

EnergyPLAN

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Part 3 and 4

- Tabs: Storage, Cooling, Individual, Industry, Transport, Cost and Regulation
- Gathering Data for EnergyPLAN
- **Types of Studies in EnergyPLAN**
- **Case Study: IDA 2030 Energy Plan**
- Exercises: 3, 4 and 5 from the EnergyPLAN website
- Discussion / Questions



Types of Studies

1. Technical Optimisation
2. Feasibility Study
3. Market Optimisation



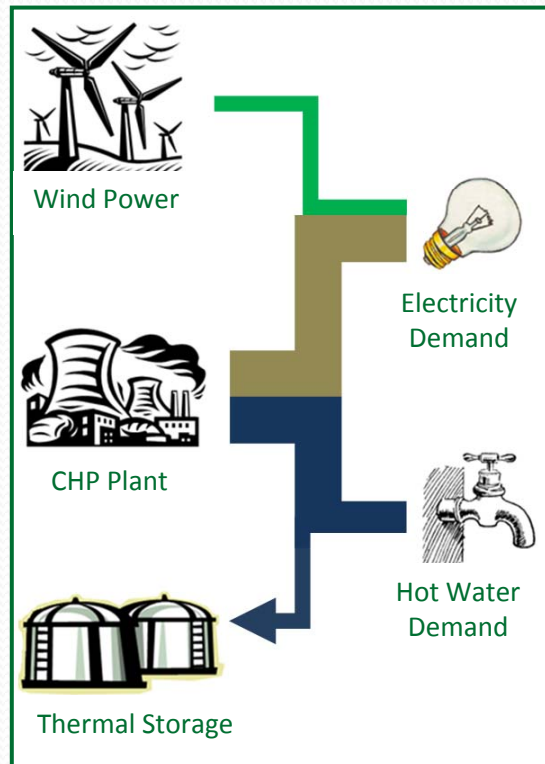
Technical Optimisation

1. Meeting heat demands
2. Meeting both heat and electricity demands (see next slide)
3. Like 2 BUT reduce CHP also when is needed for stabilisation reasons
4. Like 1 BUT meeting triple tariff.

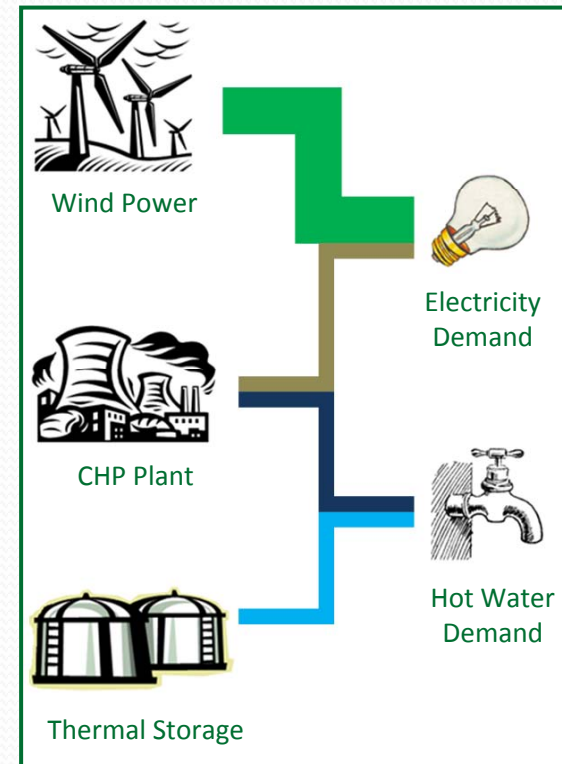


Technical Optimisation 2

Low Wind-Production



High Wind-Production



Feasibility Study

- A technical optimisation with cost details
- Enables user to quantify the cost of creating the technical optimisation
- Socio-economic costs:
 - Jobs
 - Environmental Benefits
 - Balance of Payment



Market Optimisation

- Models the energy system based on existing economic-regulations i.e. Most economic rather than most technologically advantageous
- Units aim for a competitive Marginal Cost of Electricity



Optimisation Sequence

1. Starting Point (Demand, RES, Boilers)
2. Optimising minimum electricity for Hydrogen for transport and Micro CHP
3. Optimising elec. Consumption (Heat Pumps etc.)
4. Optimising Hydro Power
5. Optimising Production Units
6. Optimising storage (Hydro and CAES)
7. Repeating 3-6
8. CEEP regulation



Optimisation Sequence

- Sort the following units in accordance with lowest costs:
 - Nuclear
 - Geothermal
 - Condensing plants
 - Indv. Biomass CHP
 - Indv Natural Gas CHP
 - CHP replacing boilers
 - CHP replacing Heat Pumps
 - CHP replacing electrolysers



Tabs

Costs and Regulation



Regulation

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Regulation:

Chose Optimisation Strategy:

1 Balancing heat demands

Electric grid stabilisation requierments:

Minimum grid stabilisation production share	<input type="text" value="0.3"/>
Stabilisation share of CHP2	<input type="text" value="0"/>
Minimum CHP in gr. 3:	<input type="text" value="300"/>
Heat Pump Maximum load:	<input type="text" value="0.5"/>

External Electricity Market Definition

Price distribution	<input type="button" value="Change"/>	Hour_nordpool.txt
Addition factor	<input type="text" value="0"/>	DKK/MWh
Multiplication factor	<input type="text" value="2"/>	
Resulting average price :	227	DKK/MWh

Critical Excess Electricity Production (CEEP)

Critical Electricity Excess Production (CEEP) regulation: Write number:

- 1 : Reducing RES1 and RES2
- 2 : Reducing CHP in gr.2 by replaing with boiler
- 3 : Reducing CHP in gr.3 by replaing with boiler
- 4 : Replacing boiler with electric heating in gr.2 with maximum capacity: MW
- 5 : Replacing boiler with electric heating in gr.3 with maximum capacity: MW
- 6 : Reducing RES3
- 7 : Reducing power plant in combination with RES1, RES2, RES3 and RES4

External Electricity Market response to import/export

Price elasticity	<input type="text" value="0"/>	DKK/MWh pr. MW
Basic price level for price elasticity	<input type="text" value="150"/>	DKK/MWh

Transmission line capacity

Maximum imp./exp. cap:	<input type="text" value="1600"/>	MW
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Cost - Fuel

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Fuel Operation Investment Additional

Fuel, Taxes and CO2 costs

	Coal	FuelOil	Diesel Gasoil	Petrol/JP	Ngas	Waste	Biomass
Fuel Price (world market prices) (DKK/GJ)	0	0	0	0	0	+ 0	0
Fuel handling costs (distribution and refinery) (DKK/GJ)							
To central CHP and power stations	0	0		0	0	0	0
To dec. CHP, DH and Industry	0	0		0	0	0	0
To Individual house holds	0		0	0			0
To transportation (road and train)			0	0	0		0
To transportation (air)				0			
Taxes (DKK/GJ)							
Individual households	0		0	0			0
Industry	0	0		0	0	0	0
Boilers (at CHP and DH plants)	0	0		0	0	0	0
CHP units	0	0		0	0	0	0
Compressed Air Energy Storage (CAES)					0		
CO2 content in th fuels:	0	0		0	0		(kg/GJ)
CO2 Price (included in marginal production prices)	0		(DKK/t CO2)				

Fuel price alternative: Basic

Business economic operation:
All costs (fuel, handling and taxes) are included in the marginal costs when optimal operation strategies for the individual plants are decided.

Socio economic consequences:
Taxes are not included when the socio economic consequences are calculated.

Taxes on electricity for energy conversion :

(DKK/MWh)	DH systems	Individual houses
Electric heating	0	0
Heat Pumps	0	0
Electrolysers	0	0
Electric cars		0
Pump (storage)	0	



Cost - Operation

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Fuel | **Operation** | Investment | Additional

Variable Operation and Maintenance Cost

District Heating and CHP systems		
Boiler	<input type="text" value="0"/>	DKK/MWh-th
CHP	<input type="text" value="0"/>	DKK/MWh-e
Heat Pump	<input type="text" value="0"/>	DKK/MWh-e
Electric heating	<input type="text" value="0"/>	DKK/MWh-e

Power Plants		
Hydro Power	<input type="text" value="0"/>	DKK/MWh-e
Condensing	<input type="text" value="0"/>	DKK/MWh-e
Geothermal	<input type="text" value="0"/>	DKK/MWh-e
GTL M1	<input type="text" value="0"/>	DKK/MWh-fuel-input
GTL M2	<input type="text" value="0"/>	DKK/MWh-fuel-input

Storage		
Electrolyser	<input type="text" value="0"/>	DKK/MWh-e
Pump	<input type="text" value="0"/>	DKK/MWh-e
Turbine	<input type="text" value="0"/>	DKK/MWh-e
V2G Discharge *)	<input type="text" value="0"/>	DKK/MWh-e
Hydro Power Pump	<input type="text" value="0"/>	DKK/MWh-e

Individual		
Boiler	<input type="text" value="0"/>	DKK/MWh-th
CHP	<input type="text" value="0"/>	DKK/MWh-e
Heat Pump	<input type="text" value="0"/>	DKK/MWh-e
Electric heating	<input type="text" value="0"/>	DKK/MWh-e

*) Total cost of storing defined pr. MWh of electricity production
 **) Minimum selling price divided by maximum buying price

Marginal Costs of producing 1 MWh electricity			
District Heating	Incr. CHP2 decr. HP2	0	DKK/MWh
	Incr. CHP3 decr. HP3	0	DKK/MWh
	Incr. CHP2 decr. B2	0	DKK/MWh
	Incr. CHP3 decr. B3	0	DKK/MWh
	Incr. B2 decr. HP2	0	DKK/MWh
	Incr. B3 decr. HP3	0	DKK/MWh
	Incr. B2 decr. EB2	0	DKK/MWh
	Incr. B3 decr. EB3	0	DKK/MWh
	incr. CHP2 decr. ELT2	0	DKK/MWh
	incr. CHP3 decr. ELT3	0	DKK/MWh
	incr. B2 decr. ELT2	0	DKK/MWh
	incr. B3 decr. ELT3	0	DKK/MWh
	incr. GTL decr. B3	0	DKK/MWh
incr. GTL decr. CHP3	0	DKK/MWh	
Power Plants	Condensing Power	0	DKK/MWh
	PP2	0	DKK/MWh
	Hydro Power	0	DKK/MWh
	Geothermal	0	DKK/MWh
Individual	Incr. Ngas.CHP decr. B.	0	DKK/MWh
	Incr. Bio.CHP decr. B.	0	DKK/MWh
	Incr. HP decrease EH	0	DKK/MWh

Marginal Costs of storing 1 MWh electricity			
	DKK/MWh	Multiplication Factor (**)	
Individual	Incr. H2.CHP decr. Boiler	0	1.85
Storage	V2G (Electric Vehicle)	0	1.23
	Pump/Turbine (CAES)	0	1.39
	Hydro Pump Storage	0	3.37



Cost - Investment

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Fuel | Operation | Investment | Additional

Investment and Fixed Operation and Maintenance Costs Interest: Percent pro anno

CHP systems	Investment	Period	O. and M.		Total Inv. Costs	Annual Costs (MDKK/year)		
			Unit	MDKK pr. Unit		Years	% of Inv.	
Solar thermal	0 TWh/year	0	0	0	0	0	0	
Small CHP units	1000 MW-e	0	0	0	0	0	0	Investment
Heat Pump gr. 2	0 MW-e	0	0	0	0	0	0	Sum Annual Costs
Heat Storage CHP	20 GWh	0	0	0	0	0	0	0 (MDKK/year)
Large CHP units	1500 MW-e	0	0	0	0	0	0	
Heat Pump gr. 3	100 MW-e	0	0	0	0	0	0	
Heat Storage Solar	0 GWh	0	0	0	0	0	0	Fixed Oper. and M.
Boilers gr. 2 and 3	10000 MW-th	0	0	0	0	0	0	Sum Annual Costs
Large Power Plants	2500 MW-e	0	0	0	0	0	0	0 (MDKK/year)
Wind	1000 MW-e	0	0	0	0	0	0	
Wind offshore	0 MW-e	0	0	0	0	0	0	
Photo Voltaic	500 MW-e	0	0	0	0	0	0	
Wave power	0 MW-e	0	0	0	0	0	0	<input type="button" value="Show All"/>
River of hydro	0 MW-e	0	0	0	0	0	0	
Hydro Power	0 MW-e	0	0	0	0	0	0	
Hydro Storage	0 GWh	0	0	0	0	0	0	
Hydro Pump	0 MW-e	0	0	0	0	0	0	
Nuclear	0 MW-e	0	0	0	0	0	0	
Geothermal	0 MW-e	0	0	0	0	0	0	
Electrolyser	0 MW-e	0	0	0	0	0	0	
Hydrogen Storage	0 GWh	0	0	0	0	0	0	
Pump	0 MW-e	0	0	0	0	0	0	
Turbine	0 MW-e	0	0	0	0	0	0	
Pump Storage	0 GWh	0	0	0	0	0	0	
Indv. boilers	0 MW-th	0	0	0	0	0	0	
Indv. CHP	0 MW-e	0	0	0	0	0	0	
Indv. Heat Pump	0 MW-e	0	0	0	0	0	0	
Indv. Electric heat	0 MW-e	0	0	0	0	0	0	
Indv. Solar thermal	0 TWh/year	0	0	0	0	0	0	

Additional various investment costs (see next page)



Cost - Additional

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Fuel Operation Investment Additional

Specification of Various Additional Investment Costs

	Period	O. and M.	Total Inv. Costs	Annual Costs (MDKK/year)	
	Years	% of Inv.	MDKK	Investment	Fixed Opr. and M.
Various 1	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	0	0
Various 2	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	0	0
Various 3	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	0	0
Various 4	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	0	0
Various 5	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	0	0
Various 6	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	0	0
Various 7	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	0	0
Various 8	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	0	0
Various 9	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	0	0
Various 10	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	0	0



Case Study: IDA 2030 Energy Plan



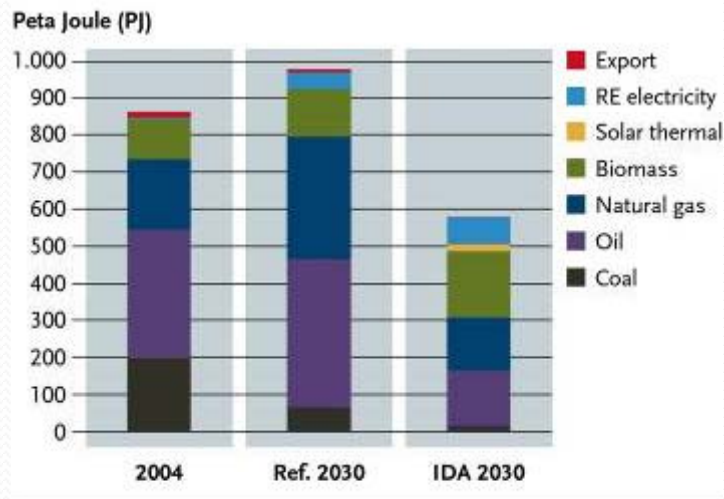
7 Themes

1. Buildings and solar thermal
 2. Industry and Process
 3. Oil and Gas (North sea)
 4. Transportation and mobility
 5. Hydrogen, Fuel cells, Batteries and Biomass
 6. Wind, Photovoltaic and Wave Power
 7. Energy systems
- For each theme:
 - Knowledge Seminar
 - Future Seminar
 - Roadmap Seminar

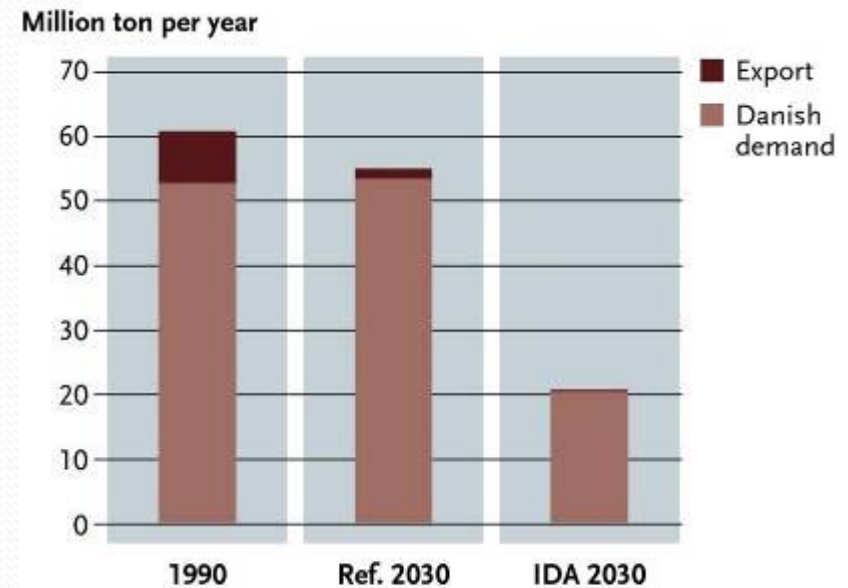


Technical Optimisation

Primary energy supply

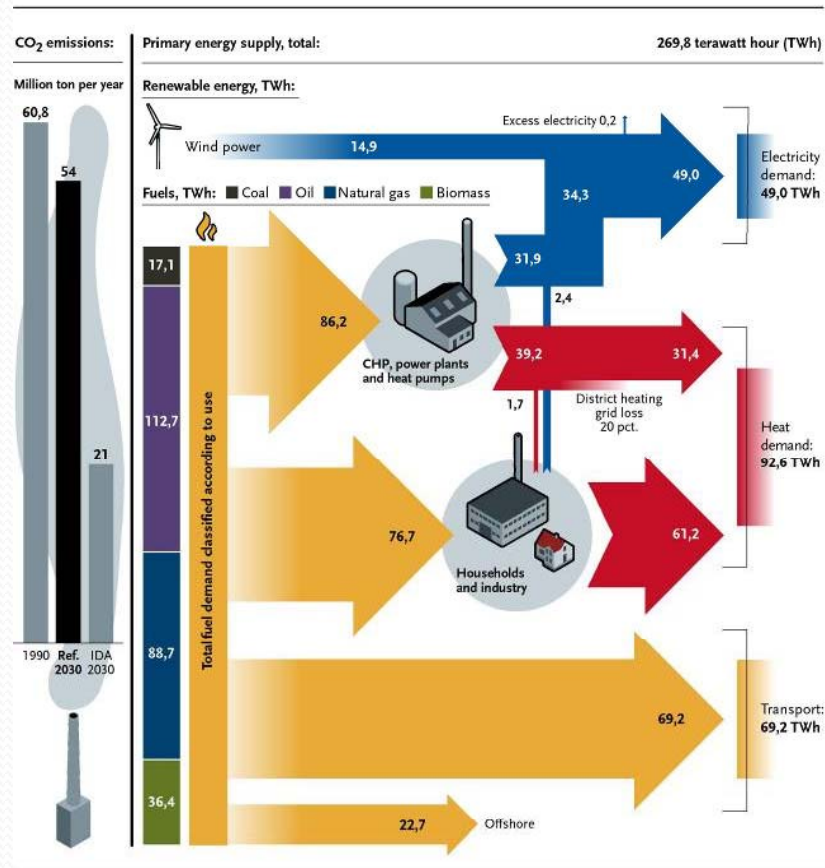


CO₂ emissions

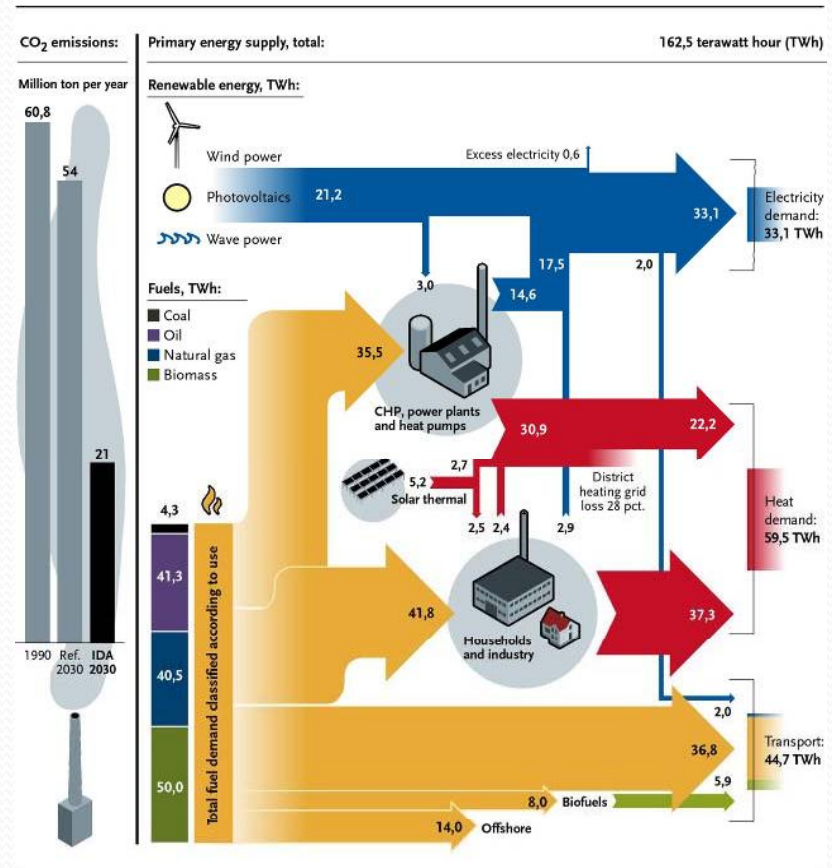


Energy Flow

DANISH REFERENCE 2030

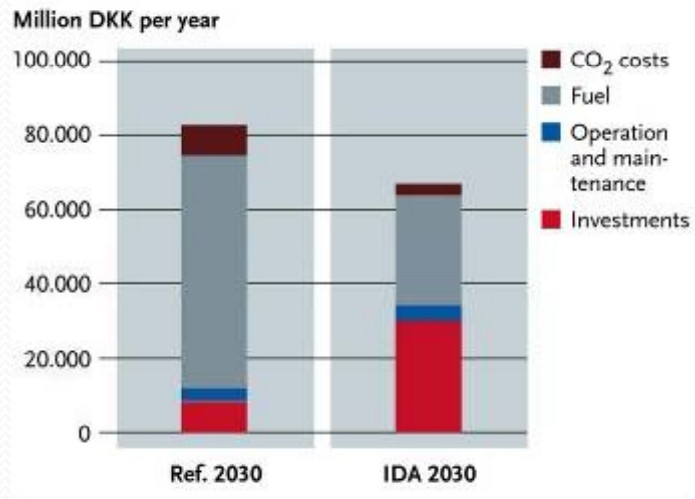


THE DANISH SOCIETY OF ENGINEERS' ENERGY PLAN 2030



Feasibility Study

Economic costs



Business potential

