PPA-schemes (24/7)

Next to new technical insights and solutions, there is a position that sector integration and shared utilities is the most sustainable path forward for the society

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However uncertainties about boundary conditions

- Will we have plenty of electricity?
  - Are 1:1 eletric boilers a sutainable way of thinking?
- Is energy efficiency still a cornerstone in the green transition?
  - The minister just said something else?
- What is the design criteria for back-up-solutions
  - 5 minuts? - 2 hours? - 4 hours? – or more
- Should we use generators to support the electricity grid during difficult periods?
  - And which fuels should we use? – biogas? – e-methanol?
- How important are flexibility and storage solutions?
  - Is there a business case to move forward with ”deep” flexibility?

- Will somebody push for demonstration projects for best-in-class-solutions?

Some experiences from US-industries (2020-2022)

(food and phamaceuticals

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Benchmarks for 2 dairies (*)

Area	Energy consumption for 2 Danish mozzarella-facilities (kWh)	Energy consumption for 76% of Danish whey-powder facility[2] (mill. kWh)	Benchmark energy consumption for Saputo Paige-facility (kWh)
Electricity	64.3	25.46	89.9
Thermal energy (gas)	94.2	137.08	231

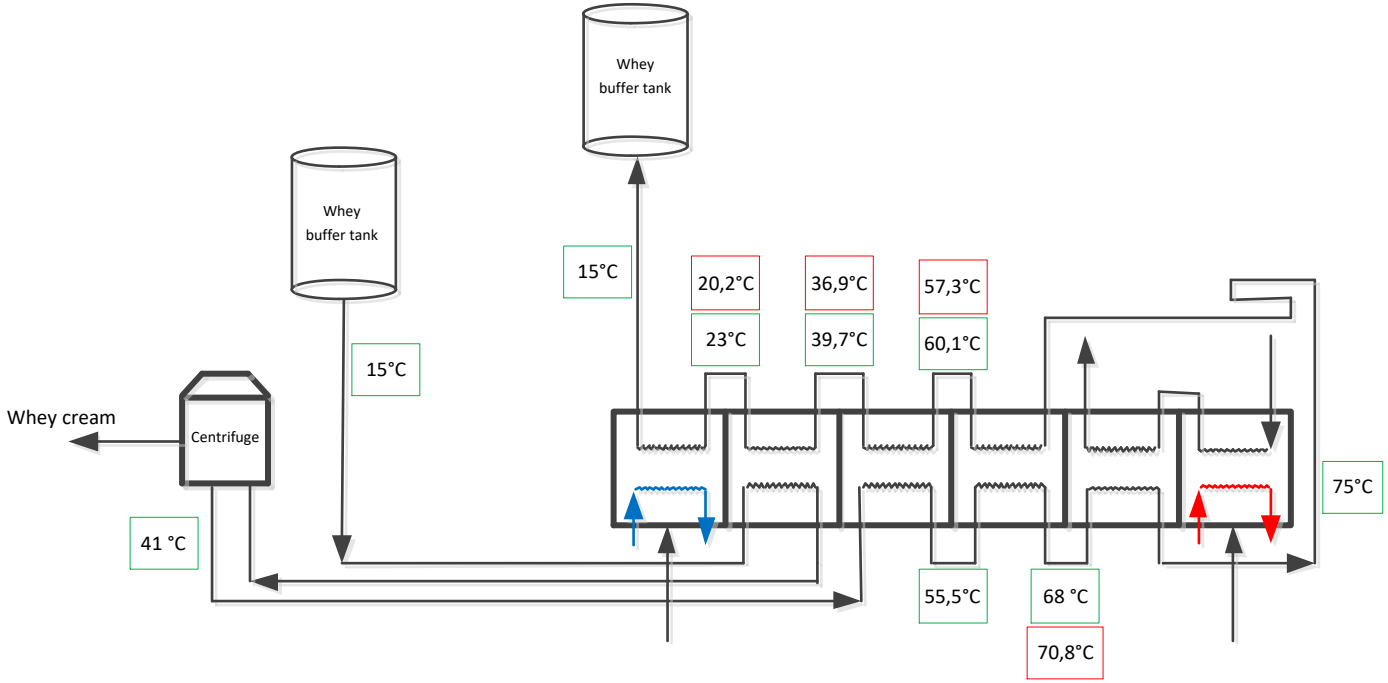
Area	KPI for Saputo (Tulare) (kWh/ton)	KPI for Scandinavian facility (kWh/ton)
Electricity	87.5	54.5
Thermal energy (gas)	166.7	79.4

Electricity consumption 50 - 80% above "good" practice

Gas consumption 70 - 100% above good practice

**Be carefull with overall benchmarks – they are influenced by many parameters as operational pattern, product quality, weather, logistics etc.*

Example: Re-configuration of pasteurizers

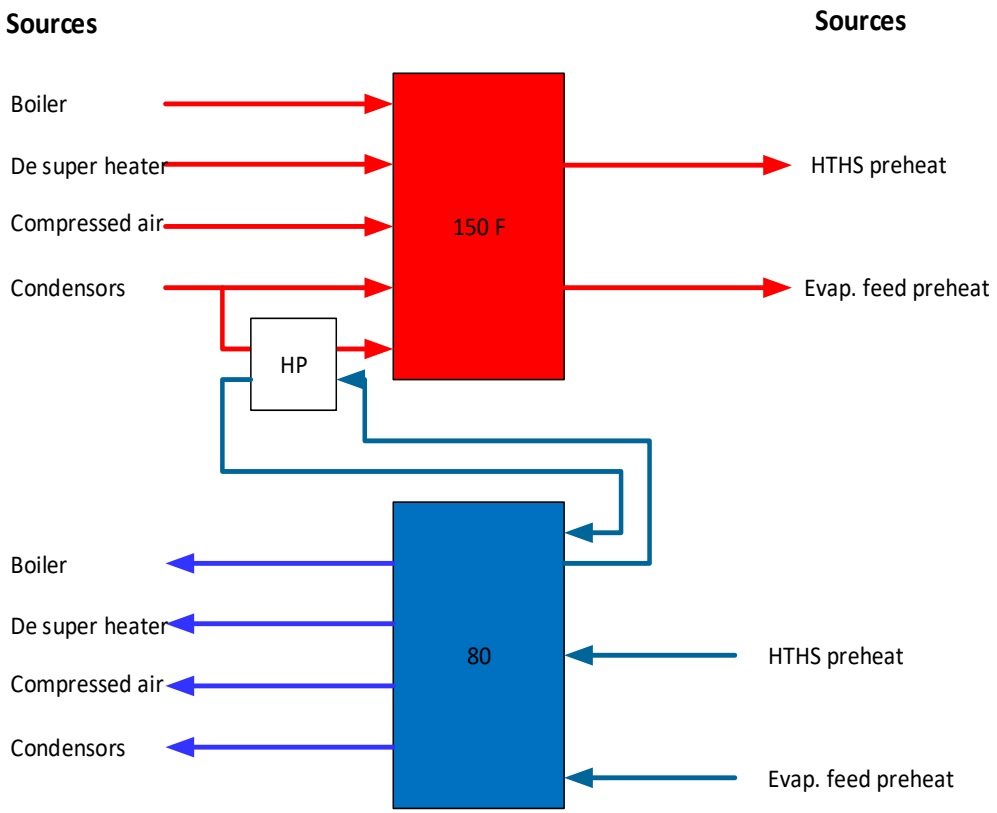


Ratio between steam heating and internal heat recovery in pasteurizers:

- Good practice 10% utility – 90% heat recovery
- Typical US-standard 60% utility – 40% heat recovery

→ *Significant savings in hot and cold utility by re-design*

Example: Central heat recovery loop



Gross savings Heat Recovery Loop:

Gas	*MMBtu*	154.000
Electricity	*GWh*	-3.6
CO2	*ton/y*	7.100
Economic	*$/y*	685.000

Total Savings All Projects	Gas	Electricity
	MMBtu	*GWh*
Pasteurizers	63.000	2,1
Dryer preheat	18.000	0
Heat Recovery Loop	154.000	-3.6
Sum	**235.000**	**-1,5**
% of site consumption	**29.8%**	**-2,3%**

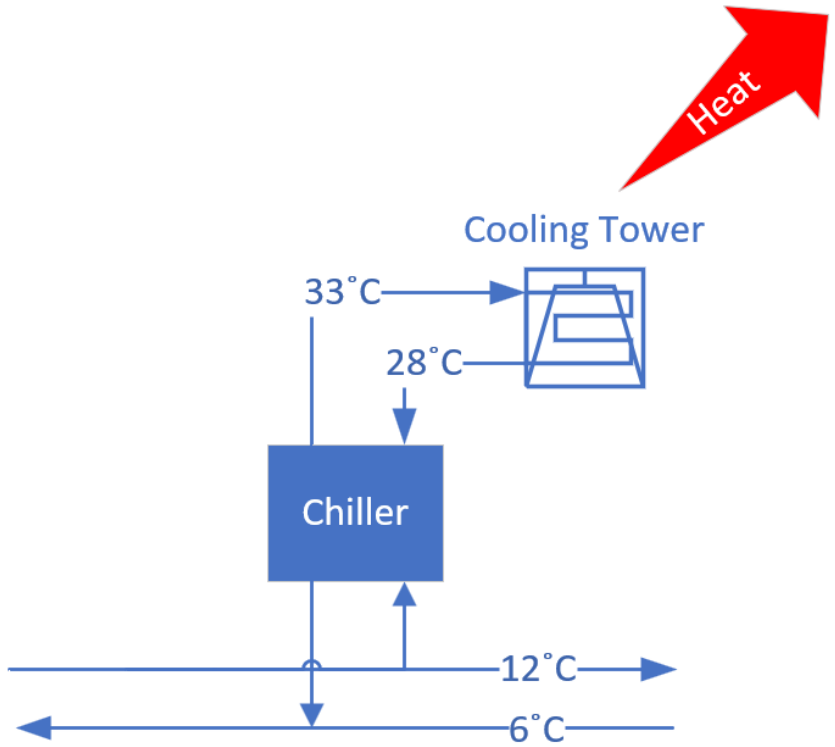
Gross saving potential heat recovery locally and globally = 30% with an 2.3% increase of electricity consumption

- Pasteurizers reconfiguration
- Air preheating for spray dryers
- Change of existing heat recovery loops

Example: Combined heating and cooling principle

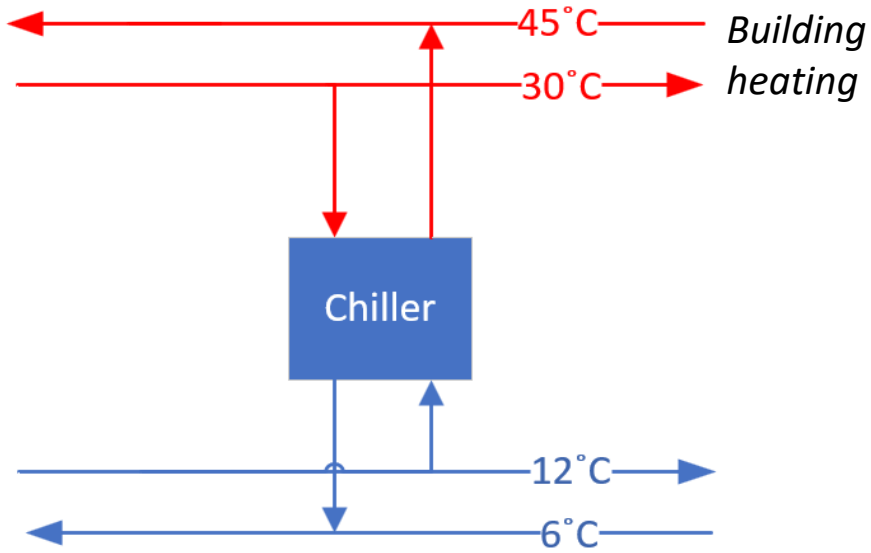
Conventional System

- Use 1 kW electricity
- We get 4 kW cooling
- We use 4 kW fossil heating



Combined system:

- Use 1 kW electricity
- We get 3 kW cooling
- We get 4 kW of heating
- (+Savings on cooling tower)



Conclusions from 5-6 US-audits

- Most (large) companies have made efforts to make utility systems more efficient (steam boilers, refrigeration plants, compressed air etc.), but some (SMEs) are lacking behind
- Only few companies have addressed energy efficiency potentials inside the production processes – energy efficiency is most often anchored at “blue coloured staff” and not in at “white coloured staff” (process)
- Only few and simple heat recovery schemes are applied – and some of those installed are out of operation due to lack of maintenance
- All companies ask for KPIs for energy and water usage and approaches to “operational control” regarding energy and water – a focus also at corporate level
- Detailed energy & water mapping and Energy Management Systems (ISO50001) not applied

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Future challenges and opportunities

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Wrap-up of future challenges and opportunities

- In the forthcomming years many decisions will be taken regarding energy supply
  - Many industries are ready for ambitious strategies and new long-term solutions
- The energy saving potentials with ”deep” eletrification strategies are huge
  - We have demonstrated 50% reduction in primary energy usage in some sectors
  - With current energy prices, payback periods for these solutions is +6 years
- We see similar potentials for ”deep” flexibility solutions
  - But this area is not mature technically and in terms of business cases
- There is a need to push the developments
  - A legal framework (from the EU) is not enough
- The industries look for:
  - Pilots and demonstration of best in class solutions
  - Clarification of future boundaries

Thank you for your time☺

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