Appendix 6

Smart Grid potential analysis at Vorbasse Fritidscenter (in English)

ForskEL projekt nr. 10744

Project partners:

Smart Grid potential analysis at Vorbasse Fritids Center

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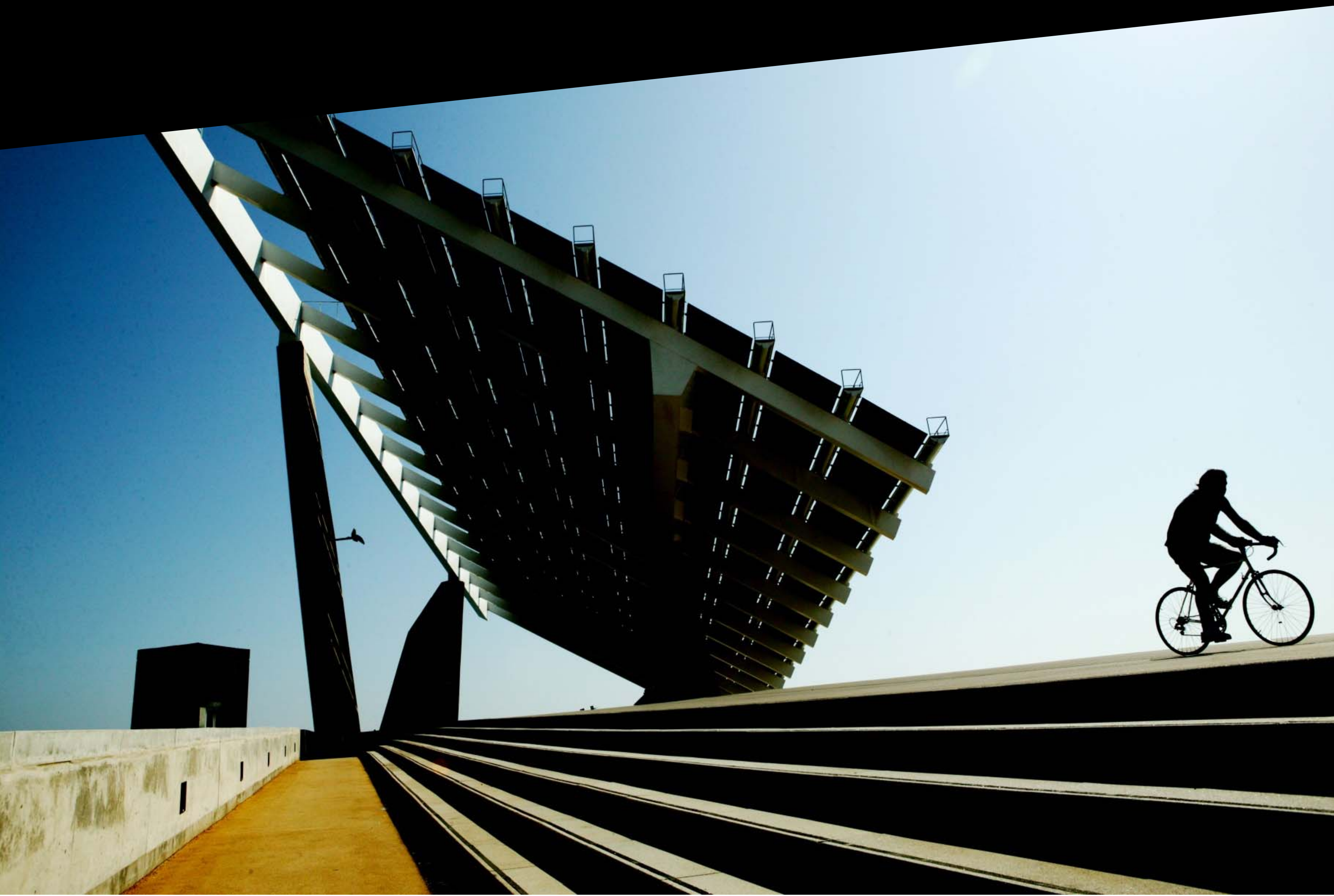

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1. Introduction

1.1 Abstract

Analysis of Smart Grid potential in a public institution as part of the DREAM phase 1 project.

By recommendation from Billund Municipality, the category of “public consumer” in the DREAM phase 1 project has been centered on a study of an activity center, Vorbasse Fritids Center (VFC) in the Municipality of Billund. The purpose of the study was to identify accessible flexibility within the center’s complex energy system and assess the potential to shift from NGAS to electric heat pump. The study concludes that in the current system, systems are energy optimized but there is almost no available flexibility potential. Some flexibility can be realized by installing Smart Grid Ready technologies such as a heat pump with a buffer system. The center’s current six gas-boilers are facing maintenance issues and the municipality has awaited the DREAM study before planning a refurbishment. The municipality is likely to choose a cheaper investment than a heat pump based solution with additional storage for flexibility.

1.2 DREAM background

The objective of DREAM is to find commercially viable solutions for rolling out Smart Grid to the majority of the electric installations with relative low energy consumption – like private houses, small industries and the public sector.

The background is the Danish strategy for changing all energy consumption to renewable sources in 2050 – primarily from electricity. Most of the electricity will have to come from fluctuating renewable sources with calls for much more flexible electric demand to absorb the renewable energy when available. The electric power system must change from ‘*consumption dependent production*’ to ‘*production dependent* *consumption*'. The change from fossil to electric energy supply will increase the load on both transmission and distribution grids and require new resources for balancing power and energy. Enabling electric consumers to act flexible depending on certain conditions is in this context referred to as 'Smart Grid'.

Smart Grid Ready is a very general term used in different ways around the World to describe an electric equipment that can be remotely managed. The DREAM projects view on Smart Grid Ready in Denmark is the ability to regulate electric load down (or up where feasible) by an external controller using existing open communications and control standards. Large energy consumers can often see a business case implementing dedicated Smart grid solutions and are therefore less dependent on product standards and standard products.

It is relevant that new equipment in kW-range in the electric distribution network (400V level) is Smart grid Ready. New electric loads that have Smart Grid control offers opportunities:

- The TSO can reduce or increase load to support grid stability.
- The customer can sell flexibility to aggregators.

A major challenge is that the Smart grid interface often adds up front cost to the products that cannot be fully offset by savings. Even though that Smart Grid may save some energy, its primary purpose is to create demand side flexibility.

There are three new types of electric equipment characterized by high continuous power > 1kW for hours that calls for smart grid management:

1. HP - Heat pumps – likely to substitute the phasing out of oil- and gas-boilers where installations are not allowed in new buildings from 2013 and existing from 2016[1].
2. EV - Electric Vehicles – likely to substitute most of the fossil fuel car fleet by 2050
3. DER – Distributed Energy Resources – E.g. PV system or other domestic energy production.

Other equipment in homes and buildings could be managed through Smart Grid Ready home automation systems. Typical home appliances use relatively little energy and for short periods only, so the cost – benefit of adding a Smart Grid interface alone for flexibility will be insignificant.

Outside the areas with collective heating systems like district heating or piped Ngas, oil burners have been the dominant heat source but as these wear out the heating source must change to a renewable energy source. Some will change to biomass boiler but it is expected that the majority will change to heat pumps if they can afford the up-front cost. The life of a heat pump installation is between 10 to 30 years, meaning that heat pumps installed now ought to match the future needs of the electric grid i.e. being Smart Grid Ready.

Even though the energy for a heat pump is cheaper than biomass many are forced or tempted to buy a biomass boiler that has a much lower up front cost. In many rural areas, it is very expensive to borrow money for house improvements.

This sets the scene for DREAM: How can Smart Grid be rolled out on a large scale?

1. People will only switch functioning equipment to new Smart grid Ready equipment if it pays off to do so (or if it is the law to do so)

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[1] http://www.ens.dk/sites/ens.dk/files/politik/dansk-klima-energipolitik/politiske-aftaler-paa-energiomraadet/energiaftalen-22-marts-2012/Aftale_22-03-2012_FINAL_ren.doc.pdf

2. If people are going to update/change their equipment anyway, they might be willing to buy Smart Grid ready equipment at a marginally higher price
   2.1. If it makes sense to them / is the right thing to do
   2.2. If they can earn back the extra cost in short time and
   2.3. If it will not influence their comfort negatively

DREAM Challenges:

a) Reduce the cost of Smart Grid Ready equipment compared to traditional equipment
   a. Standardized packages enable large volume purchase discount
   b. Use commercially available og proven SG Ready products
   c. Standardized packages simplify the installations – reducing installation cost
   d. Massive roll out in one geographic area at the time gives significant serial production savings potential and less management overhead
b) Find affordable financing models to mitigate higher up-front costs of new SG Ready solutions.
c) Analyse different customers' acceptance of standard package solutions (is a solution like the neighbour's to be OK?)
d) Analyse some relevant DSO- grids for possible consequences of a massive roll out in a limited geographic area.
e) Analyse SG potential in private, **public** and industries within the target area.

1.3 Smart Grid potential analysis at Vorbasse Fritids Center

The Municipality of Billund is partner in DREAM phase 1 and reviewed their own potential public buildings and institutions to find an interesting institution for further analysis in the DREAM phase 1 project. The integrated institution Vorbasse Fritids Center was suggested and chosen for the energy flexibility study.

Vorbasse Fritids Center (VFC) is an integrated institution with an indoor swimming facility, two large gyms, a fitness room, kindergarten, cafeteria and bathing/change facilities for two outdoor soccer fields. VFC is heated by NGAS and uses a lot of electric power for ventilations, pumps, light etc.

Figure 1: Vorbasse Fritid Center integrated sports facility and kindergarten can be seen left in the picture with surrounding areas and suggested potential areas for collecting thermal heat with a heat pump (the area far to the right beeing optional).

The purpose of this particular study was to identify any accessible major flexibility within the large energy consumption and assess the potential to shift from NGAS to electric heat pump.

An overview on the actual and historic energy consumption were compiled from monthly records of energy consumption from meters and networked climate controllers over the last 5 to 10 years. An overview over the gas and electricity consumption from 1997 to 2013 is shown in Figure 2: VFC Historic yearly energy consumption; Blue is NGAS [MWh] and Red is electricity [MWh]. The increase in energy match the extensions added to the institution and higher number of guests.
The analysis of the data were done with assistance from local caretakers with deep knowledge of the systems. It is obvious that the institution has a high energy consumption year round but nearly all the local air and water treatment systems is designed with focus on reducing energy consumption and best practice for the type of solutions. An overview over the yearly electricity consumption from 2009-2013 is shown in Figure 3: VCF Last 5 years electricity consumption per month. Only small sesonal variation; The lowest monthly consumption is 22.9 MWh.
When looking for possible new combinations of energy supply for such a complex institution it is important to have detailed information on energy consumption on an hourly basis. It is important to know both peak power demand and distribution day/night and weekdays /weekend. Unfortunately, no data was available with time resolution higher than month level. A primitive central logging by printing automatic reports every hour was initiated few weeks before the conclusion of this study. Converting the printed reports to electronic tables were done to some extent by the institution but fairly labor intense. Higher resolution data for a few weeks was not enough to establish a basis for any system optimization. The different scenarios discussed is therefore based on average energy consumption and general

experience which also means the economic comparisons are rough and showing tendencies rather than accurate figures.

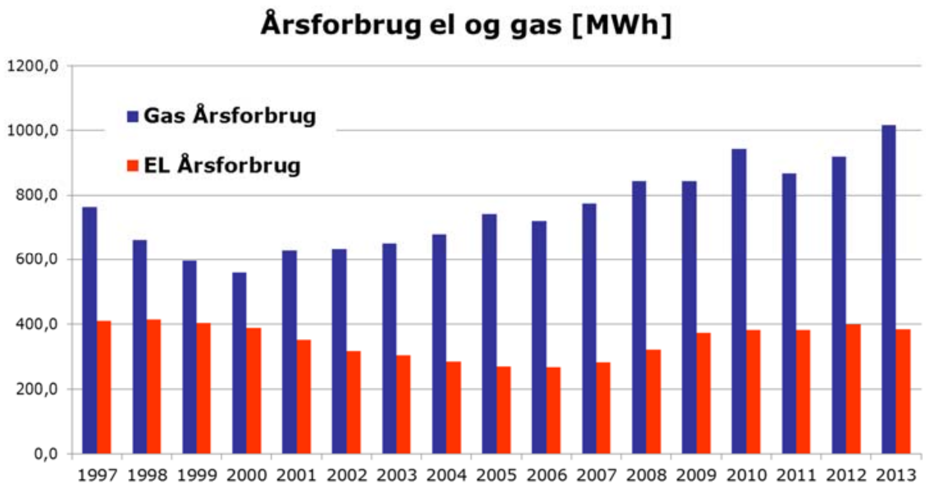


Figure 2: VFC Historic yearly energy consumption; Blue is NGAS [MWh] and Red is electricity [MWh]. The increase in energy match the extensions added to the institution and higher number of guests.

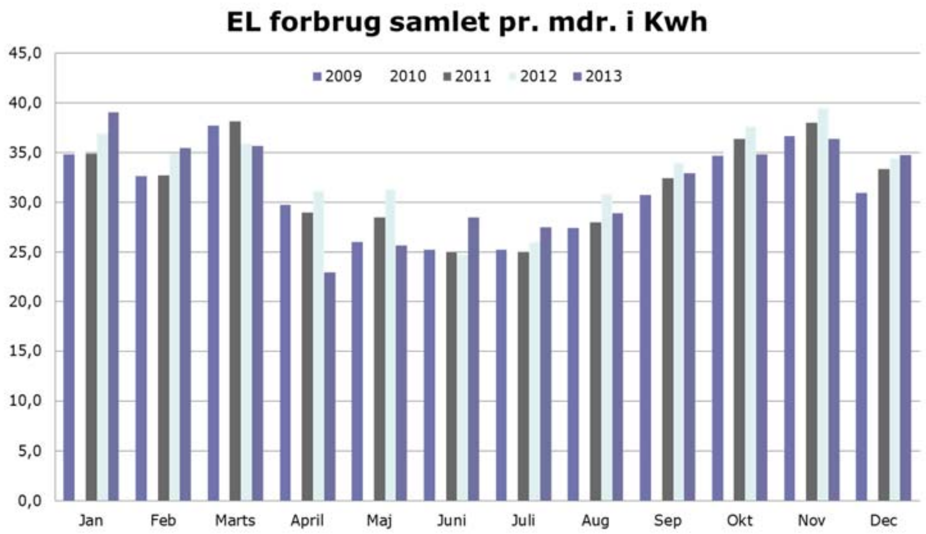


Figure 3: VCF Last 5 years electricity consumption per month. Only small sesonal variation; The lowest monthly consumption is 22.9 MWh.

The ventilation system of the swimming facility is seen in Figure 4: Schematic diagram of the air treatment system for the swimming hall. Notice the heat pipe based heat exchanger (right side), that recover much of the energy in the exhaust air. Unfortunately, the ventilation has to run around the clock year round to protect the buildings from aggressive vapors and humidity, so a buffersystem is needed in order to create some flexibility.

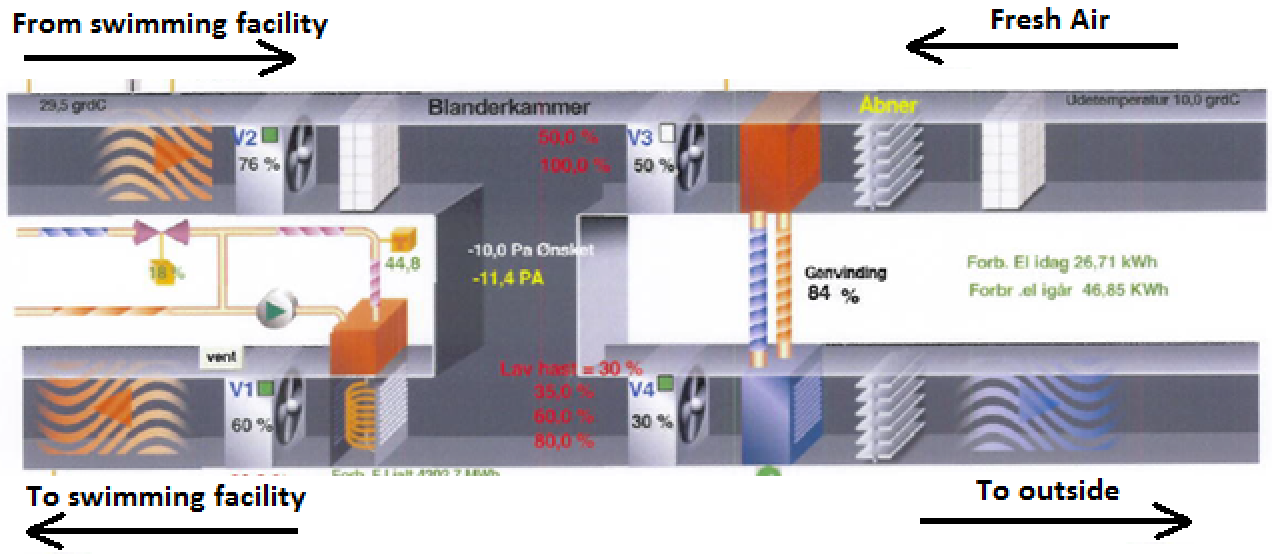


Figure 4: Schematic diagram of the air treatment system for the swimming hall. Notice the heat pipe based heat exchanger (right side), that recover much of the energy in the exhaust air.

A relative high energy waste was identified at the exhaust from the swimming facility. The exhaust air is heat exchanged with the intake air through a heat pipe but still holds considerable energy in form of very humid air at temperatures well over ambient.
Using a heat pump to further cool down and dry the exhaust air will recover enough energy for the 5-10 m3 hot tap water used every day- mainly for showers. Three examples of this heat recovery are shown in the I-X diagram of Figure 5: I-X diagram showing that cooling the axhaust air down. How much energy is recovered will depend on the final temperature and potential condensation of the water vapor in the exhaust air from the ventilation system. The I-X diagram is complicated and will not be explained in detail here, but the relative length of the red lines shows the potential of cooling the exhaust air further. The cooling of the exhaust air with the heat pipe currently installed follows line 1. Cooling the air further down to 20 ˚C releases more energy as indicated in line 2 but still no condensation of the water vapor contained in the exhaust air is happening. Both the heat pipe may transfer some of the heat and a heat pump may be installed to further cool down the air. If the exhaust air is cooled down to 10 ˚C the water vapor in the exhaust air is condensated and the amount of energy released is greater as indicated by line 3. Thus cooling down the exhaust air with a heat pump holds a great heating potential.

Calculations have shown that enough heat (and more) is available from the exhaust air to heat up the hot water consumed. Also the economy of installing a heat pump to utilize the residual heat in the exhaust air seems promising and cheaper than using gas boilers for the task.
Assuming a total cost of 250.000 kr for a heat pump producing hot water (1'st priority) and hot inlet air (2'nd priority), a payback time around 5 years may be expected based on >8000 active hours pr. Year.

Recoverable heat from the ventilation system is available during the day and night. The consumption of hot water does only occur during daytime and varies a lot. In order to recover the full amount of heat produced during the day and night, and make this available at another time of consumption in the form of hot water, a hot water storage tank of considerable size is needed. The current recently installed hot water tank is just over 1 m3 and are therefore not of sufficient size to utilize the full amount of heat available from the ventilation system. A larger hot water tank matching the daily consumption (around 5-10 m^3) is needed. This tank may be coupled to the already installed tank and the two tanks utilized through cascading (i.e. empty the tanks one at a time) between the two. This solution may save the investment compared to the alternative of installing one new big tank.

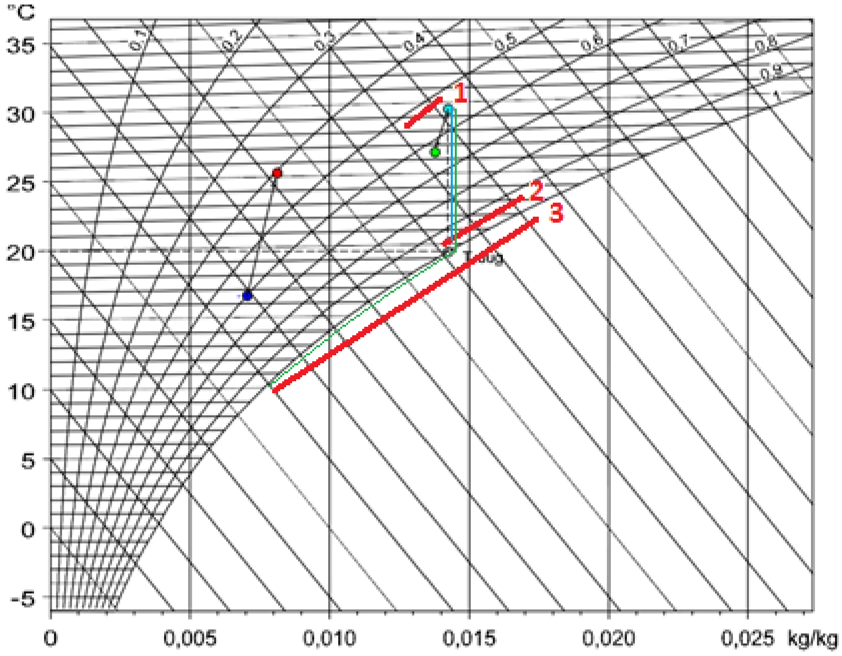


Figure 5: I-X diagram showing that cooling the axhaust air down. How much energy is recovered will depend on the final temperature and potential condensation of the water vapor in the exhaust air from the ventilation system.

Even though a lot of energy is exchanged around the swimming facility and the pool holds a huge amount of heat energy, there is no available flexibility in energy consumption. A very fine balance must be kept with comfort temperatures, pressure, humidity, and requirement for air exchange in a room with a large warm water surface evaporating water proportional to temperature and humidity. The climate system is considered by experts to be in the best league energy wise and working well. The same experts admit that the design criteria has been only safe operation and low energy consumption and this has been achieved by keeping all variation minimal all the time. There may be some energy flexibility available in the swimming facility but it will require research into new control algorithms. Water treatment systems cannot be stopped at any time due to health approval of the swimming facility.

This study looked at the possibility for exchanging the gas boilers with heat pumps. The possibility to lay out horizontal heat collectors (ground coils) were examined. According to “Den Lille Blå om Varmepumper” ground source coils are advised to be dimensioned according to the following:

- Maximum load of the ground: 40 kWh/m2 år
- Maximum load of the ground coil: 20 W/m (wet ground)
- Average load of the ground coil over the year: 6 W/m år
- Distance between the ground coils: at least 1 meter (normally 1,5 meter)
- Maximum cooling of the heat transfer fluid in the ground coil: 3 – 5 °C

Firstly, bullet 1 should be investigated to ensure enough space is available. The size of the two areas next to the institution (Figure 1: Vorbasse Fritid Center integrated sports facility and kindergarten can be seen left in the picture with surrounding areas and suggested potential areas for collecting thermal heat with a heat pump (the area far to the right beeing optional).) adds up to around 33000 m^2 which allows a maximum load from the ground of 1,3 GWh. Compared to the total average energy consumption pr. Year the area available is big enough for a ground source heat pump. The maximum capacity of the already

installed gas boilers are 240 kW.Bullet 2 tells that the maximum (advised) load of the ground should be under 660 kW. Enough space is therefore available to cope with the maximum load of the ground. Bullet 3 is also met.
There seems to be sufficient open area owned by the municipality around the institution for horizontal heat collectors in the ground. Many places in the area there is hardpan - a concrete hard mineral layer close to the top soil. This can make the placement of heat absorbers more expensive. A heat buffer would also be needed to give any of the flexibility desired for smart grid control. The heating systems in the institution is so conservative designed (good safety margins) that it seems possible to heat up circulating water to only 55°C. This is within the range where the heat pump is efficient.

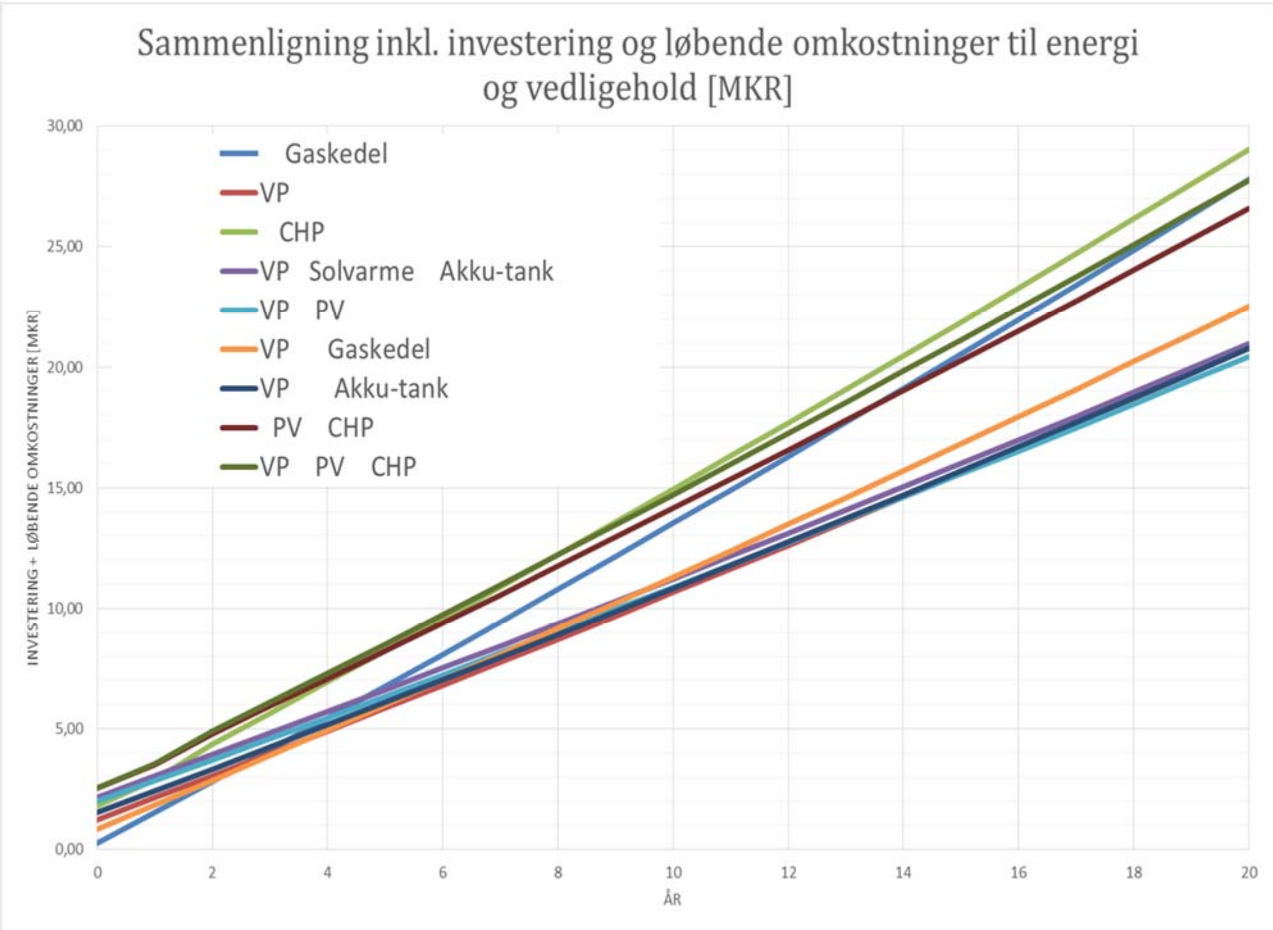


Figure 6: Cost comparison including investments, maintenance and operational expences on energy. [Mio DKK vs years]

A comparison was made between gas heating and heat pump heating, using current energy prices and taxes.
With a new gas boiler, 11.7kWh heat per Nm3 gas is realistic. With a NGAS price of 7.24 DKK/Nm3 the price on heat is: 0.62 DKK/kWh

With MiniCHP (Combined Heat and Power using a small genset with a gas engine close coupled to an electric generator), 3.3kWh electricity and 7.2kWh heat produced per Nm3. Assuming the electricity has a value of 1.5 DKK/kWh when all is consumed in the institution the heat price will be 0.32 DKK/kWh. The initial and maintenance cost for a gas engine is much higher than for a gas boiler. Therefore the CHP solution, when taking initial and maintenance cost into account, will not be economically competitive. Under the current tax regime and regulatory framework it is not attractive to sell electric energy from a genset to the grid. Acquiring and maintaining status as energy producer has a high premium and the electric energy from a NGAS fired genset has to be sold at normal market conditions for energy.

The heat price from a heat pump with a COP at 4 is 0.27 DKK/kWh assuming the following elements of the electricity price:

Electric energy: 0.30 DKK/kWh
Electricity transport local: 0.10 DKK/kWh
Electricity transmission national: 0.07 DKK/kWh
PSO: 0.18 DKK/kWh (assumed PSO tax reduction)
Electricity TAX (reduced for heating purpose): 0.42 DKK/kWh
Total per kWh: 1.07 DKK/kWh

Based on the price the most interesting scenarios could be:

1. Ground source heat pump
2. Ground source heat pump and PV[2]
3. Ground source heat pump and an accumulation tank
4. Ground source heat pump, Solar heating and an accumulation tank
5. Ground source heat pump and a gas-boiler

To zoom in on an optimal solution further analysis including peak load information and hour-by-hour consumption under cold conditions.

1.4 Flexibility predictability:

The value of flexibility is somewhat proportional to predictability of available flexibility. Reliable prediction of consumption may increase flexibility potential.

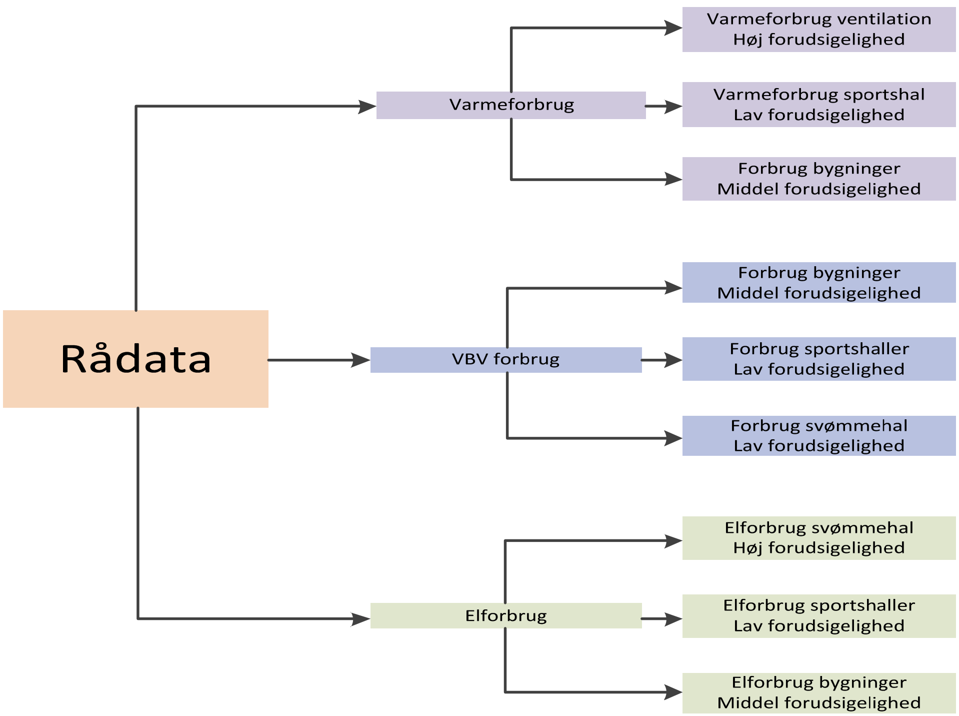


Figure 7: Overview of flexibility available.

[2] No obvious set-ups have been identified that would enable a higher selling price than the standard renewable flat rate.

In is shown an overview of the available flexibility at Vorbasse fritidscenter. It shows that the predictability of the various energy consumptions are different, but that some are more predictable and this may be exploited to lower the energy consumption through demand response.
Figure 7 shows the reservation calendar for Vorbasse Fritidscenter. Automatic proactive energy planning based on this calendar may help lower some of the energy consumption shown in Figure 1 with the highest predictability.

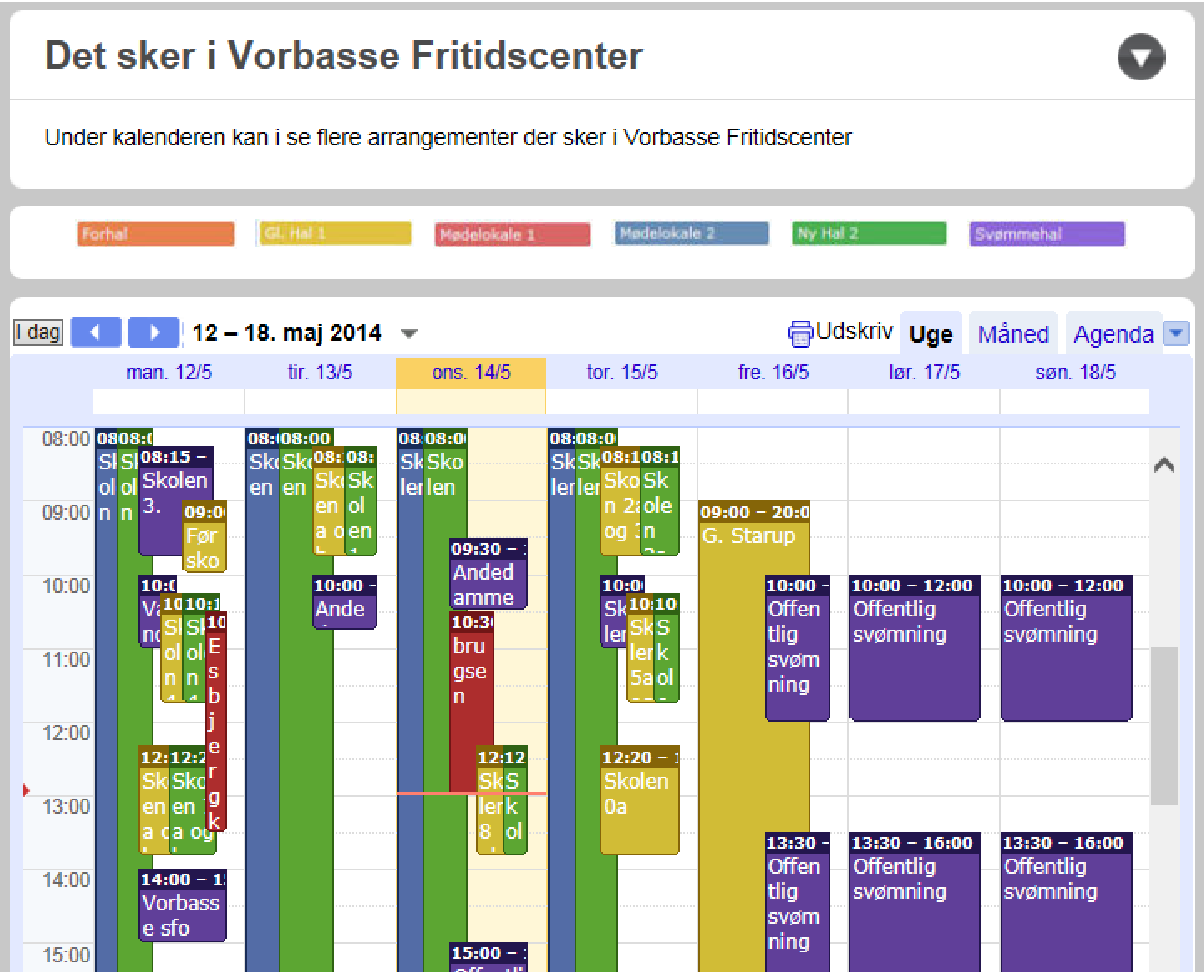


Figure 8: Proactive energy planning based on the on-line reservation calendar for the institution might enable some flexibility for Smart Grid.

2. Conclusion

1. Using heat pump technology the heating of the institution can technically and economically be switched from Ngas to electricity.
2. In spite of the high energy consumption year round, mainly for the swimming facility, the fine balance needed to maintain good comfort, safe environment and long life for the swimming hall building is critical.
   2.1. There is therefore nearly no available flexibility in the current system.
   2.2. Exploiting any flexibility will require a major upgrade to the different CTS-systems (building automation), to automatically compile status data and assess flexibility for intelligent interaction with Smart grid control.

2.3. Apart from the gas-boilers, the current system is in good condition and no major maintenance is planned in near or medium future.
2.4. There is an energy saving potential at the exhaust air from the swimming hall. Both residual heat and condensation heat from humidity can be recovered using a heat pump.
2.4.1. The heating system is designed very conservative with good design margins. The heating surface in the ventilation system need only be 55°C to heat the air which is a suitable temperature for a heat pump.
2.4.2. A cost – benefit analysis will be needed to estimate the optimal time for upgrading the air treatment system with a heat pump, since no major renovation is foreseen currently.
2.5. Looking at different energy scenarios of sourcing the energy for the institution, the heat pump comes up in all the best business cases. A ground source heat pump alone or in combination with another renewable source or in combination with top-up gas boilers for cold winter conditions.
2.6. The business case for CHP suffer from high investment and operational cost.
2.7. In the case of an electric based heat producing system (i.e. a heat pump) energy flexibility can be enabled by adding buffer systems.
2.7.1. The average hot water consumption for bathing etc. is four times the size of a new hot water tank installed recently. By increasing the hot water tank size to at least hold an average days consumption the heat production can be shifted to off-peak hours and a heat pump in the exhaust air has a reservoir to fill excessive heat into.
2.7.2. To enable some flexibility with a ground source heat pump based system a heat accumulation tank will be needed. To decouple two hours heat in daytime a tank around 41 m^3 may be needed. This means that the constant need of heat to the swimming facility can still be supplied while the production of the heat is shifted to hours with cheaper electricity.
2.8. Switching from fossil Ngas to electric powered heat pump seems economical attractive and will help shift the Danish energy consumption on to electricity as requested by the politicians and experts. Switching to all electric power supply will make the institution less sensitive to politically influenced fluctuations in international energy prices.
2.9. The study showed that a larger hot water tank would enable flexibility to be introduced into the system. The introduction of this larger tank is interesting in connection with the introduction of renewable technologies and by the hour variable energy prices.
2.10. The study showed that the energy consumption in connection with the flushing tanks was negligible from a flexibility point of view.

3. The possibility to find flexibility decreases if the energy system already has been optimized.
3.1. Flexibility needs to be implemented during the design phase.
3.2. The standard operating parameters under which the swimming facility is kept may be changed and hereby achieve flexibility. However changing these conditions may cause problems to the building. The decision to change these operating parameters needs to be based on research into the consequences and how these may be dealt with.

Recommendations

1. Proactive energy planning based on the on-line reservation calendar for the institution (calendar is shown in Figure 8. This should have potential for planning both energy saving and energy buffering with minimal comfort trade off.
2. Increased hot water tank to hold at least an average days consumption, produced outside peak load hours.
3. Heat pump harvesting residual energy in the swimming hall exhaust. The heat can be used primarily for heating the intake air and secondarily for heating hot water and heating in other parts of the institution.

4. Ground source Heat Pump absorbing heat from the outdoor areas around the institution. There are different possible combinations but a good hybrid solution could be a ground source heat pump with a continuous heating capacity covering 50% of the winter peak requirement combined with gas boilers to top up during the coldest season. This will reduce the needed investment for the heat pump system, both for the heat pump size and the need for digging around the institution. An important additional benefit will be the more reliable heat supply by independent redundant systems.
5. Additional to recommended idea 4 a heat accumulation tank placed next to the heating central at the institution could increase the flexibility and provide means for Smart Grid control.

3. Enclosure 1 – Power Point presentation.

TEKNOLOGISK INSTITUT

DREAM

Danish Renewable Energy Aligned Market

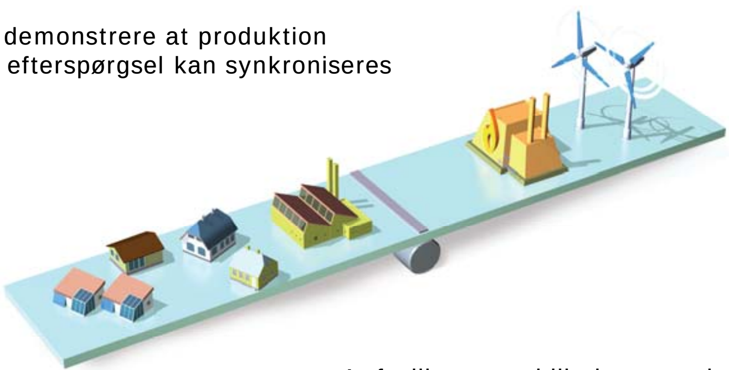
Fase 1 – fleksibilitetsstudie Vorbasse Fritids Center

Vi arbejder for tidlig kommerciel udrulning af Smart Grid løsninger

DREAM

Overordnet mål

At demonstrere at produktion og efterspørgsel kan synkroniseres



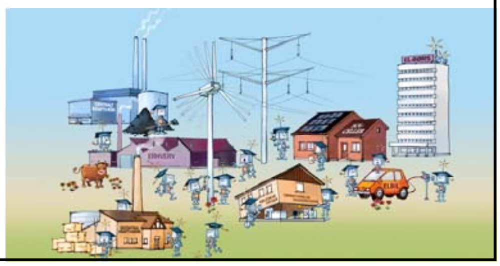
At facilitere en tidlig kommerciel udrulning af Smart Grid løsninger

DREAM

Hvordan opnås dette mål?

DREAM arbejder i spillerummet mellem teknik, økonomi og brugeradfærd:

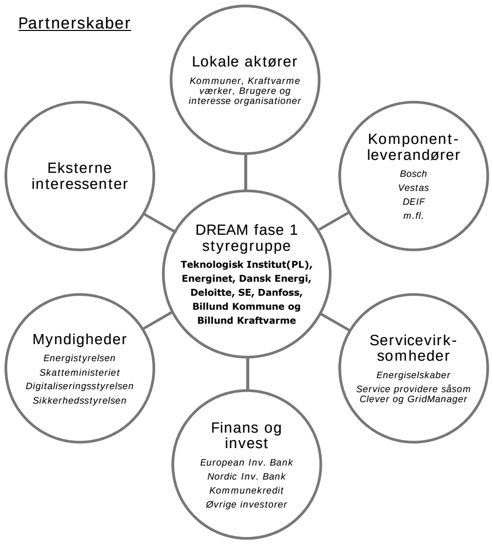
- Teknik: Smart Grid teknologier og styringssystemer
- Økonomi: Finansieringsmodeller og business cases
- Brugeradfærd: Antropologiske metoder og brugerinvolvering



DREAM

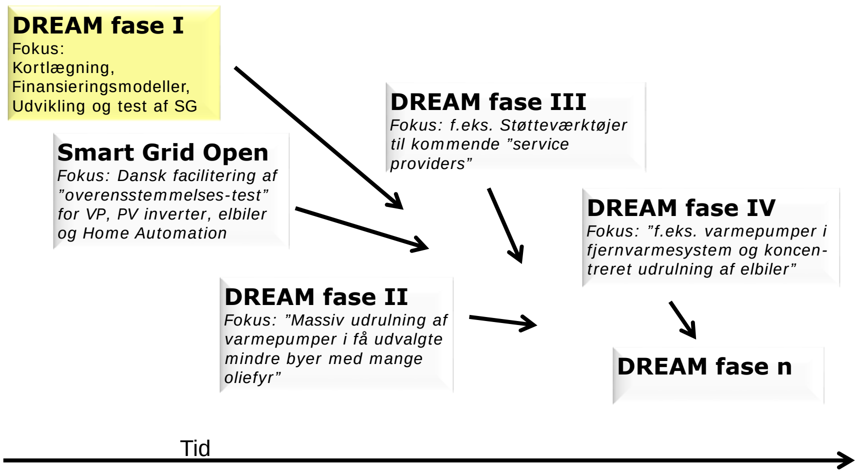
DREAM fase 1

- Identifikation af potentielle testområder
- Analyse: El-net, tilgængelig fleksibilitet, forbrugsmønstre, finansieringsmodeller, teknologimodenhed, implementeringsdesign og for nye kommercielle aktører
- Sætter rammerne for massiv udrulning i kommende faser
- Gennem formidling og vidensudveksling initieres kommende partnerskaber



DREAM

DREAM – et projekt i flere faser



DREAM

Formål med mødet

- Præsentation af arbejdet siden sidst
- Præsentation af nogle forskellige scenarier
- Findings
- Reaktion
- Videre forløb

Forbehold

- Bemærk at der er tale om et forstudie rettet mod DREAM projektet.
- Dette studie er primært baseret på oplysninger på grove data (eksempelvis forbrugsoplysninger på års og måneds niveau)
- Løsningsmuligheder er baseret på vurderinger og størrelsesordner, og må ikke anvendes som dimensioneringsgrundlag uden grundig verificering med bekræftede data fra leverandører og specialister.

DREAM

Formål med projektet

- Projektet søger fleksibilitet i forhold til elnettet.
- Omstilling fra fossil energi til bæredygtig energi er et af grundlagene.
- Værktøjerne skal ned i værktøjskassen
- Opbygge en robust triple helix model:
  - Økonomiske modeller
  - Bruger involvering
  - Teknologiske løsninger der faciliterer fleksibilitet

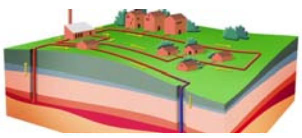
DREAM

Danish Energy Goals:

2035: Electricity and heating must be based on Renewables only.

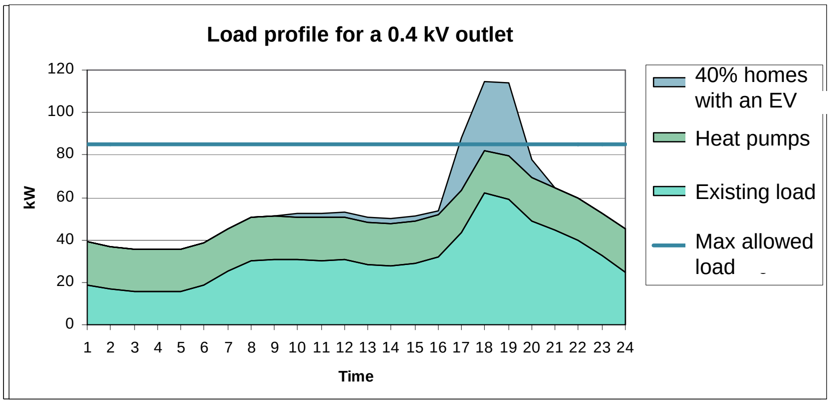
2050: The Danish energy system must be fossil free.



DREAM

Elektricitetsforbrug

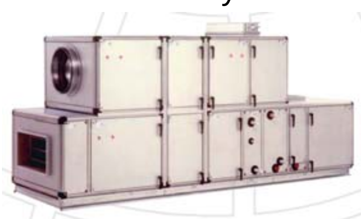


iPower

Eksempler på erhverv

DREAM

ventilationssystemer



Kølesystemer og varmepumper

Pumper, etc.

Supermarkeder

iPower

DREAM

Calculation example from iPower showing that Smart Grid can postpone investment in distribution grid reinforcement.

0.4 kV substation outlet with 48 houses
No reinforcement of the grid
Cold Christmas evening

- Business as usual: black out limit at 12 heat pumps
- Smart grid: black out limit at 24 heat pumps

DREAM

Eksempler på mulig fleksibilitet

150 m² villa	Δt [K]	Muligt varme lager [kWh]	Varmetabs-koefficient UA ved t_a -12°C [kW]	Mulig tids-forskydning [timer]
Medium termisk masse: 80 Wh/m²K	2	24	70'ies: 12 BR08: 7 BR10: 6 2020: 2,5	2 3.4 4 9.6
Høj termisk masse: 120 Wh/m²K	2	36	70'ies: 12 BR08: 7 BR10: 6 2020: 2,5	3 5.1 6 14.4
+ tungt gulv med varme	2-4	60?	70'ies: 12 BR08: 7 BR10: 6 2020: 2,5	5 8.6 10 24

Varmt brugsvands tank	Δt [K]	Muligt varme lager [kWh]
200 l (60°C til 45°C)	15	3,4
5000 l (60°C til 45°C)	15	87,5

DREAM

Reaktion alene på nettets øjeblikkelige udfordringer, kan betyde:

- Øget varme tab
- reduceret COP
- ekstra slidtage på varmepumpen
- elektroniske termostater nødvendige
- Større variation i indendørsklimaet

behov for forudsigelse af energibehov

A.3 Recommended indoor temperatures for energy calculations

Table A.3 — Temperature ranges for hourly calculation of cooling and heating energy in three categories of indoor environment

Type of building or space	Category	Temperature range for heating, °C Clothing ~ 1,0 clo	Temperature range for cooling, °C Clothing ~ 0,5 clo
Residential buildings, living spaces (bed room's living rooms etc.) Sedentary activity ~1,2 met	I	21,0 -25,0	23,5 - 25,5
	II	**20,0-25,0**	**23,0 - 26,0**
	III	18,0- 25,0	22,0 - 27,0
Residential buildings, other spaces (kitchens, storages etc.) Standing-walking activity ~1,5 met	I	18,0-25,0	
	II	**16,0-25,0**	
	III	14,0-25,0	

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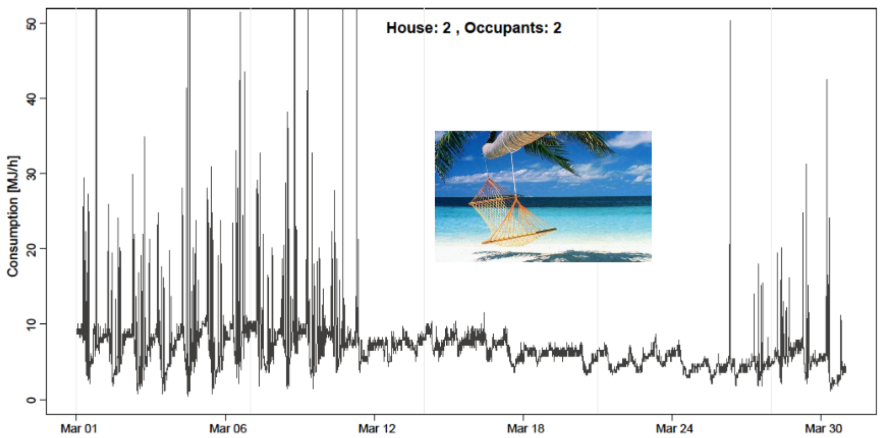
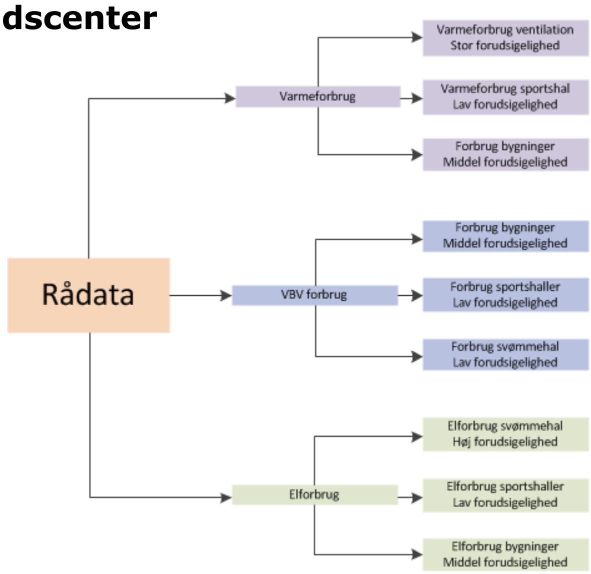
DREAM

Forudsigelse af energibehov – Adfærd kan være svær at forudsige



DREAM

Forudsigelse af energibehov - Fritidscenter



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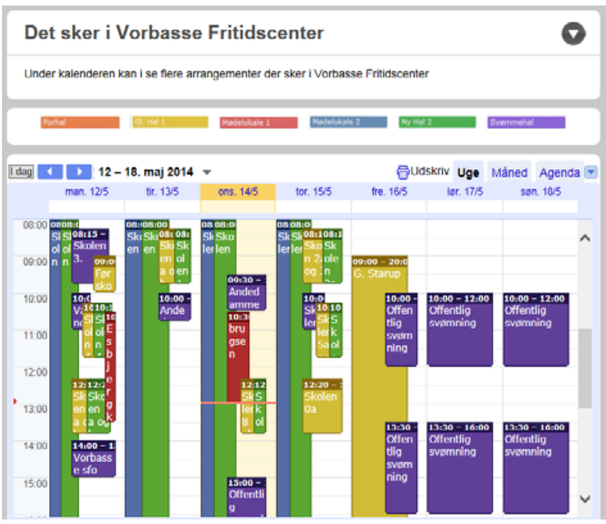
Adfærdsforudsigelse – er kalenderen troværdig?

- Teoretisk burde centerets kalender kunne udnyttes til at tillade større fleksibilitet i energibehov.
- Anvendelse af kalender til energiplanlægning er endnu ikke særligt udbredt, og slet ikke i forbindelse med Smart Grid.



DREAM

Spørgsmål 1. april 2014

1. Findes der timebaseret energimålinger? Kun fra få uger i et varmt forår, men kun i printet form.
2. Hvornår ligger varmtvandsforbruget? Er der højt forbrug om morgenen der muliggør at akkumulere før åbning? Fremgår af timemålinger, men der forlægger kun information fra en periode hvor svømmeholdene er delvis stoppet (reduceret på grund af sæson).
3. Natsænkning? Hvordan benyttes dette? Dette benyttes ikke.
4. Er der i bygningerne noget kølebehov? Nej, bortset fra et mindre kølerum og fritstående køle fryseskabe i cafeteria, men i forhold til begrænset potentiale og ejerforhold ses bort fra dette.
5. Hvorfor blev kedlerne skiftet i 2003 og 2004? Dette kan ikke ses på forbruget… Første skift til én stor kedel, derefter skift til 6 mindre kedler, som man håbede ville give en bedre økonomi.
6. Ventilationsanlægget i svømmehallen: John, Ole, Anne og Karl fra TI Svømmebadsteknik har suppleret med information. Ventilationsanlægget fungerer overordnet effektivitet. Affugtningen foretages med friskluft og varme genvindes.
   a) Hvad skal serviceres og hvor ofte? Ej relevat.

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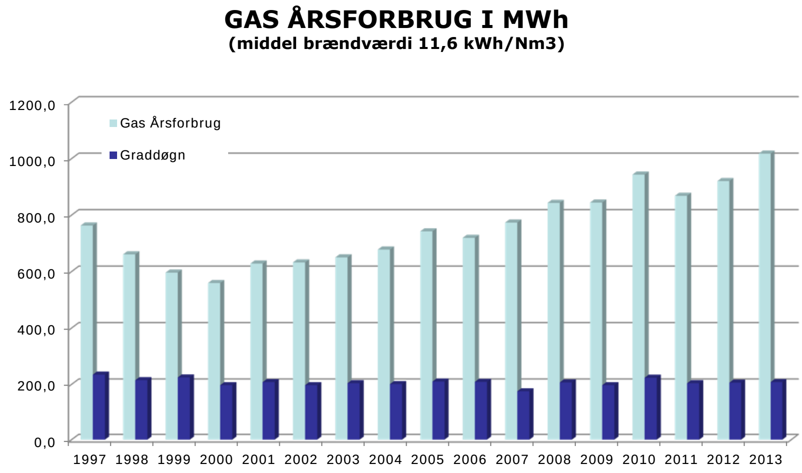
Spørgsmål 1. april 2014

7. Hvad er prisen pr. kWh el til de forskellige afdelinger? Hvilke afgifter er de pålagt? Hvilke afregningsstrukturer? Kun mulig afgiftreduktion ved elopvarmning.
   a) Er varmeforbruget til ventilationen i svømmehallen afgiftsbelagt som procesvarme? Nej – Skattevæsen accepterer pt. ikke svømmebad som proces. Er muligheden for variabel tidstarif blevet undersøgt? Nej.
8. Er der potentiale for jordvarme? Kan sportspladsen benyttes til jordvarme slanger? Ja
9. Hvorledes ser jordbundsforholdene ud? Tør sand med et markant lag al overalt i varierende dybde.
10. Er solvarme blevet overvejet? Ingen information

DREAM

Energiforbrug - historisk



- Varmeproduktion har kun meget svag sammenhæng med klimatisk varmebehov

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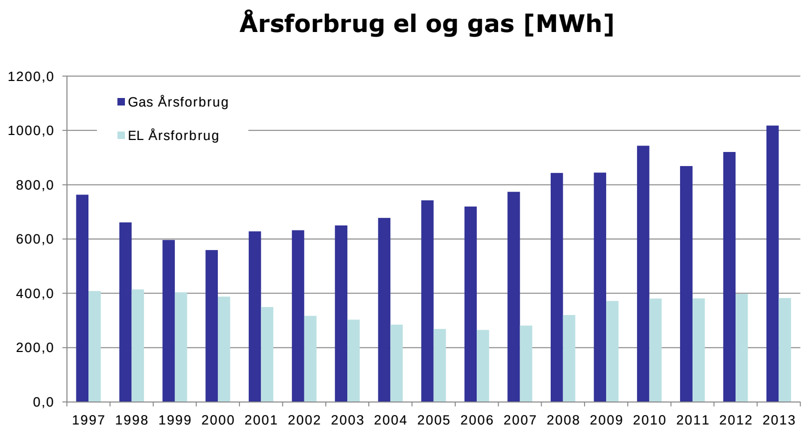
Varmeforbrug betydelig større end elforbrug.



- Varmeproduktion varierer forholdsvis mere end elforbrug i 2010 til 2013

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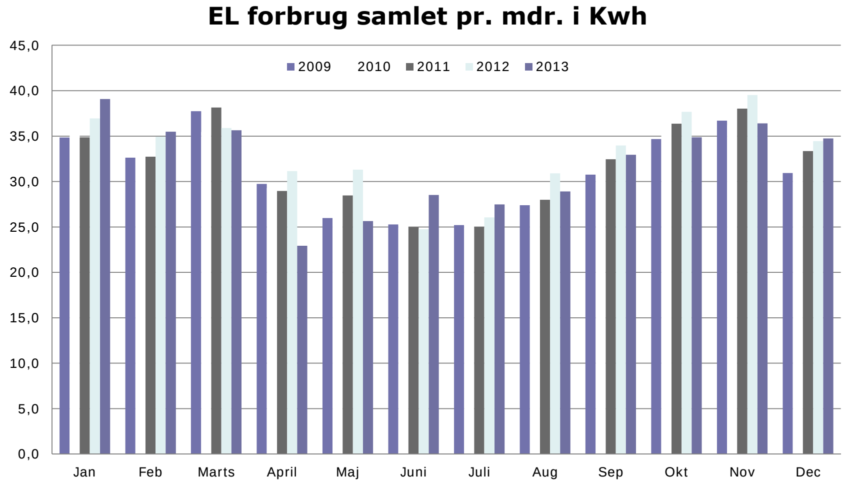
Elforbrug



Kun et svagt sæsonudsving i elforbruget – mindste månedsforbrug: 22,9 MWh

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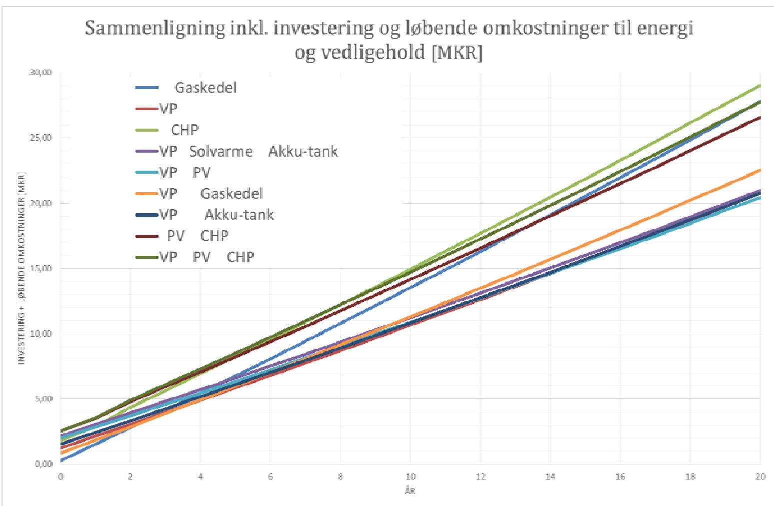
Anbefalinger



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Driftomkostningerne peger meget entydigt på omstilling af varmeproduktion fra gas til el.

De mest interessante scenarier er derfor følgende:

1. Varmepumpe
2. Varmepumpe og PV (solceller)
3. Varmepumpe og akkumuleringstank
4. Varmepumpe, solvarme og akkumuleringstank
5. Varmepumpe og gaskedel

Der er endvidere en fremtidssikring i at konvertere fra gas til el – mindre følsomhed overfor politisk påvirkning af europæiske gaspriser.

DREAM

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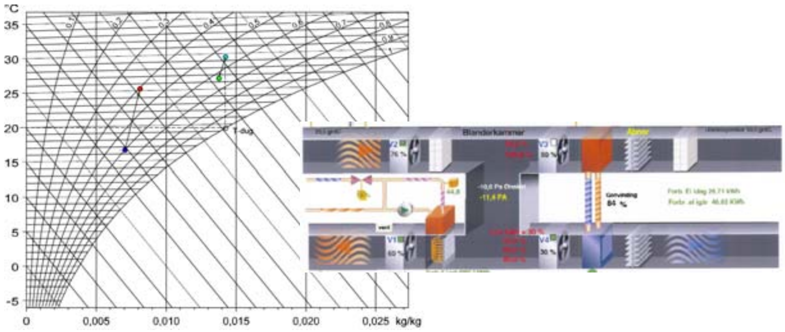
CHP

- Investeringsomkostningen er stor sammenlignet med konkurrende teknologier
- Løbende driftsomkostninger er høje
- For hver 6000-8500 driftstimer skal der skiftes olie og oliefilter.
- Der kan tegnes udvidet fastpris vedligeholdelse som udvider garanti men øger årlig omkostning.
- Fremtidssikring OK – kan omstilles til biogas. Skal dog dimensioneres anderledes da biogas giver færre kW.
- CHP reguleres normalt alene ud fra el-forbrug og kan kun erstatte gasfyr, såfremt anlægget er i kombination med gasfyr eller varmepumpe.
- Den forventede afgiftsreduktion for el benyttet til rumopvarmning gør endvidere regnskabet mere fordelagtigt for varmepumpen.

DREAM

Brugsvandsvarmepumpe i ventilationsanlægget til svømmehallen

- Der udblæses en stor mængde luft til "fuglene" ved en relativ høj temperatur og luftfugtighed



- En varmepumpe kan indsættes i ventilationen og udnytte denne afkastluft

DREAM

Konlusion 1

1. Centeret kan omstilles fra Ngas til opvarmning med el via varmepumpe
2. Der blev ikke fundet så meget energi fleksibilitet som håbet
3. Der blev konstateret at energibalancen og luftbehandling i svømmebadet er kritisk og at ventilationsanlægget er velfungerende i forhold til de tekniske krav.
    1. Hedeflade i svømmebadsventilationsanlæg er så konservativt dimensioneret, at varmefremløbstemperatur op til 55°C er tilstrækkeligt = jord til vand varmepumpe installation mulig.
    2. Et betydeligt energitab i afkastluft fra svømmebad kan hentes med en varmepumpe, der afleverer varme til indblæsningsluft og til varmt brugsvandstank. Kan overvejes i forbindelse med fremtidig renovering af ventilationsanlæg.
4. Akkumuleringsmuligheder.
    1. Ny eksisterende varmtvandstank på 1,5m3 giver lille buffer – burde nærmere være 7 m3 for at kunne afkoble forbrug og produktion på døgnbasis.
    2. Skylletanke 10 + 3 m3; vurderes at have ubetydelig effekt, men skylning bør foregå om natten.
    3. Der foreslås en ny akkumuleringstank på 65m3 til at afkoble 2 timers dagvarme vinter for hele fritidscenteret.

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Konlusion 2

1. Varmepumpe vs, gas vs miniCHP falder ud til varmepumpens fordel, på grund af lavere driftsomkostninger til hhv. el og vedligeholdelse.
2. Man er nødt til at introducere akkumulering for at opnå fleksibilitet.
3. I forbindelse med fritidscentret har det vist sig at omstillingen fra fossil brændsel (naturgas) er økonomisk bæredygtig.

DREAM

Observationer og overvejelser

Sømmebadet viser sig ikke at have så meget energi fleksibilitet som håbet.

1. Der blev konstateret at energibalancen og luftbehandling i svømmebadet er kritisk – der skal holdes et konstant undertryk i svømme hallen for at beskytte bygningen mod fugt og klordampe.
2. Temperaturen holdes konstant for at balancere fordampning og luftfugtighed.
3. Ventilationsanlægget er velfungerende i forhold til de tekniske krav.
    1. Hedeflade i svømmebadsventilationsanlæg er så konservativt dimensioneret, at det vurderes tilstrækkeligt med en varmefremløbstemperatur op til 55°C
    2. Dette giver mulighed for at varme produceres med en jord til vand varmepumpe installation.
4. Der er et betydeligt energitab i afkastluft fra svømmebad, som kan hentes med en varmepumpe, der køler luften til f.eks. ca. 10°C.
    1. Da ventilationsanlægget kører konstant skal varmen enten anvendes direkte til opvarmning af indblæsningsluft eller kunne afleveres i en buffer – hvor en stor tank til varmt brugsvand er oplagt.

Op-/ned-regulering kan kræve en udvidelse af CTS anlægget.

DREAM

Næste skridt?

- Analyse af Vorbasse Fritidscenter har vist sig meget relevant i DREAM sammenhæng
    - Centeret kan omstilles til opvarmning med el via varmepumpe.
    - Der kan indbygges nogen flexibilitet.
    - Der er energibesparelsesmuligheder, som kan være med til at finansiere flexibilitet.
- En separat ansøgning med fokus på Vorbasse Fritidscenter kunne være en mulighed der er værd at overveje
- Det vil kræve mere aanalyse-arbejde at få det fulde potentiale kvantificeret og kvalificeret
- Indtil nu er svømmebad generelt blevet udviklet med henblik på lavt energiforbrug og høj bygningsmæssig sikkerhed. At svømmehaller også kan udvikles med henblik på fleksibilitet med økonomisk gevinst for øje er nyt. TI's specialister indenfor varmepumper, svømmebadsteknologi, ventilation, etc. er klar til at indgå i en dialog målrettet dette.