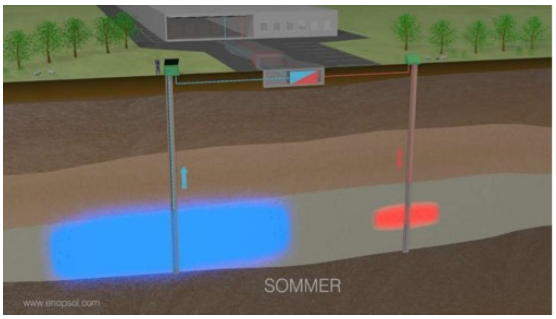
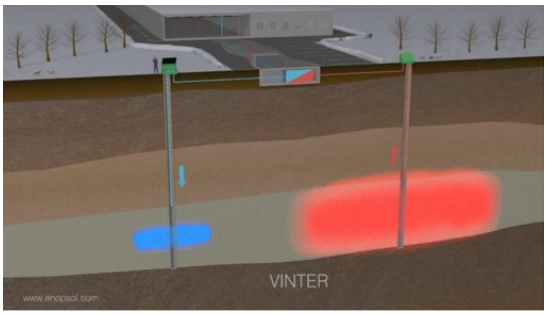
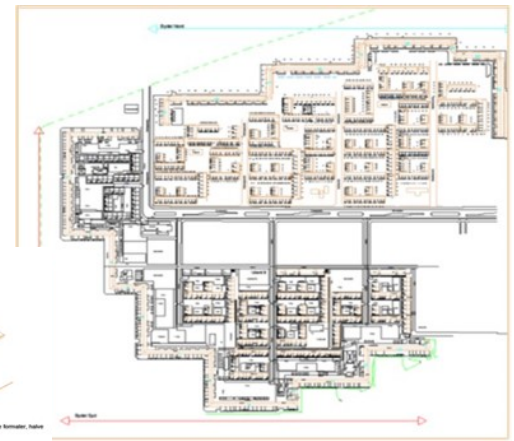
Smart Energy Green Cities, Annex



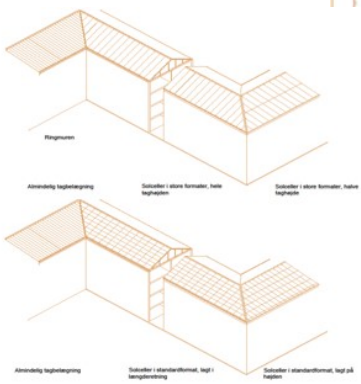














Slutrapport, Juni 2021
Energi- Forsynings- og Klimaministeriets
Smart Energy pulje, J. nr. 2018 – 2119
Peder Vejsig Pedersen, European Green Cities

EUROPEAN GREEN CITIES

Annex

Smart Energy Green Cities projektet.

Annex 01:	Smart Energy Design Guidelines for CO2 neutral city development
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Annex 04	BIPV: Powering the European Green deal
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Smart Energy Design Guidelines for CO_2 neutral city development

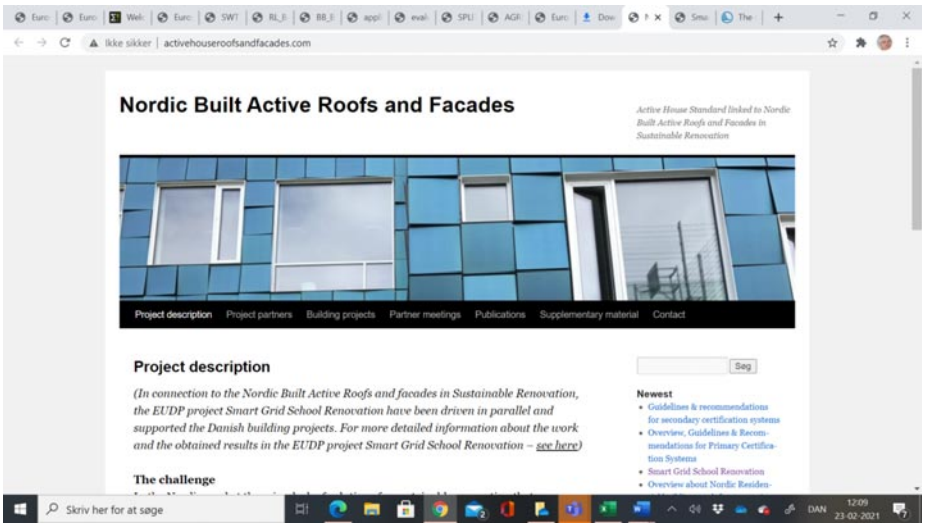
Peder Vejsig Pedersen from European Green Cities describes a CO_2 neutral city development based on Smart Energy Design Guidelines

For more than 15 years, European Green Cities has been the secretariat of the Danish Association of Sustainable Cities and Buildings, FBBB, with 18 Danish cities as well as housing associations and consultants as members. And in connection to this and the realised "Nordic Built Active Roofs and Facades" project, it has been possible to realise the sustainable building database, (also in English) with documentation of best practice building projects, which combine a focus on low energy design with the use of renewable energy solutions, and also with a view to "performance documentation". Here, there was also ongoing cooperation with the international "Active House Alliance". And an outstanding result of this was the best practice BIPV demonstration project for the Copenhagen International School, CIS, which is also presented in the mentioned database, including the practical result of an online Active House Radar showing the development in continuous qualities concerning Energy, Comfort and Sustainability. This led to the international Active House Award in 2018.

Developing CO_2 neutral communities

Since then, there has been made work on how to develop and model CO_2 neutral communities practically within the Smart Energy Green Cities project coordinated by European Green Cities. Here, cooperation has been made with four different city areas in Denmark on how to optimise the energy supply system, f.ex with the electrification of district heating systems in combination with BIPV and PVT systems, also working with ATES systems in communities (Aquifer Thermal Energy Storage). A very interesting recent demonstration project concerning this is the use of ground water-based cooling for Bispebjerg Hospital in Copenhagen, where a 90% saving of electricity for cooling was obtained together with a 60% district heating saving with the help of large heat pumps using the heated groundwater. See latest news here.

And at present, several Smart Energy systems are being developed as part of the Avedøre Green City cooperation, both for Avedøre Stationsby which has 2,000 apartments in concrete housing blocks from the 1960s, which will be renovated and for Avedøre Village, where in both cases, low-temperature district heating with ATES will be combined with PVT-systems, to obtain an aimed at CO_2 neutral city design. See here.



Activehouseroofsandfacades website. See the latest news on our European 'Smart Energy Design Guidelines' initiative here

As a special challenge concerning the use of BIPV in cities, we have seen that it is very important, as part of models for "performance documentation", to include detailed documentation work concerning LCA and EPD's for the used BIPV technologies. If you only use generic values, there will be a very limited effect on sustainable building certification (with DGNB, LEED or the Nordic Swan label).

When you look at the heating market in Denmark, where more than 60% involves use of district heating, the main energy source today is biomass, and unfortunately not always based on sustainable sources, since f.ex city areas like the Larger Copenhagen region is dependant on large imports of wood pills from foreign countries. This is a better choise than the former use of imported coal, but still not an acceptable solution for the future.

And if you look at the general situation in Denmark with respect to meeting the needed and agreed CO_2 emmission reductions in connection to the energy supply, there are clear visions on how to provide centrally produced renewable energy solutions by help of large offshore windmill parks and similar solar parks in the country site, for the common electricity system.

But when it comes to visions on how to incorporate locally produced renewable energy, there is, like in most other places in Europe not such a clear strategy.

This is despite the fact that it is very important to secure a local involvement, when you want to obtain a zero CO_2 emmission society in practice. An aim to introduce local renewable energy solutions will at the same time support reduced connection and transmission costs, while it also reduces energy system losses and provides a better energy supply security.

To ensure a more successful introduction of local renewable energy solutions in practice, it is the vision of European Green Cities, www.europeangreencities.com to create a partnership to develop actual CO_2 neutral communities, based upon an agreed toolbook, in connection to what we define as "Smart Energy Design Guidelines".

From a European perspective it is important to note that the European Green Cities organisation, has had a long term cooperation with the SIR organisation from Salzburg in Austria, since they were partners in a large European targeted demonstration project that started in 1996. And from 2007 both organisations were also partners in the EU Concerto large scale demonstration project, "Green Solar Cities" for a 6 year period, focussing on Copenhagen and Salzburg. See here.

From this cooperation it has been clear, that when you look at how to incorporate local renewable energy solutions, the situation in the Salzburg region has led to a special focus on how to utilise the large amounts of local biomass ressources in a sustainable way, and then combine this with use of solar thermal heating, often in combination with local district heating networks. At the same time the focus on using PV systems has untill recently only been limited, due to the available large hydro power resources in Austria. It can also be noted that use of new and innovative technologies have emerged, like f.ex the "Voll Solar" concept, which combines a high solar thermal contribution with an electrical based backup in a cost effective way, a little like what have also been seen in Norway, where large hydro power resources are also available.

European Green Cities

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From European Green Cities to the proposed Carbon Zero Digital Platform

Chairman of the board and partner Peder Vejsig Pedersen explores the evolution of the European Green Cities in 1996 to the proposed Carbon Zero Digital Platform in 2021

Based on a number of successful and innovative EU supported solar low energy housing demonstration projects realised in Denmark from 1990 to 1993, Peder Vejsig Pedersen and his company Cenergia took the initiative to organize the European Housing Ecology Network in 1992, which until 1998 realised 9 solar low energy demonstration projects in 7 EU member states.

And as a follow up on this a new European Ecobuilding initiative was realised also involving Solarplan in 1996 by joining 9 European cities into the European Green Cities cooperation, which realised local solar low energy demonstration projects until year 2000. Here Green Cities were an agronym for: Global Renewable Energy and Environmental optimised Neigbourhoods and Cities.

In Denmark it was the city of Copenhagen that was the partner city working with large scale urban renewal at Vesterbro. Together with a number of other initiatives to integrate PV technologies in buildings, also with local RTD support in Denmark, a large number of demonstration projects were created until year 2001, where also the BIPV plan for Valby in Copenhagen had been created in a cooperation with the Urban Renewal Copenhagen company and the city of Copenhagen.

After 2001 the participation in a large European project on BIPV, "Resurgence" secured the continuation of BIPV development and demonstration work, also in a new cooperation with the city of Copenhagen, where the Solar City Copenhagen association was established, and where it was also possible for Peder Vejsig Pedersen and Cenergia to secure funding for the unique demonstration of the CO_2 neutral rooftop apartment, SOLTAG in a cooperation which also involved the VELUX company and Urban Renewal Copenhagen together with architect maa. Martin Rubow.

And from 2007 Peder Vejsig Pedersen made a new initiative together with the now established nonprofit company European Green Cities and Urban Renewal Copenhagen which now was a part of the Kuben Management company, to realise an EU Concerto project, "Green Solar Cities"[1], which had a focus on large scale BIPV and solar thermal integration in both Valby in Copenhagen as well as Salzburg in Austria.

Unfortunately, the official policy concerning renewable energy in Denmark has always been based on a "Top Down" procedure, also when it comes to the use of wind energy and district heating technology. In a situation where there is a clear public support to improve the climate and to implement the EU´s Green Deal for Europe, this is very unfortunate and the result is that there is in fact no policy to support the use of local renewable energy technologies at all.

The belief is that what is needed is only large wind energy and solar energy installations, which have a low cost per produced kWh, but at the same time needs large investments in energy infrastructure, while system losses are also high. In practice there is unfortunately no interest in local renewable energy technologies, like f.ex. building integrated PV, BIPV, which can deliver renewable energy directly to electricity consumers.

Supporting the development of CO_2 neutral communities in Denmark and in Europe

None the less European Green Cities is still pushing to support the development of CO_2 neutral communities in Denmark and in Europe. And here we found that none of the existing certification and labelling schemes in Europe take into account the new challenge that we now face in urban districts of using the renewable energy resources that we have efficiently.

A label is needed that leads designers, users and operation staff to make the right decisions and secure a minimisation of the district carbon footprint.

In a proposed Carbon Zero Digital Label project it has been agreed to develop a Carbon Zero Digital Platform in a cooperation between partners from Denmark, Sweden and Switzerland, and to implement its use at 3 different sites in Denmark with an online documentation of CO_2 emission levels both at a building level as well as at a district level.

In these pilot cases the aim has been an ideal combination of a sustainable low energy building design together with Smart Energy solutions for the energy supply system based on optimised use of local renewable energy sources.

One example is the city of Frederiksberg, situated in the center of Copenhagen, working together with their energy supply company, Frederiksberg Forsyning. The focus of the cooperation will be the redevelopment of the former Frederiksberg Hospital area into a new city part. Here an ATES system will be utilised to deliver district cooling for Frederiksberg Forsyning, while the produced" waste heat" will be stored in the ground water below the ground at the site, leading to an increased temperature level, which can be used by heat pumps for the renovated and new build buildings. The energy balance of the ATES system and documentation of the aimed at low temperature operation, as basis of performance demands, will be documented in connection to the" Carbon Zero labelling" work. This will also include results of BIPV production in connection to demands concerning CO_2 neutral building.

Pushing the best technologies

An important aim of the proposed Carbon Zero Digital Platform is to support a push for the choice of the best technologies, which will secure the lowest CO_2 emissions in practice.

An example of this is to support the aim for the lowest possible district heating temperatures, and in some cases even consider so-called "ultra" low temperature district heating, where the operation temperatures are typically below 20°C, and you use decentralised heat pumps installed at the users. Barriers for the last-mentioned technology is that it is not a normal district heating solution, and that district heating companies are reluctant to operate and being dependent on a large number of individual heat pumps.

Also, for the ATES technology with ground water based heating and cooling a Carbon Zero Digital Platform can help to secure the choice of the best solutions with the lowest CO_2 emissions on a yearly basis. Here it is often seen that the interest for ATES based cooling is the driving force to establish a groundwater-based energy system, while the investment in a heat pump based heating solution is often not done since the economic benefit is not as high. This is unfortunate since it is the combined use that both secure a thermal balance of the groundwater seasonal storage and at the same time secure the lowest CO_2 emissions on a yearly basis.

Another example is the use of BIPV technologies (Building Integrated PV). Here it is well known that an LCA (Life Cycle Analysis) calculation is very depended on how the BIPV panels are produced, which means that if you just use the cheapest PV wafers from China, then the total CO_2 emission reduction from use of PV is not high, while use of PV panels produced in e.g., Norway to a large extend based on hydropower will lead to the highest total CO_2 emission reductions.

And if you use PV panels which also have the possibility to deliver solar heat in the form of PVT modules, then you obviously will get an even higher saving in form of CO_2 emission reductions.

A video which is presenting Smart Energy Green Cities work has been made. See the following link:

https://vimeo.com/563933723/ccfa928113

(1) Green Solar Cities, Peder Vejsig Pedersen, Jakob Klint, Karin Kappel and Katrine Vejsig Pedersen, Earthscan from Routledge 2015, isbn: 978-0-415-73119-5

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Racell PVT in combination with ATES seasonal storage

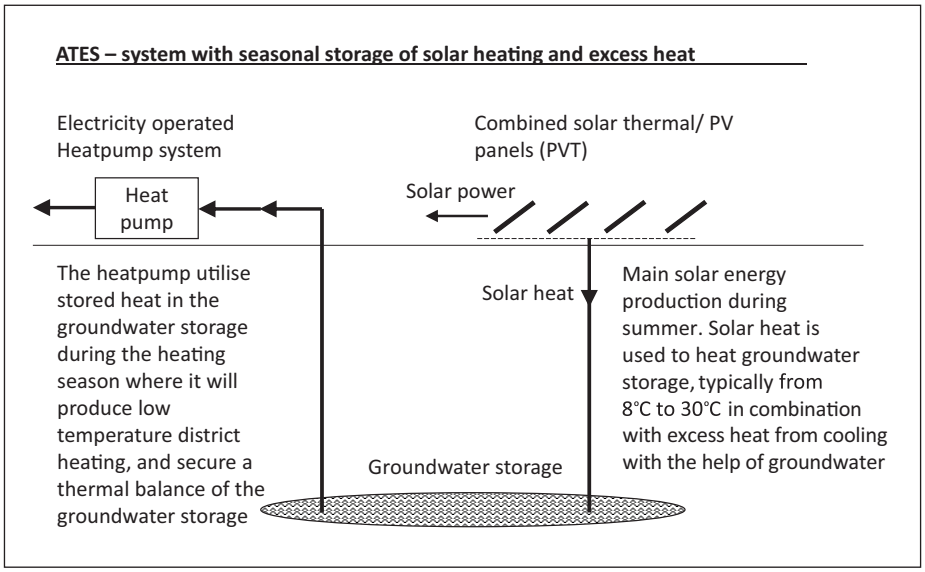
Here, Peder Vejsig Pedersen, European Green Cities, tells us about the latest Racell PVT technology which has been combined with Aquifer Thermal Energy Storage (ATES) to be used for seasonal storage

The Danish PV producer Racell has over a decade been improving their combined PV and solar thermal technology with so-called PVT elements, that both produces solar power as well as solar heating. At the same time, this can be provided in almost all colours. At present, several smaller PVT installations have been installed in Denmark, where the solar heating elements are combined with use of heat pumps.

Recently, a very interesting combination of this new technology has been proposed together with ground water-based energy systems called ATES or Aquifer Thermal Energy Storage developed in Denmark by the Enopsol company. This can be utilised as a seasonal storage for the solar heating coming from the PVT elements, while heatpumps will have a high efficient operation in the heating season by help of the solar heated ground water storage.

The Danish company Solarplan has developed a plan of integrating large 4-6m^2 Racell PVT modules into sloping roofs of housing blocks from the 1970s in Avedøre, south of Copenhagen as part of the so-called Avedoere Green City Project, where European Green Cities works as secretariate leader.

The benefit of this solution is the ability to introduce cost-effective renewable energy solutions in cities, since ground water is available most places and there are no noise problems from the operation.



Large Racell PVT modules can easily be integrated in buildings and as mentioned also in various colours.

With the new developed PVT technology, it is now an obvious solution to use solar thermal energy to heat large volumes of ground water during the summertime and then use large heat pump systems to utilise the seasonal stored heated ground water during winter. This is a policy which also supports the need to move society into electricity-based heating even for district heating systems, so we can use the large amounts of wind energy sources in a better way, e.g. in Denmark.

European Green Cities

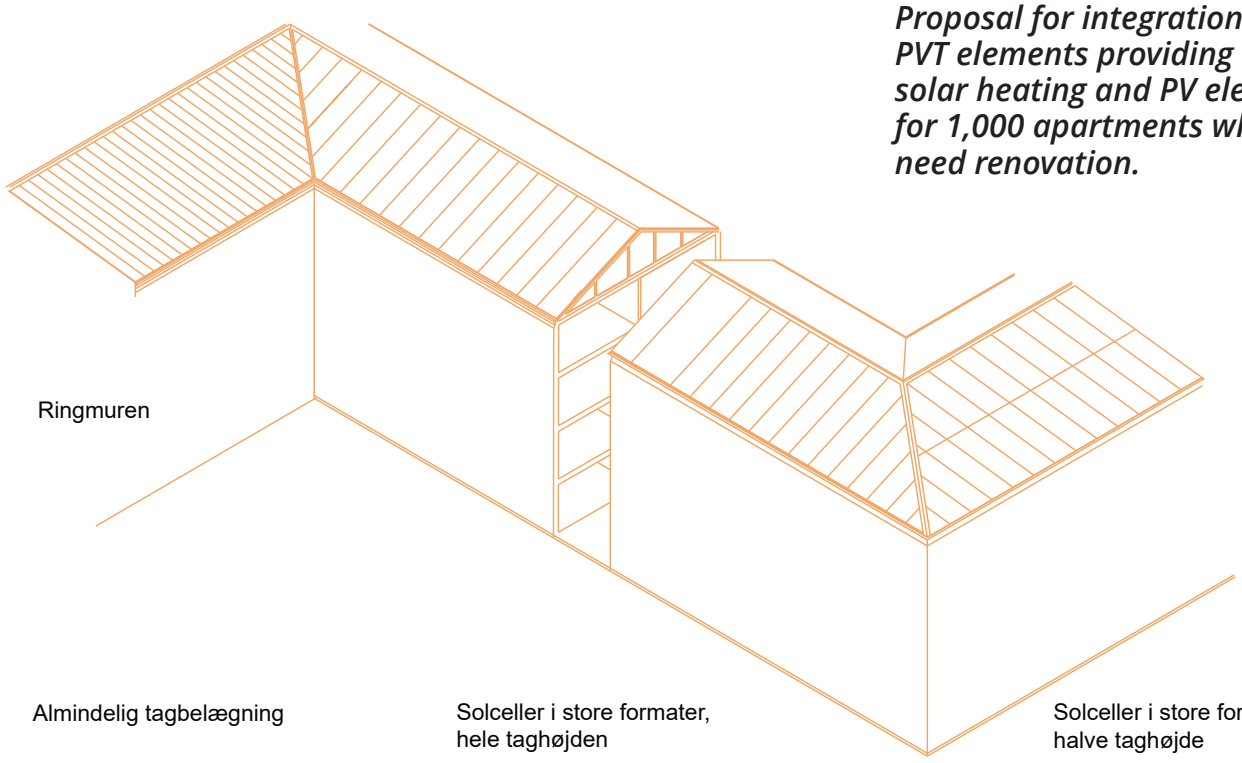
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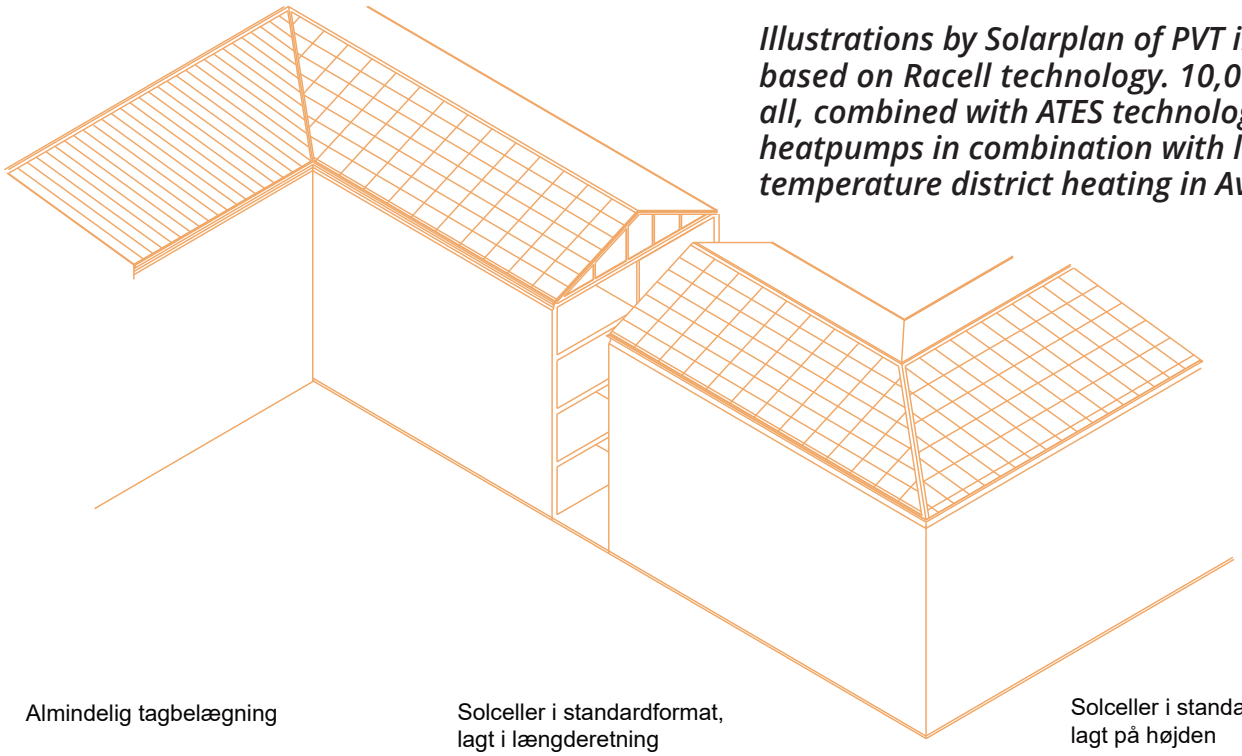
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Green City Avedøre

Proposal for integration of large PVT elements providing both solar heating and PV electricity for 1,000 apartments which also need renovation.



Illustrations by Solarplan of PVT integration based on Racell technology. 10,000m² in all, combined with ATES technology and heatpumps in combination with low temperature district heating in Avedøre.



In Avedøre there is more than 2,000 social housing apartments from the 1970s that need renovation. A plan has been made to integrate 10,000m² PVT modules in 1,000 apartments based on work from Solarplan.

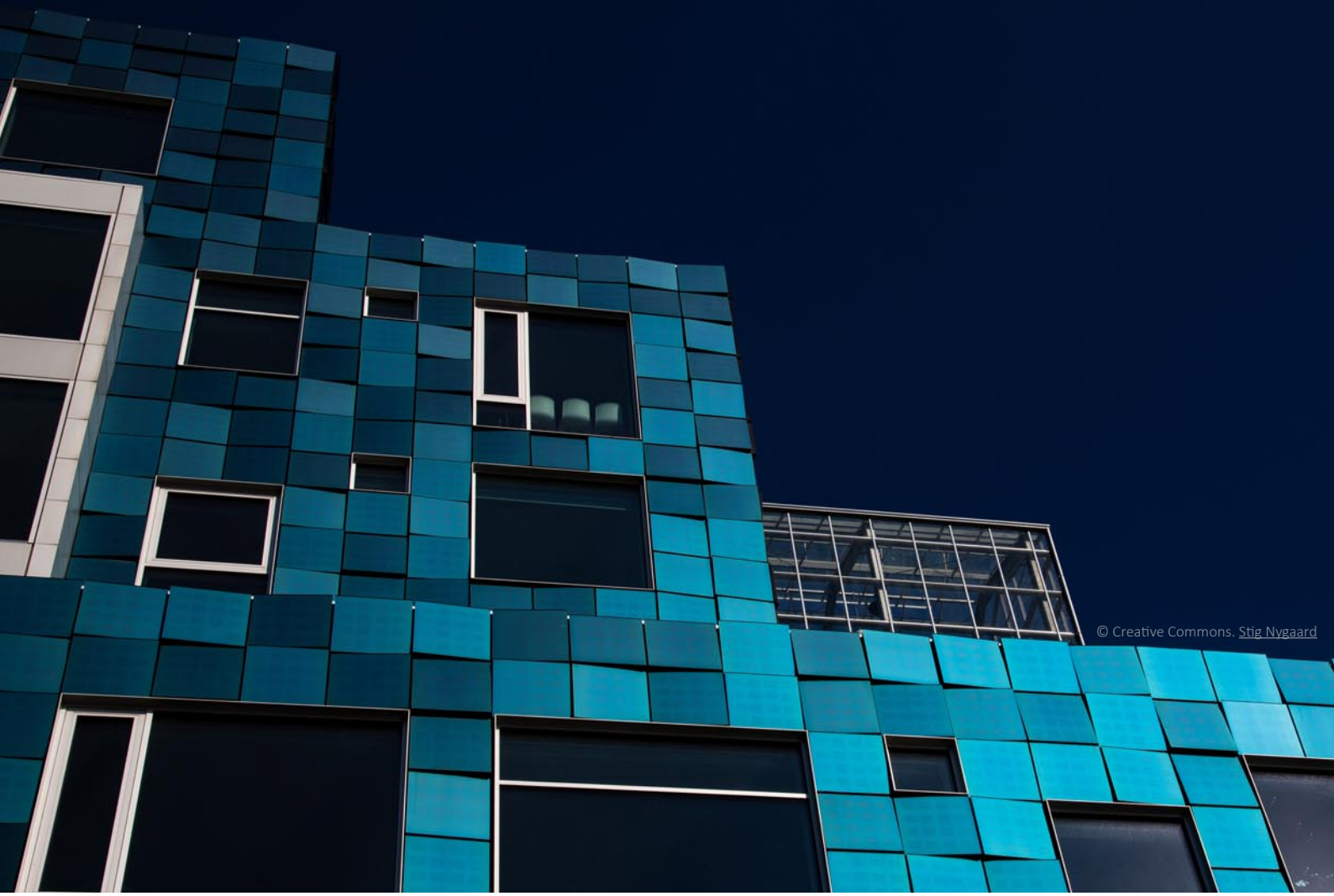
Avedøre Stationsby

Bygning: Ringmuren	Tegn.format: A3 Målforhold: 1:350
Emne: Principper for paneldækning på tagflader	Dato: 28.04.2020

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www.europeangreencities.com

BIPV: POWERING THE EUROPEAN GREEN DEAL



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European Green Cities

BIPV AS PART OF GREEN DEAL FOR EU

In Denmark there is at present a huge export of Green technology (122 billion DKr. equal to 16.3 billion Euro In 2019), and wind energy technology is a large part of that.

And this is not so much due to the Danish government which f.ex. back in 1984 insisted that wind energy could never cover more than 1% of Danish electricity use, in a situation where Danish wind energy export had reached more than 1 billion Danish Kr. For the first time.

Now with the Green Deal for Europe to be CO_2 neutral in 2050, it is proposed to realise a "Renovation Wave" to improve the efficiency of buildings, and to support implementation of renewable energy like f.ex use of solar panels and wind energy, at the same time as acceleration of electrification, f.ex also for heating use by help of heat pumps.

This is also supported by EU directives supporting the "Clean Energy for all Europeans" policy. This suggests that everybody should be allowed to produce their own renewable energy, and even sell excess energy to their neighbour.

At a webinar in March 2020 held by the Danish Industry association the General Director of Eurelectric (Corporation of electricity producers in Europe), Kristian Ruby presented his perspective: "In 10-15 years from now, it will be just as normal to have your own PV panel installation as having a fridge in your home".

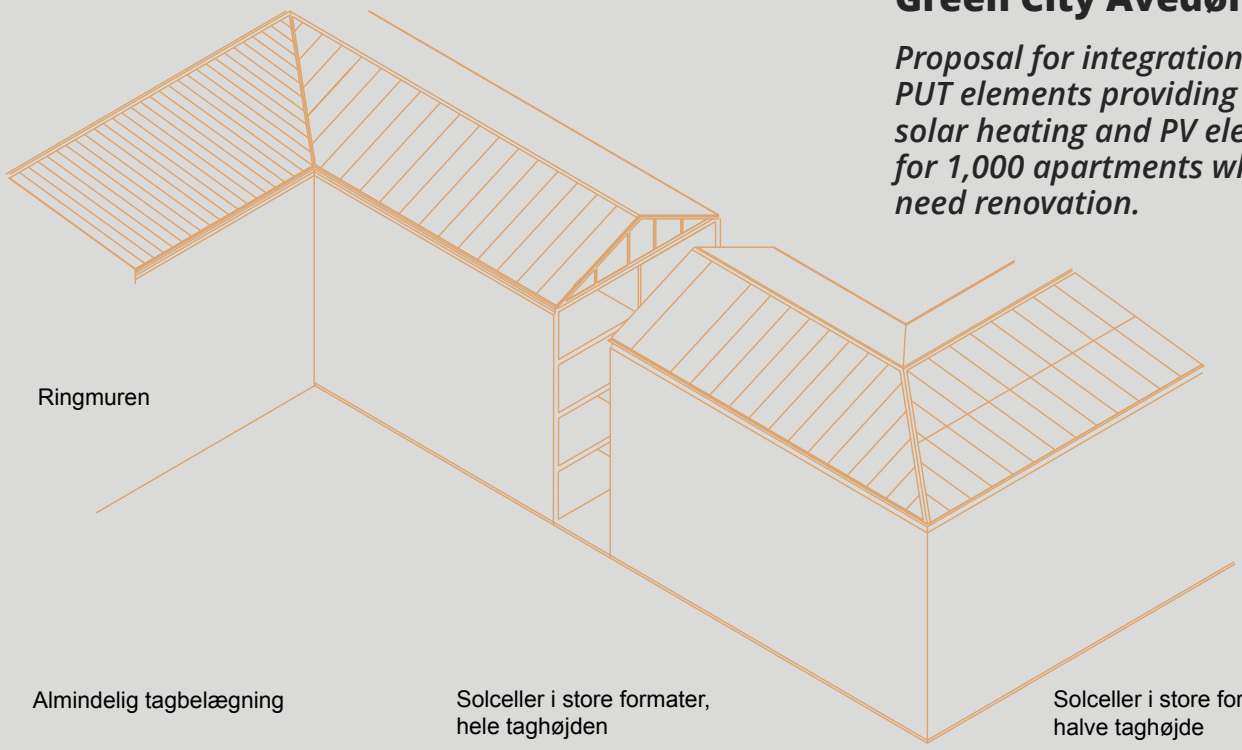
What if the EU attempts to combine these aspects into a regeneration policy, also from the Corona crisis, to support use of the most advanced building integrated PV panels, BIPV with the already agreed policies for renovation and new built in Europe? And hereby, the EU supports new technology that can imitate the best elements of the wind energy adventure that was realised in Denmark.

Recently, there was a webinar on BIPV and Active House labelled results from the iconic Copenhagen International School, CIS, held with more than 4000 Chinese attendees. There was really a good response on the prospects concerning BIPV, and the interesting situation we have with new BIPV materials which can actually substitute almost all kind of façade and roofing materials.

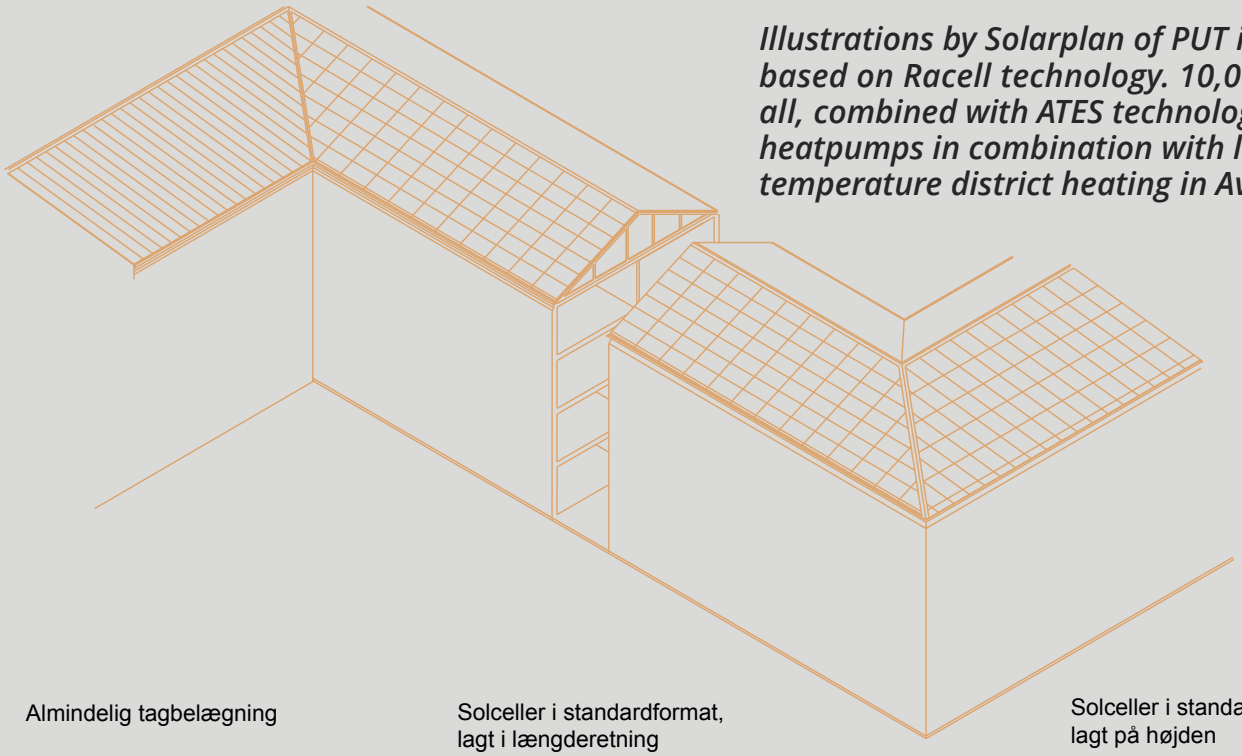
So, the obvious choice is really to go ahead with the needed Smart Energy initiatives and include BIPV in connection to this.

Green City Avedøre

Proposal for integration of large PUT elements providing both solar heating and PV electricity for 1,000 apartments which also need renovation.



Illustrations by Solarplan of PUT integration based on Racell technology. 10,000m² in all, combined with ATES technology and heatpumps in combination with low temperature district heating in Avedøre.



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SMART ENERGY GREEN CITIES

Under the coordination of the non-profit European Green Cities, with the support of the Danish Energy Agency's Smart Energy pool during 2019 and 2020, a targeted development and dissemination work on "Smart Energy" solutions has been carried out in several locations in Denmark, where the focus is on the widespread use of renewable energy in combination with optimised energy supply solutions that seek to utilise heat pumps in combination with so-called groundwater heat and groundwater cooling.

I want to emphasise here that based on the expertise from the company Enopsol, and in a collaboration with the Copenhagen energy supply company HOFOR, as early as 2019, that an energy plant has been commissioned to utilise groundwater as a cooling medium in connection with the overall major redevelopment project for Bispebjerg Hospital in Copenhagen.

This so-called ATES * technology avoids the normal installation of large and noisy mechanical cooling systems on roofs, while at the same time saving 75% of the total energy consumption for cooling and heat. This is because it is possible to utilise the heat supplied through cooling by the groundwater during the summer season, using heat pumps in the winter, which then cover the peak of the heating needs during the coldest months. This also ensures that the groundwater temperature is not affected from year to year as it is possible to achieve a thermal balance for this.

The investment in the overall ATES solution has a positive user and community economy and pays home in five or six years. This can also be used advantageously for other hospital buildings and the like.

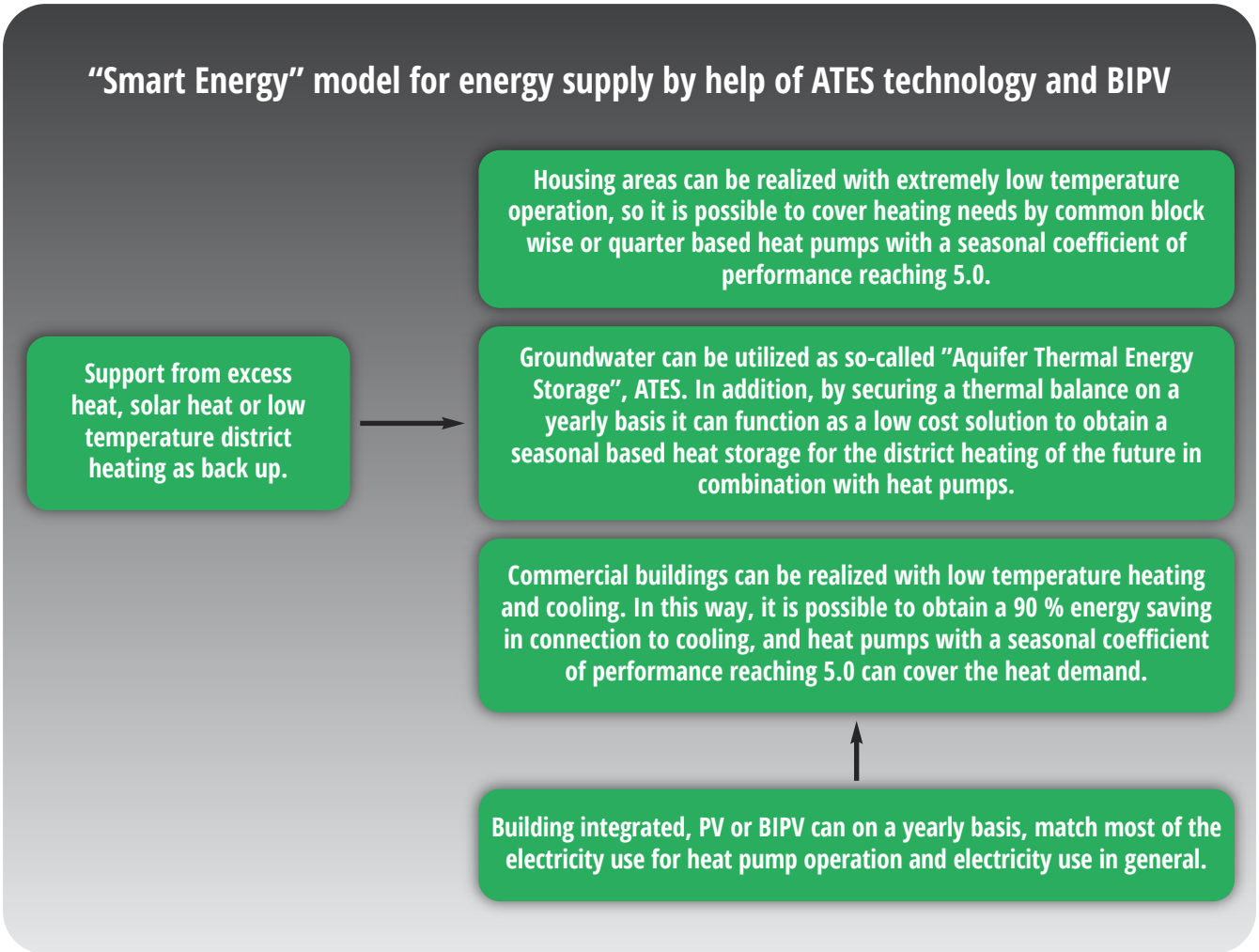
In addition to this project, there is also a collaboration with the company, Green Island, which is involved in the development of a fossil-free district at Vinge Nord in the Frederikssund municipality. You can find out more about this at **http://www.greenisland.dk**, as well as a dialogue on similar solutions using heat pumps and building-adapted solar cells for a new urban development area in Køge Nord, as well as renovation projects at Avedøre in the Hvidovre municipality.

Information about the above will be provided on the "Sustainable Cities and Buildings" association **website** and database and on the **website**. * Aquifer Thermal Energy Storage (ATES)

ATES groundwater cooling and heating

For the Bisperberg Hospital in Copenhagen was chosen to use Aquifer Thermal Energy Storage or ATES groundwater based cooling as a cheaper alternative than district cooling from HOFOR, the Copenhagen Energy Company.

The yearly energy saving is 75% and more than 90% of stored heat during summer can be recovered. 2 stage heat pumps from Sabroe is used (owned by Johnson Controls).



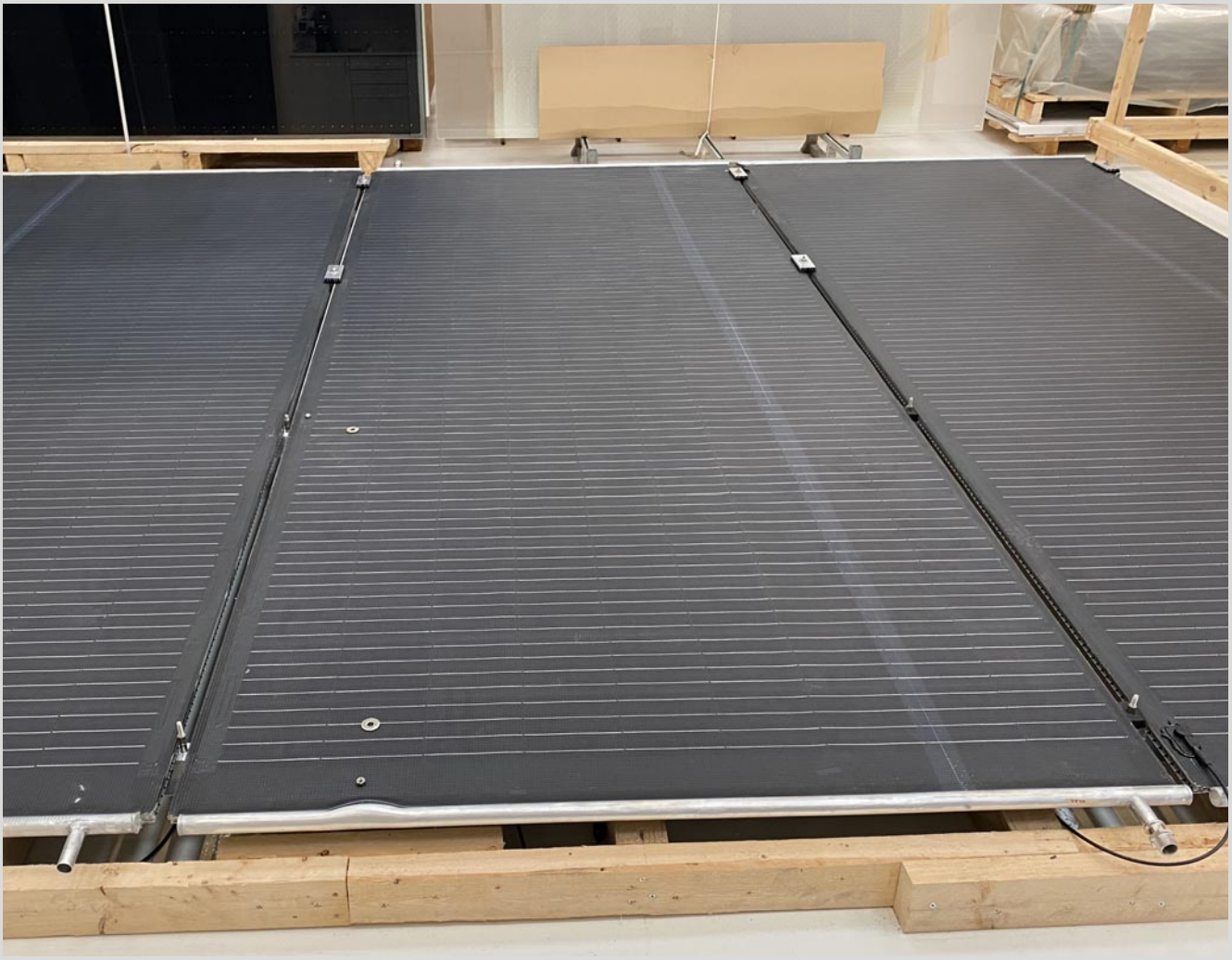
In winter, district heating is base load and heat pumps delivers the peaks. (Only from November to March).

In Denmark it has been proven that ATES systems can be used even quite near to drinking water pumping stations, but it is a demand that the ground water temperatures are never heated more than 0,5°C in the vicinity of this.

Besides an important effect has been that there has never been any net consumption of water, and there is no noise from the system. This can be compared to normal compressor cooling systems, which have a clear noise problem from the condenser in the roofs in summer.

From the ATES system developer Enopsol's point of view, the new and innovative SOLUS heating/cooling system, from Lindab with 19° - 24°C operation temperatures, is really interesting. Since there can be a perspective of avoiding the use of a large part of the heat pump operation, with its quite high electricity use, if the ground water temperatures can be raised somewhat in summer periods.

For a new city development area, Køge Nord south of Copenhagen it has been suggested to implement an advanced low temperature bidirectional district heating solution, which can be ideally combined with the above mentioned technologies, and new types of BIPV facades for a large commercial building development area.



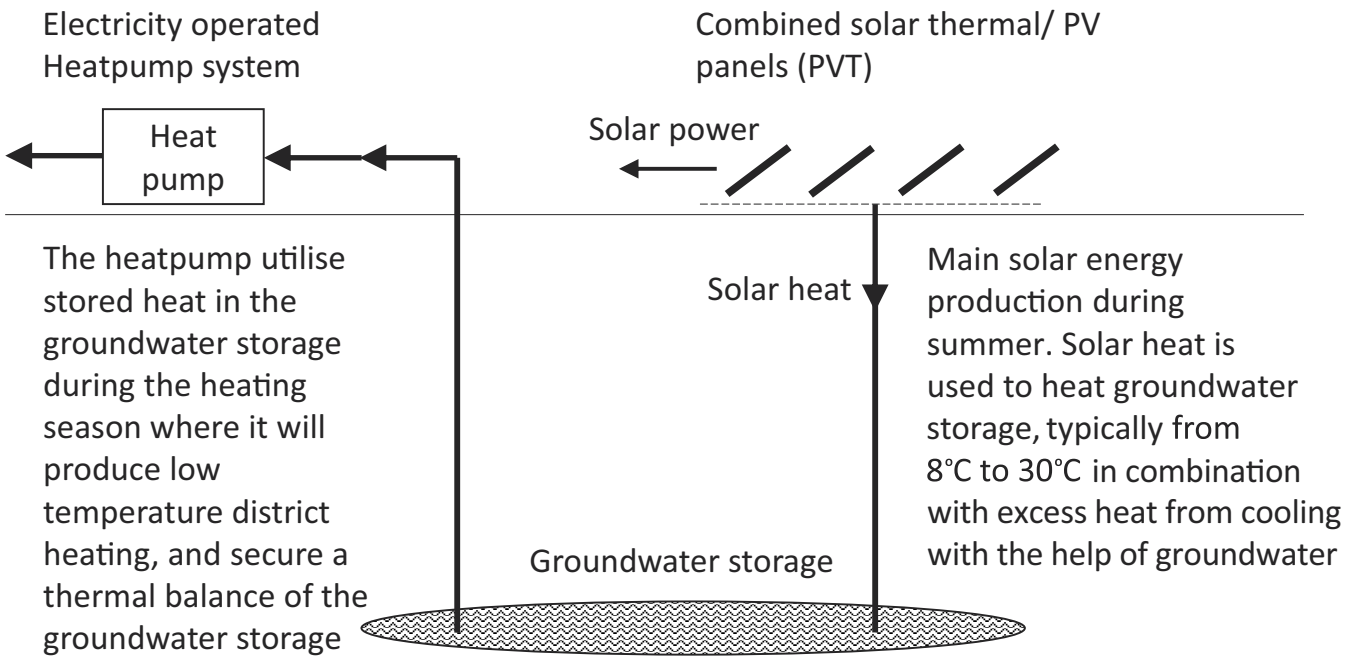
Racell PVT module

RACELL PVT IN COMBINATION WITH ATES SEASONAL STORAGE

The Danish PV producer Racell has over a decade been improving their combined PV and solar thermal technology with so-called PVT elements, that both produces solar power as well as solar heating. At the same time, this can be provided in almost all colours. At present, several smaller PVT installations have been installed in Denmark, where the solar heating elements are combined with use of heat pumps.

Recently, a very interesting combination of this new technology has been proposed together with ground water-based energy systems called ATES or Aquifer Thermal Energy Storage developed in Denmark by the Enopsol company. This can be utilised as a seasonal storage for the solar heating coming from the PVT elements, while heatpumps will have a high efficient operation in the heating season by help of the solar heated ground water storage.

ATES – system with seasonal storage of solar heating and excess heat



The Danish company Solarplan has developed a plan of integrating large 4-6m^2 Racell PVT modules into sloping roofs of housing blocks from the 1970s in Aredore, south of Copenhagen as part of the so-called Avedoere Green City Project, where European Green Cities works as secretariate leader.

The benefit of this solution is the ability to introduce cost-effective renewable energy solution in cities, since ground water is available most places and there are no noise problems from the operation.

Large Racell PVT modules can easily be integrated in buildings – also in various colours.

With the new developed PVT technology, it is now an obvious solution to use solar thermal energy to heat large volumes of ground water during the summertime and then use large heat pump systems to utilise the seasonal stored heated ground water during winter. This is a policy which also supports the need to move society into electricity-based heating even for district heating systems, so we can use the large amounts of wind energy sources in a better way, e.g. in Denmark.



COMPETITIVE KEY TECHNOLOGIES NEEDED FOR FOSSIL-FREE CITY DEVELOPMENT

Preparations are being made by the company Green Island, to develop the so-called Vinge North area in the city of Frederikssund into a fossil free city area with 1,600 housing units.

For the builders involved, it is very relevant to secure use of the most economic technical solutions, so the aimed 100% renewable energy design can be made at the lowest possible extra costs.

An example of this is the possible use of building integrated PV (BIPV). In connection to this, there has already been work made by DTU students in relation to a Building Integrated Photovoltaics course in autumn 2019, with several innovative suggestions on how to make use of BIPV in the best way. Besides this, there is also an important need to be able to identify the real extra costs for BIPV materials, when they substitute normal building materials.

Heat supply for the housing areas in Vinge will be obtained by help of low temperature district heating coming from a common energy plant utilising an Aquifer Thermal Energy Storage (ATES) system. This works together with centrally placed heat pumps, which also use thermal regeneration coming from a nearby factory which will use groundwater for cooling besides an input from a local thermal solar collector plant. This secures a thermal balance for the groundwater on a yearly basis, and a practical mean COP for the heat pumps of at least 5.0 on a yearly basis.



*The four housing units simulated geometry in PV*SOL*

In relation to the central heat pump energy supply system with low temperature district heating for each housing unit, it is very important to ensure that the used heating system in the houses will actually make it possible to have an optimised low temperature operation in practice.

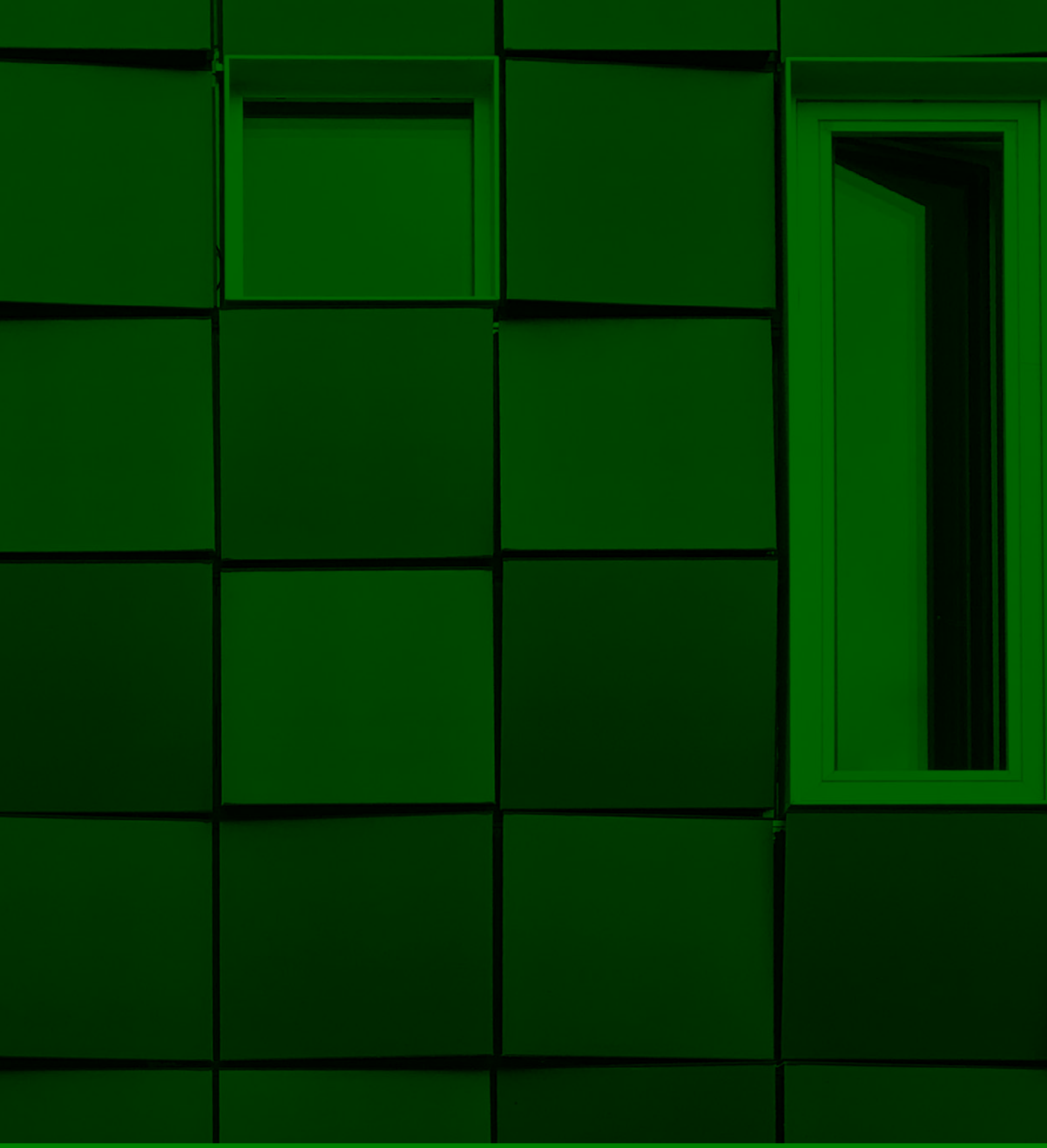
In connection to this it is very important to be able to use practical “performance documentation” methodologies for low temperature heating systems because it will be the main influence, which impacts the central heat pump COP and the associated use of electricity for heating in practice.

For BIPV production based on the existing legislation in Denmark, you can only get the full value of the produced kWh if you have an equal consumption in the hour it is produced. In practice, this means that you will only get an acceptable economy from your system if you cover less than 30% of the yearly consumption by solar power.

But based on calculated results of using a layout of the housing area with several orientations varying from east to west - at least 50% BIPV supply should be possible on a yearly basis.

At the same time it is also important to be aware of relatively new EU legislation, e.g. concerning Clean Energy for All Europeans (aiming that EU is CO_2 neutral in 2050). Based on this, 8 new directives are being implemented in all EU countries before the end of 2021. See also: **https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans**

For BIPV this will mean that you should be allowed to sell part of your PV production in a local market e.g. to your neighbours or to a new kind of aggregators with built-in batteries, which can handle smaller amounts of excess renewable energy production. This means that in the future it is likely that you can make BIPV solutions which look nice and cover a whole roof or facades and still obtain an acceptable economy e.g. for projects like the above mentioned.



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European
Green Cities

Supporting the green transition? A unique building project in Denmark

April 11, 2019



Peder Vejsig Pedersen, Senior Advisor at European Green Cities outlines a unique building project, Copenhagen International School (CIS) as an example of supporting the green transition

Due to BIPV oriented funding in Denmark from the EUDP and ForskVE RTD programmes (see: **www.activehouseroofsandfacades.com**), it has been possible for Cenergia (now a part of Kuben Management to make an agreement with Copenhagen International School) to realise an Active House labelling for them, and to include an online Active House radar with assistance from the company, Leapcraft.

Copenhagen International School (CIS) is a **unique building project,** for which it has been a pleasure for me and my former colleagues, Miriam Sanchez and Vickie Aagesen to work

on. This cooperation also included Karin Kappel from Solar City Denmark, who have carried out amazing work in promoting best practice BIPV architecture since 2004, and Gate21, engaged as a collaborator in relation to the ForskVE realisation.

For Kuben Management, I hope that winning the Active House award will support the idea of working with the Active House standard in practice because it has many benefits and it is not costly to work with. In relation to ForskVE, it has been possible to include several Active House labelled projects in the Danish sustainable building database which can now be viewed in English at **www.bæredygtigebygninger.dk**.



Peder Vejsig Pedersen receiving the Active House Award 2018 for the CIS building in Copenhagen, at the Active House Symposium in Lecco, Italy

The idea of working with performance documentation has always been a part of the Active House approach and with the demands for this in the EU Building Directive, it has become increasingly relevant, and something that will be supported by the development towards more digitalisation in buildings.

CIS is a good example of a school building with an emphasis on a healthy indoor climate, which had a strong focus in the design process, also based on special demands from the builder, f.ex. when it comes to using decentralised ventilation systems. This is in a scenario where bad indoor climate issues are not uncommon in Danish schools. It is our hope that the qualities documented in the online Active House radar will help to ensure a continuous focus on the indoor climate.

I agree that homebuyers can use Active House documentation to help them secure quality but also due to the reasonably low costs to use it. Good advice would be to try to cooperate with

other sustainable building quality systems. In the Nordic countries, f.ex. have the Nordic Swan Label which one of the leading contractors (NCC), uses for all their housing projects.

My advice for the future is to really focus on new and unique projects, which support the green transition, and to work with engaged builders, such as what we witnessed with the CIS building. CIS is a really good example of what a determined builder can do in practice. Here, the driving force was one of the board members of the school who at the same time was a designer and secured full-scale BIPV Mock-Ups on the actual building site to identify the best possible BIPV design (in cooperation with the experienced BIPV manufacturer, Solar Lab). This actually led to the withdrawal of the architect (C.F. Møller), for a short period, due to risks they saw in connection to the use of completely new technology for almost all facades. In the end, they came back and was deeply engaged in securing the qualities in practice of many of the technical and architectural solutions.

Active House labelling: **www.activehouse.info**

Please note: This is a commercial profile

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A focus on Building Integrated Photovoltaics technologies in Denmark

Peder Vejsig Pedersen from European Green Cities focuses on Building Integrated Photovoltaics technologies in Denmark

This article presents results in connection with RTD work supported by the Danish EUDP programme and Nordic Innovation funding. Since 2014, there has been ongoing cooperation taking place with the companies Cenergia and Solarplan and Danish manufacturers and suppliers of Building Integrated Photovoltaics (BIPV) technologies to develop new electricity-producing active roofs and facades, where BIPV can be a real alternative to normal roof and facade materials. Here, completely new and innovative coloured BIPV solutions have made it possible to present roof and facade designs which can be accepted by architects, builders and the general public.

Since 2018, it has been possible to realise a new BIPV Demosite at The Technological Institute in Tåstrup west of Copenhagen, where you can see more than 20 different BIPV solutions in practice. This is an initiative coordinated by architect maa. Klaus Boyer Rasmussen from Solarplan. At the same time, there has been cooperation with Solar City Denmark and European Green Cities/FBBB, on dissemination work in the form of brochures and thematic magazines. You can find more information about this here: www.activehouseBIPV.com.

PROFILE









When it comes to new and innovative BIPV solutions, it is especially relevant to highlight the Danish Solar Energy company, with its HEM-CFR BIPV modules that are produced in 11 different colours and come with a 25-year yield warranty. The coloured BIPV modules have an efficiency which is 85-95% of normal non-coloured PV modules. At the BIPV Demosite, you can see a BIPV roof solution in the same colour as red tile roofs and a facade design with two light grey BIPV modules placed between two Rockpanel-antrasit facade panels www.dansksolenergi.dk.

Another unique technology comes from the Danish company SolarLab, which delivered 12,000 chromatic blueish BIPV modules for the Copenhagen International School. The BIPV Demosite demonstrates tilted BIPV modules for facades or gables (www.solarlab.dk).

It should also be mentioned here that the Danish company Solartag (www.solartag.dk) can deliver BIPV modules that exactly matches roof or facade modules from the Norwegian company STENI (www.steni.com).

The company VELUX (www.velux.com) also has an interesting BIPV solution presented at the BIPV Demosite. It is the VELUX Modular Skylight roofing system, that can be purchased with integrated monocrystalline PV modules.

European Green Cities

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DEVELOPMENT OF FOSSIL FREE CITY AREAS

GREEN ISLAND

European Green Cities

A FOCUS ON SMART ENERGY GREEN CITIES

Peder Vejsig Pedersen from European Green Cities tells us about the use of ATES technology with groundwater cooling and heating at Bispebjerg Hospital, Copenhagen

Under the coordination of the non-profit European Green Cities, with the support of the Danish Energy Agency's Smart Energy pool during 2019 and 2020, a targeted development and dissemination work on "Smart Energy" solutions will be carried out in several locations in Denmark, where the focus is on the widespread use of renewable energy in combination with optimised energy supply solutions that seek to utilise heat pumps in combination with so-called groundwater heat and groundwater cooling.

The Danish company Enopsol, made an agreement, with the Copenhagen energy supply company, HOFOR, to realise an energy plant which utilise groundwater as a cooling medium in connection with the overall major redevelopment project for Bispebjerg Hospital in Copenhagen.

This so-called ATES * technology avoids the normal installation of large and noisy mechanical cooling systems on roofs, while at the same time saving 75% of the total energy consumption for cooling and heat. This is because it is possible to utilise the heat supplied through cooling by the groundwater during the summer season, using heat pumps in the winter, which then cover the peak of the heating needs during the coldest months. This also ensures that the groundwater temperature is not affected from year to year as it is possible to achieve a thermal balance for this.

The investment in the overall ATES solution, which started operation in February 2019, has a positive user and community economy and pays home in five or six years. This can also be used advantageously for other hospital buildings and the like.

In addition to this project, there is also a collaboration with the company, Green Island, which is involved in the development of a fossil-free district at Vinge Nord in the Frederikssund municipality, northwest of Copenhagen. You can find out more about this at **http://www.greenisland.dk**, as well as a dialogue on similar solutions using heat pumps and building-adapted solar cells for a new urban development area in Køge Nord, as well as renovation projects at Avedøre in the Hvidovre municipality.

Information about the above will be provided on the "Sustainable Cities and Buildings" association **website**, and database and on the **website: www.europeangreencities.com**

** Aquifer Thermal Energy Storage (ATES)*

ATES groundwater cooling and heating

For the Bisperberg Hospital in Copenhagen was chosen to use Aquifer Thermal Energy Storage or ATES groundwater based cooling as a cheaper alternative than district cooling from HOFOR, the Copenhagen Energy Company.

The yearly energy saving is as mentioned 75% and more than 90% of stored heat during summer can be recovered. 2 stage heat pumps from Sabroe is used here.

In winter, district heating is base load and heat pumps delivers the peaks.
(Only from November to March).

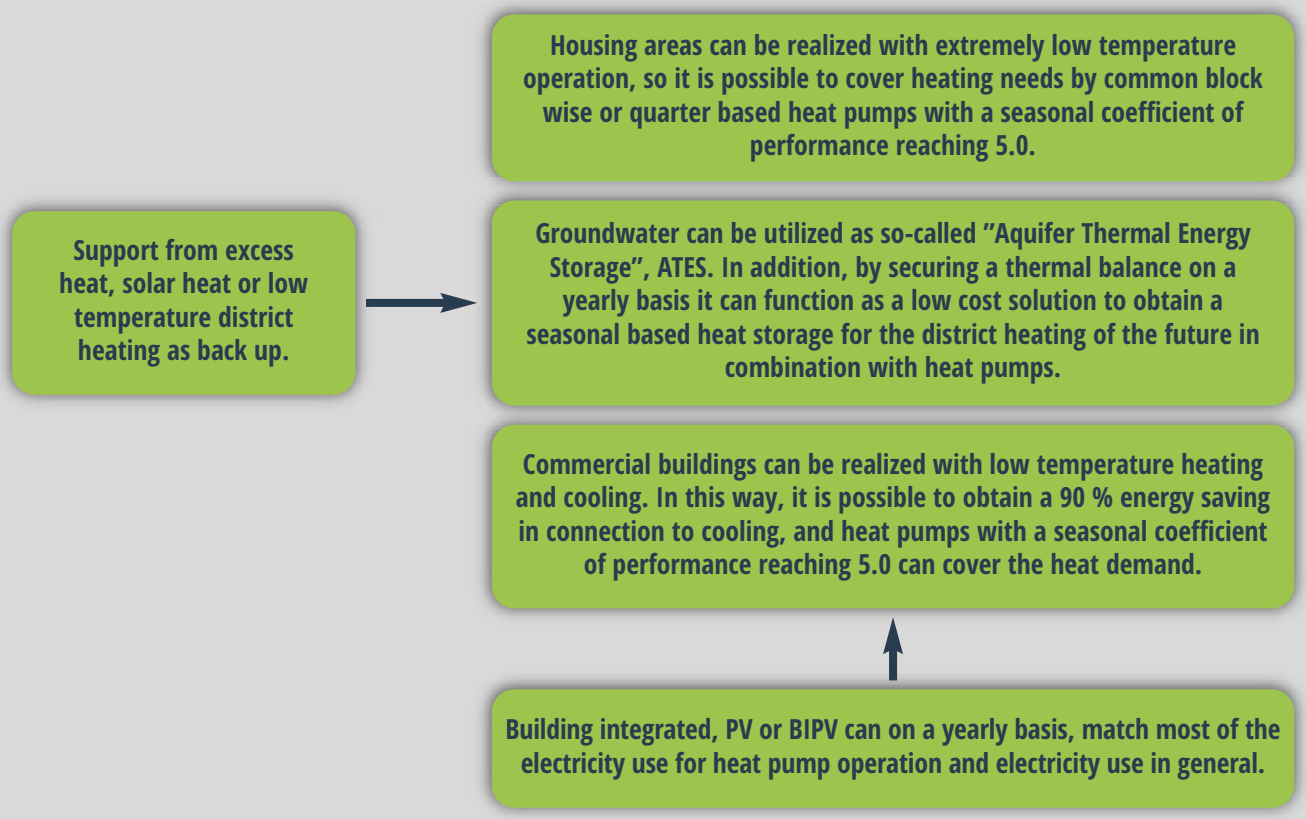
In Denmark it has been proven that ATES systems can be used even quite near to drinking water pumping stations, but it is a demand that the ground water temperatures are never heated more than 0,5°C in the vicinity of this.

Besides an important effect has been that there has never been any net consumption of water, and there is no noise from the system. This can be compared to normal compressor cooling systems, which have a clear noise problem from the condenser in the roofs in summer.

From the ATES system developer Enopsol's point of view, the new and innovative SOLUS heating / cooling system, from Lindab with 19° - 24°C operation temperatures, for both heating and cooling in the same component is really interesting. Since there can be a perspective of avoiding the use of a large part of the heat pump operation, with its quite high electricity use, if the ground water temperatures can be raised somewhat in summer periods.

For a new city development area, Køge Nord south of Copenhagen it has been suggested to implement an advanced low temperature bidirectional district heating solution, which can be ideally combined with the above mentioned technologies, and new types of BIPV facades for a large commercial building development area.

"Smart Energy" model for energy supply by help of ATES technology and BIPV



SOLUS LOW-TEMPERATURE HEATING AND COOLING AT THE MUNKSJÖ TOWER IN JÖNKÖPING

Here, we find out about SOLUS low-temperature heating and cooling at the Munksjö tower in Jönköping, Sweden, presented 16th March 2018 (proposed technology for Køge Nord)

Munksjö tower was made as an office building in 2014 according to a low energy standard using only 52 kWh/m^2, year in district heating use and obtains cooling with the help of outdoor air and cooling water from the nearby lake.

There are used 550 SOLUS beams in the loft area which operate with a forward temperature for cooling of 16°C and heating of up to 35°C by the help of the same installation element. The used windows are low energy windows with four layers of glass, with a U-values of 0,5 W/m^2 °C.

The Solus beams operate with 20 l/sec m^2 in airflow and 100 PA pressure loss for the office while for the conference room, 40 l/sec m^2 is used in airflow.

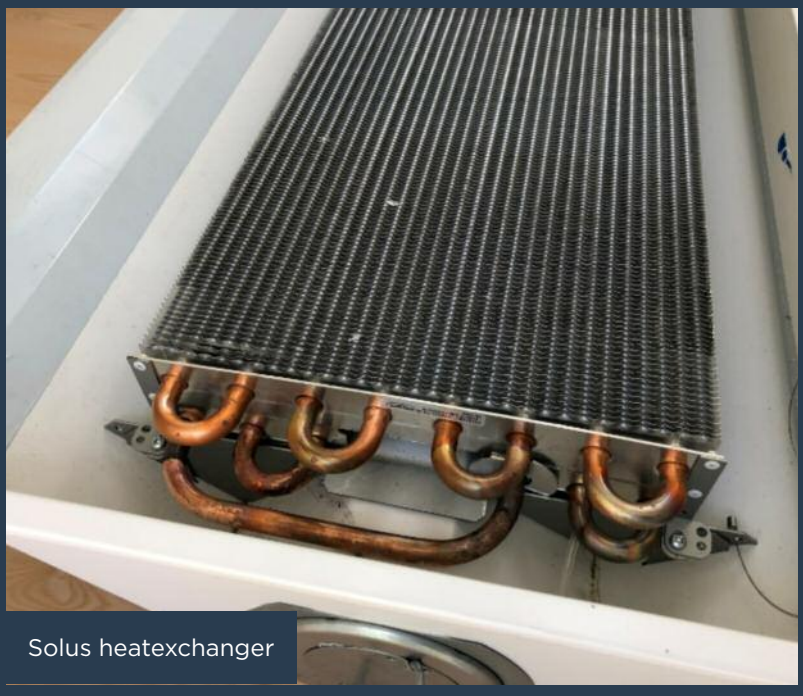
The HTC operation (High-Temperature Cooling) means that you can use the outdoor temperature for cooling in many cases and at the same time, it is not necessary to insulate the air ducts and if a air to a water-based heat pump is used, it will have 48% better performance compared to normal HVAC systems. At least twice a year, the heating element is equal to the cooling demand and it is possible to have a very simple operation.

The Munksjö tower was built based on a normal building economy securing a rent level of 2,000 s.kr /m^2 in yearly rent and operation cost as low as 150 s.kr/ m^2, and according to Göran Hultmark from Lindab, the actual heating use is only 25-30 kWh/m^2 year, with much-reduced losses and a better capacity for district heating. Noise levels are below 25 dBa and the user is, therefore, satisfied with the indoor climate.

The construction of high airflow and low temperatures also secures a better average temperature gradient in the rooms.

Besides, it is also possible to utilise thermal storage in a much better way.

The builders of the project, “Tolust” confirmed the project was economical but also mentioned that building cost was 25% lower in Sweden in 2014 compared to 2018.



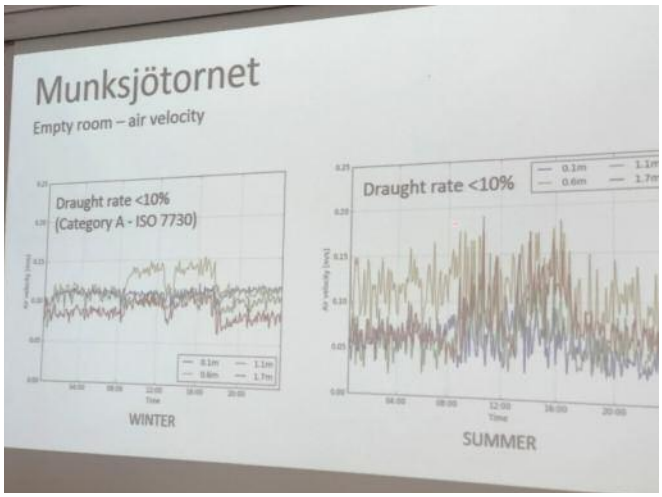
Solus heatexchanger

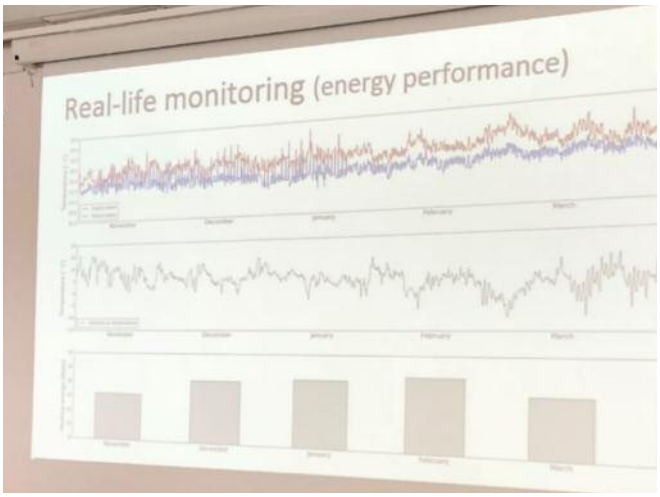


Munksjøtårn in Jønkjøbing, Sweden was used for a full scale demonstration

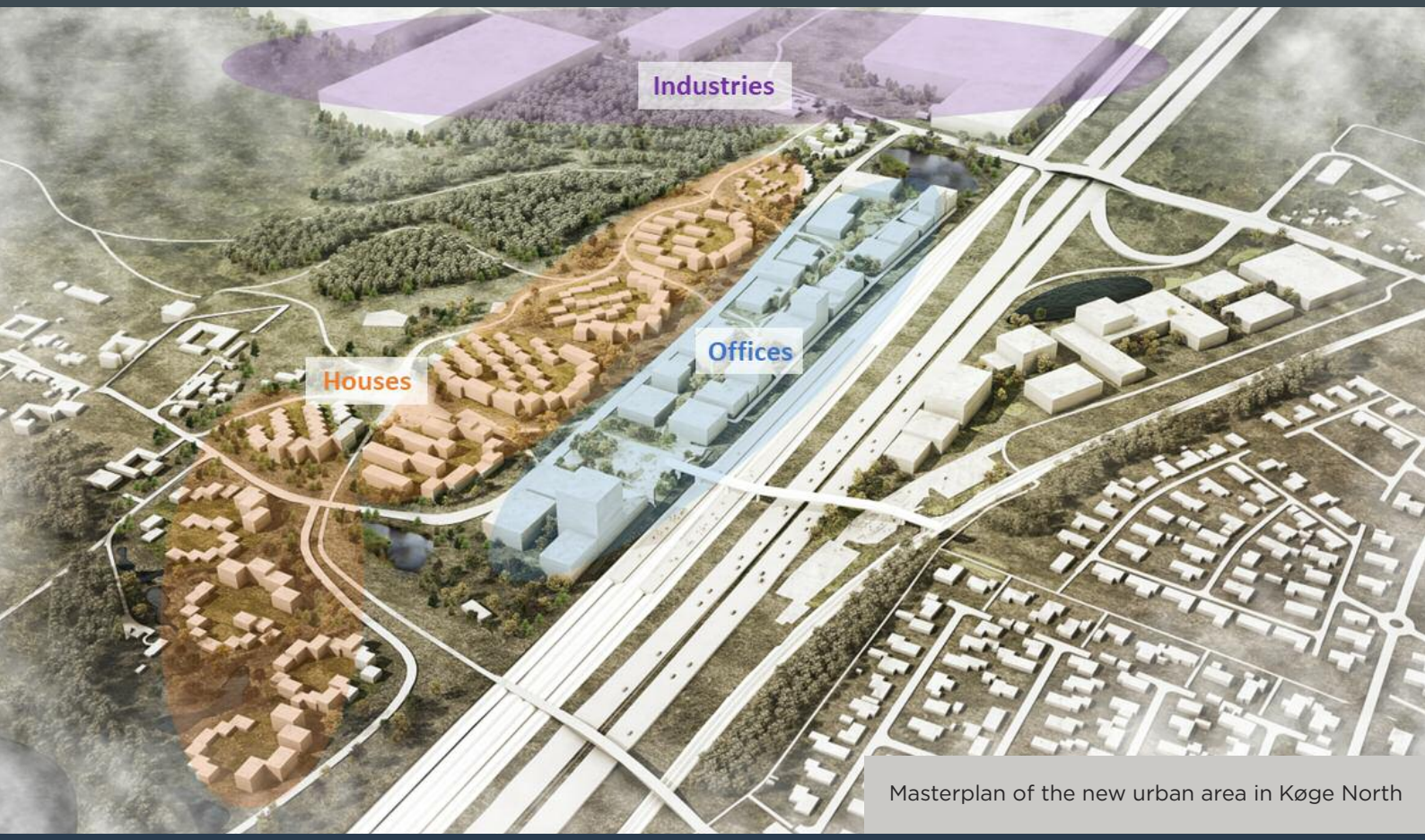


Solus beams in Munksjøtårn





Solus measurements by SBi/Aalborg University confirms good operation in practice



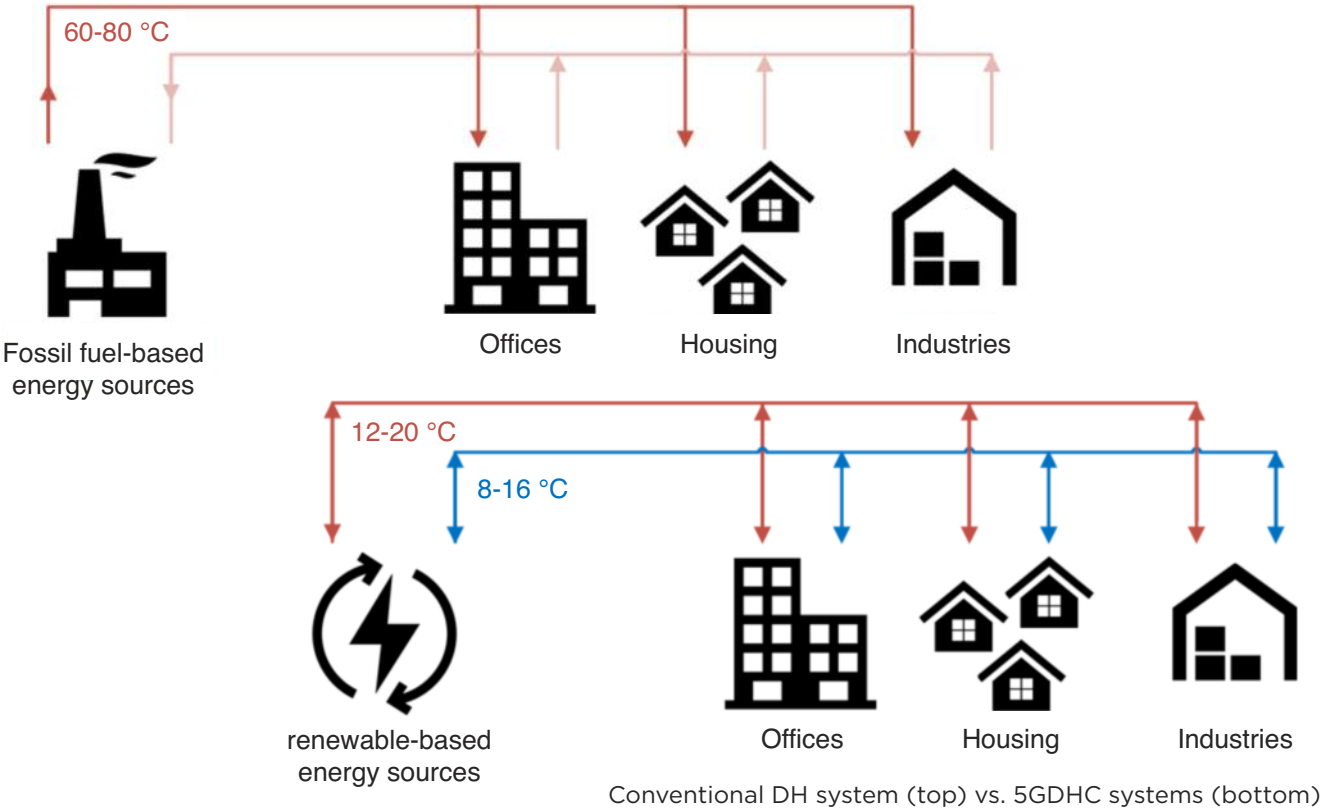
Masterplan of the new urban area in Køge North

PROPOSED 5TH GENERATION DISTRICT HEATING AND COOLING IN THE CITY OF KØGE

Peder Vejsig Pedersen, Senior Advisor at European Green Cities outlines how to effectively implement energy infrastructure that has the potential to affect progress toward sustainability goals

About 87% of people in Denmark live in urban areas. The urbanisation is a challenge that includes social, economic and ecological issues; on the other hand, from the energy point of view, it also offers the opportunity to effectively implement infrastructure that has the potential to affect progress toward sustainability goals. In particular, district heating and cooling systems play an important role in the task of increasing energy efficiency and, thus, meeting these goals.

The idea of district heating was developed to provide greater efficiency and a less negative environmental impact than localised boilers through the centralised production of heat and its distribution to final users by a network of pipes. The so-called 1st generation of district heating networks was introduced in the late 1800s using steam as a heat carrier. These systems were replaced by 2nd generation networks, which use pressurised liquid water instead of steam, with supply temperatures over 100 °C. The 3rd generation of systems was introduced in the 1970s and was characterised by supply water temperatures often below 100 °C. The so-called 4th generation of district heating networks is a quite recent district heating concept and it is identified by even lower temperature levels (30-70 °C) and integration of sustainable energy sources.

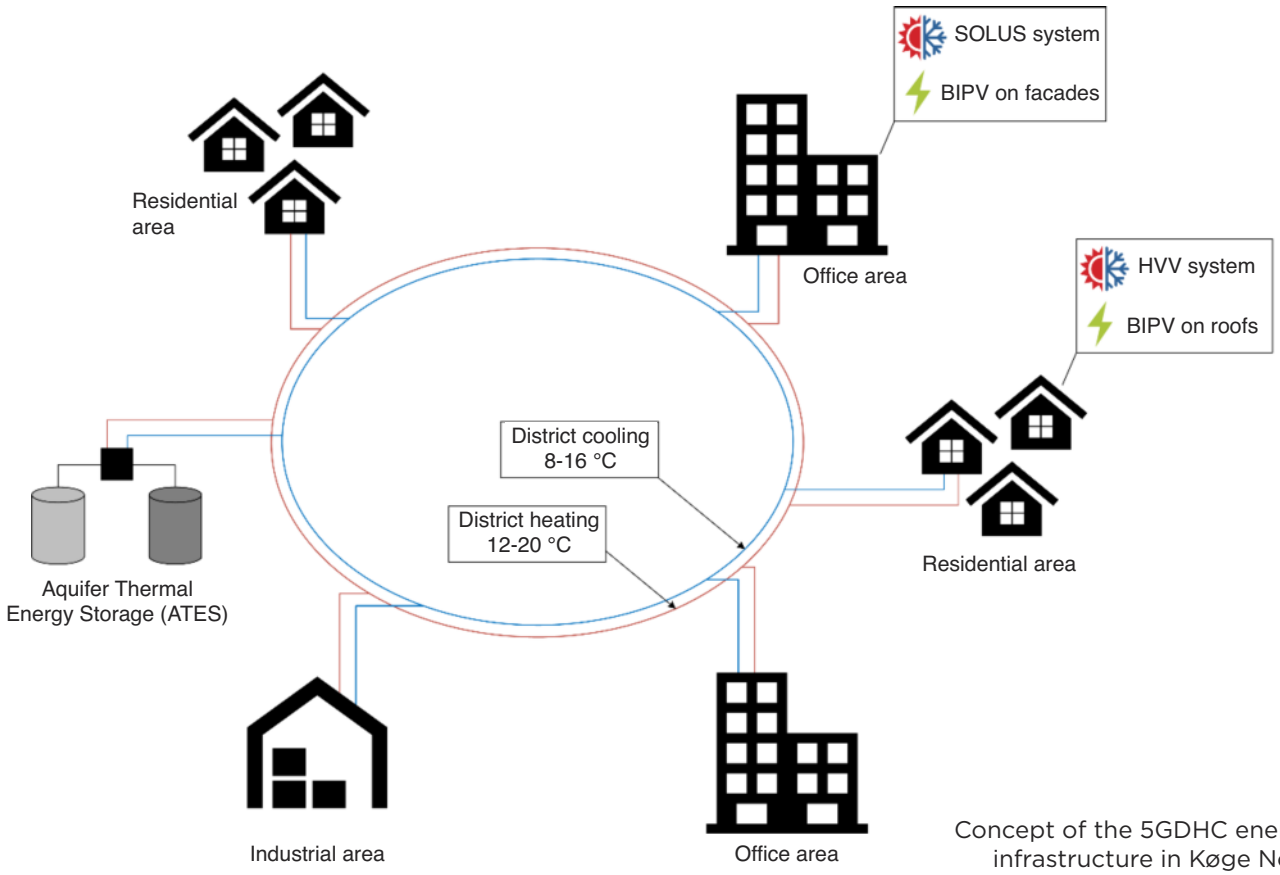


Conventional DH system (top) vs. 5GDHC systems (bottom)

The technology of district cooling is based on the idea of delivering centralised chilled water to buildings to provide greater efficiency than traditional air-conditioning systems. The development of district cooling has been more a recent one in contrast to district heating; therefore, district cooling systems are neither as common nor as extensive as district heating systems. On the other hand, energy demand for space cooling has grown rapidly since the 1990s. This is confirmed by the number of central air-conditioners and room air-conditioners installed which increased by more than 50 times from 1990 to 2010 in the European Union (EU). Other parameters that underline this trend are heating degree days and cooling degree days, which have, respectively, decreased and increased in the last decades in Europe.

Therefore, the combined effect of the decrease in heat demand and the increase in the cooling request is making the creation of district heating networks alone (i.e. without cooling) less profitable and reliable. On the other hand, from an infrastructure perspective, the creation of both a district heating and cooling system serving the same urban area would require the installation of two separated water network circuits (four pipes system) and as a consequence, the cost is more or less doubled if compared to district heating alone.

A possible solution to favour a high degree of integration between district heating and cooling networks and still maintaining a competitive cost is the creation of a so-called 5th Generation District Heating and Cooling systems (5GDHC).



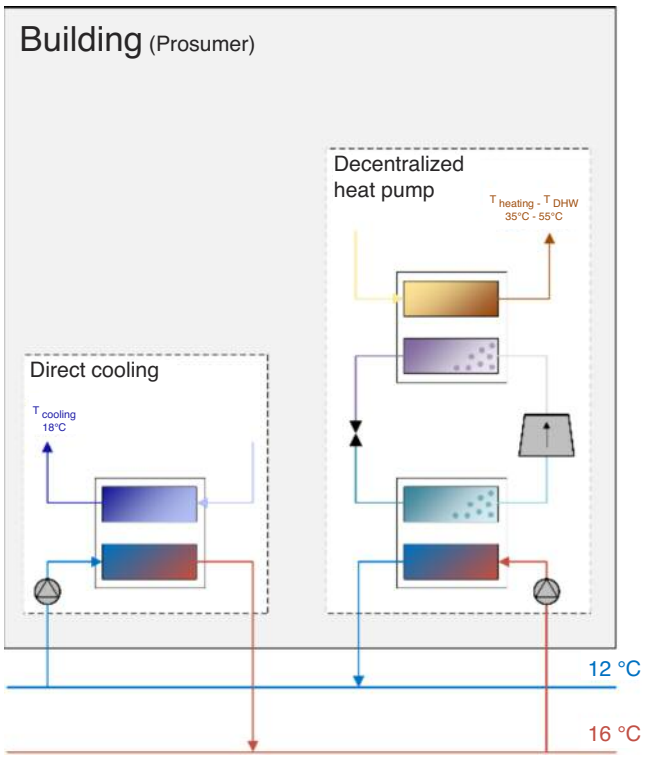
Concept of the 5GDHC energy infrastructure in Køge Nord

Historically, all-district heating and cooling systems have been “unidirectional”, meaning that the water in each pipe segment only flows in one direction. A particularity of 5GDHC systems is that they feature a “bidirectional distribution”, in which the water in each pipe segment can flow in alternating directions, depending on the net thermal fluxes on the system. In this case, there is a single network loop (two pipes system) for both district heating and cooling. 5GDHC systems consist of two pipes. The warmer pipe has temperatures between 12°C and 20°C, while the cold pipe has 8-16°C.

Heating and cooling in buildings are provided by means of decentralised heat pumps and chillers. This thermal distribution system functions much like the electrical grid, which can convey energy both from a centralised generator to a consumer and back from a rooftop PV into the grid. Therefore, 5GDHC systems allow buildings to become “prosumers” as they not only draw but also feed thermal energy into the grid.

The concept of 5GDHC systems is in the early stages of development. Recent studies have been carried out in terms of thermodynamic analyses and the Swiss Competence Center for Energy Research is currently building and monitoring few demonstration pilot projects in Switzerland.

The vision of Køge Municipality for the development in Køge Nord is to create a characteristic landmark for green mobility and sustainable energy in order to fulfill the local climate goals indicated in the Strategic Energy Plan “Energi på Tværs”, which envisions for the Region



Typical example of prosumer substation for integration into the 5GDHC system in Køge Nord



Peder Vejsig Pedersen

Hovedstaden's electricity and heat supply to be fossil fuel-free by 2035. When fully developed, the new urban area of Køge Nord is expected to have approx. 1,000 houses, 15-20 large office buildings and industrial sites.

Besides introducing novelties at district level, related to the 5GDHC configuration, the future energy infrastructure of Køge Nord foresees novelties also at building level. To take advantage of a large amount of thermal energy sources available at ambient temperatures, solutions such as low-temperature heating (LTH) and high-temperature cooling (HTC) systems will be installed in buildings. In particular, office buildings will be equipped with the SOLUS system, a novel active beam system which can provide simultaneous heating and cooling by using a single water circuit with temperatures close to ambient conditions (20-23°C). Residential buildings will be equipped with the Heat Valve Ventilation (HVV) system, an innovative temperature-based demand-controlled ventilation system that uses warm air to provide heating to a space. Innovative BIPV (Building Integrated Photovoltaics) will be installed on roofs and facades of office and residential buildings in order to cover a large share of the electricity use of heat pumps and other equipment.



ATES system at Bispebjerg

USE OF ATES TECHNOLOGY WITH GROUNDWATER COOLING AND HEATING AT BISPEBJERG HOSPITAL IN COPENHAGEN

The basis for the assessment carried out by the company Enopsol is that, in conjunction with the Copenhagen Energy Company (HOFOR), an energy plant has been established which is the only ground on which to base its decision in connection with the overall major reconstruction project for Bispebjerg Hospital, Copenhagen.

This type of ATES technology (Aguifer Thermal Energy Storage) also includes the standard installation of a large and supporting mechanism for cooling down and, at the same time, it saves 75% of the total energy supply for cooling and heating, Therefore, it is possible to remove the variety that provides the foundation for the future in the summer, in the shape of the heat pump that is used by the heating authority during the winter months.

Investment in the overall ATES solution has a positive impact on the economy and society and in that it pays for itself from between five to six years. It can also be used to benefit other healthcare professionals.



Office buildings with
BIPV in facades



ATES system at Bispebjerg

GREEN ISLAND: FOSSIL FREE CITY AREAS

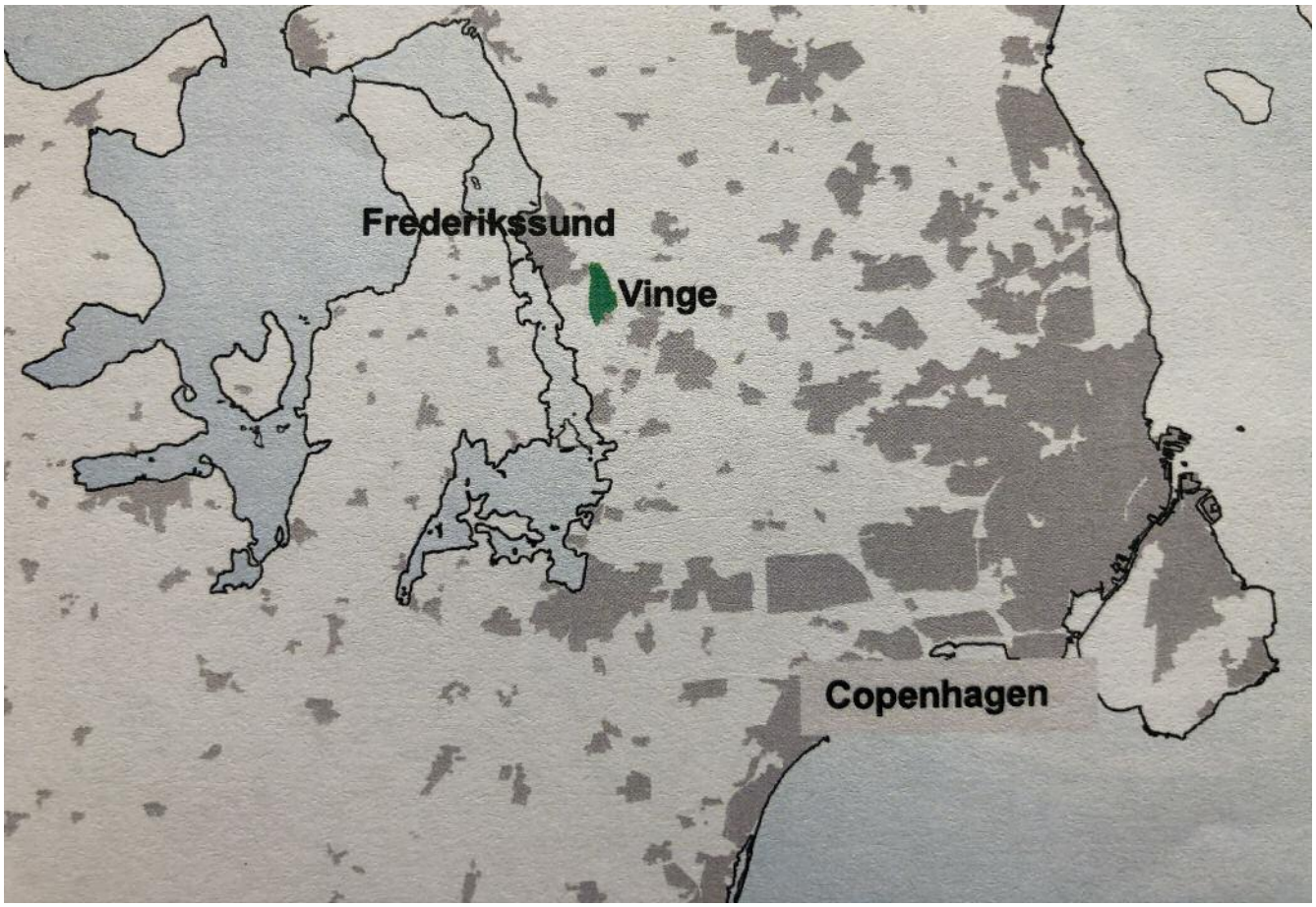
Peder Vejsig Pedersen, Senior Advisor, MSc, European Green Cities highlights how Green Island is developing fossil free communities

At the moment (during 2019), Green Island is developing a plan for a fossil-free city area with 2,000 housing units at Vinge in the municipality of Frederikssund, situated 40 km north-west of Copenhagen in Denmark.

The vision is to obtain 100% of the energy supply from renewable energy in a cost-effective way for the inhabitants there. This will, in practice, mean use of both wind and solar PV (photovoltaic) as well as solar thermal collectors in the area, hereby, supplying the main part of the energy needs, together with a local biogas plant.

The heat supply for the "Active House" optimised housing units will utilise low-temperature district heating, distributing heat from local heat pumps, which are connected to a local Aquifer Thermal Energy Storage (ATES) system. The ATES system utilises the groundwater as a heat source but it is based on a thermal balance from year to year, secured by supply from a large solar thermal collector installation as well as excess heat from a local industry.

To be certain all the heating and electricity needs are covered, local battery storage will also be used and besides there is a backup supply of heat and electricity from generators that utilise locally





produced biogas, coming from wastewater and organic waste. And a second priority, also use of certified biogas-based gas coming from the gas grid.

In the Green Island project at Vinge, there is used a new multi-layout thought process taking place, in that you replace the normal linear economic model (take, make, dispose) with a sustainable circular approach.

And this new way of thinking benefits from the fact that in Denmark, where almost 60% of all buildings are supplied by district heating, there is now a challenge to make a transition to a much more electricity-based district heating model, due to the high supplies of wind energy during long periods of time. This has been agreed by all political parties in Denmark and the laws and regulations have now changed accordingly, so it becomes beneficial to introduce heat pumps on a large scale in connection with district heating systems.

In many cases, this can also include use of the mentioned ATES technology, which the Danish company Enopsol has long-term experience in and is preparing a new project for the village of Kyndby Huse, also situated in the municipality of Frederikssund, where 160 existing housing units will be equipped with local heat pumps in combination with an ATES system, at a total investment cost of €20,000 per housing unit.



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GREEN ISLAND

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A focus on smart energy green cities

Peder Vejsig Pedersen from European Green Cities tells us about the use of ATES technology with groundwater cooling and heating at Bispebjerg Hospital, Copenhagen

Under the coordination of the non-profit European Green Cities, with the support of the Danish Energy Agency's Smart Energy pool during 2019 and 2020, a targeted development and dissemination work on "Smart Energy" solutions will be carried out in several locations in Denmark, where the focus is on the widespread use of renewable energy in combination with optimised energy supply solutions that seek to utilise heat pumps in combination with so-called groundwater heat and groundwater cooling.

> "The yearly energy saving is 75% and more than 90% of stored heat during summer can be recovered."

I want to emphasise here that based on the expertise from the company Enopsol, and in a collaboration with the Copenhagen energy supply company HOFOR, as early as 2019, that an energy plant has been commissioned to utilise groundwater as a cooling medium in connection with the overall major redevelopment project for Bispebjerg Hospital in Copenhagen.

This so-called ATES * technology avoids the normal installation of large and noisy mechanical cooling systems on roofs, while at the same time saving 75% of the total energy consumption for cooling and heat. This is because it is possible to utilise the heat supplied through cooling by the groundwater during the summer season, using heat pumps in the winter, which then cover the peak of the heating needs during the coldest months. This also ensures that the groundwater temperature is not affected from year to year as it is possible to achieve a thermal balance for this.

The investment in the overall ATES solution has a positive user and community economy and pays home in five or six years. This can also be used advantageously for other hospital buildings and the like.

In addition to this project, there is also a collaboration with the company, Green Island, which is involved in the development of a fossil-free district at Vinge Nord in the Frederikssund municipality. You can find out more about this at http://www.greenisland.dk, as well as a dialogue on similar solutions using heat pumps and building-adapted solar cells for a new urban development area in Køge Nord, as well as renovation projects at Avedøre in the Hvidovre municipality.

Information about the above will be provided on the "Sustainable Cities and Buildings" association website and database and on the website.

* Aquifer Thermal Energy Storage (ATES)



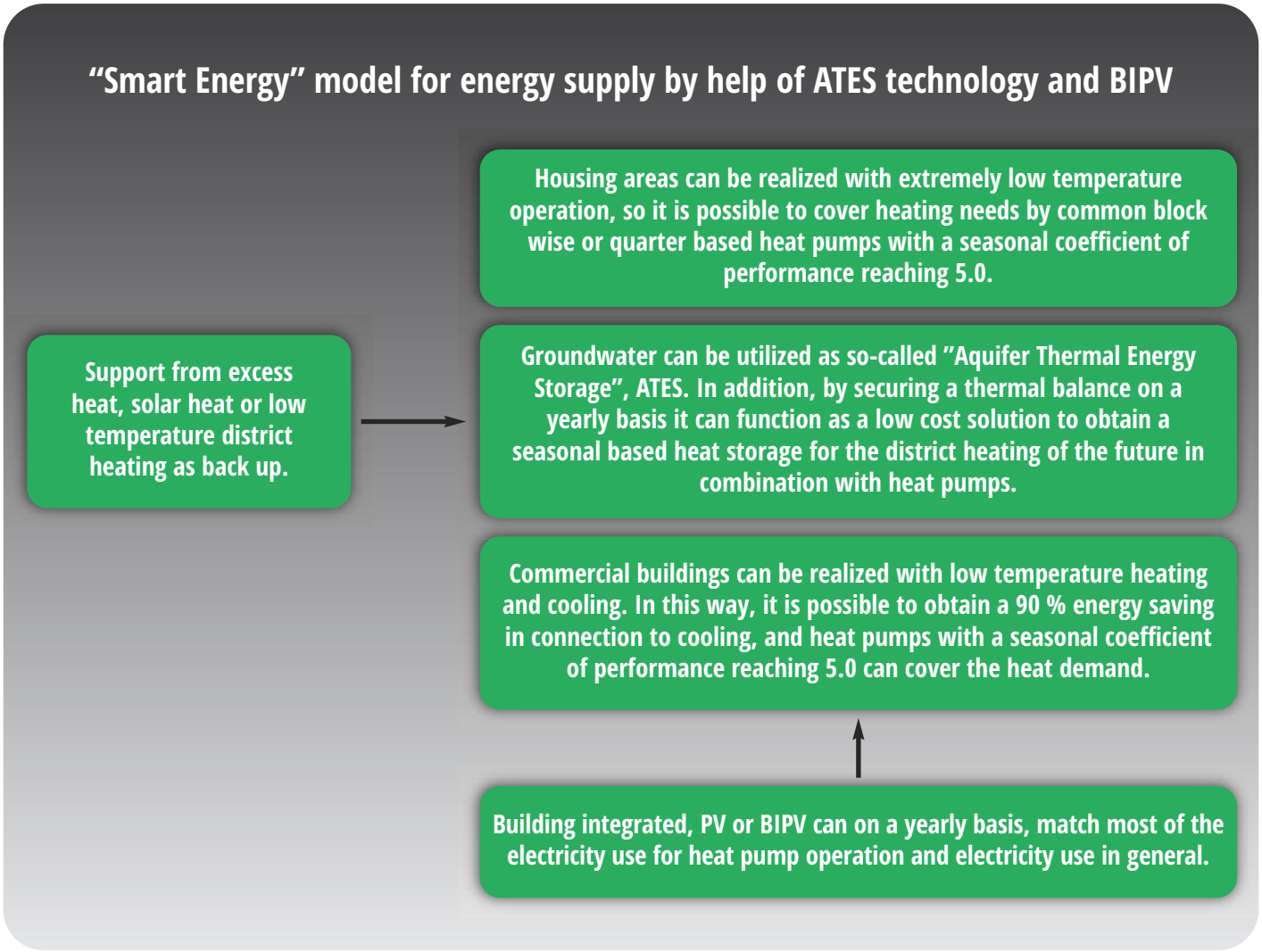
Peder Vejsig Pedersen

ATES groundwater cooling and heating

For the Bisperberg Hospital in Copenhagen was chosen to use Aquifer Thermal Energy Storage or ATES groundwater based cooling as a cheaper alternative than district cooling from HOFOR, the Copenhagen Energy Company.

The yearly energy saving is 75% and more than 90% of stored heat during summer can be recovered. 2 stage heat pumps from Sabroe is used (owned by Johnson Controls).

In winter, district heating is base load and heat pumps delivers the peaks. (Only from November to March).



In Denmark it has been proven that ATES systems can be used even quite near to drinking water pumping stations, but it is a demand that the ground water temperatures are never heated more than 0,5°C in the vicinity of this.

"The investment in the overall ATES solution has a positive user and community economy and pays home in five or six years. This can also be used advantageously for other hospital buildings and the like."

Besides an important effect has been that there has never been any net consumption of water, and there is no noise from the system. This can be compared to normal compressor cooling systems, which have a clear noise problem from the condenser in the roofs in summer.

From the ATES system developer Enopsol's point of view, the new and innovative SOLUS heating / cooling system, from Lindab with 19° - 24°C operation temperatures, is really interesting. Since there can be a perspective of avoiding the use of a large part of the heat pump operation, with its quite high electricity use, if the ground water temperatures can be raised somewhat in summer periods.

For a new city development area, Køge Nord south of Copenhagen it has been suggested to implement an advanced low temperature bidirectional district heating solution, which can be ideally combined with the above mentioned technologies, and new types of BIPV facades for a large commercial building development area.

European Green Cities

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A look at Carbon Zero Cities

Peder Vejsig Pedersen from European Green Cities provides a fascinating glimpse at Carbon Zero Cities

Existing certification systems do not handle the aim to utilise local renewable energy solutions in cities in a useful way. A Carbon Zero label for city districts can be a help to improve this situation and secure a development to identify how existing electricity and district heating systems live up to the aim of supporting an agenda of CO_2 neutrality. Here a criterion could be that local renewable energy solutions should cover at least 50% of the energy supply.

Renewable energy production

Here it is important to accept, that it is not sufficient just to refer to a high amount of renewable energy in our electricity supply system, for example, based on a faraway offshore windmill or solar park capacity.

The local involvement in our renewable energy production is extremely important because it means that the transformation to 100% renewable energy is being accepted by our society, while it also secures reduced system losses in the electricity system, which also becomes more stable, while the security of electricity supply is at the same time improved.

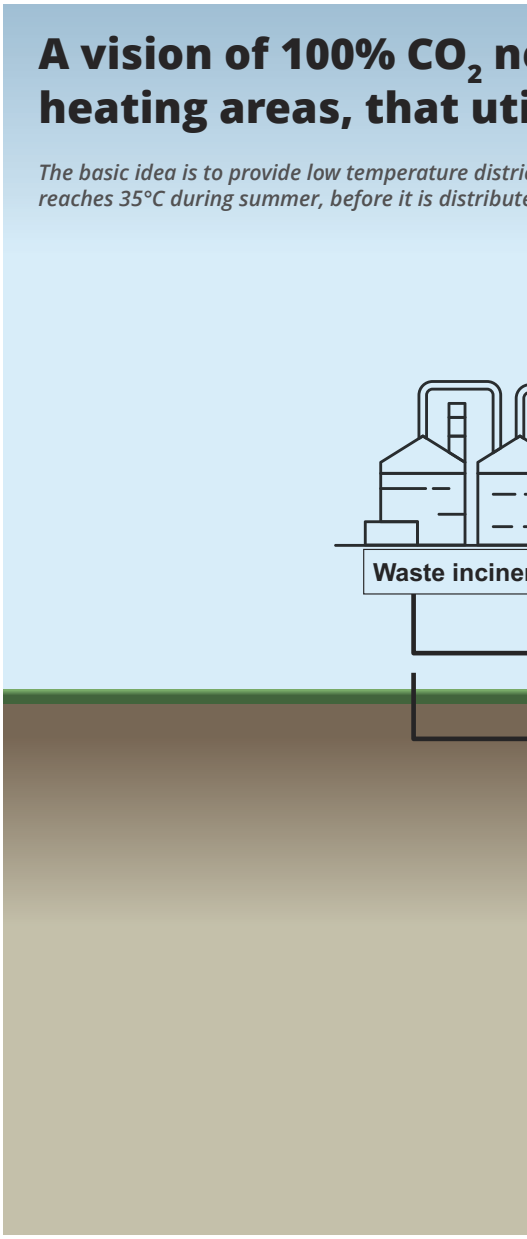
In connection to this, it is important to agree on what you mean by renewable energy, so you only work with technologies, which actually reduce the CO_2 emissions. Here the situation concerning biomass is still not so clear, and it is important to note that it was only due to an aim to get everyone on board in the UN-Kyoto Protocol in 1992, where it was accepted that all kinds of biomass were CO_2 neutral.

Smart Energy Solutions

An example of Smart Energy Solutions being used with heat pumps is mentioned here, which together with new types of low-temperature district heating can combine with local renewable energy technologies as a next-generation 100% carbon zero city strategy, utilising waste- and groundwater as a resource.

Present-day waste incineration systems have the dilemma, that they have large amounts of surplus heating during summer, that cannot be utilised in the existing district heating systems.

An interesting solution to this problem can be to expand the district heating areas with the help of new ultra-low



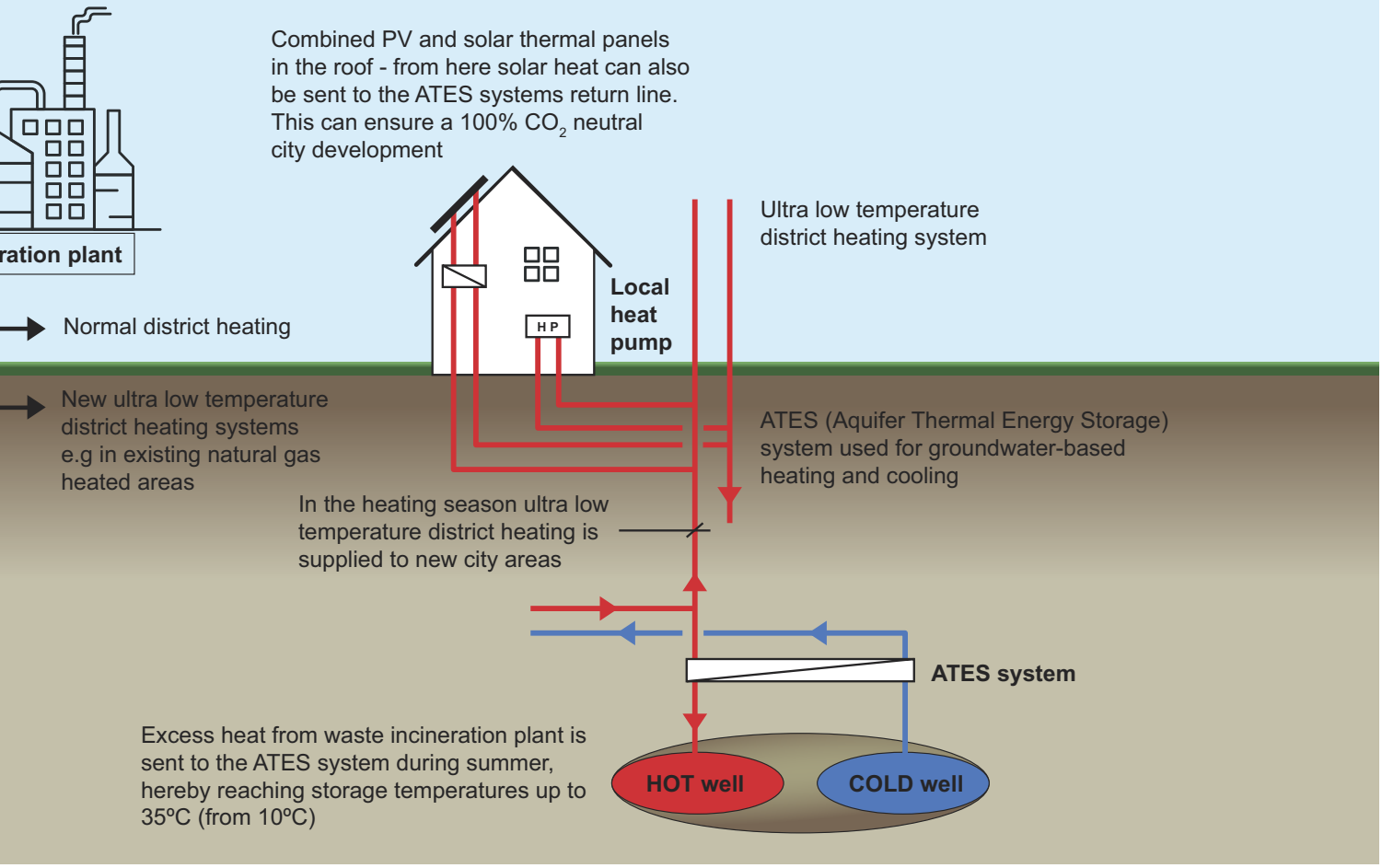
temperature district heating, which is based on the use of groundwater based Aquifer Thermal Energy Storage (ATES) combined with heat pumps, which also support the needed electrification of our heating needs.

This can be implemented as an "island" energy system, which, for example, can be established in existing, natural gas, supplied city areas, where you need to find new "non-fossil fuel" solutions.

In the figure shown here, there is an illustration of how this can be done in practice. In this case, you will get an

eutral heating of city areas by a "proposed" expansion of district ilise waste incineration

ct heating to new local so-called island district heating areas with own ATES systems, where the groundwater ed through ultra-low temperature district heating networks to dwellings with small water-to-water heat pumps.



improved operation of the waste incineration plant with the help of a new district heating line, where the local "island" energy systems will obtain an increase of the ATES groundwater temperature of up to 35°C during summer. And during the heating season, new cheap ultra-low temperature district heating systems will supply local dwellings with groundwater-based district heating for their individual water to water heat pumps in a very energy-efficient way.

And as a possibility to obtain a 100% CO_2 neutral energy supply it can also be a good option to combine this with the use of local solar energy panels as well, where solar heat in the summer can be transferred to the groundwater storage system with high efficiency.

The present information is also available together with a recent video film and Smart Energy Green Cites reporting at www.carbonzerocities.eu and www.carbonzerocities.dk.

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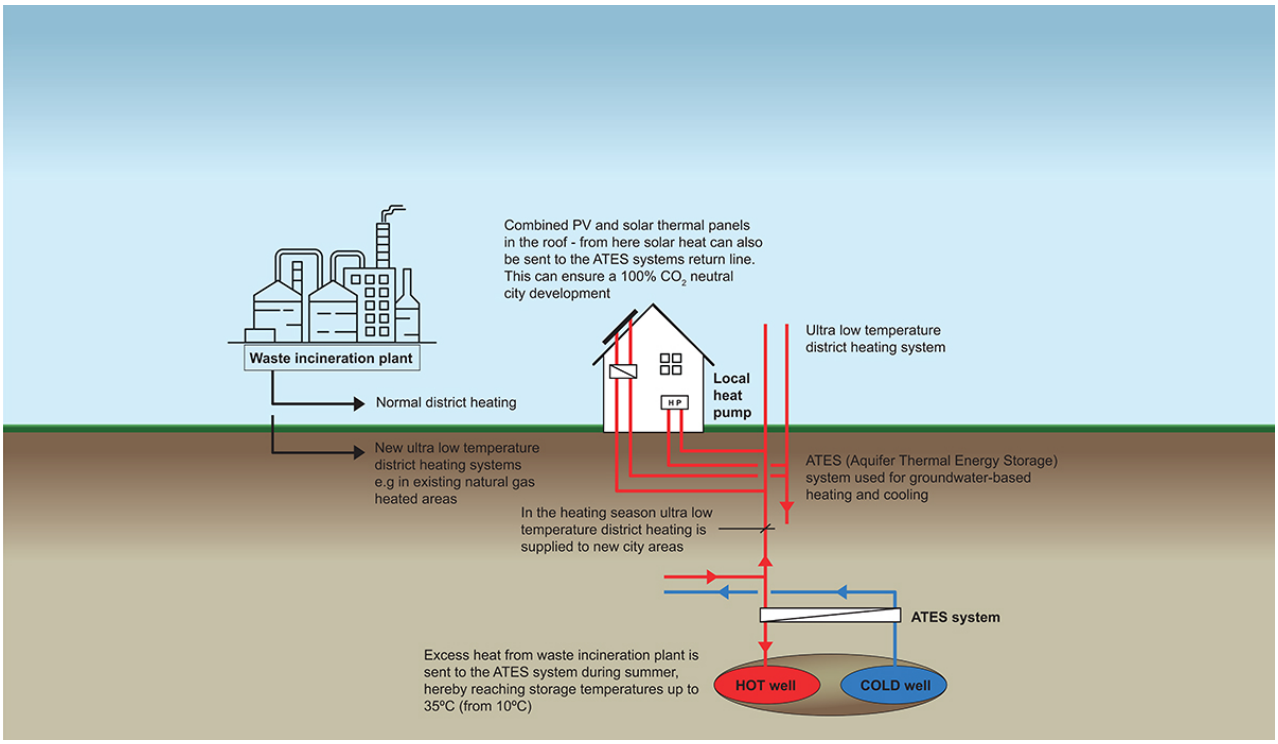
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More About Stakeholder

European Green Cities

European Green Cities (EGC) – striving for a sustainable Europe
European Green Cities (EGC) is a network aiming to work together for a sustainable Europe, through a number of innovations and collaborations.

Contributor Profile



Read Profile

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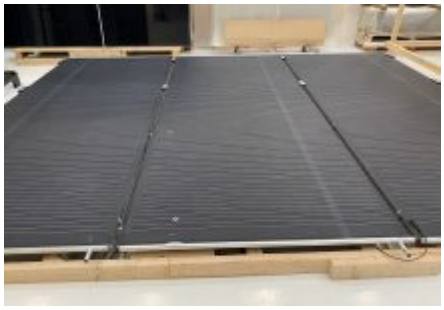
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  Must Read >> Smart Energy Design Guidelines for CO2 neutral city development

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  Must Read >> From European Green Cities to the proposed Carbon Zero Digital Platform

- 

  Must Read >> Racell PVT in combination with ATES seasonal storage

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