Danish experiences in district heating on renewable energy sources

- District heating in Denmark, planning
- Examples of plants
- SmartReFlex workshops

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- Unabhängiges Ingenieurbüro
- Gründungsjahr: 1983
- Etwa 30 Angestellte
- Abteilungen in:
  - Skørping
  - Aarhus
  - Kopenhagen

Morten Hofmeister
Max Guddat
PlanEnergi
Denmark
mh@planenergi.dk

- Arbeitsbereiche:
  - Fernwärme
    - Solarthermie
    - Saisonwärmespeicher
    - Wärmepumpen
  - Energieplanung
  - Biogas
  - Umweltverträglichkeits-studien für Windmühlen

Planning

Multiple advantages (comfort, environment)

Competitive price for consumers – society economy

Facilitates solving of e.g. waste problem

An enabling energy infrastructure

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Public participation and acceptance

- Public acceptance ensured by local initiative
- Advantages for all actors – ”what’s in it for me” (can, will, want)
- Perceive district heating as energy infrastructure – enabling and facilitating utilisation of energy resources
- Requires appropriate framework conditions – providing incentives to the actors

Today, municipalities are the main authority on heat planning and can own a heat supply utility, and thus be involved in operation. But originally, heating of homes was solely an individual task

- In the beginning of the 1900s the surplus heat from the power plants was utilised in e.g. hospitals and other large buildings
- In the 1920s and 1930s, centralised collective heating emerged in larger new-build areas of houses
- In the 1950s a largescale establishment of district heating plants was initiated – 5 new plants per year.
- The peak was in the 1960s, with 45 new plants in 1964
- The development of district heating was on private initiative – consumers organised themselves and established a district heating plant
- Only in a few cases, municipalities was behind the establishment of a district heating plant
- The primary role of the municipalities was to provide guarantees for loans

- District heating started without national political objectives
- Private initiatives, consumers organised themselves (consumer owned utilities)

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– Steps
  - Municipalities to map the existing (and estimate the future) heat demand, the applied heating methods and energy usage
  - Interaction between the municipalities and the counties (regional heat plans)

– The contents of the plans
  - Identify in which areas the different heat supply technologies had priority
  - The location of future heat producion plants and pipelines

- Oil crises in the 1970s initiated energy policy
- Heat Supply Act in 1979 – detailed planning
- Security of energy supply, reduce oil imports
- No more ”free choice” for consumers

- Environment
- CHP
- New technologies
  - Small CHP, biomass and waste
- Mandatory connection
  - 1982, still in force, but not widely applied
  - The municipalities could secure the investments made by the utilities as regards heat density
- Ban against electrical heating
- Taxes
  - Biomass and biogas was exempt from taxes
  - High level of taxes also in times of low fuel prices to keep incentive for energy conservation

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Danish Heat Planning – the 1990s

- After successful implementation in the 1980s
- Objective was to simplify and decentralise the decision process for establishment of new DH plants
- Project based planning scheme
- Reduce CO_2-emissions and secure investments in natural gas infrastructure
- Detailed regulation facilitated implementation

- Phases of regulation (issued by the state to municipalities)
  - 1 phase (1990-1994): Large coal-fired district heating plants with access to natural gas, to be converted. Introduction of waste incineration
  - 2 phase (1994-1996): Remaining coal-fired district heating plants with access to natural gas to be converted. Biomass (straw, wood chips)
  - 3 phase (1996-1998): Small natural gas fired district heating plants converted to CHP. Remaining small plants converted to biomass

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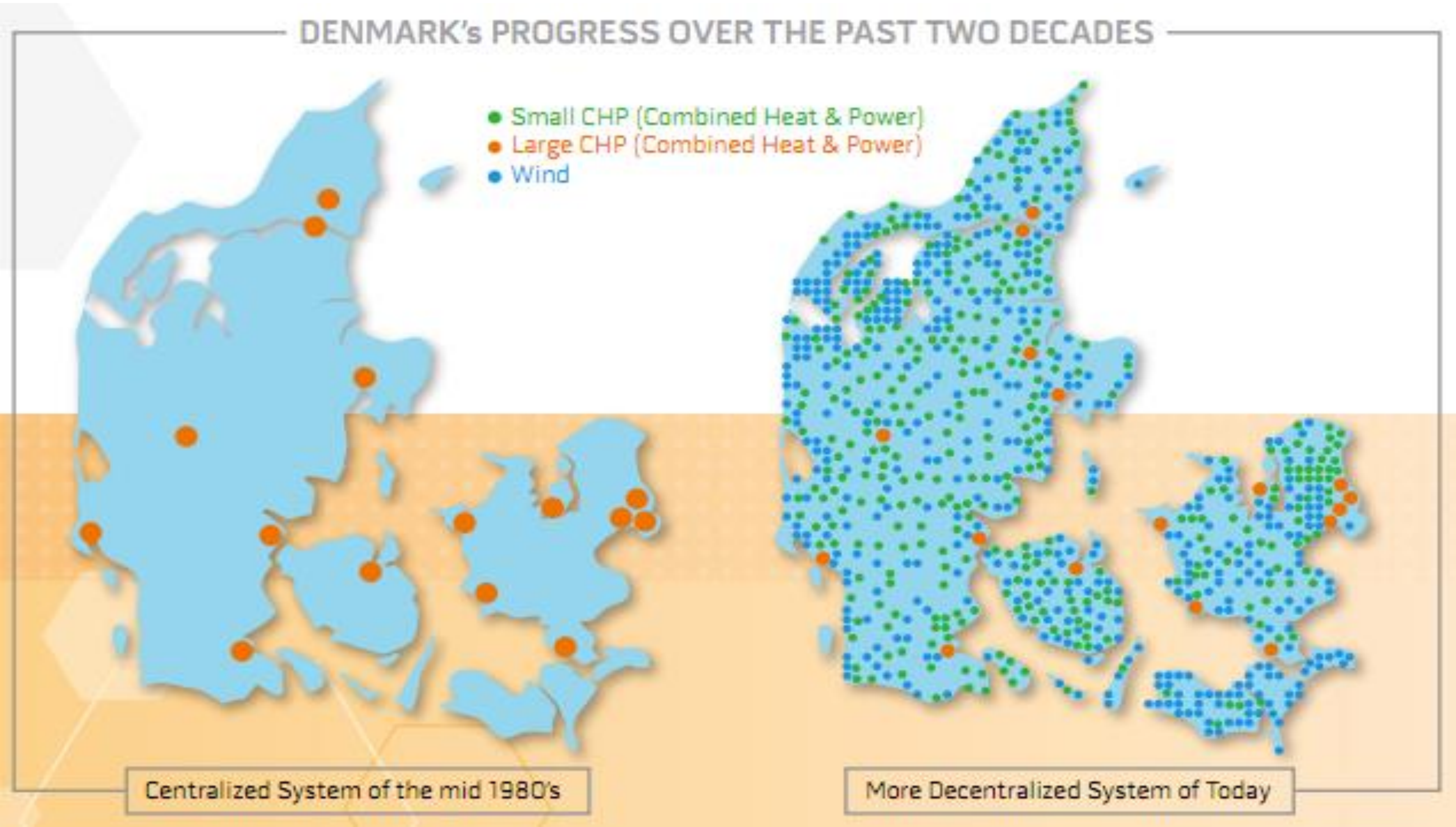

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Danish Heat Planning – Summary

- 1980’s: Security of supply
  - After the oil crisis, substituting oil with natural gas (own production)
  - Zoning of geographical areas – individual natural gas and district heating (in total four types of zones)
  - Process driven by the energy utilities
  - The municipalities had an active role in the planning process
- Since approx. 2007: **Climate agenda**
  - New round of heat planing, new employees in the municipalities
  - Project-scheme
  - The municipalities has a role again (after some years without heat planning, after the success in the 1980s and 1990s).
  - Municipal guarantee
  - Resources from the municipalities: hours (no investments)
  - Now more focus on the differentiated role of the munipalities; authority (taxes) and operation (fees for heat supply)
- The development is driven by political targets (security of energy supply, climate, etc.)
  - Value of the political targets should be reflected in the regulatory framework (e.g. taxes)

- The planning hierarchy in the 1980s:

  The state

  The counties

  The municipalities

- In 1990: The municipalities became solely responsible for the heat planning, given some overall regulations by the Minister

- Regulatory framework is somewhat outdated

- Today: The municipalities

  May wish for a more active national planning, enabling the municipalities to obtain the overall political targets

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- Broad scope and long time horizon is crucial for district energy
- Public acceptance – and adoption, i.e. local initiative is crucial
- ”Organic growth”, supported by national and regional planning

- The current trend is strategic energy planning – a broader scope in terms of both topics and geographical areas
- The subject of public participation – or acceptance – is crucial for the success of collective systems
  - Unless participation is made mandatory (which was the case in Denmark).
  - A crucial argument for introducing collective systems (including heat systems) is that it is an advantage to both the individual and the society.
  - You need organizations to organize the investments etc., i.e. linking the individual and the society (in this case district heating companies).
- Planning of district heating should be made in coordination with other energy planning, in particular electricity
  - The large – and increasing – amount of wind power in the Danish energy system can only be utilized effectively if electricity is used in heat pumps, which also utilize waste heat from industry etc.
  - District heating does not only concern heat supply and supply of hot tap water – district heating is a crucial part of the energy infrastructure, enabling utilization of fluctuating renewable energy sources.

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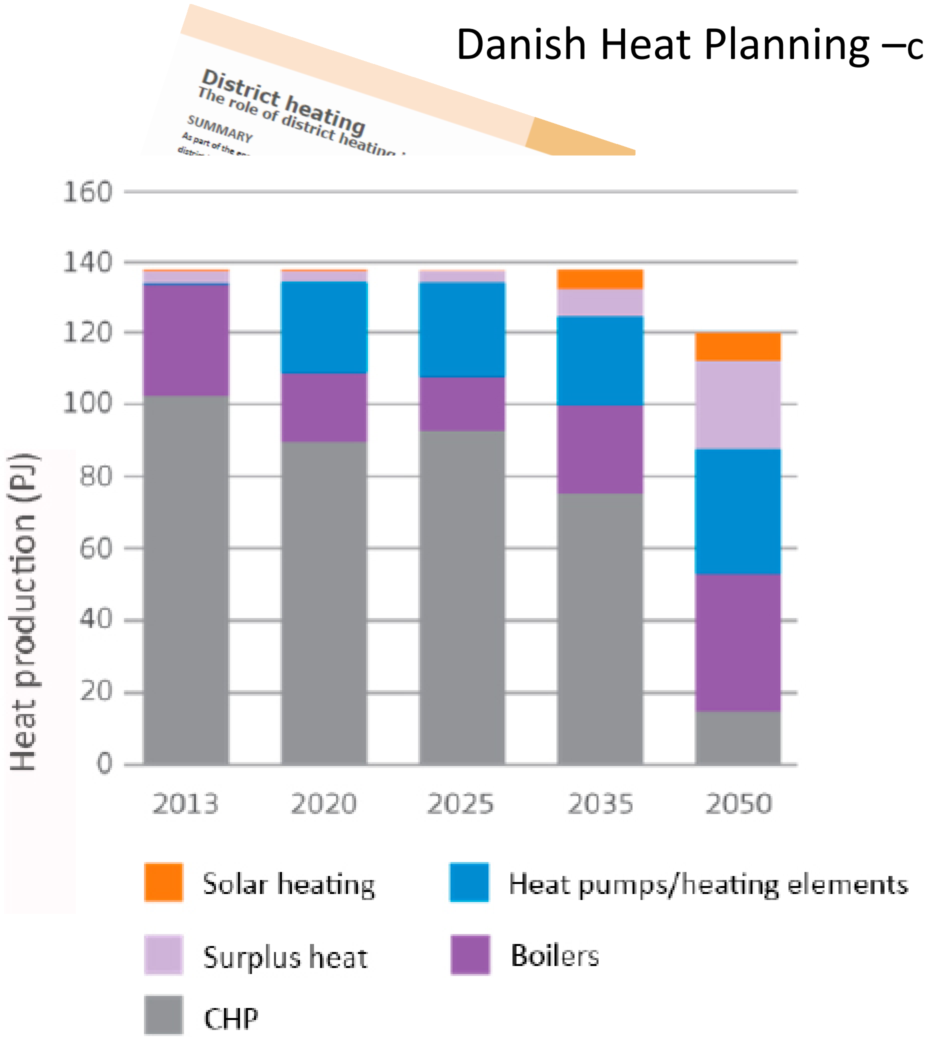
Danish Heat Planning –current status



- May 2014: Analyses issued by the Danish Energy Agency, www.ens.dk
- Share of solar and wind in the nordic countries and Germany is assessed to be 25% by 2025 and 40% by 2050
- Small DH: natural gas based CHP substituted by solar thermal and heat pumps
- Medium-sized DH: Increased CHP based on waste and biomass, substituting natural gas
- Large DH (see figure): Increase of CHP until 2035, then surplus heat and limitation in biomass. Waste on boilers.

- Role as heat authority
  - Planning authority – responsible for planning the heat supply in the municipality together with utilities and other relevant actors
  - Approving authority – approving specific projects in the municipality, ensure implementation
  - The municipality can take initiative on specific projects
  - Reponsible for coordination with other municipal planning
- Role as owner and operator of district heating utilities
  - Approx. 55 district heating utilities (of more than 400) are municipal, but delivering more than 60 % of the district heating.
  - Close cooperation – often representatives from the municipality in the board of the utility

- Role as authority
- Role as owner and operator

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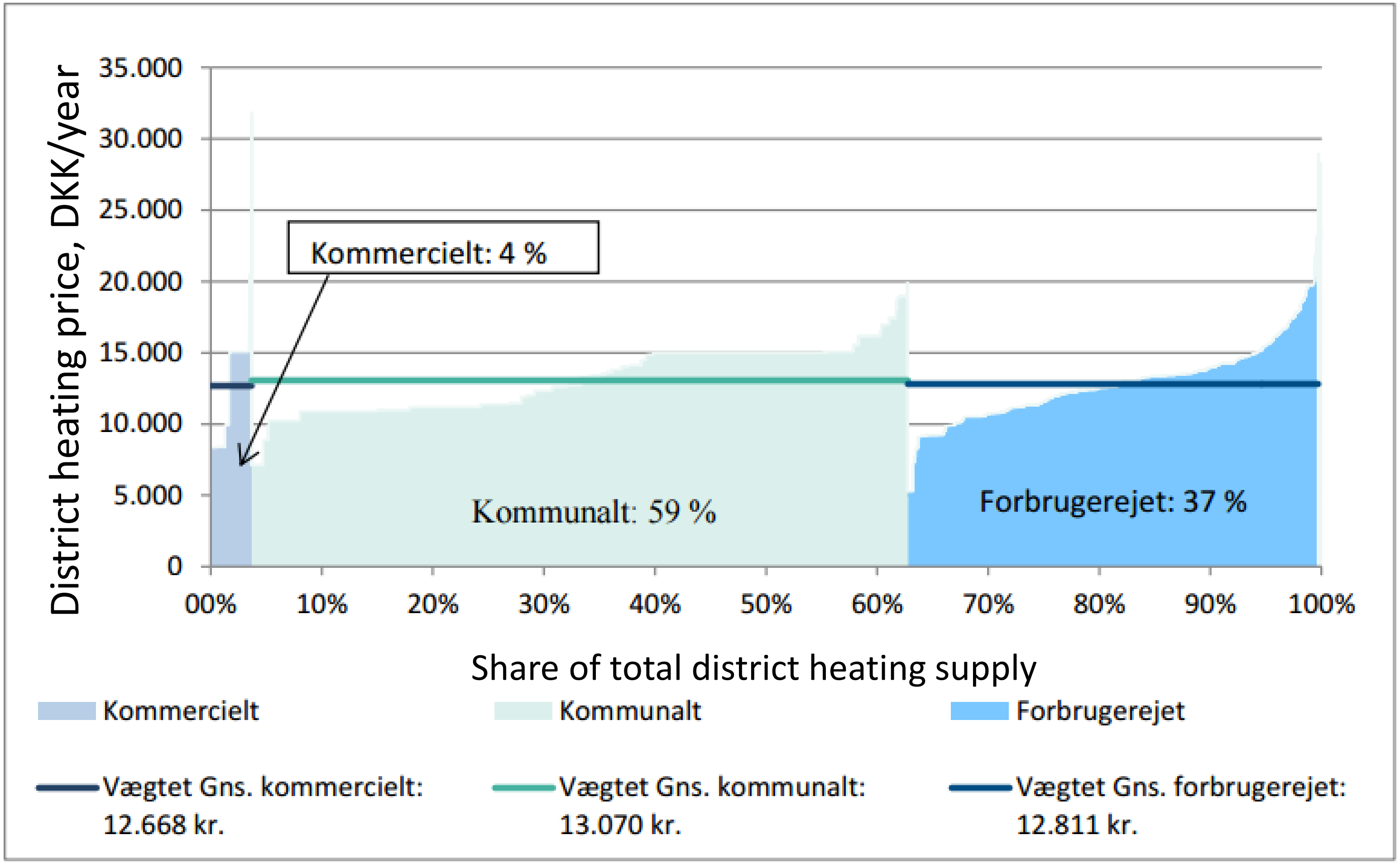
District heating price
– According to ownership; commercial, municipal or consumer-owned



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- Challenge of capacity and competences in the municipalities
- The municipalities has a large responsibility
- Strategic energy planning address this gap

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- Community energy planning
  - Strategic Energy Planning, in Denmark not including transport. Main focus is on district heating and electricity.
  - In Denmark: The municipality is the key authority for heat plans.
  - Heat Supply Act – role of municipality. Role of the state (Danish Energy Agency).
  - Taxes plays an important role – can be counterproductive related to the energy and climate policies. Hence, the state plays an important role.
  - Regional level – no formal responsibility. Facilitates coordinaton between municipalities (own initiative, not regulated role). Motivation – generate employment.

- Roles of different actors changing over time

- Outdated regulation is counterproduc-tive for obtaining new political objectives

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- Acknowledge district energy as key energy infrastructure

- Create framework for establishment of local organisations investing in and operating district energy

- It is a common challenge – create the framework and focus on local initiative

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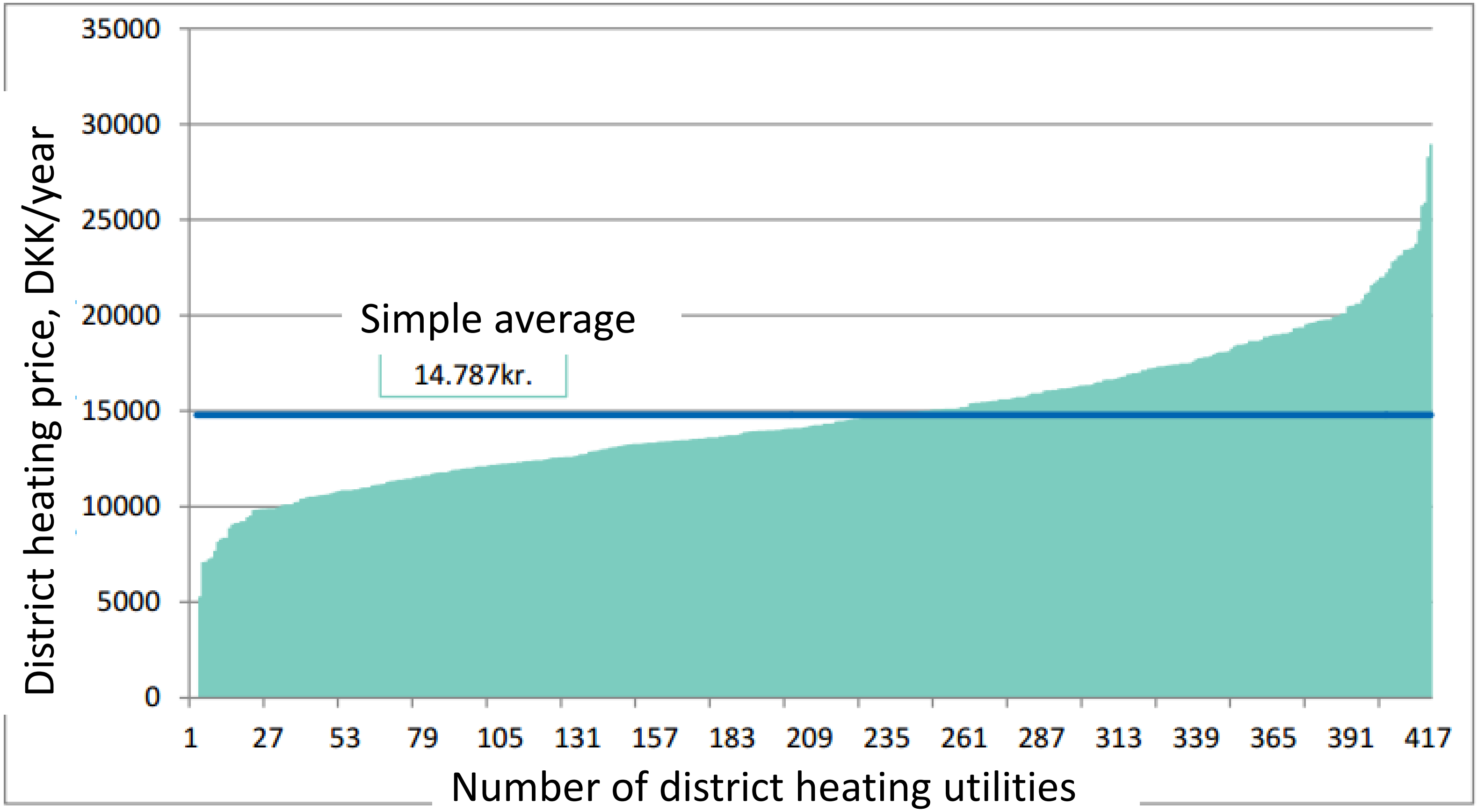
District heating price
– Heat price for standard house of 130 m2 and yearly heat consumption of 18,1 MWh



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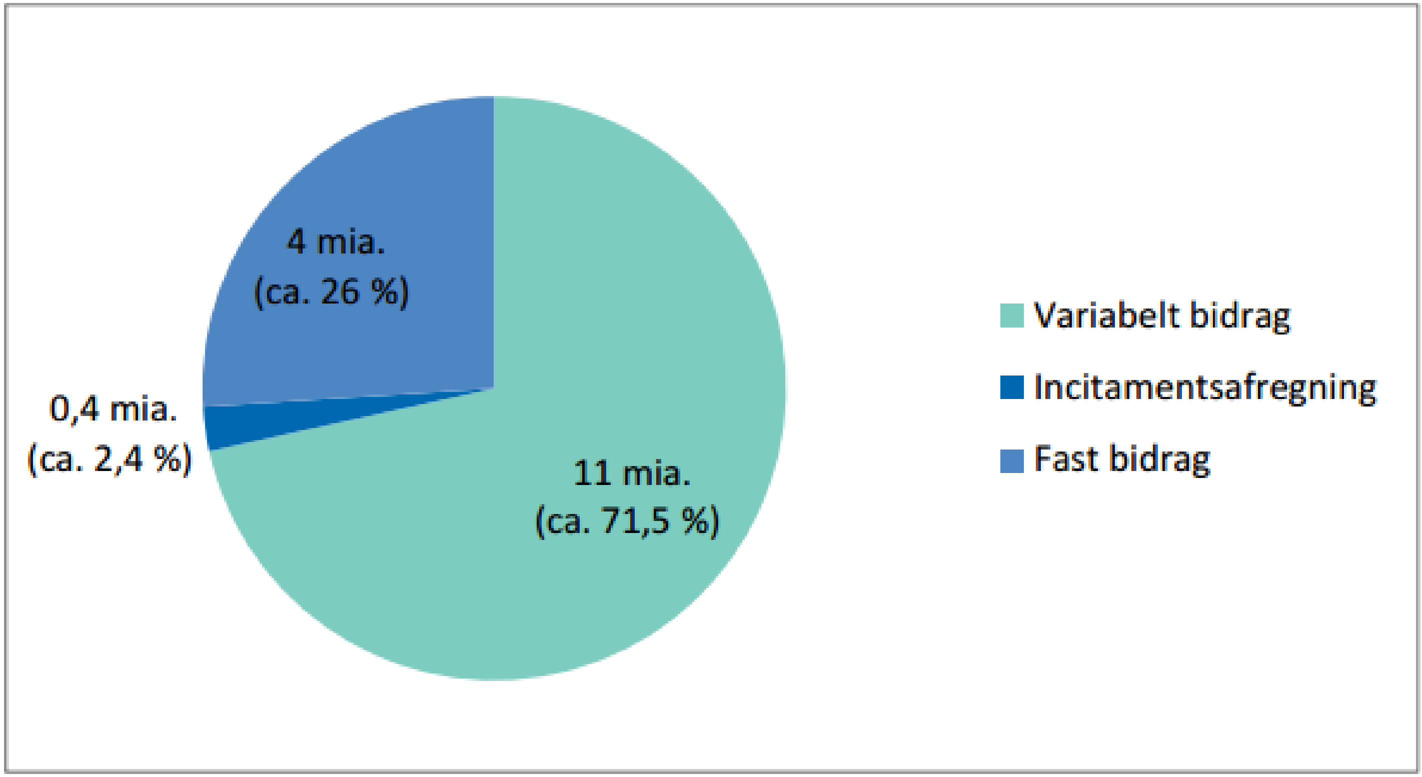
District heating tariffs
– Income 2014/2015 split on variable and fixed payments and motivation tariff



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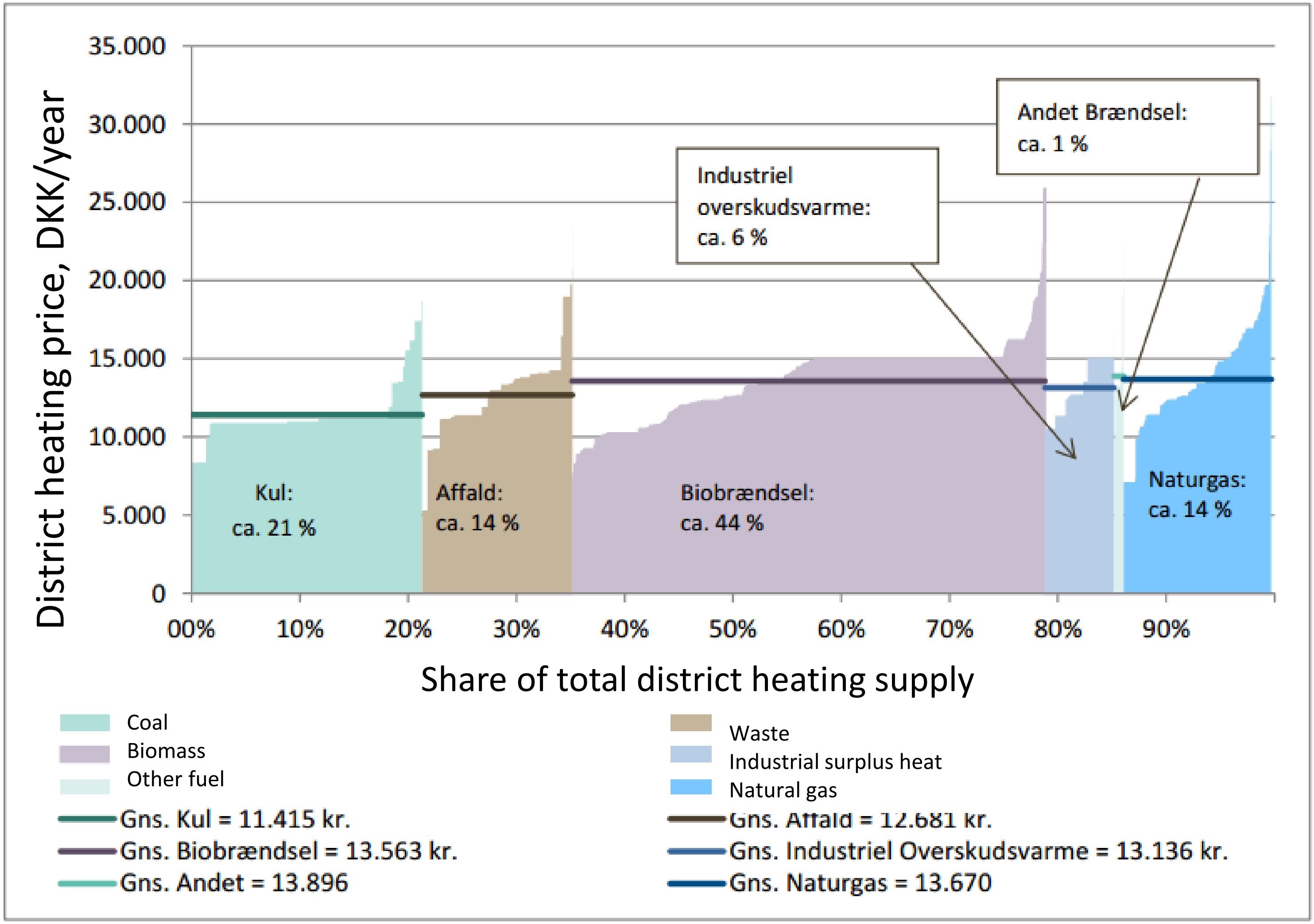
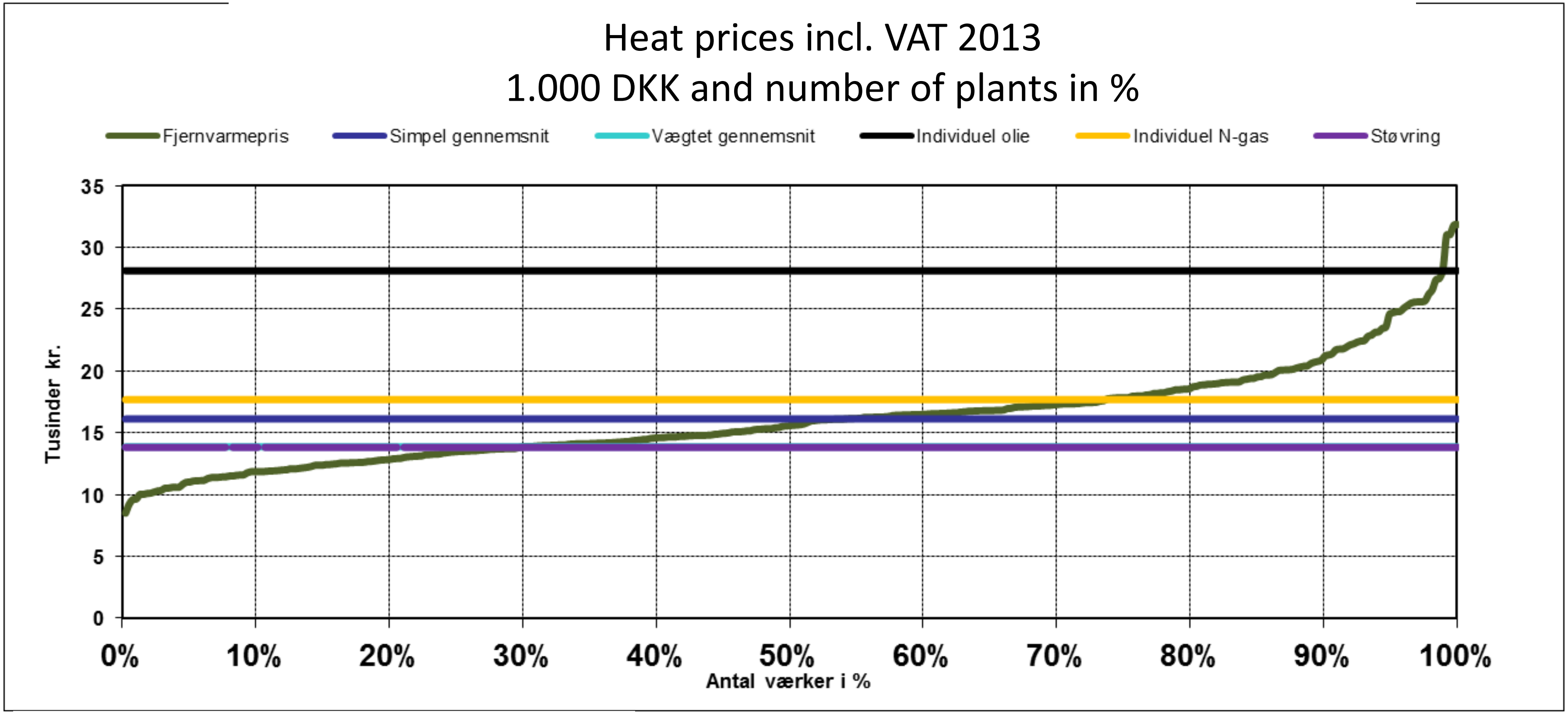
District heating price
– According to primary fuel type



District heating is competitive (in most cases)



130 m2 house, 18.1 MWh/year

Depreciation not included

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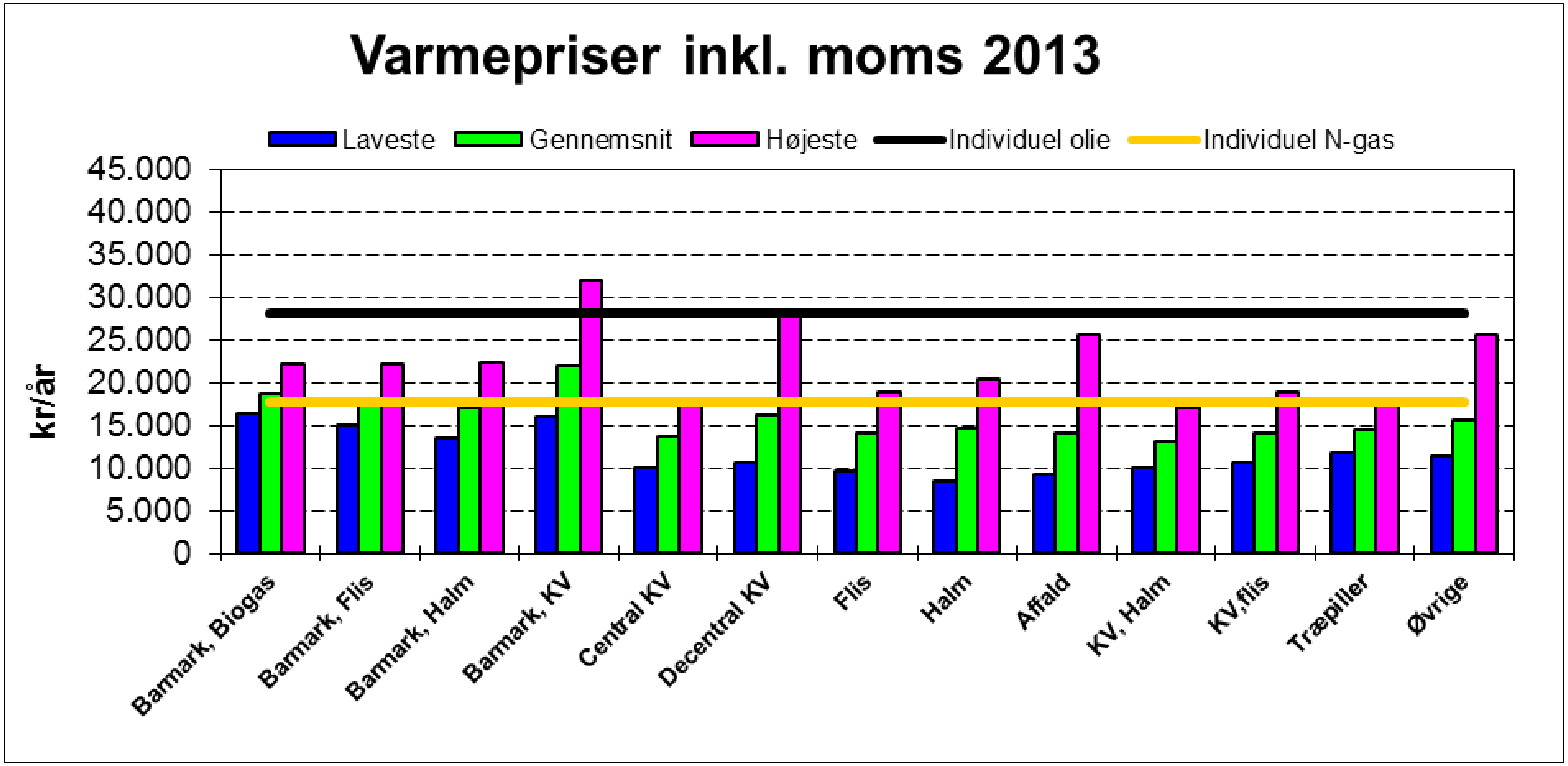
Competitiveness of district heating based on different fuels



130 m2 house, 18.1 MWh/year
Depreciation not included

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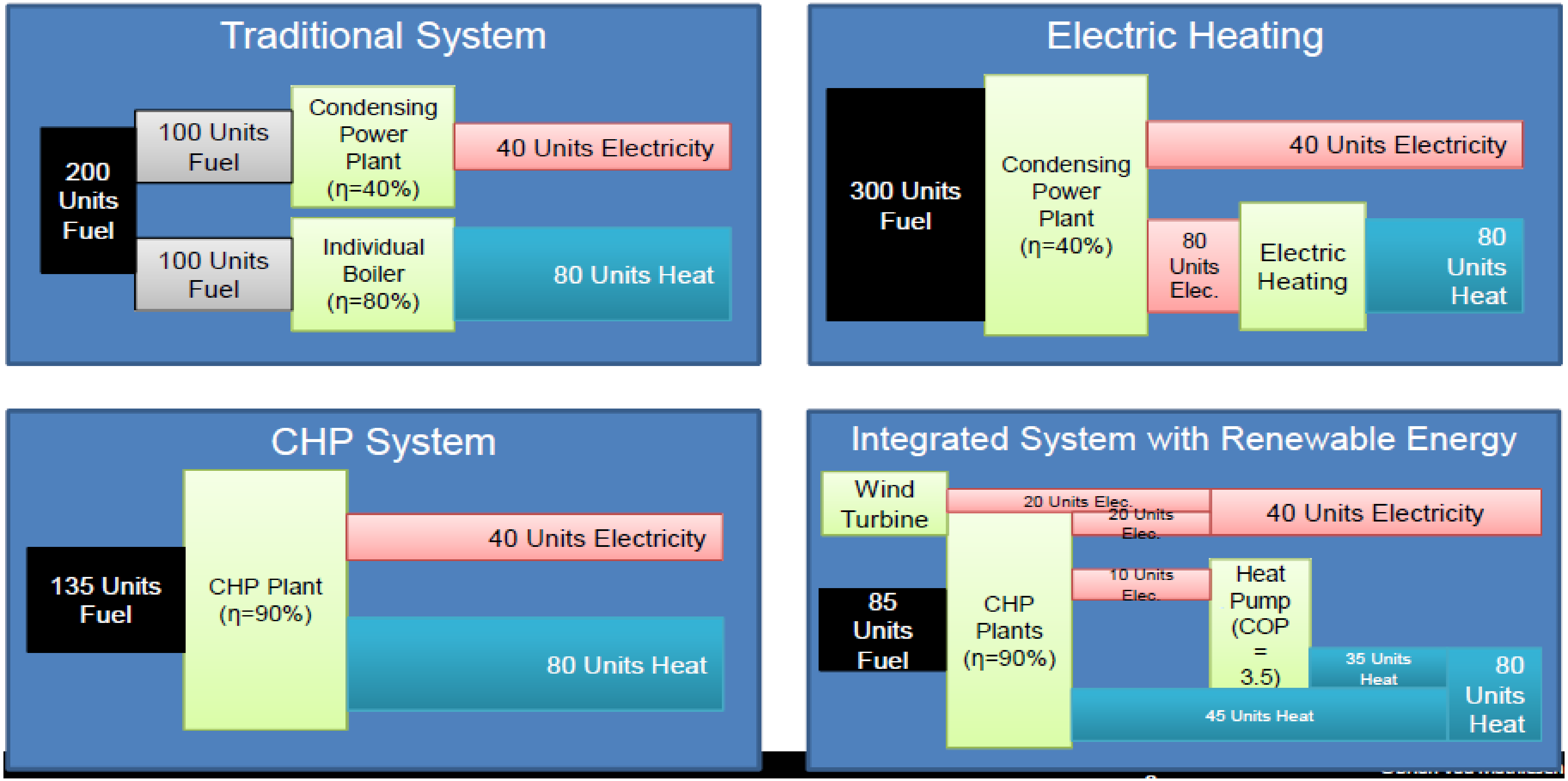
Types of energy systems



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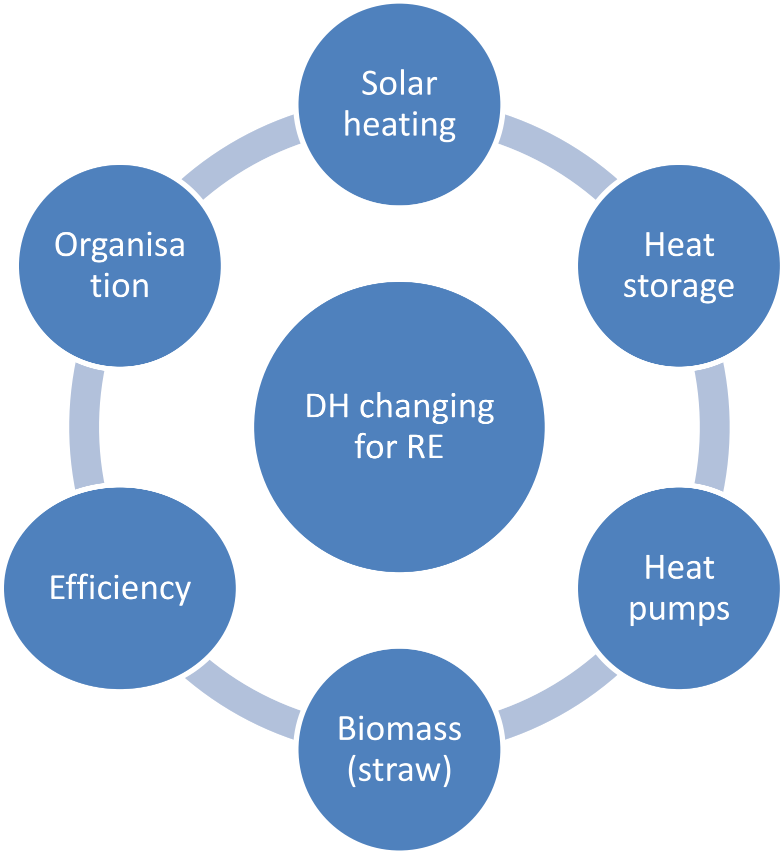
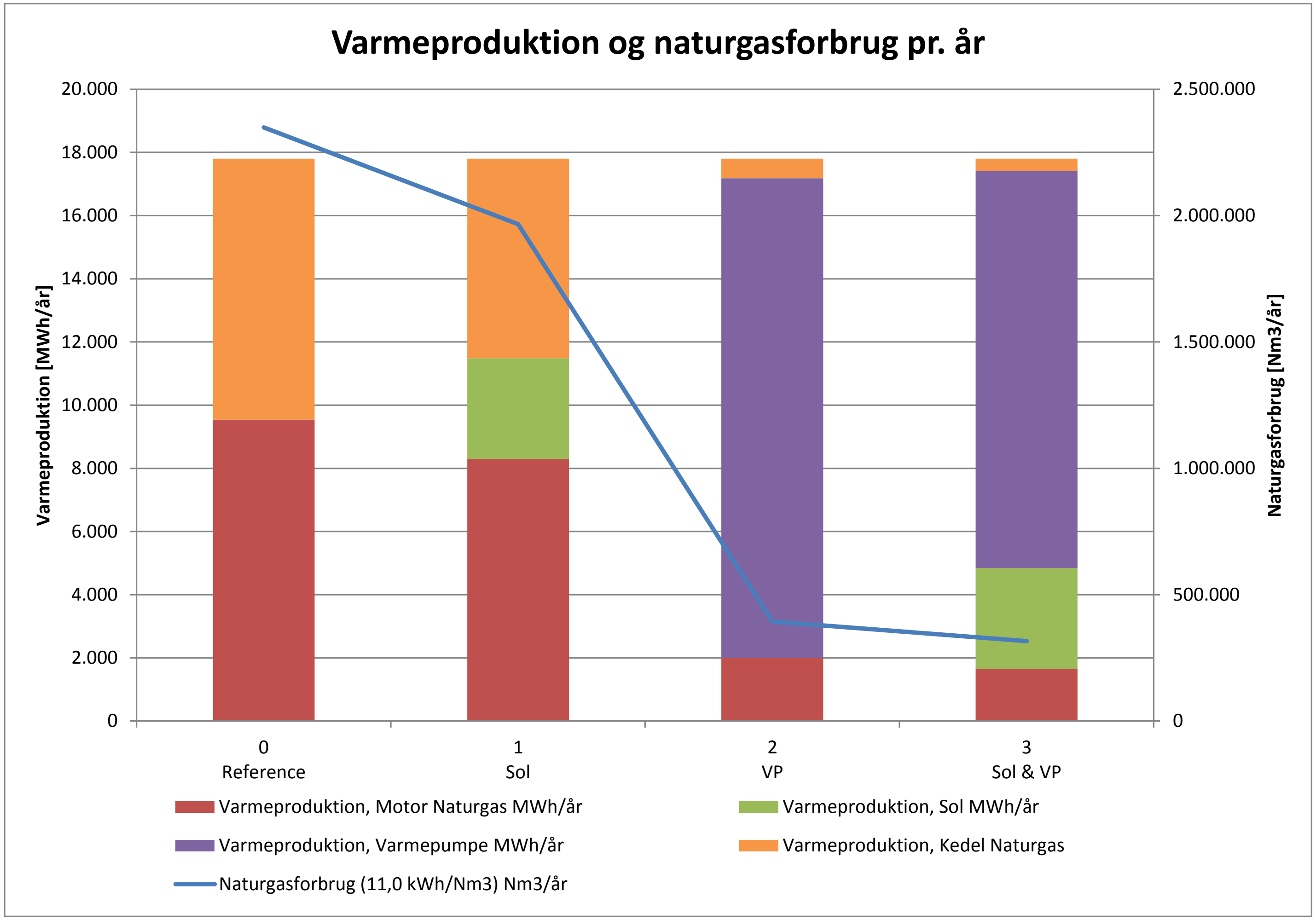
Change for renewable energy - options



District heating with renewables in Denmark

Combination – CHP, solar thermal and heat pump



- Subsidy for electricity production (1992)
- Electricity production – not always
  - In 2003; change in the subsidy for electricity production for CHP-plants
  - Avoid economic losses for society, only producing electricity when there is a demand (not exporting below production costs)
  - Flexible, storages

- Denmark has 16 central CHP – plants which originally was only power plants
- Denmark has 415 decentral plants, of which 285 are CHP and 130 are heat-only plants. All decentral plants was originally heat-only plants
- Main purpose of the decentral plants is heat production

- Observe the system advantages and disadvantages
- Flexibility is key
- Central and decentral plants

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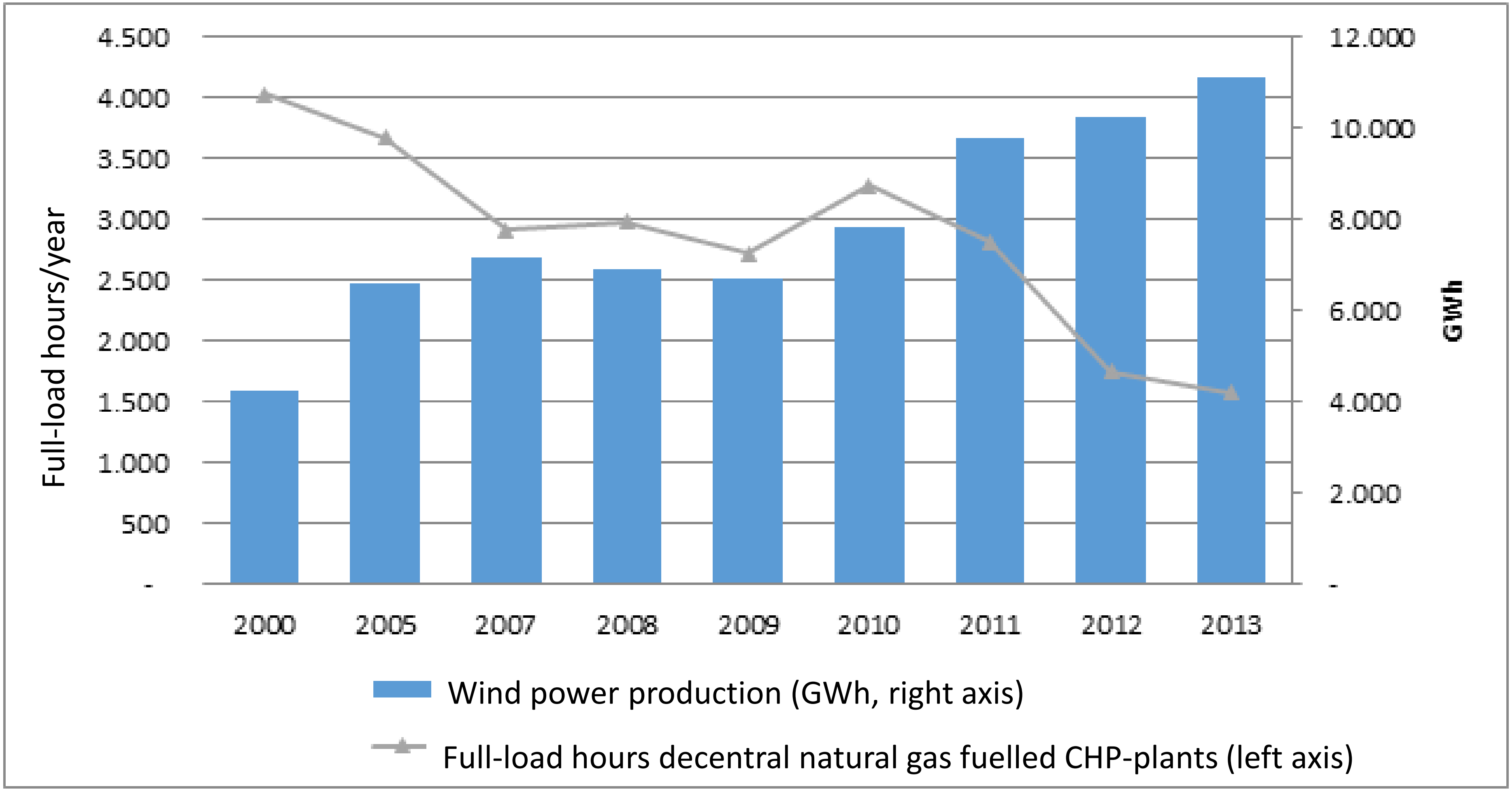

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Interaction between the German electricity system and the Danish district heating system

Challenges for the German electricity system

- Due to inbalances caused by wind power and bottlenecks in the German electricity system
- Northern electricity markets are more efficient

Export from Denmark to Germany of regulating capacity – down regulation

- ”Special regulation” – does not affect the domestic pricing on the regulation market
- Price is defined by the bidder, including profit

Options for down-regulation

- Plants, reduce power production
- Electric boilers, increase power consumption
- Wind turbines, reduce power production

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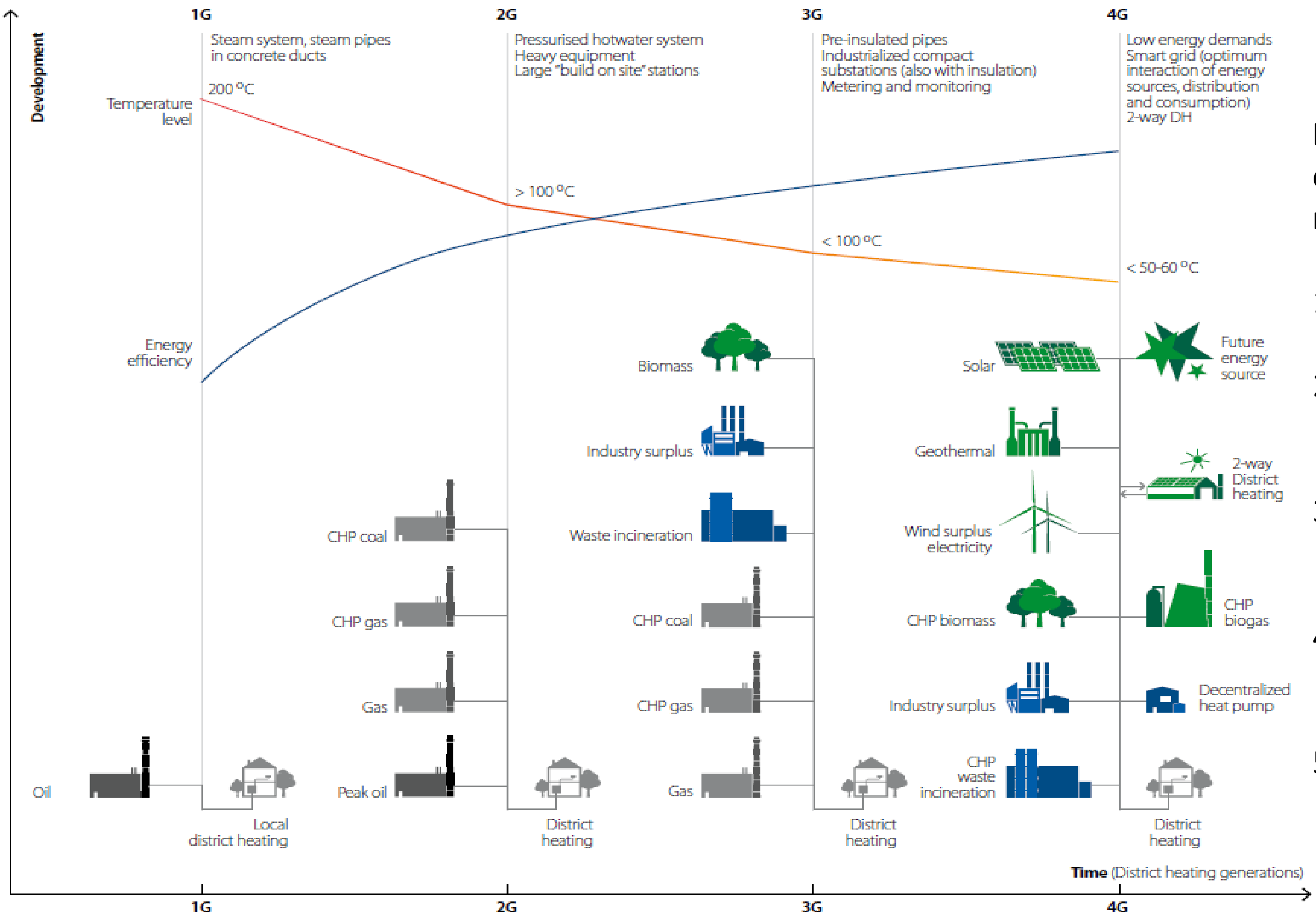
District heating from 1G to 4G



Source: Lund H., et al., 4th generation District Heating (4GDH), Energy 2014, http://dx.doi.org/10.1016/j.energy.2014.02.089

www.4dh.dk

DH's role in future sustainable energy systems requires meeting the challenges:

1. Low temperature DH to old and new buildings
2. Distribute heat with low heat losses
3. Recycle heat from low temperature sources and integrate renewables
4. Integrated part of smart energy systems
5. Suitable planning, cost and motivation structures

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Examples

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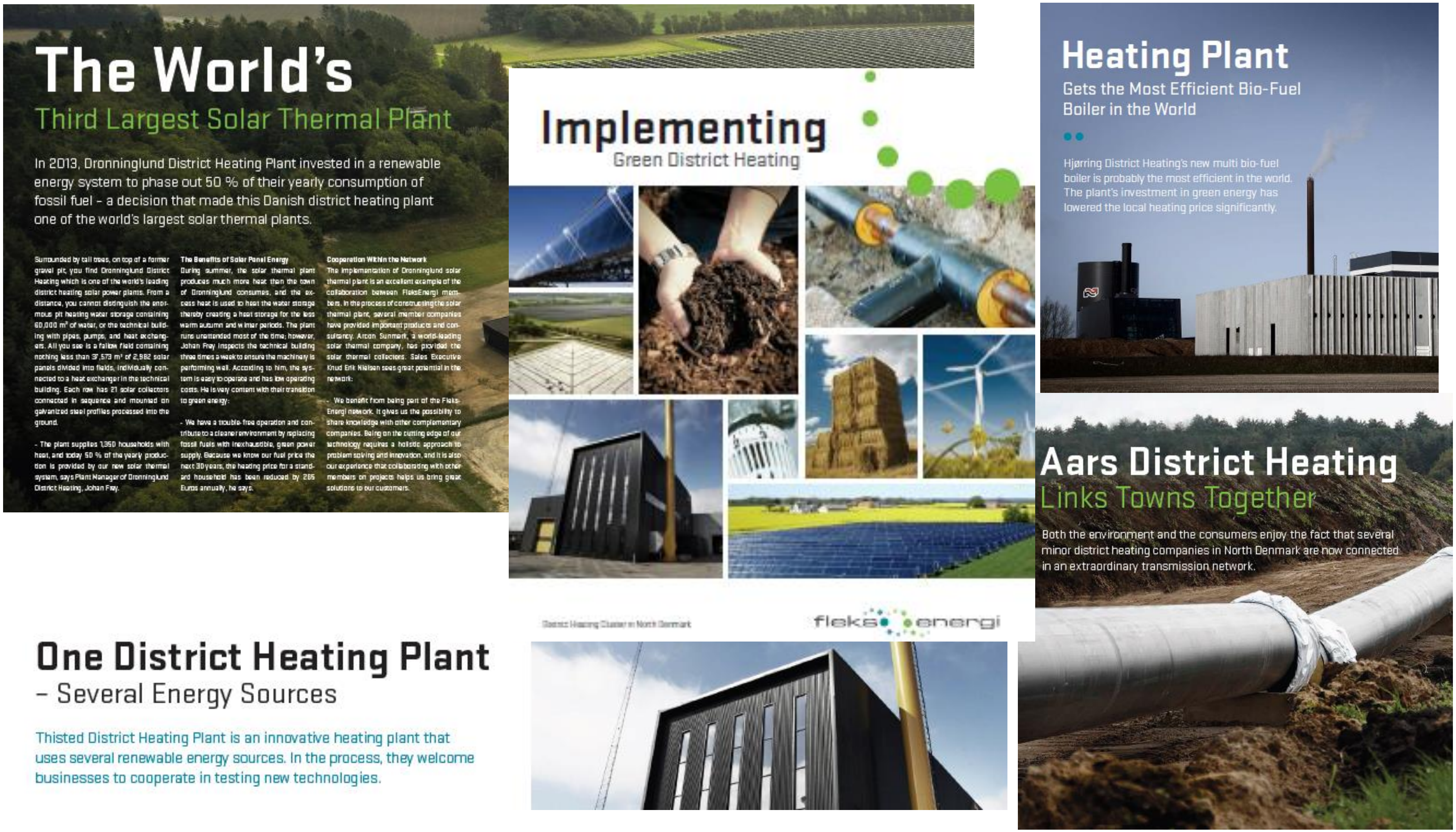
Small, modular district heating with renewables in Denmark

See brochure from FleksEnergi at: http://fleksenergi.dk/2015/05/22/nyhed-2/



The World's
Third Largest Solar Thermal Plant

In 2013, Dronninglund District Heating Plant invested in a renewable energy system to phase out 50 % of their yearly consumption of fossil fuel – a decision that made this Danish district heating plant one of the world's largest solar thermal plants.

Surrounded by tall trees, on top of a former gravel pit, you find Dronninglund District Heating which is one of the world's leading district heating solar power plants. From a distance, you cannot distinguish the enormous pit heating water storage containing 60,000 m^3 of water, or the technical building with pipes, pumps, and heat exchangers. All you see is a fallow field containing nothing less than 37,573 m^2 of 2,982 solar panels divided into fields, individually connected to a heat exchanger in the technical building. Each row has 21 solar collectors connected in sequence and mounted on galvanized steel profiles processed into the ground.

- The plant supplies 1,350 households with heat, and today 50 % of the yearly production is provided by our new solar thermal system, says Plant Manager of Dronninglund District Heating, Johan Frey.

The Benefits of Solar Panel Energy

During summer, the solar thermal plant produces much more heat than the town of Dronninglund consumes, and the excess heat is used to heat the water storage thereby creating a heat storage for the less warm autumn and winter periods. The plant runs unattended most of the time; however, Johan Frey inspects the technical building three times a week to ensure the machinery is performing well. According to him, the system is easy to operate and has low operating costs. He is very content with their transition to green energy:

- We have a trouble-free operation and contribute to a cleaner environment by replacing fossil fuels with inexhaustible, green power supply. Because we know our fuel price the next 30 years, the heating price for a standard household has been reduced by 265 Euros annually, he says.

Cooperation Within the Network

The implementation of Dronninglund solar thermal plant is an excellent example of the collaboration between FleksEnergi members. In the process of constructing the solar thermal plant, several member companies have provided important products and consultancy. Arcon Sunmark, a world-leading solar thermal company, has provided the solar thermal collectors. Sales Executive Knud Erik Nielsen sees great potential in the network:

- We benefit from being part of the FleksEnergi network. It gives us the possibility to share knowledge with other complementary companies. Being on the cutting edge of our technology requires a holistic approach to problem solving and innovation, and it is also our experience that collaborating with other members on projects helps us bring great solutions to our customers.

Implementing
Green District Heating

District Heating Cluster in North Denmark

fleks energi

Heating Plant
Gets the Most Efficient Bio-Fuel Boiler in the World

Hjørring District Heating's new multi bio-fuel boiler is probably the most efficient in the world. The plant's investment in green energy has lowered the local heating price significantly.

Aars District Heating
Links Towns Together

Both the environment and the consumers enjoy the fact that several minor district heating companies in North Denmark are now connected in an extraordinary transmission network.

One District Heating Plant
– Several Energy Sources

Thisted District Heating Plant is an innovative heating plant that uses several renewable energy sources. In the process, they welcome businesses to cooperate in testing new technologies.

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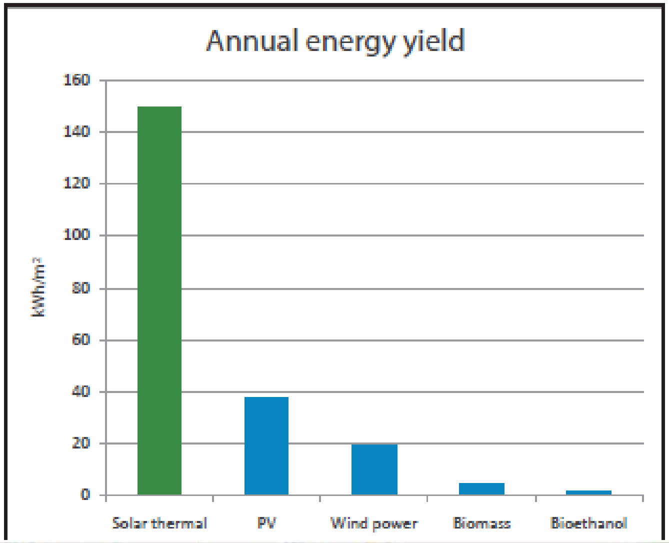
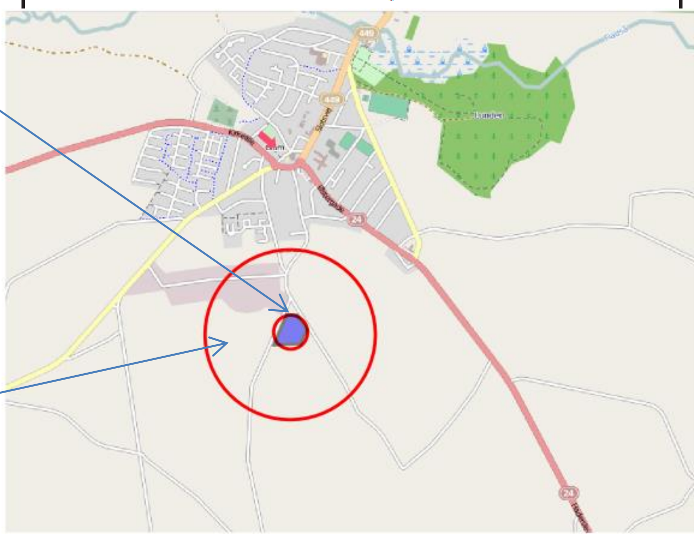
District heating with renewables in Denmark

Types of renewables, land area requirement



Area of solar thermal field, which delivers 17 % of the yearly heat demand

Area requirement for biomass to produce the same yearly energy production is 25 times larger



Parameters to consider:

- Investment
- O&M
- Fuel price
- Area (factor 25 solar thermal and biomass)
- Other…

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Solar district heating

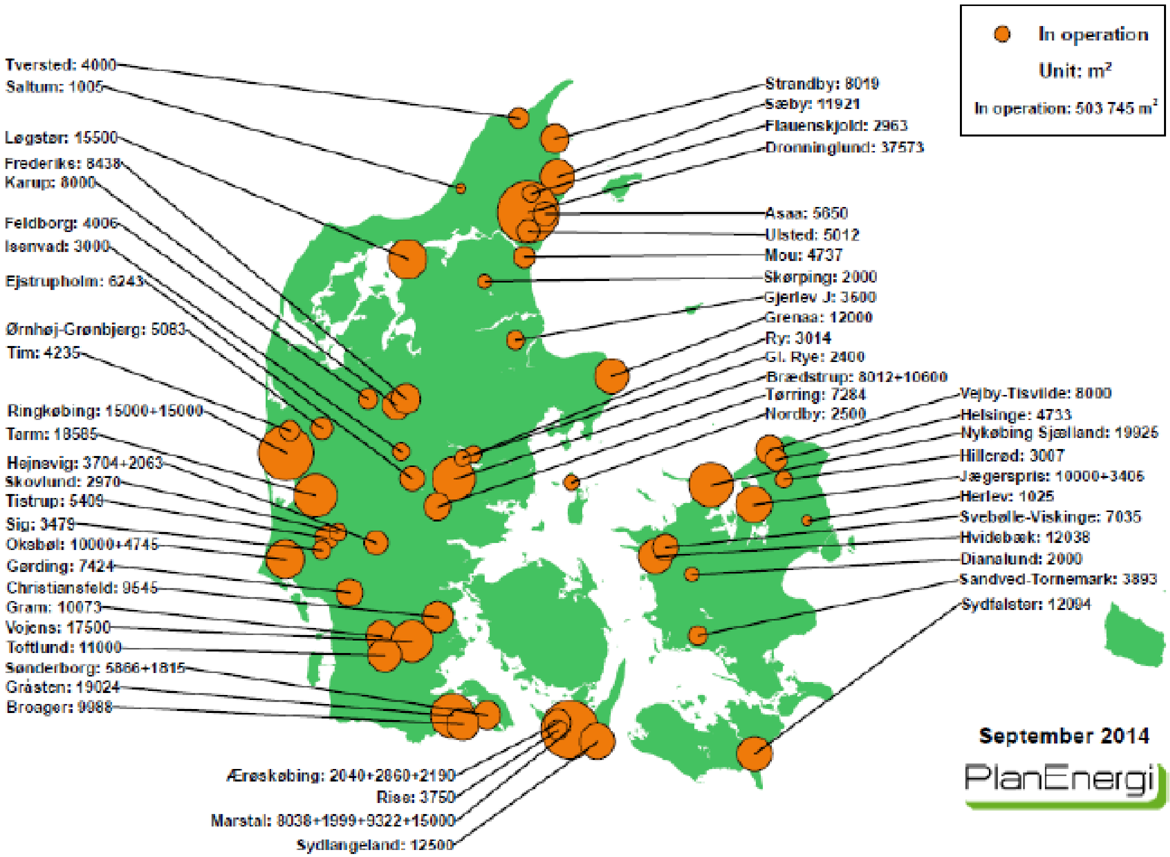
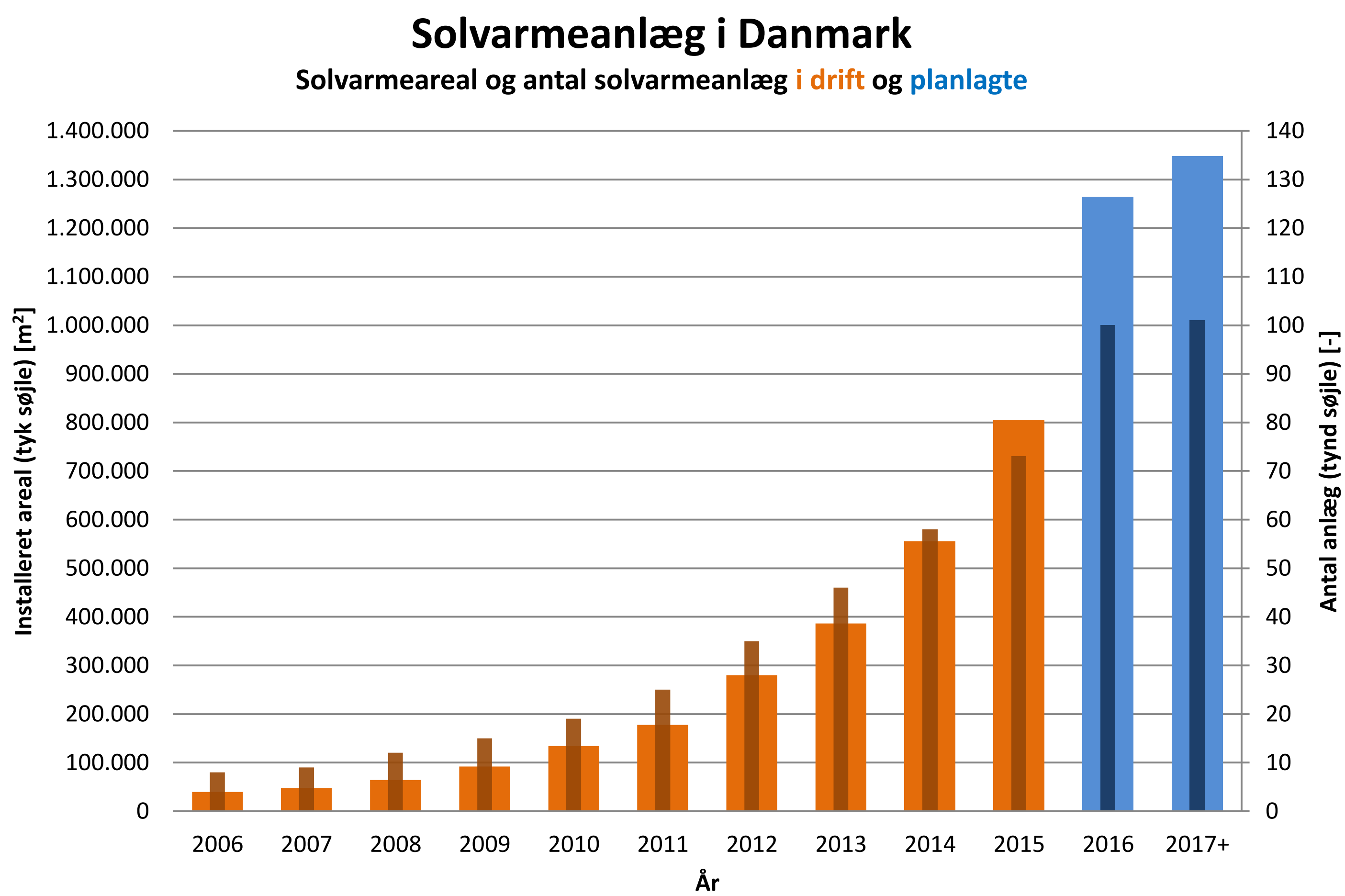


Figure 3: Overview of the installed Danish solar district heating systems in operation by September 2014

Reasons for this development:

- Energy tax on natural gas
- Restrictions on choice of fuel (natural gas)
- ”Energy saving” first year production
- Municipal loan guarantees
- Exchange of experience and information in the Danish District Heating Asociation
- Reliable technology with long life-time

Solar thermal plants in Denmark
Area and number of plants (accumulated), in operation and planned



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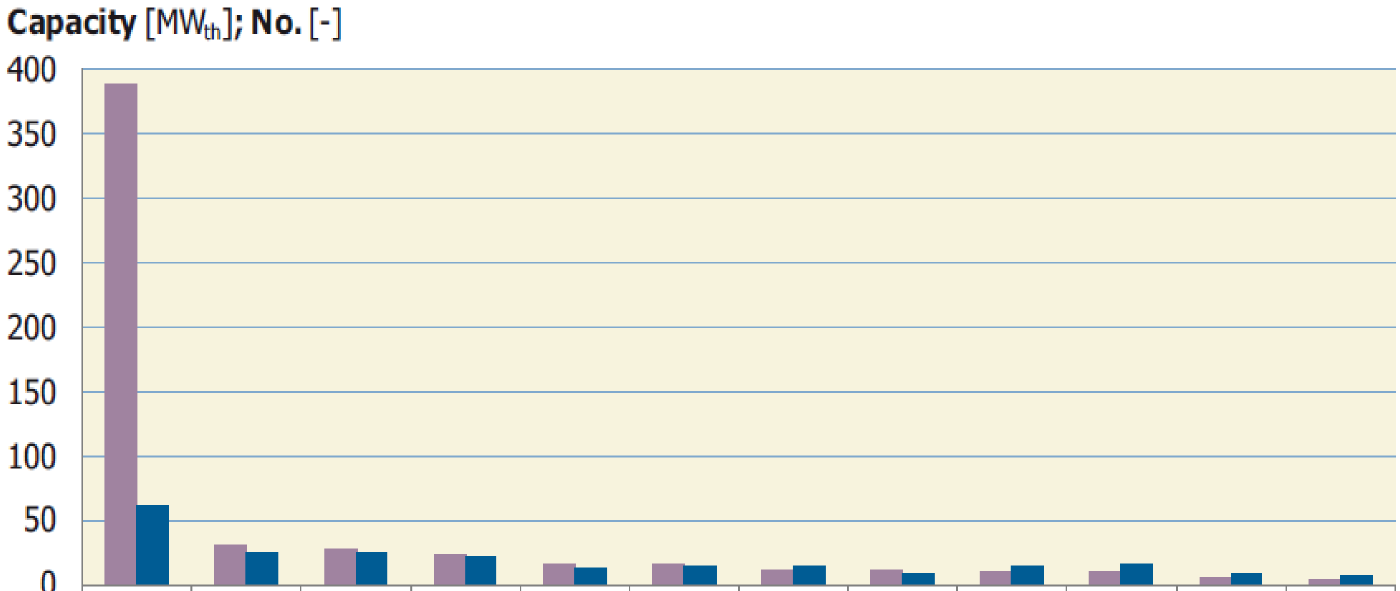
Solar thermal in other European countries, see www.solar-district-heating.eu



	DK	DE	AT	SE	OTH	PL	GR	NL	FR	ES	CH	IT
Capacity [MW_{th}]	389	30	27	22	16	15	11	11	10	9	6	4
No. of systems [-]	61	25	25	22	12	14	14	8	14	16	9	7

Figure 41: Solar district heating and cooling in Europe – capacities installed and No. of systems by end of 2014

(Data source: Jan-Olof Dalenbäck - Chalmers University of Technology, SE)

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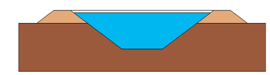
- 2007: Solar thermal strategy, Danish Energy Agency and Energinet.dk
- 2011: Action plan, initiated by the Danish Energy Agency

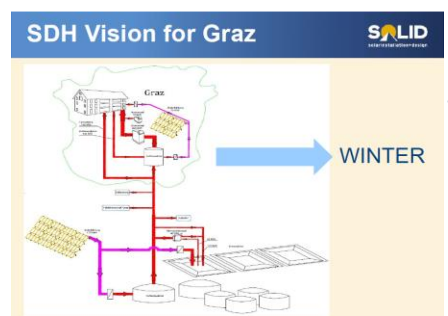
Key points of the action plan:

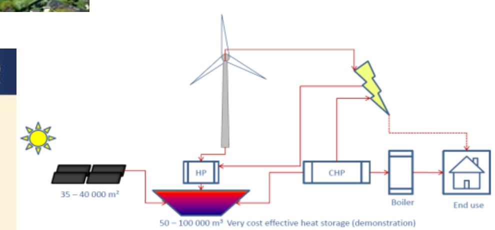
1. Research, development and demonstration of system integration, control optimisation and development of seasonal heat storages
2. (Decentralised solar thermal panels supplying to district heating network)
3. Optimisation of components
4. Information and education (calculation tools, guidelines, training courses, quality assurance)

Development perspectives for solar thermal

- More suppliers
  - Arcon-Sunmark, Viessmann, KBB, Clipsol, Savo Solar, Greenonetech
  - More development and competition
- Solar thermal and biomass
  - Feasible in combination with wood chips and straw (including ”energy saving” subsidy)
- Solar thermal with storages
  - Up to 80 % of yearly heat demand
- Hybrid systems
  - Combinations with other technologies
- Solar thermal for large cities
  - Graz; 265.000 inh., 450.000 m2 solar panels, 1,8 million m3 storage
- Solar with higher temperatures
  - For industry and district heating
  - E.g. CSP (concentrated solar power and ORC (organic rankine cycle)







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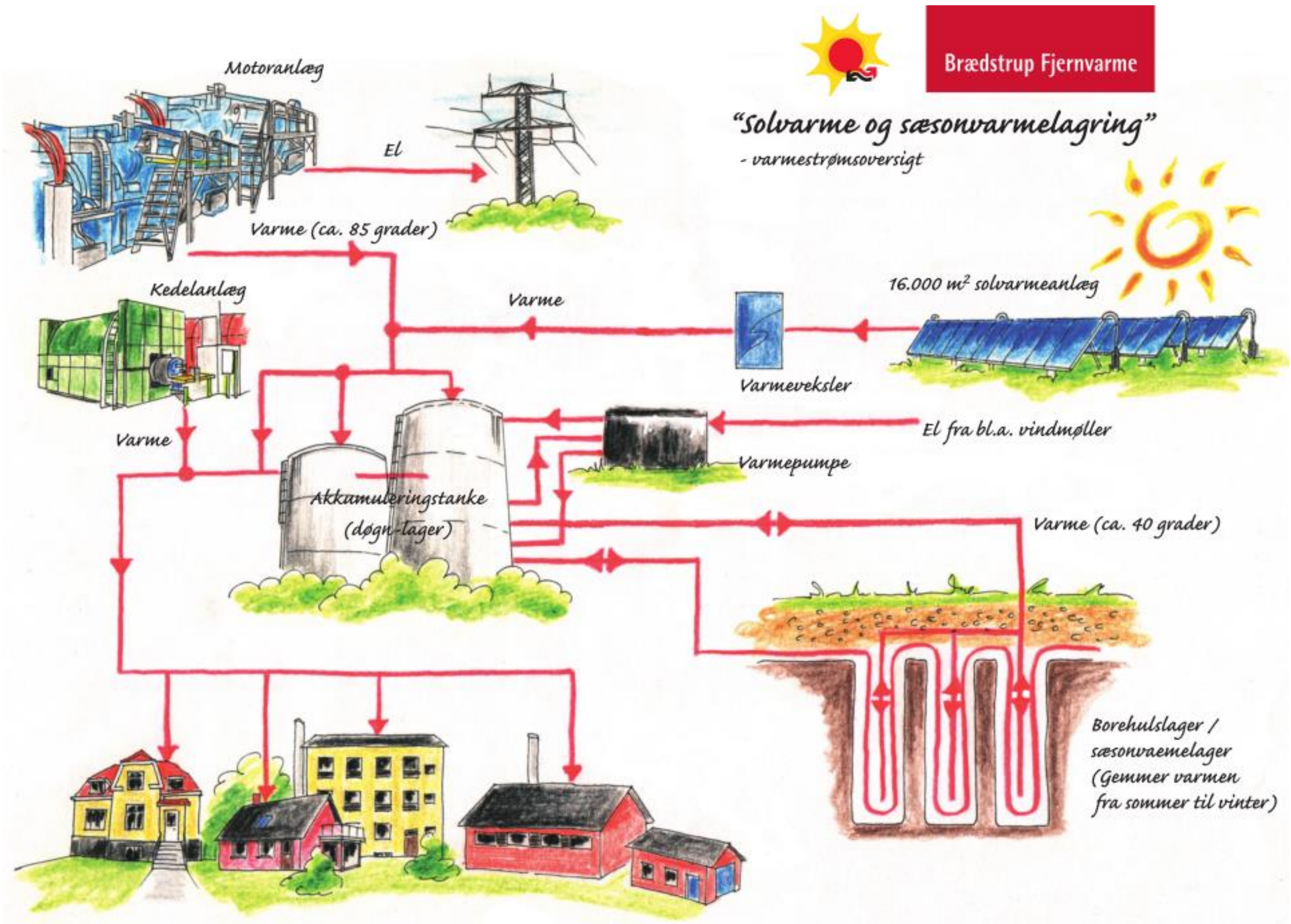
District heating with renewables in Denmark

Brædstrup



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District heating with renewables in Denmark

Example; Føns

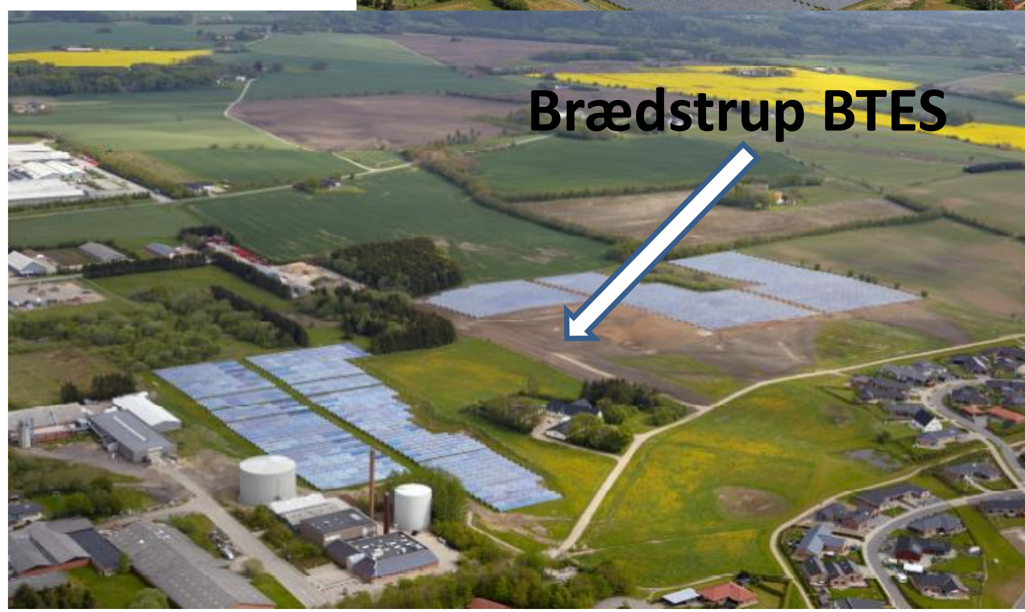
- 2*200 kW biomass boilers
- 40 consumers
- Started operation 2015

District heating with renewables in Denmark

Combinations – solar thermal and seasonal heat storages

Coverage of solar thermal:

- Approximately 20 % of yearly heat demand
- Higher with seasonal heat storages
    - Pit Thermal Energy Storage (PTES)
        - Dronninglund, **Marstal**, Gram
    - Borehole Thermal Energy Storage (BTES)
        - **Brædstrup**



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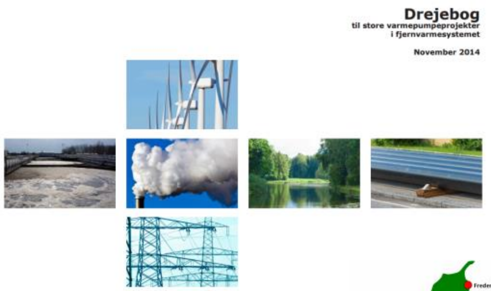
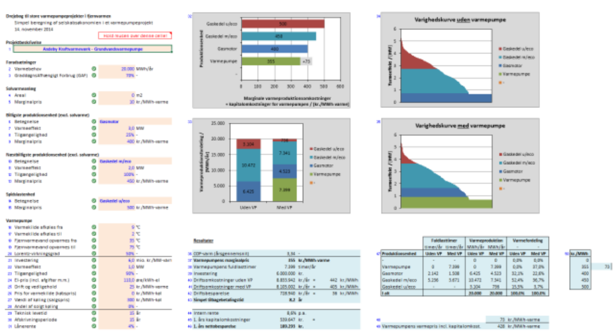
Heat pumps in DH



<u>Output:</u>
Drehbuch
Inspirationskatalog
Arbeitsblatt für interessierte Werke (Excel)



- Introduction
  - Why consider heat pumps?
  - How could heat pumps fit in the current district heating supply? Short and long term
- Initial assessment
  - Which heat sources are available? Cf. the types in the inspiration catalogue
  - Choice of heat pumps, plant concepts, system solutions
  - Approvals (authorities)
- Economy
  - Taxes, PSO
  - Connection to electricity grid, fees
  - Possibilities for income from the electricity market
- Organisation
  - Contracts (e.g. with supplier of surplus heat)
  - Tender and choice of heat pump supplier
  - Performance test
- Conclusions
  - Perspectives

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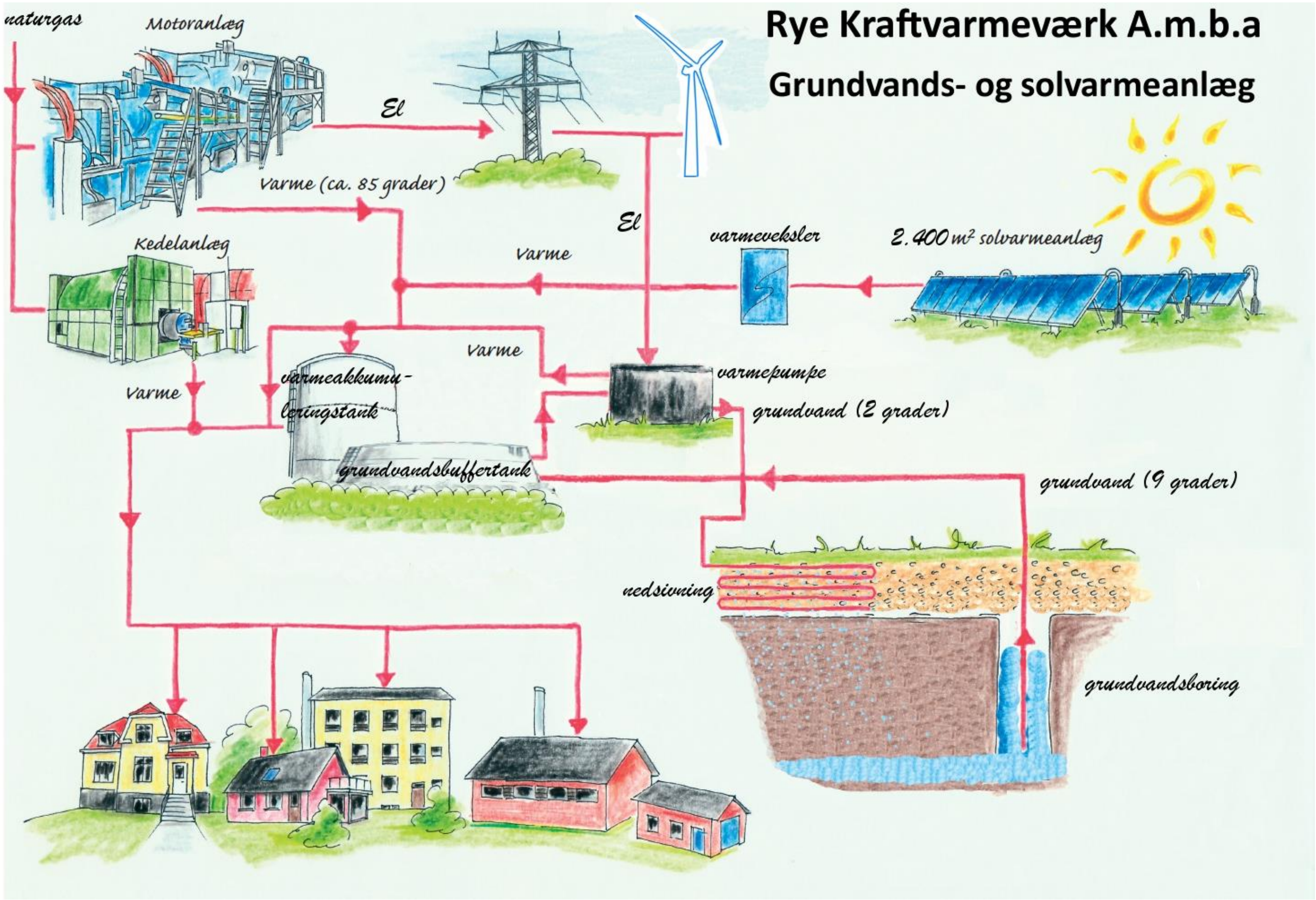
District heating with renewables in Denmark

Combination – CHP, solar thermal and heat pump (ground water) – Rye (DK)



- Reduce natural gas dependency
- Natural gas, electricity production
- Solar thermal (free fuel)
- Heat from ground water (flexible electricity consumption)

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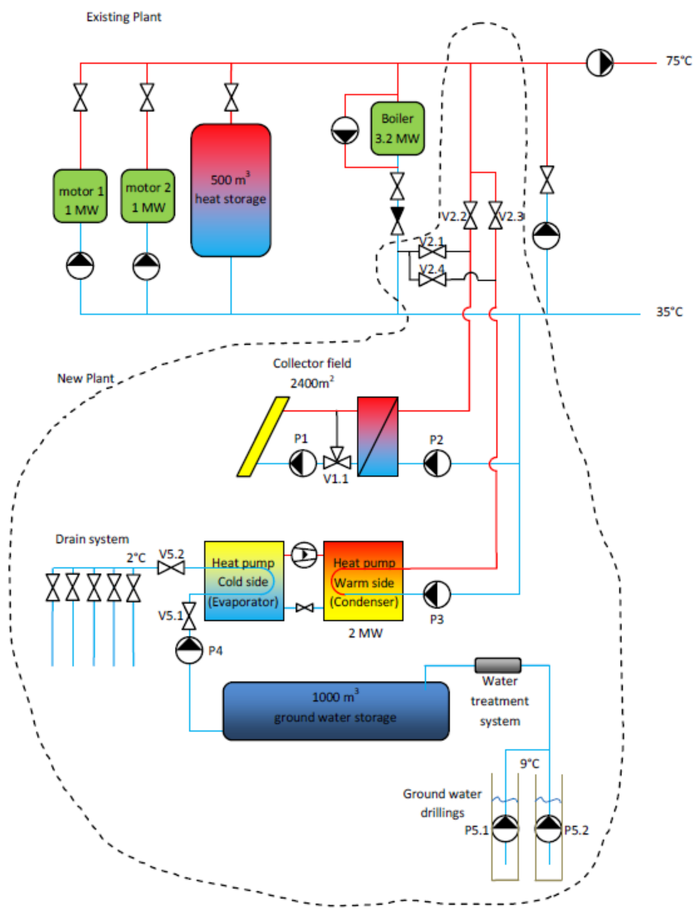
District heating with renewables in Denmark
Combination – CHP, solar thermal and heat pump (ground water) – Rye (DK)

- Das Werk:
  - 360 Verbraucher
  - 9.325 MWh/a
  - Erdgasmotoren ($2x1MW_{th}$)
  - Erdgaskessel (3,2 MW_{th})
  - 2.400 m² Solarthermie



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Wirtschaftlichkeit Rye

Wärmepumpe Rye - 2.000 kW		
Investition	1.370.000	€
Jährlicher Betrieb	3.000	Stunden
Jährliche Wärmeerzeugung	6.000	MWh
Ersparnis pr. MWh	26	€/MWh
Jährliche Ersparnis	150.000	€
Amortisationdauer	8,9	Jahre
Interner Zinsfuß 15 Jahre	7%	

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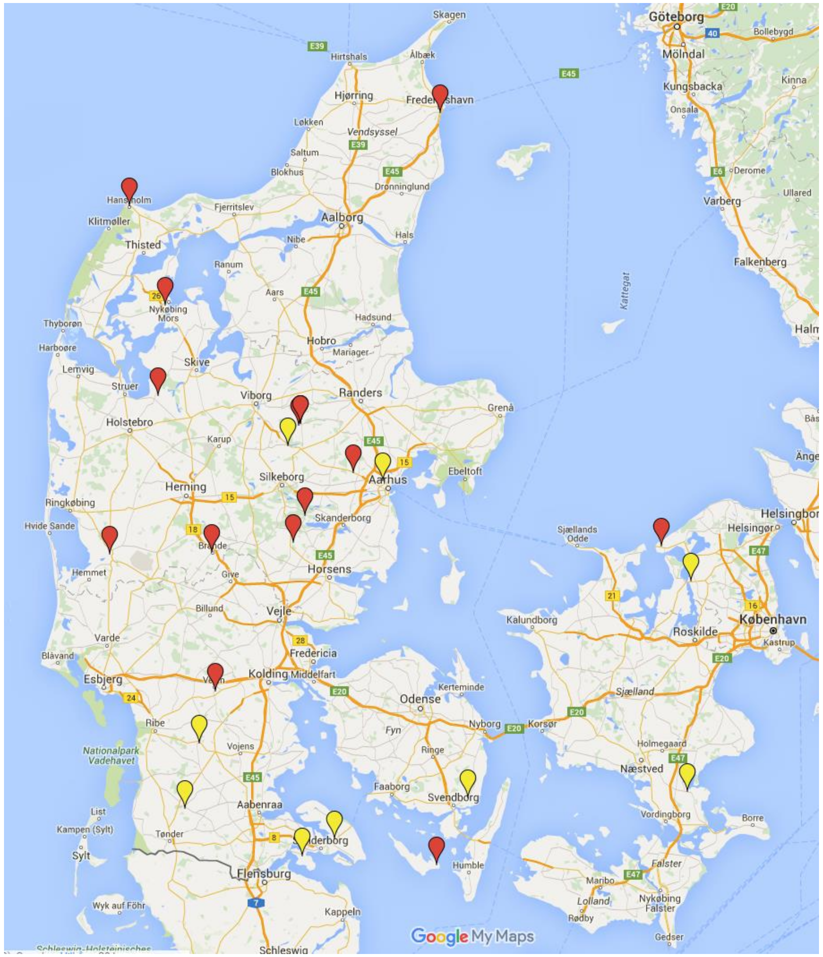
Großwärmepumpen, Status 2015



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PlanEnergi-Projekte mit Baubeginn 2016

- Broager
  - Klein-Mittel, Erdgas-KWK mit Solarthermie
  - Grundwasser
- Ans
  - Klein-Mittel, Erdgas-KWK + Kessel
  - Seewasser
- Dronninglund
  - Klein-Mittel, Erdgas-KWK, Bioöl-Kessel, Grossflächen-Solarthermie + Erdbeckenspeicher
  - Grundwasser
- Rødkærsbro
  - Klein, Erdgas-KWK
  - Abwärme von Meierei
- Farstrup-Kølby
  - Klein, Erdgas-KWK + Kessel
  - Grundwasser
- Præstø
  - Klein-Mittel, Erdgas-KWK mit Pellet-Kessel
  - Grundwasser

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Hadsund Bys Fjernvarmeværk a.m.b.a.

Grundlagenanalyse zu Masterplan

Redner: Max Guddat, PlanEnergi

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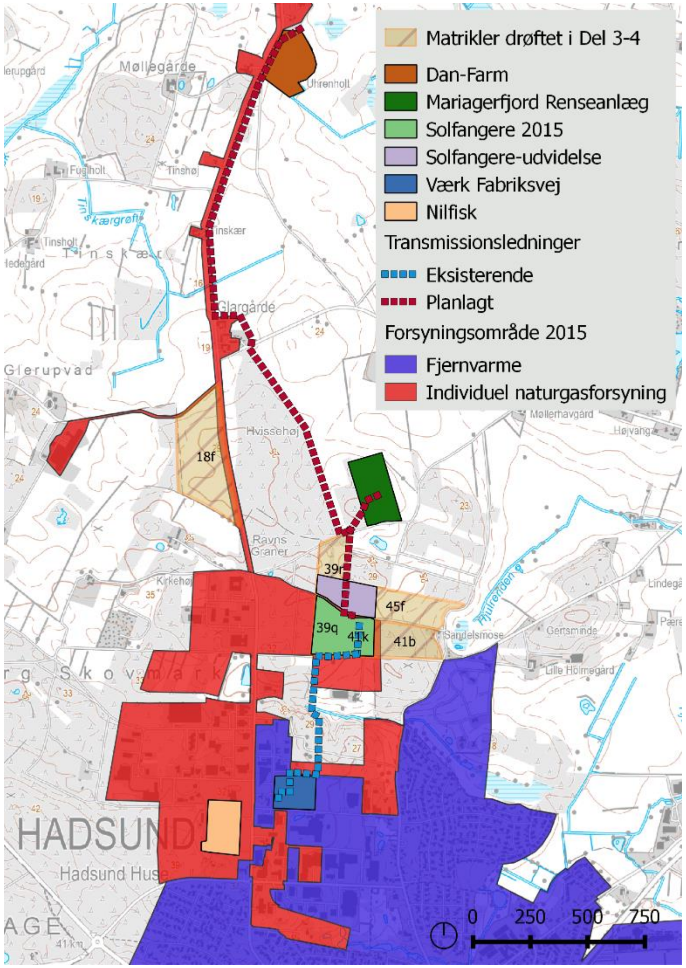
Agenda: Beschlussgrunde Hadsund

- Vorraussetzungen & Referenz-Scenario
- Teil 1: Versorgung von Erdgas-Großverbraucher
- Teil 2: Abwärme
- Teil 3: Erweiterung der Solathermie
- Teil 4: WKA zur Wärmeerzeugung
- Sensitivitätsanalysen
- Konklusion



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Das Werk

- 1962 etabliert, 315 Verbraucher (Öl-Kessel)
  - 1985: 1.000 Verbraucher
- 2016: 2.000 Verbraucher, Transmissions-leitungen zu benachbarten Wärmesystemen, Hackschnitzel, Solarthermie
- Jahreswärmebedarf: 70.000 MWh/a ab Werk im „Normaljahr“

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Vorgehensweise

- Berechnungsgrundlagen: Schätzungen, Erfahrungswerte und bekannte lokalspezifische Voraussetzungen.
  - Strombörsenpreise 2014, Abgaben 2015
  - Sensitivitätsanalysen von u.a. Hackschnitzelpreis & Abgaben-Änderungen
  - Angaben von Ist-Werten von Großverbrauchern, potenziellen Abwärmequellen und Lieferanten

- Techno-ökonomisch optimierte Modellierung in energyPRO

- Betriebswirtschaftliche Analyse in Excel anhand von energyPRO-Output

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Der Referenz-Betrieb

- Ist-Betrieb: Hauptsächlich Hackschnitzel, Solarthermie mit Inbetriebnahme primo 2016

- **Wärmezentrale Fabriksvej**:
  - 2x7 MW_{th}, Hackschnitzelkessel mit Wärmerückgewinnung
  - 4.595 m^3 Wärmespeicher
- **Solarthermie**:
  - 20.516 m^2, ca. 480 kWh/m^2
- **Ölzentralen (Spitzenlast & Reserve)**:
  - 2x6 MW_{th}, 1x2,25 MW_{th}, 2x2 MW_{th}
- **Wärmespeicher im Netz**:
  - 100 m^3, im Wärmebedarf enthalten

Brennstoffpreise, Abgaben & IWI

- 2015-Ist-Preise
  - Hackschnitzel:
    - Brennstoff: 22,2 €/$MWh_{FW\ Ab\ Werk}$
    - NO_x-Abgabe: 0,32 €/$GJ_{Brennstoff}$
    - IWI: 2 €/$MWh_{th\ Ab\ Anlage}$
  - Heizöl:
    - Brennstoff: 65 €/$MWh_{FW\ Ab\ Werk}$
    - Energie-Abgabe: 0,299 €/$kg_{Brennstoff}$
      CO_2: 0,0726 €/ $kg_{Brennstoff}$
      NO_x: 0,020 €/$kg_{Brennstoff}$
    - IWI: 8 €/$MWh_{FW\ Ab\ Anlage}$
  - Solarthermie:
    - IWI: 0,801 €/$MWh_{FW\ Ab\ Anlage}$

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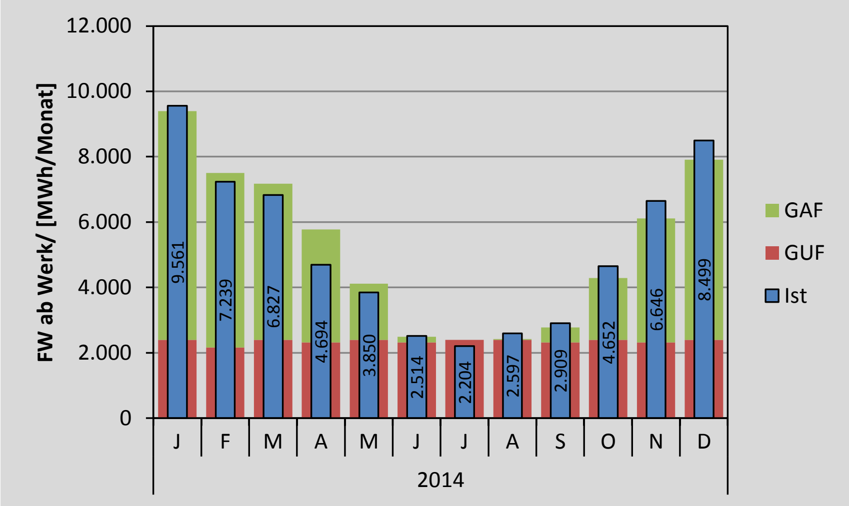
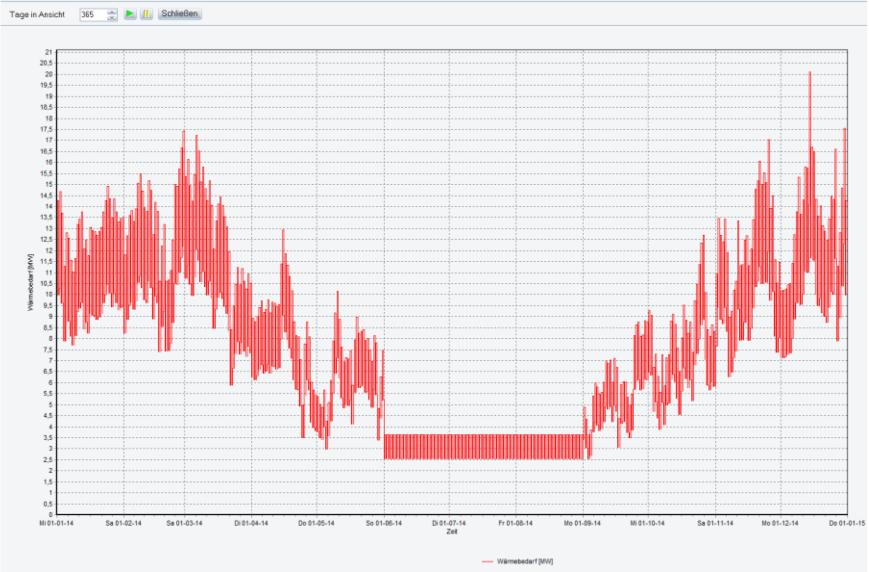
Wärmebedarf, Gradtagmethode

Skyggegraddøgn for NORDJYLLAND sammenholdt med HELE LANDET

År	Måned	NORDJYLLAND Skygge- graddøgn	NORDJYLLAND Skygge- graddøgn, EMD- normal	NORDJYLLAND Afvigelse fra EMD- normal	HELE LANDET Skygge- graddøgn	HELE LANDET Skygge- graddøgn, EMD- normal	HELE LANDET Afvigelse fra EMD- normal
.	.	(Antal graddøgn)	(Antal graddøgn)	(%)	(Antal graddøgn)	(Antal graddøgn)	(%)
2014	1	519,3	505,9	2,6	521	492,6	5,8
2014	2	397,6	440,9	-9,8	373,2	431,4	-13,5
2014	3	376,5	458,3	-17,8	356,8	444,8	-19,8
2014	4	286,3	342,7	-16,5	256,5	329	-22
2014	5	179,5	210,8	-14,8	168,8	202,9	-16,8
2014	6	74,9	118,8	-37	68,8	108,5	-36,6
2014	7	13,8	62,2	-77,8	11,7	52,5	-77,7
2014	8	70,2	67,9	3,4	57,7	52,7	9,5
2014	9	93,3	155,6	-40	66,1	133,4	-50,4
2014	10	190,6	279,8	-31,9	161,1	258	-37,6





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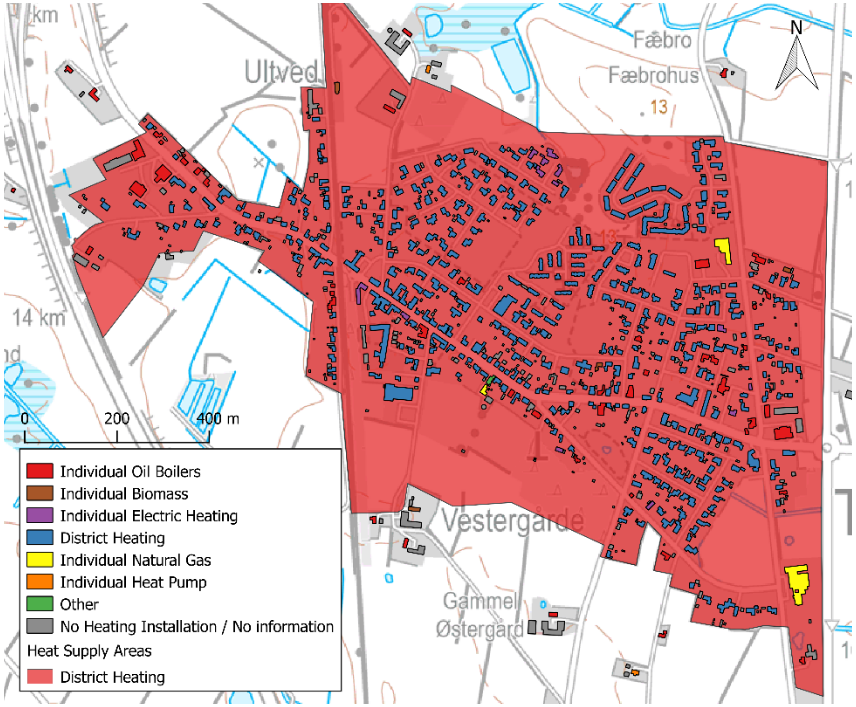
Bei Erschließung neuer Versorgungsgebiete: Wärmeatlas



GIS-basierter Wärmeatlas für Tylstrup

(Enthält Daten der Geodatastyrelsen)

Tabel 11. Beregnede nuværende enhedsforbrug i de analyserede bygningstyper og byggeperioder jf. registreringer af konstruktionernes nuværende termiske egenskaber i forbindelse med energimærkning.

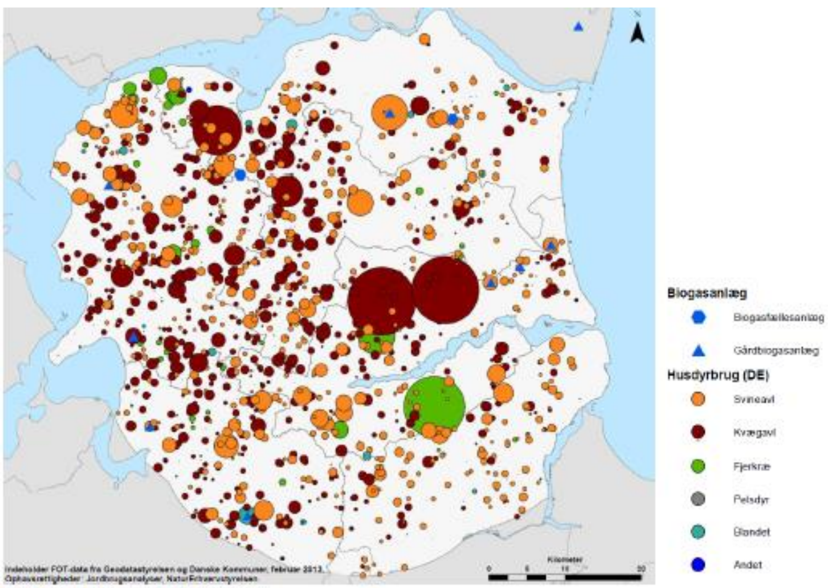
kWh/m² pr. år	Før 1890	1890-1930	1931-1950	1951-1960	1961-1972	1973-1978	1979-1998	1999-2006	Efter 2006
Stuehus	184,3	171,4	161,8	151,2	136,2	116,9	100,3	81,0	66,6
Parcelhus	170,3	164,7	164,1	154,9	134,3	119,8	105,4	83,9	67,3
Række/kædehus	158,2	157,7	149,3	142,8	119,9	112,6	96,8	81,5	66,4
Etagebolig	151,1	153,9	157,0	148,0	132,3	121,0	108,5	84,0	60,7
Kollegium	137,9	149,2	136,4	145,7	130,6	139,1	131,7	84,0	58,2
Døgninstitution	164,1	161,9	152,3	140,2	143,2	136,9	116,0	94,1	63,3
And. helårsbolig	161,1	165,7	158,4	161,4	135,8	132,7	101,0	80,4	66,6
Kontor/handel	129,8	125,2	129,0	126,7	117,5	120,0	103,3	89,6	82,8
Hotel og service	172,0	166,5	152,4	160,9	157,2	172,0	141,8	122,6	121,1
And. hand/serv.	82,7	119,0	123,6	107,4	125,7	139,9	116,6	102,7	96,0
Kulturbygning	166,0	156,1	156,5	139,2	125,8	118,4	131,2	105,1	96,6
Undervisning	126,2	136,3	141,0	133,8	135,1	145,6	115,1	100,0	86,2
Sygehus	195,3	178,4	173,2	177,3	153,8	156,5	149,6	138,6	129,7
Daginstitution	170,7	181,7	173,8	171,6	172,8	166,1	143,5	133,9	115,9
And. institution	177,9	175,8	178,2	201,7	179,1	169,1	139,4	135,3	117,6
Sommerhus	205,8	162,5	150,0	176,7	154,6	126,6	134,8	90,8	73,1
Feriebygning	139,6	150,5	172,4	112,1	137,9	122,1	125,4	68,9	35,9
Sportsanlæg	198,1	206,8	187,8	173,4	165,3	163,1	155,0	138,3	119,3
And. fritidsbygn.	163,4	132,0	149,7	154,7	129,8	129,0	115,0	98,6	76,8

1) Det beregnede enhedsforbrug for bygninger til anden handel og service, opført i perioden før 1890, er urealistisk lavt. Data er forbundet med stor usikkerhed da der kun findes meget få bygninger fra denne periode i databasen fra EMO ordningen. Der er meget få bygninger registreret i BBR registeret for denne periode, og usikkerhed i denne periode vil derfor kun have marginal indflydelse på de samlede resultater.

SBi 2014:01: Potentielle Varmebesparelser ved løbende Bygningsrenoveringer frem til 2050, p. 26

Biobrennstoffe: Potenzialerfassung

- Potenzialerfassung in kommunalem Projekt
  - Methode entwickelt durch Aarhus Universität



Figur 16: Husdyrbrug i kommunerne.

Revideret 4. december 2012 - afgrødedata for 2011, dyrehold GHI 2011 - halm og udbytter mv. ikke opdateret - ark regionale data

Indtast kommunenr 851 **Aalborg** **Region** **1081 Nordjylland**

Udnyttelses-procent Nuvær-ende	Udnyttelses-procent Scenario	Tiltag	Aalborg Potentiale	Scenario (Hektar)	Udnyttet	Scenario (PJ)	Udnyttet (PJ)	195.145 indb Pr indb. (GJ)	Beregningsfaktorer Tørstof pr ha	Procent olie	GJ pr ton	PJ pr ha
		1. Energiafgrøder										
74%	25%	af arealet med energiafgrøder og udtagne arealer på højbund anvendes til energiafgrøder (ex raps og miljøordninger)	936	234	694	0,04	0,11	0,2	10		16	0,00016
0%	15%	af arealet med korn til modenhed anvendes til energiafgrøder	38.765	5.815	0	1,12	0,00	5,7	12		16	0,000192
		2. Olieproduktion										
70%	100%	af rapsarealet udnyttes til energi	4.208	4.208	2.945	0,15	0,11	0,8	3,1	33%	35	0,000036
		3. Halm										
		Reduceret kornareal	32.950									
		Foder og strøelse	12.299									
0%	80%	af halmproduktionen fra korn, der ikke anvendes til foder og strøelse udnyttes til energi	20.650	16.520	0	0,78	0,00	4,0	2,8		17	0,000048
13%	80%	af halmproduktionen fra raps udnyttes til energi	4.208	3.366	526	0,14	0,02	0,7	2,4		17	0,000041
		4. Brændsel fra skove, hegn og haver										
100%	100%	Skovarealet antages anvendt til tømmer, med en tyndingshugst på 1,5 ton ts pr. ha årligt anvendt til energi. I scenariet øges tyndingshugsten til 2.25 tons ts pr. ha anvendt til energi.	8.813	8.813	8.813	0,32	0,21	1,6	2,3		16	0,000036
100%	100%	En tilsvarende energimængde antages på landsplan udnyttet fra mindre skove, hegn og haver	104.489			0,35	0,35	1,8	1,5		16	0,000024
		Biogas							Tørstof pr ha	m3 methan/kg tørstof	PJ/mill m3 methan	
		5. Græs										
0%	75%	af lavbundsareal med græs eller ekstensive afgrøder høstes til biogas	4.343	3.257	0	0,14	0,00	0,7	3,5	0,35	0,036	0,0000441
		6. Husdyrgødning		1000 m3 metan								
6%	75%	af husdyrgødning på stald anvendes til biogas	19.051	14.288	1.182	0,51	0,04	2,6		5,28	0,036	0,000036

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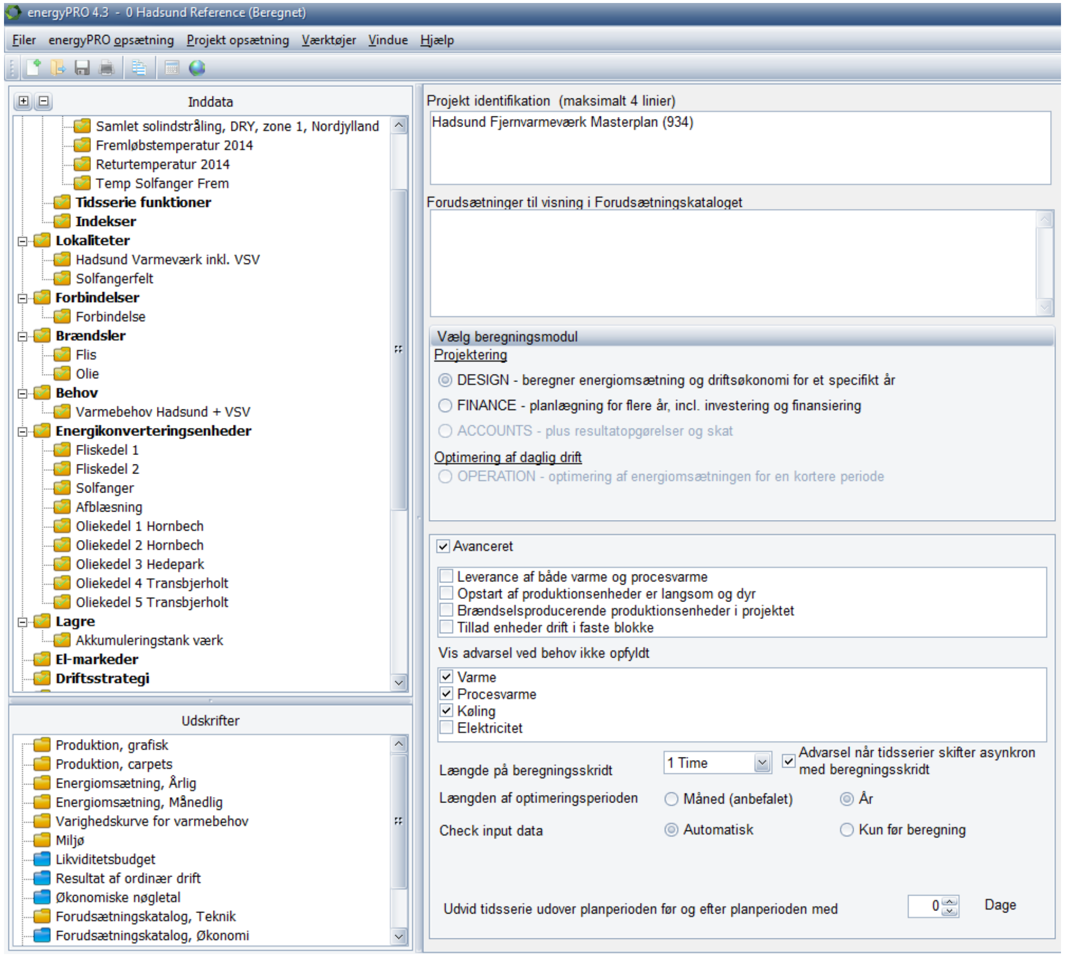
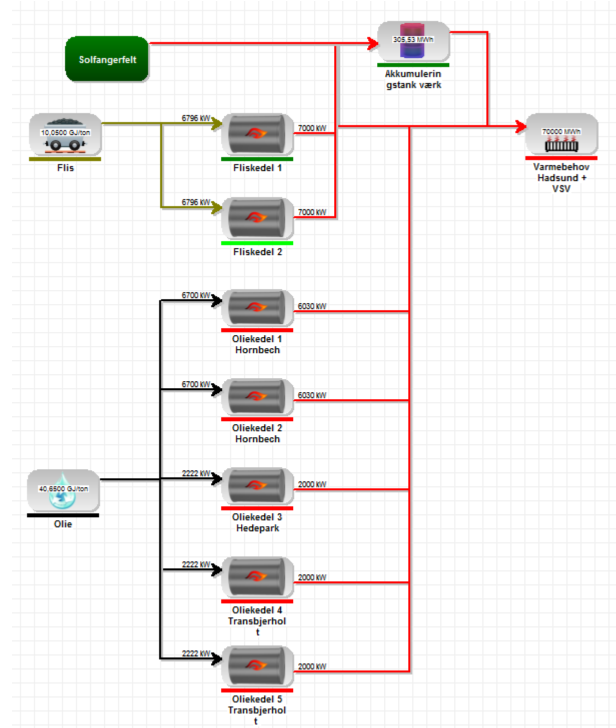
energyPRO - Grafisches Interface





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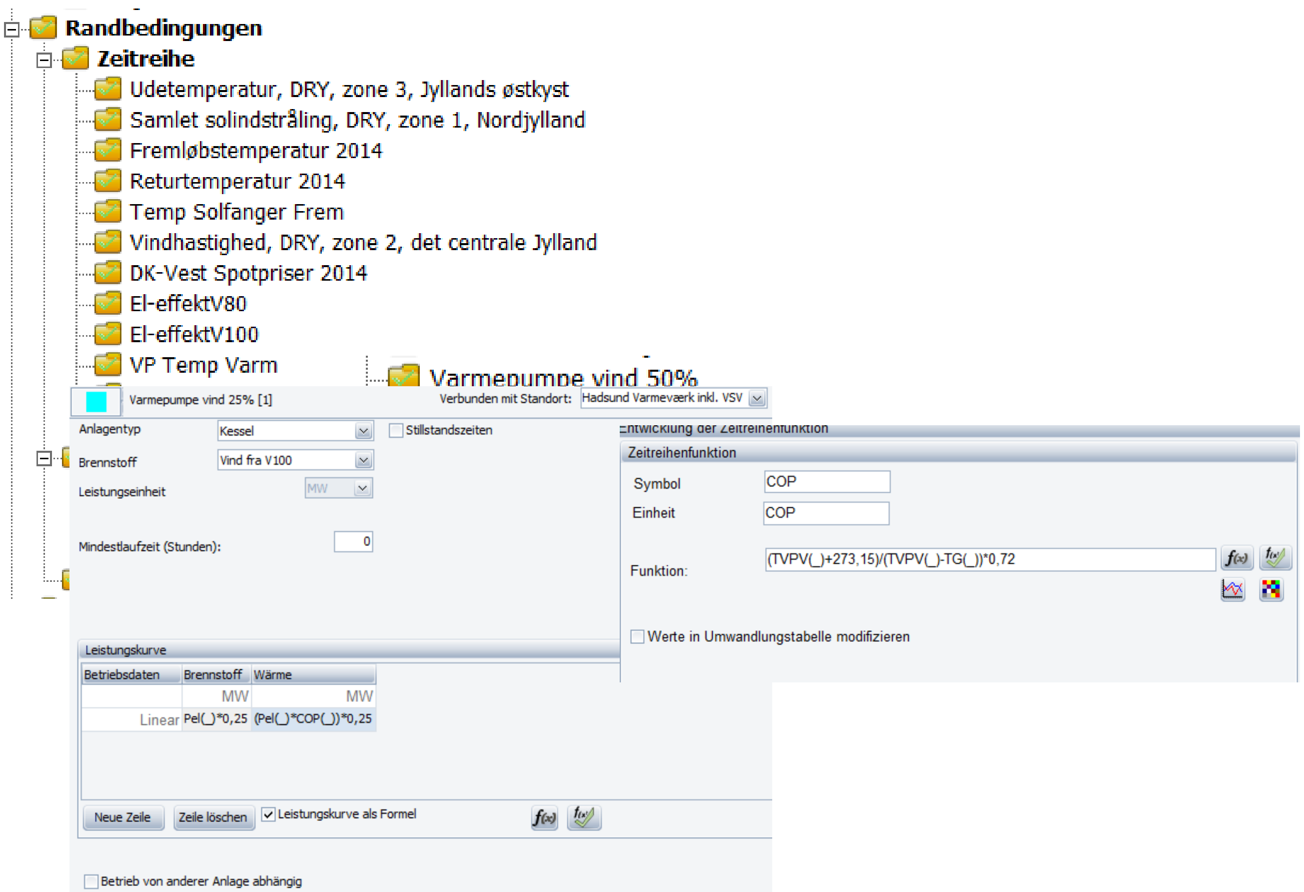
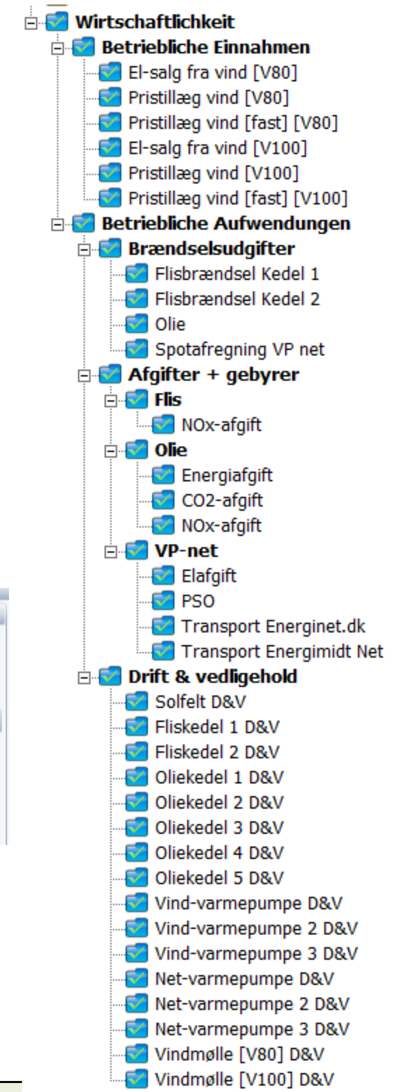
energyPRO - Input

Individualisierbares Modell, dank Zeitrehen & Zeitreihe-Funktionen





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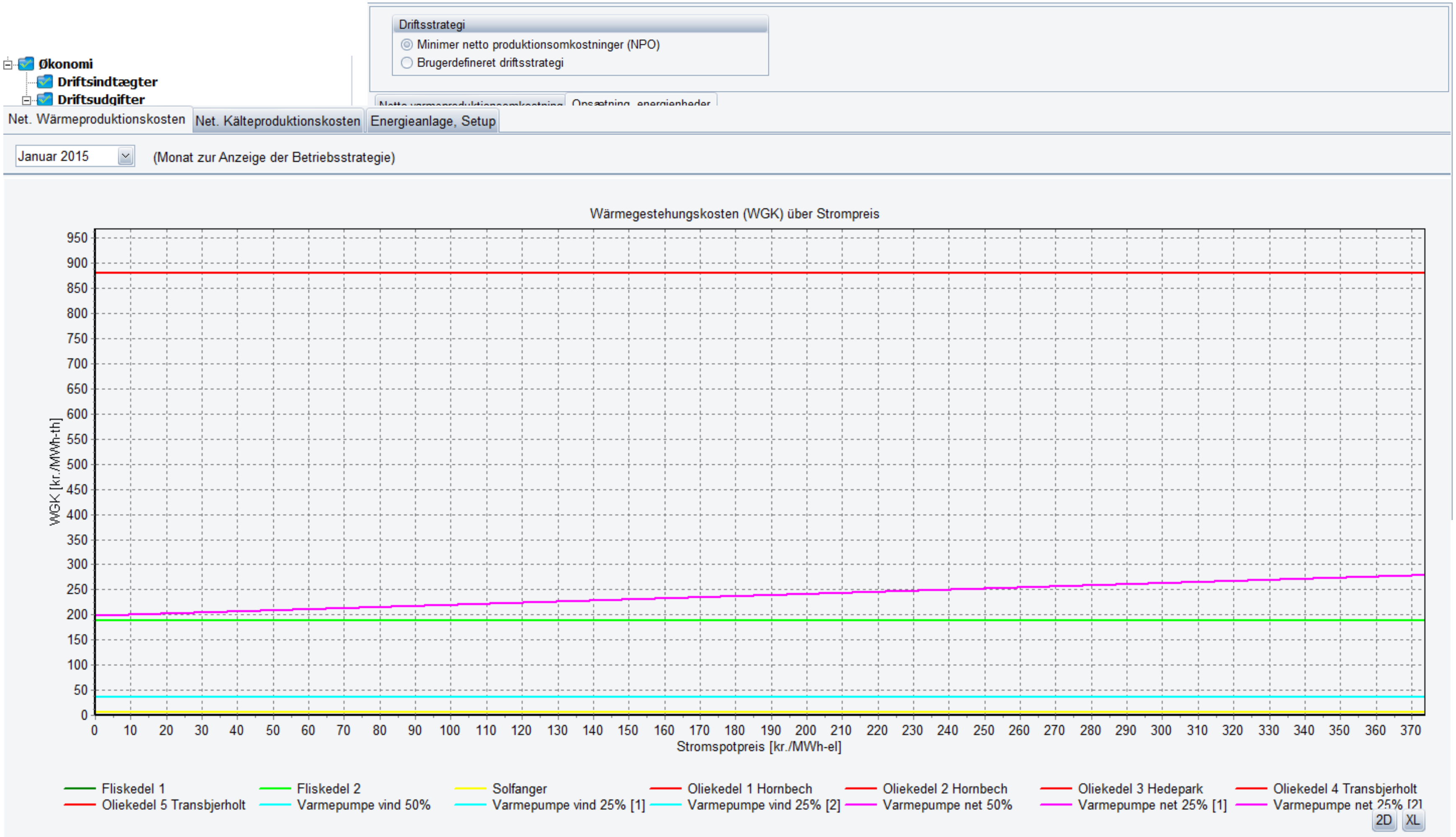
energyPRO - Betriebsstrategie



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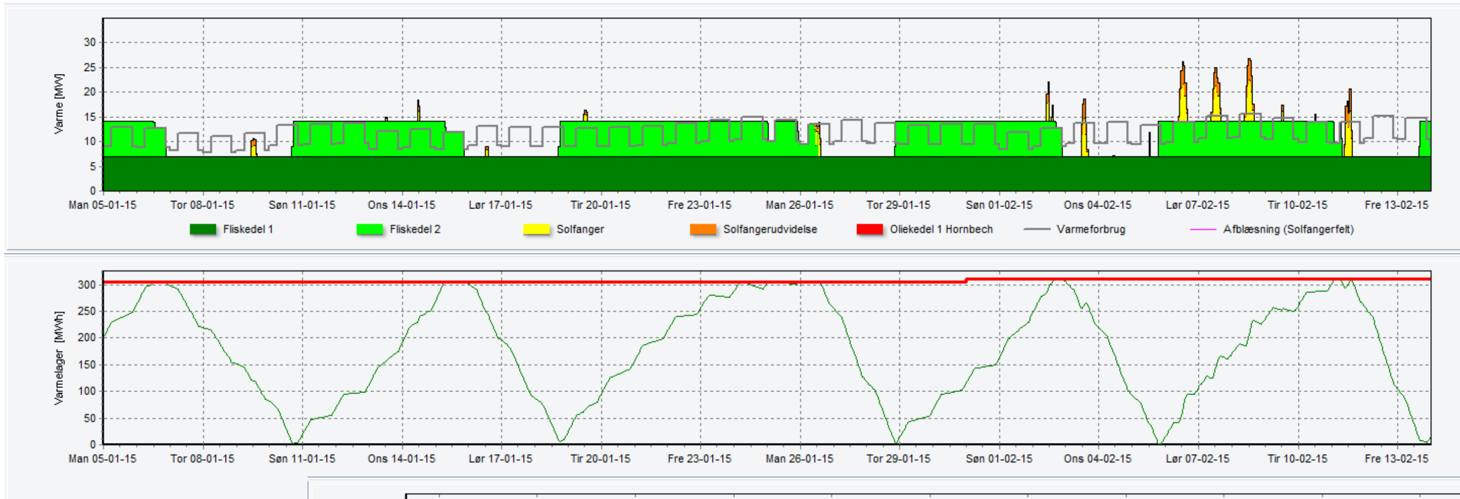
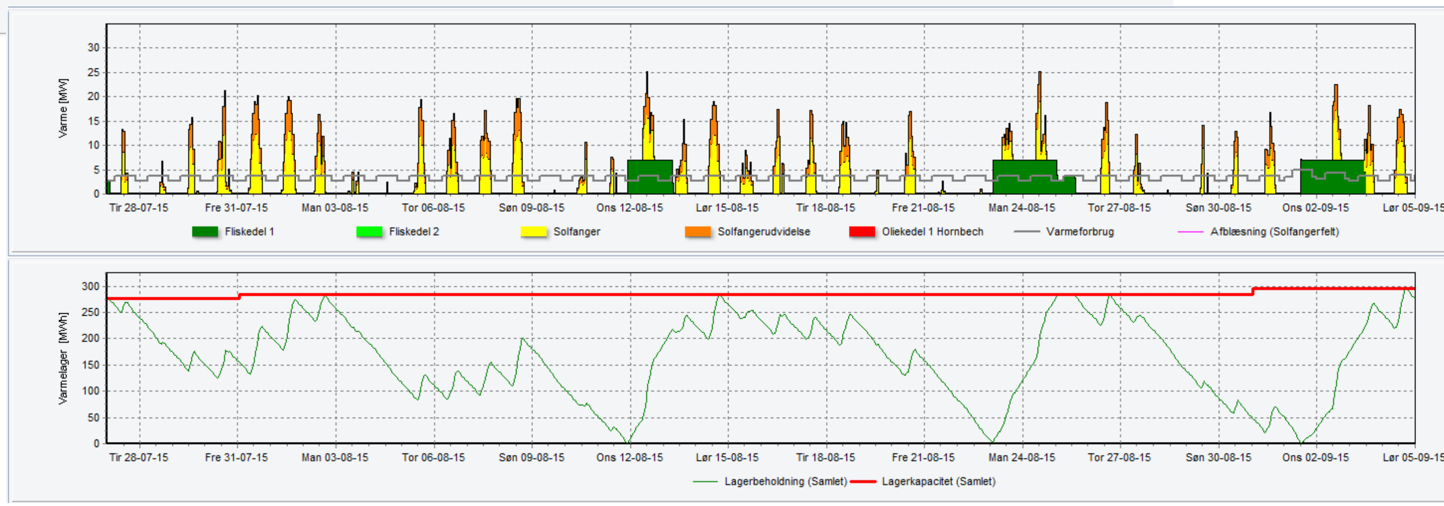
energyPRO – Saisonale Betriebsunterschiede





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Ergebnisse – Referenz

Selskabsøkonomi Del 0, Referencen		Del 0, Referencen Reference
Varmeproduktion ab værk	MWh/år	70.000
Driftsomkostninger	kr./år	11.413.000
Driftsomkostninger, inkl. kapitalomk. til nuv. solvarme	kr./år	13.441.000
Varmeproduktionspris	kr./MWh	192

Varmeproduktionsfordeling ab værk	Del 0, Reference	
	MWh/år	%
Fliskedler	60.246	85,8%
Oliekedler	3	0,0%
Solvarme	9.981	14,2%
Overskudsvarme	-	0,0%
Transmissionstab & evt. afblæsning	-230	
Varmepumpe		0,0%
Total	70.000	

Brændsels- og ressourceforbrug		Del 0, Reference
Flis	MWh/år	58.519
Olie	MWh/år	3
Flis	ton/år	20.962
Olie	ton/år	0

Ergebnisse – Solarthermie

Selskabsøkonomi Del 3, Grundberechnung		Teil 0, Referenz	Teil 3.1 Erweiterung Solarthermie + Trockenkühler	Teil 3.2 Erweiterung Solarthermie + erweiterter Wärmespeicher	Teil 3.3 Erw. Solarthermie + Abwärme Klärwerk	Teil 3.4 Erw. Solarthermie + Biogas-Abwärme
Wärmeerzeugung Ab Werk	MWh/a	70.000	70.000	70.000	70.000	70.000
Betriebskosten	€/a	1.538.000	1.423.000	1.420.000	1.423.000	1.409.000
Betriebskosten inkl. Annuität zur 2015-Solarthermie	€/a	1.811.000	1.697.000	1.693.000	1.696.000	1.682.000
Betriebsersparnis	€/a		115.000	118.000	115.000	129.000
Solarthermie, inkl. Wärmetauscher, Pumpen, Rohrführung etc.	€		2.255.000	2.255.000	2.255.000	2.255.000
Trockenkühler	€		44.000	-	44.000	44.000
Wärmespeicher	€		-	288.000	-	-
Anschluss, Abwärme	€		-	-	189.000	707.000
			-	-	-	-
Projektierung & Aufsicht	€		61.000	61.000	71.000	94.000
Unvorhergesehene Kosten	€		101.000	101.000	121.000	135.000
Investition total	€		2.461.000	2.705.000	2.681.000	3.236.000
Simple Amortisation	Jahre		21,4	22,9	23,3	25,1
Annuität, 3%, 25 Jahre	€/a		141.000	155.000	154.000	186.000
Netto-Ersparnis	€/a		-27.000	-37.000	-39.000	-56.000
Wärmegestehungskosten	€/MWh		24,2	24,2	24,2	24,0
Wärmegestehungskosten, inkl. Annuität	€/MWh	25,9	26,3	26,4	26,4	26,7
Netto-Ersparnis in den Wärmegestehungskosten	€/MWh		-0,4	-0,5	-0,6	-0,8

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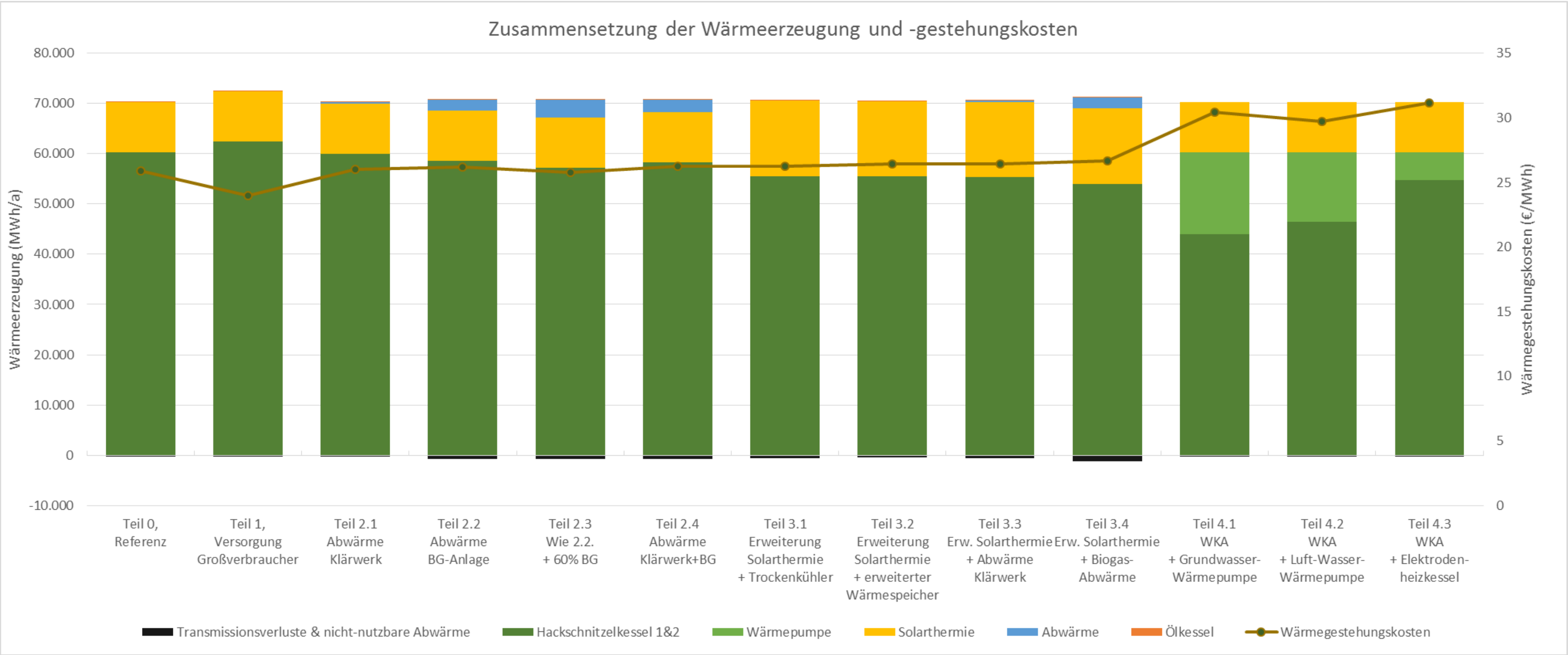
Ergebnisse – Szenarienanalyse



Sensitivitätsanalysen

- Um die Robustheit der Konklusionen zu untersuchen
  - Keine der untersuchten Änderungen führt veränderte Konklusionen mit sich.
- Analysen:
  - Hackschnitzelpreis: +20%
  - Abschaffung der NO_x-Abgabe
  - Energieeinsparungen durch Solarthermie nach 2015
  - Berechnung des balancierenden Hackschnitzelpreises
  - Substitutionspreis für industrielle Abwärme
  - Bei Erdgas-KWK: Strom- und Erdgaspreis in mehreren Ausgaben

Konklusion

- Die größte Reduktion des Hackschnitzel-verbrauchs bei Grundwasser-WP & WKA
  – Erweiterung Solarthermie reduziert um 1.600 t/a
- Betriebswirtschaftliche Vorteile nur bei Versorgung des Großverbrauchers & erhöhter Biogas-Lieferung
- Weitere Szenarien resultieren in Mehrkosten von etwa 11.500 – 40.400 €/Jahr, bei merkbarer Reduktion des Hackschnitzelverbrauchs
  – Max. 0,577 €/MWh = 13,05 €/Verbraucher (inkl. MWst.)

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Workshops

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SmartReFlex, workshops

Energy sources	Heat production	Distribution	Consumer installations	End consumption
• W1 • Urban heat planning, DHC vs. individual heat supply, real examples of project development	• W2 • RES production plants and how to calculate production prices • Presentation of technologies: Solar thermal, Biomass boiler, Biomass CHP, Biogas CHP, Heat pumps….	• W2 • Design of substations and lay-out of DHC grid with low temperatures • The transmission and distribution network. • Pipe types, dimensioning of pipes (pressure, flow, software, heat loss), heating and cooling, pumps, excavation, prices	• W2 • Types of consumer installations	• W1 • Mapping of heat demand

W3:

- Metering, payment, service to customers, administration
- Costumer involvement and ownership, business models and financial analysis

W2 includes:

- Calculation of district heating production plant.
- Simple calculation of production costs in reference and RES system.
- Calculation in EnergyPRO of production costs in reference and RES system

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The Steps in Planning of Heating Systems

1. Mapping of present and future heat and cooling demands
2. Mapping of resources
3. Cost and competitiveness. Where to have individual solutions and where to have common solutions (district heating and cooling)

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energyPRO

Simulation and optimisation of energy production hour by hour

Techno-economical analyses

- Operation budgets
- Operation optimisation
- Operation follow-up
- Investment analyses
- Market participation and simulation
- Analyses of connection of DH networks

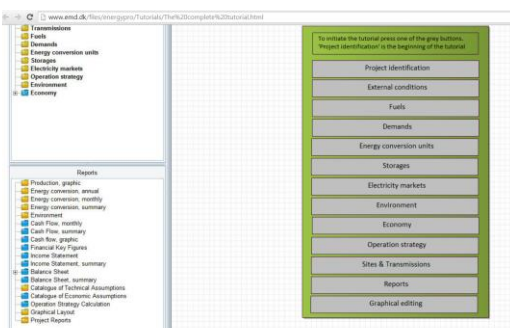
Feasibility on company level (not society or consumer)

Modules

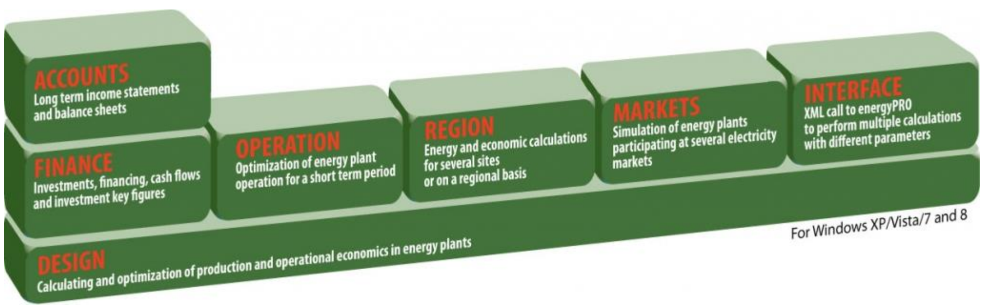
www.emd.dk

- Brochure
- Tutorial

http://www.emd.dk/files/energypro/Tutorials/The%20complete%20tutorial.html



energyPRO



energyPRO, modules

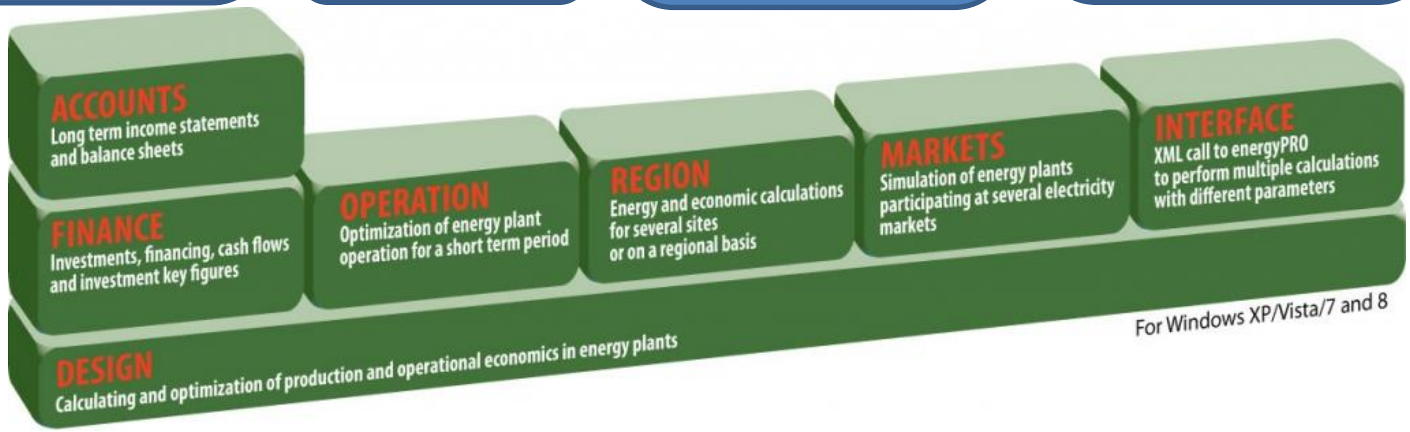
Accounts:
- Income statement
- Taxes, more detailed
- Feasibility on company level (not yet socio-economic)

Operation:
- < 1year

Regions:
- Several locations
- Transmission pipelines

Markets:
- Several electricity markets in the same model

Finance:
- Several years
- NPV
- Financing
- IRR (only greenfield)



Design:
1 year
Operation budget
Investment analyses

Export of data:
- As PDF files
- As data (e.g. to Excel)

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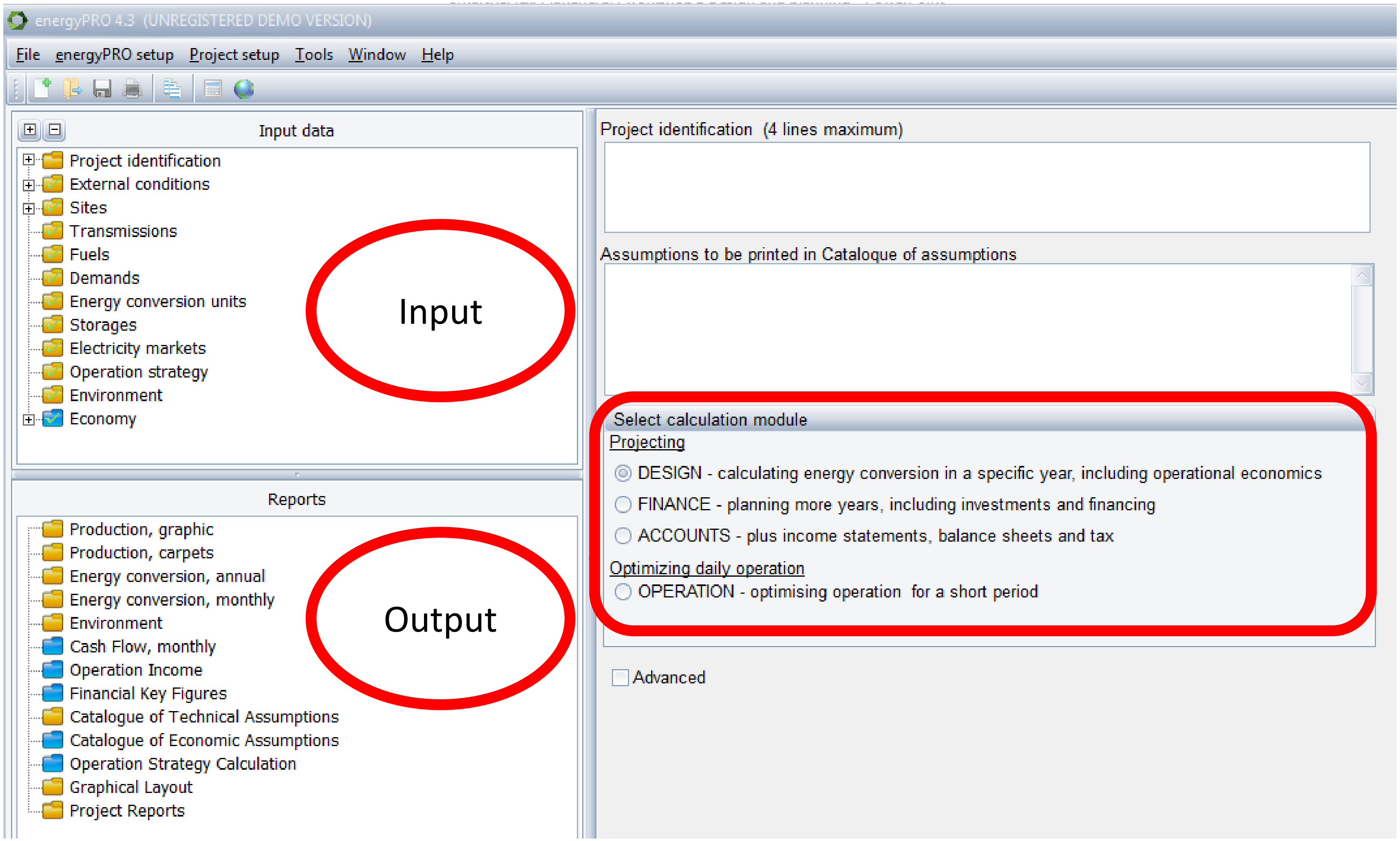
energyPRO, user interface



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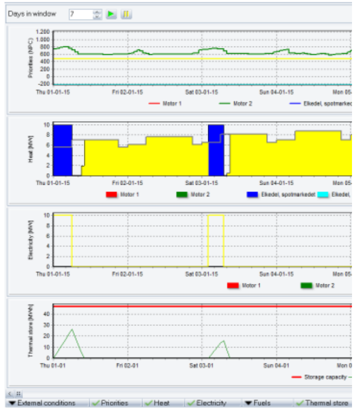
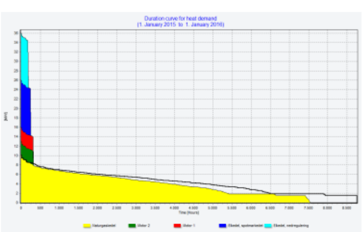
energyPRO, output

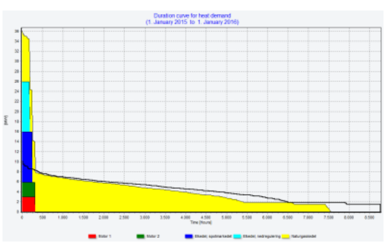
- Production graphic

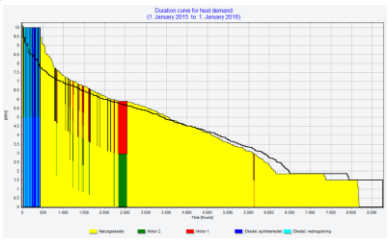


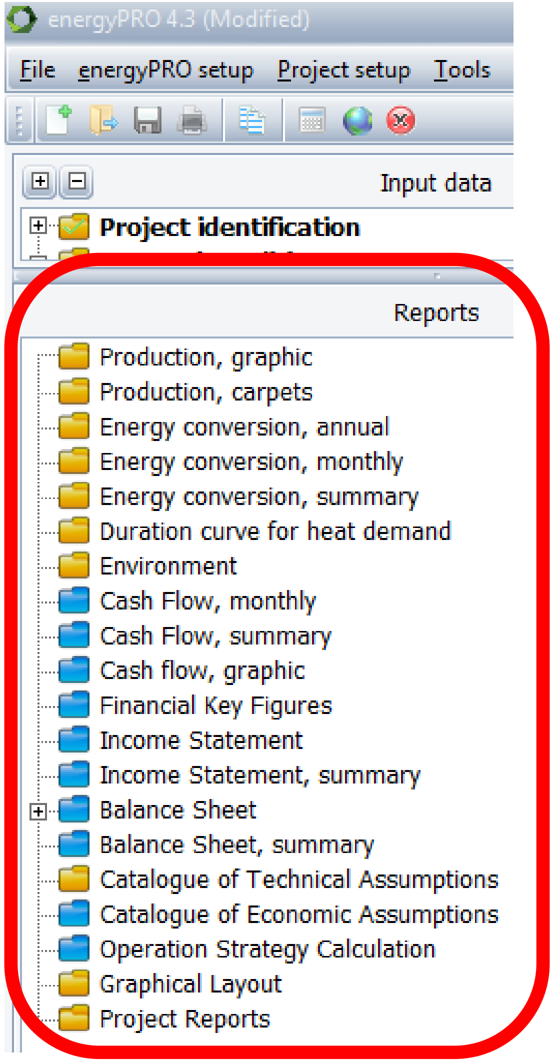
- Production carpets

- Duration curves; Operation time, input, productions









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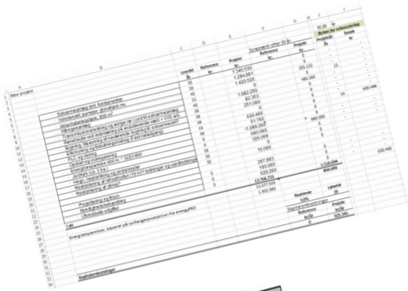
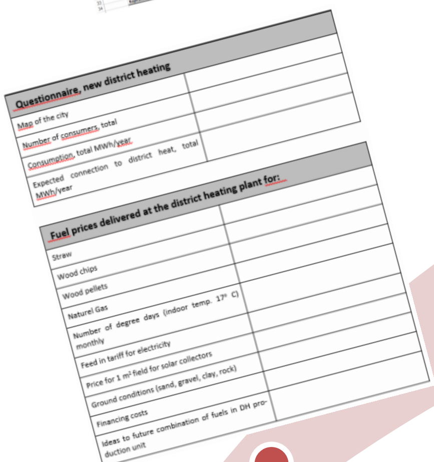
energyPRO, application context





Technical and economical data

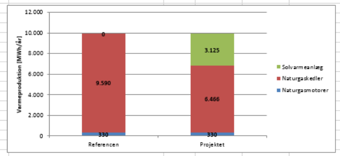
- Questionnaires
- Project budget

energyPRO

- Cf. guide etc.
- ”Design”, 1 year
- Two files
  - Project
  - Reference (same as project, no operation on new units)

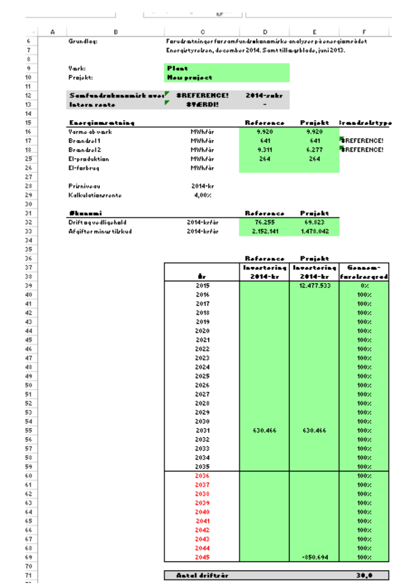
Spreadsheet

- Input from energyPRO energy conversion and operation economy
- Calculations on feasibility (consumer, company, society)
- Project period (e.g. 20-30 years)
- Environment (not in energyPRO)



Selskabsøkonomi	Enhed	Reference	Projekt	Projekt minus reference
Investering	kr.	0	13.766.733	**13.766.733**
Resultat af drift, jf. Bilag A	kr./år	2.714.000	1.222.000	**1.492.000**
Simpel tilbagebetalingstid	**år**	–	–	**9,2**
Kapitalomkostninger, gnsn.	kr./år	0	925.341	**925.341**
Nettobesparelse	**kr./år**	–	–	**566.659**

Forbrugerøkonomi	Enhed	Reference	Projekt	Reference minus projekt
Resultat af drift, jf. Bilag A	kr.	2.714.000	1.222.000	**1.492.000**
Investering	kr.	0	13.766.733	**-13.766.733**
Kapitalomkostninger, gnsn.	kr./år	0	925.341	**-925.341**
Resultat af drift inkl. kapitalomkostninger	kr./år	2.714.000	2.147.341	**566.659**
Varme ab værk	MWh/år	9.920	9.920	–
Varmeproduktionspris inkl. kapitalomkostninger	kr./MWh	274	216	**57**
Varmebehov, standardhus	MWh/år	18,1	18,1	–
Ledningstab	%	27,7	27,7	–
Varmebehov, standardhus "ab værk"	MWh/år	25,03	25,03	–
Moms	%	25%	25%	–
Variable varmeudgifter inkl. moms, standardhus	**kr./år**	8.561	6.774	**1.788**



SmartReFlex Workshops

Design and planning

- 23 February

Technical

- 28-29 April im Wissenschaftszentrum Kiel
- Sign up to eki@ib-sh.de

Organisation and Financing

- 18 May **im** BNUR in Flintbek
- Sign up to eki@ib-sh.de

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4th International
Solar District Heating
Conference
21-22 September 2016, Billund, Denmark
www.solar-district-heating.eu

The fourth edition of the International Solar District Heating Conference will take place on 21 and 22 September 2016 in Europe's No.1 SDH market in Denmark.

More information on:

www.planenergi.dk
www.solar-district-heating.eu
www.smartreflex.eu

Morten Hofmeister, mh@planenergi.dk, 0045 2234 4703
Max Guddat, mgag@planenergi.dk, 0045 2386 2482

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