SDH with seasonal thermal storage integrated with the electricity market

European framework and Swedish case

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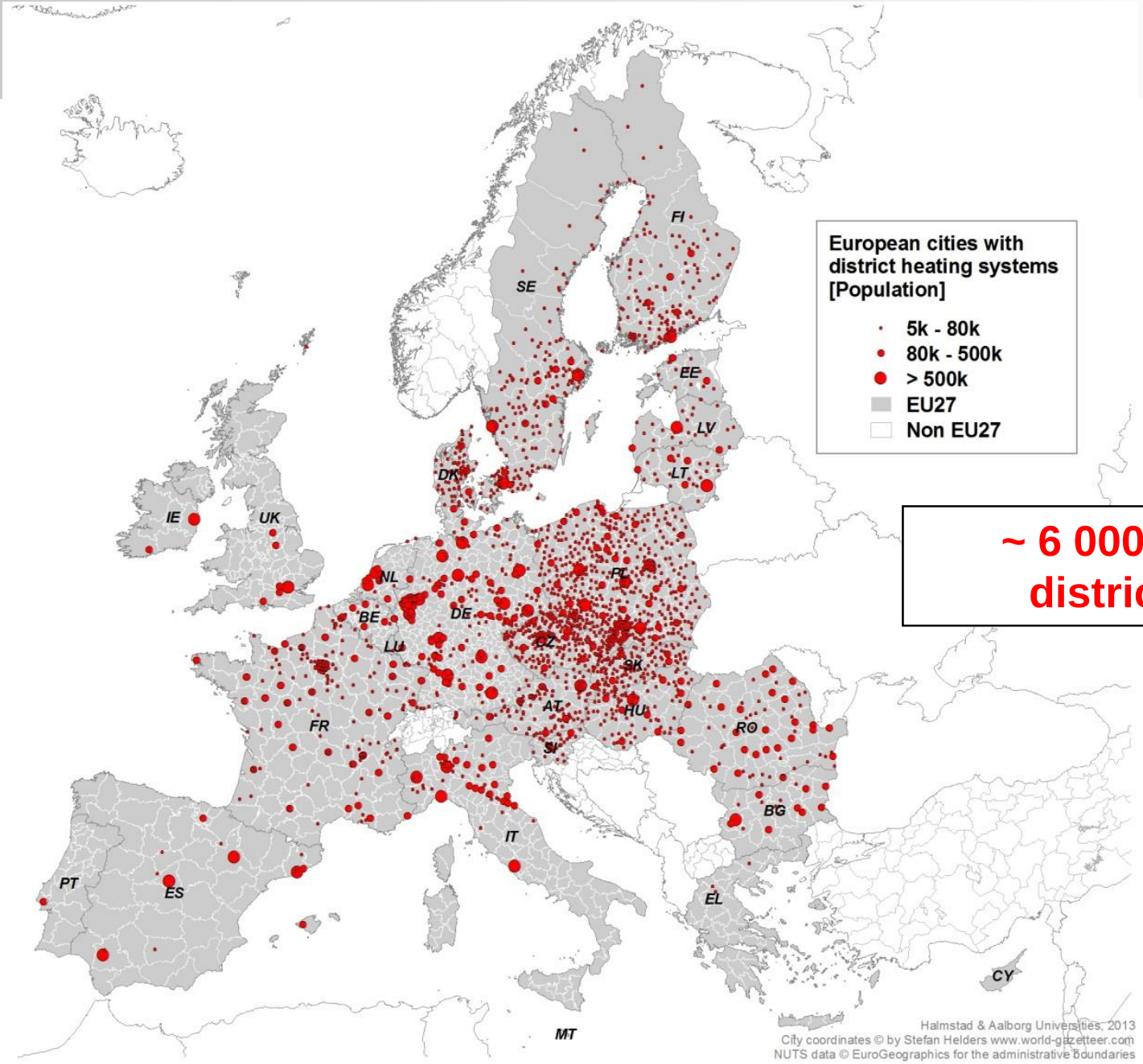
SDH p2m - Warsaw – January 17, 2018

ELECTRICITY MARKET

- Increased wind and solar power will require (seasonal) storage
- Three main options, Hydro power dams, Power to Gas (P2G) and Power to Heat (P2H)
- Nordic market has Hydro power dams
- European market lacks Hydro power dams ..

DISTRICT HEATING IN EU

- Dominated by fossil fuel CHP (Coal, NG, etc)
- Potential/need to increase renewable energy, e.g. bio ?
- Potential to introduce SDH with (seasonal) storage ?
- Potential to balance RE electricity as demonstrated in DK!

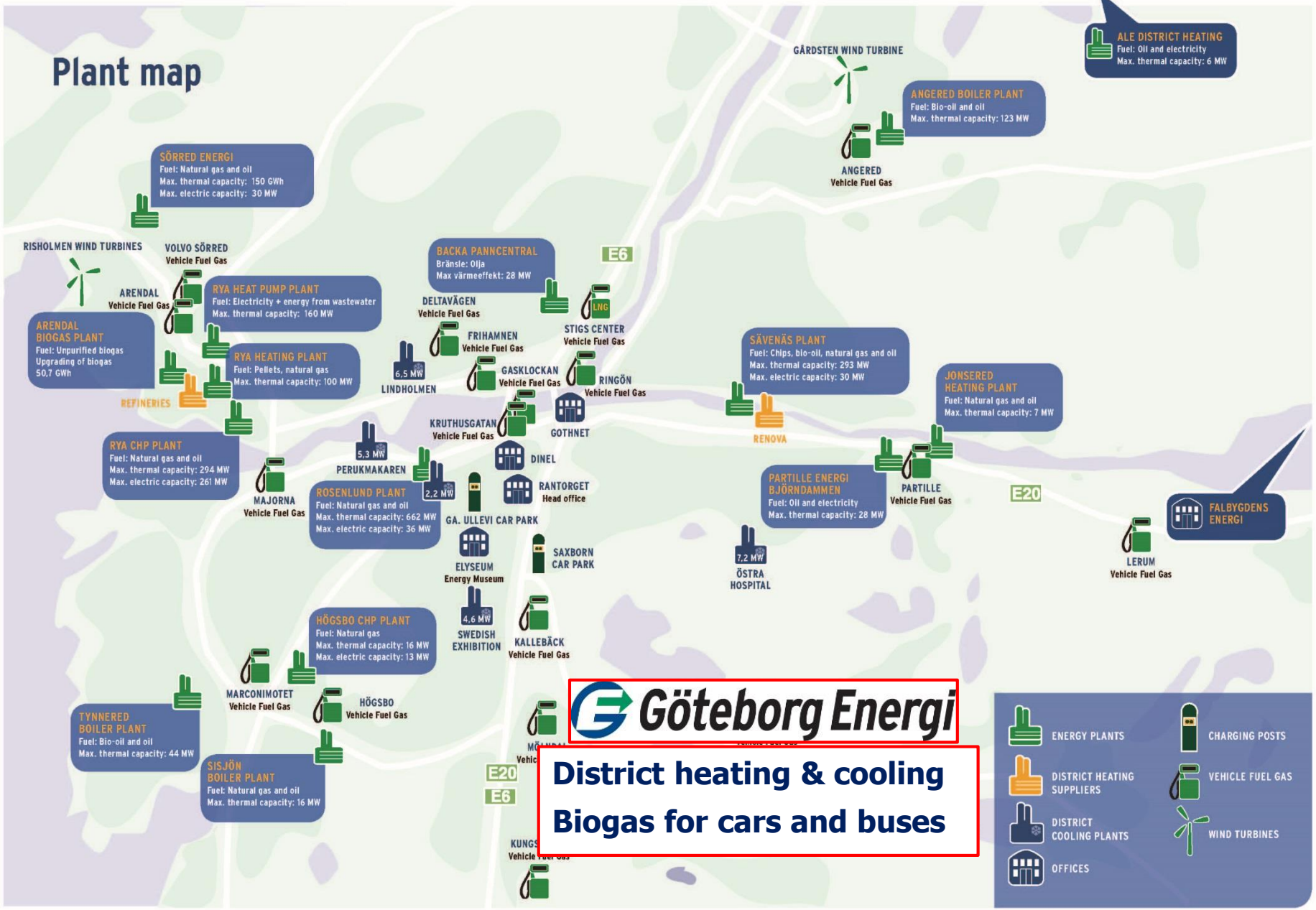


~ 6 000 cities with district heating

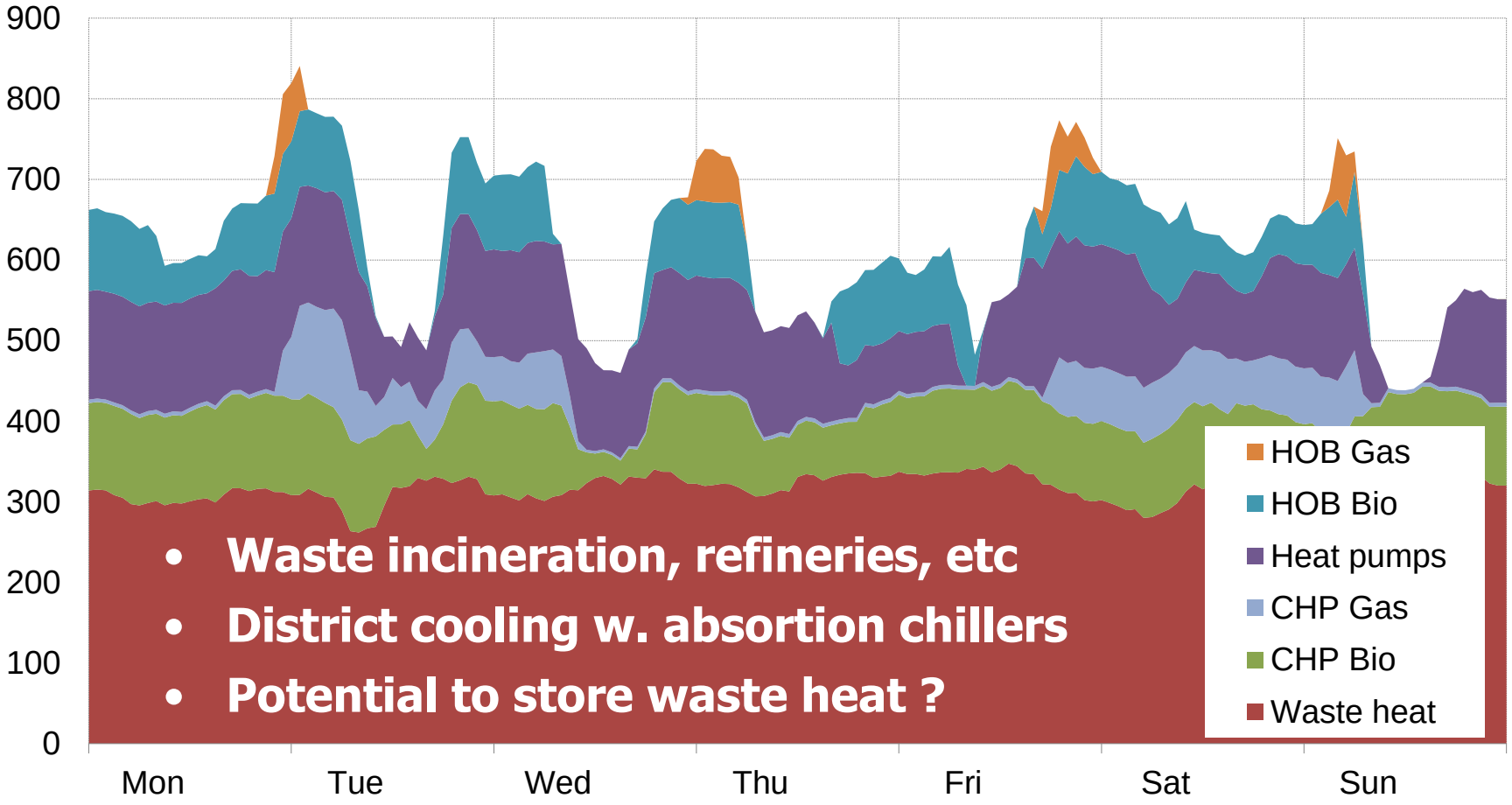
DISTRICT HEATING IN SE

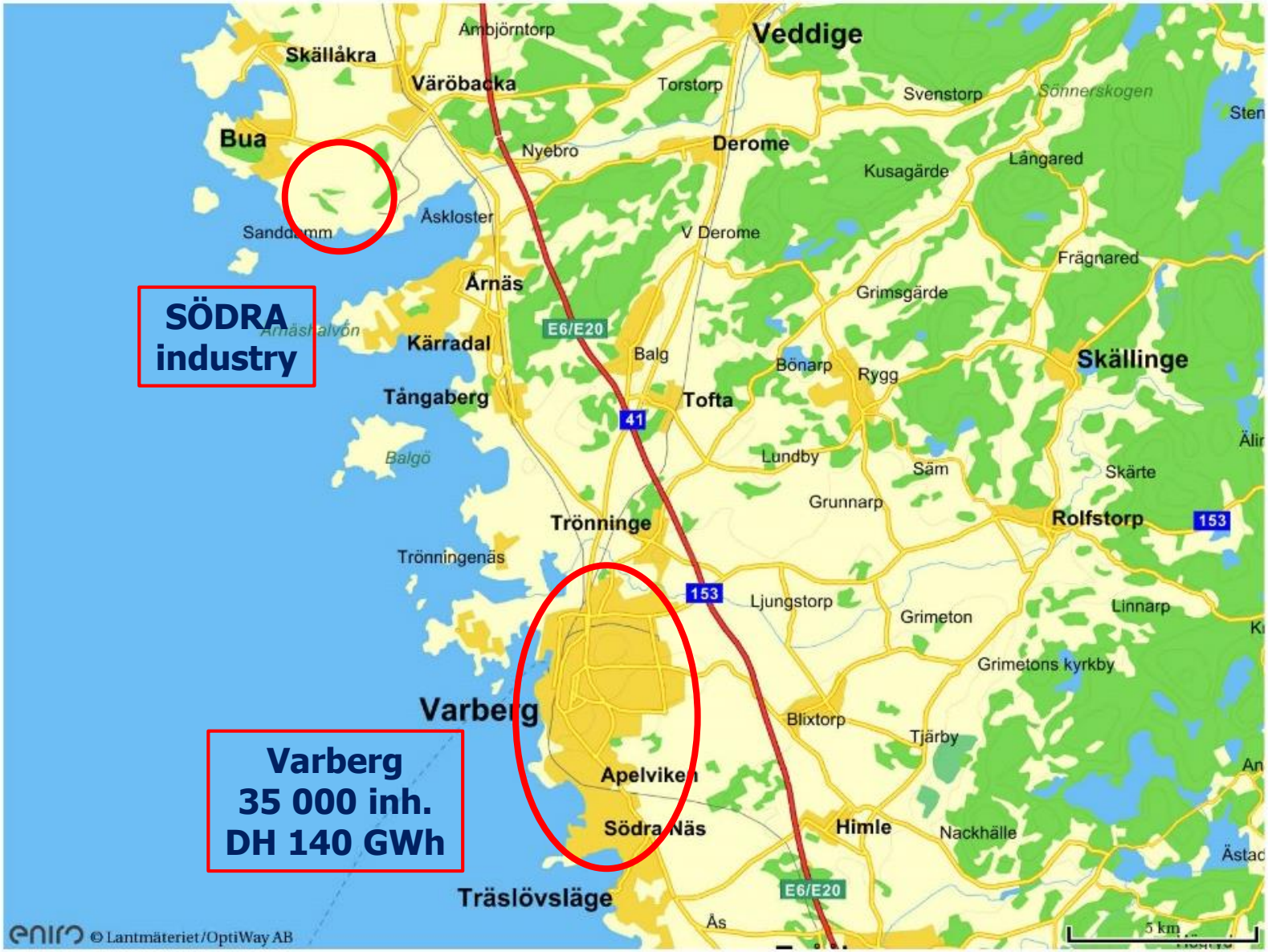
- **Bio energy (wood chips) CHP & HOB**
  Dominates in large DH systems
- **Bio energy (wood pellet) HOB**
  + solar in a number of small DH systems
- **Wood can be stored !**
- **Gothenburg heated by waste heat cooled by the river and waste heat**
- **Varberg heated by a wood industry**
- **Potential to store waste heat ?**

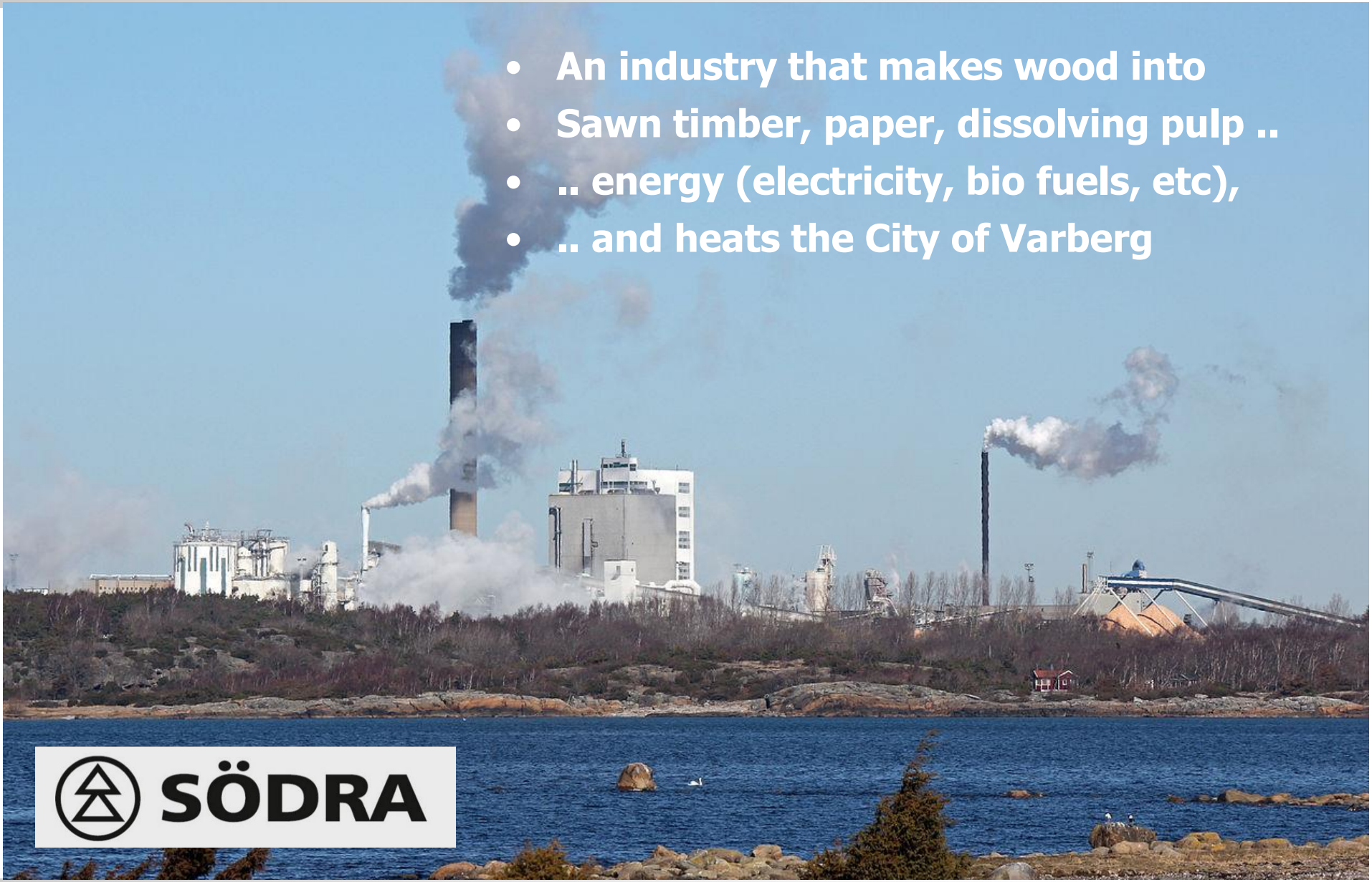

Gothenburg
600 000 inh.
DH 3.5 TWh
Varberg
Kragerø
Risør
Arendal
Kongshavn
Lillesand
Skålevik
Lysekil
Vänersborg
Trollhättan
Lidköping
Skara
Skövde
Mariestad
Motala
Finspång
Linköping
Malmslätt
Mjölby
Falköping
Tranås
Kisa
Habo
Alingsås
Kungälv
Stora Höga
Göteborg
Borås
Jönköping
Nässjö
Vimmerby
Mölndal
Billdal
Kinna
Fritsla
Tranemo
Skillingaryd
Vetlanda
Hultsfred
Gislaved
Värnamo
Hyltebruk
Mönsterås
Växjö
Ljungby
Nybro
Kalm
Skagen
Hirtshals
Hjørring
Brønderslev
Aabybro
Aalborg
Nibe
Thisted
Nykøbing Mors
Hobro
Lemvig
Skive
Viborg
Randers
Grenaa
Holstebro
Hammel
Silkeborg
Aarhus
Ry
Tarm
Give
Horsens
Grindsted
Vejle
Kalundborg
Varde
Brørup
Kolding
Otterup
Høng
Slagelse
Falkenberg
Kattegat
Halmstad
Båstad
Strömsnäsbruk
Bjärnum
Ängelholm
Helsingborg
Helsingør
Hillerød
Jægerspris
København
Lund
Malmö
Tomelilla
Trelleborg
Köge
Höör
Ronneby
Karlskrona
Kristianstad
E45
E20
E4
E22
Vänern
50 km
© Eniro/Krak/Geodatastyrelsen Lantmäteriet/OptiWay AB


Plant map
SÖRRED ENERGI
Fuel: Natural gas and oil
Max. thermal capacity: 150 GWh
Max. electric capacity: 30 MW
RISHOLMEN WIND TURBINES
VOLVO SÖRRED
Vehicle Fuel Gas
ARENDAL
Vehicle Fuel Gas
RYA HEAT PUMP PLANT
Fuel: Electricity + energy from wastewater
Max. thermal capacity: 160 MW
ARENDAL BIOGAS PLANT
Fuel: Unpurified biogas
Upgrading of biogas
50,7 GWh
RYA HEATING PLANT
Fuel: Pellets, natural gas
Max. thermal capacity: 100 MW
REFINERIES
RYA CHP PLANT
Fuel: Natural gas and oil
Max. thermal capacity: 294 MW
Max. electric capacity: 261 MW
MAJORNA
Vehicle Fuel Gas
BACKA PANNCENTRAL
Bränsle: Olja
Max värmeeffekt: 28 MW
E6
DELTAVÄGEN
Vehicle Fuel Gas
LNG
STIGS CENTER
Vehicle Fuel Gas
FRIHAMNEN
Vehicle Fuel Gas
6,5 MW
LINDHOLMEN
GASKLOCKAN
Vehicle Fuel Gas
RINGÖN
Vehicle Fuel Gas
GOTHNET
KRUTHUSGATAN
Vehicle Fuel Gas
DINEL
5,3 MW
PERUKMAKAREN
2,2 MW
ROSENLUND PLANT
Fuel: Natural gas and oil
Max. thermal capacity: 662 MW
Max. electric capacity: 36 MW
GA. ULLEVI CAR PARK
RANTORGET
Head office
ELYSEUM
Energy Museum
SAXBORN CAR PARK
4,6 MW
SWEDISH EXHIBITION
KALLEBÄCK
Vehicle Fuel Gas
HÖGSBO CHP PLANT
Fuel: Natural gas
Max. thermal capacity: 16 MW
Max. electric capacity: 13 MW
MARCONIMOTET
Vehicle Fuel Gas
HÖGSBO
Vehicle Fuel Gas
TYNNERED BOILER PLANT
Fuel: Bio-oil and oil
Max. thermal capacity: 44 MW
SISJÖN BOILER PLANT
Fuel: Natural gas and oil
Max. thermal capacity: 16 MW
E20
E6
KUNGS
Vehicle Fuel Gas
GÅRDSTEN WIND TURBINE
ANGERED BOILER PLANT
Fuel: Bio-oil and oil
Max. thermal capacity: 123 MW
ANGERED
Vehicle Fuel Gas
ALE DISTRICT HEATING
Fuel: Oil and electricity
Max. thermal capacity: 6 MW
SÄVENÄS PLANT
Fuel: Chips, bio-oil, natural gas and oil
Max. thermal capacity: 293 MW
Max. electric capacity: 30 MW
RENOVA
JONSERED HEATING PLANT
Fuel: Natural gas and oil
Max. thermal capacity: 7 MW
PARTILLE ENERGI BJÖRNDAMMEN
Fuel: Oil and electricity
Max. thermal capacity: 28 MW
PARTILLE
Vehicle Fuel Gas
E20
7,2 MW
ÖSTRA HOSPITAL
FALBYGDENS ENERGI
LERUM
Vehicle Fuel Gas
Göteborg Energi
District heating & cooling
Biogas for cars and buses
ENERGY PLANTS
DISTRICT HEATING SUPPLIERS
DISTRICT COOLING PLANTS
OFFICES
CHARGING POSTS
VEHICLE FUEL GAS
WIND TURBINES

Heat Generation in Gothenburg April 2-8, 2012 [MW]



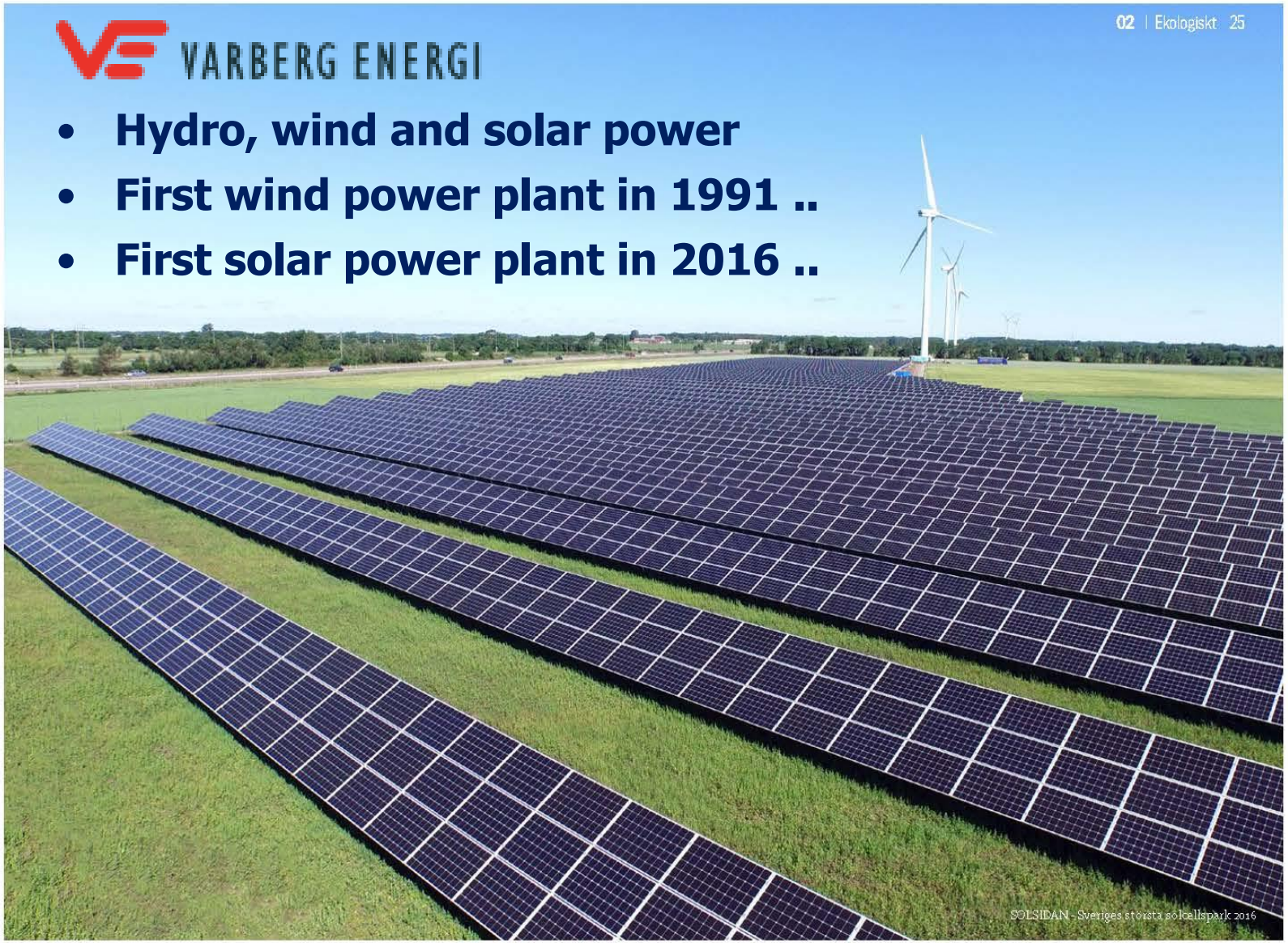

SÖDRA industry
Varberg 35 000 inh. DH 140 GWh
Veddige
Skällåkra
Väröbacka
Torstorp
Svenstorp
Sönnerskogen
Bua
Nyebro
Derome
Kusagärde
Långared
Åskloster
V Derome
Frägnared
Grimsgärde
Årnäs
E6/E20
Kärradal
Balg
Bönarp
Rygg
Skällinge
Tångaberg
Tofta
41
Balgö
Lundby
Säm
Skärte
Grunnarp
Trönninge
Rolfstorp
153
Trönningenäs
Ljungstorp
Grimeton
Linnarp
Grimetons kyrkby
Varberg
Blixtorp
Tjärby
Apelviken
Södra Näs
Himle
Nackhälle
Träslövsläge
E6/E20
Ås
5 km
© Lantmäteriet/OptiWay AB

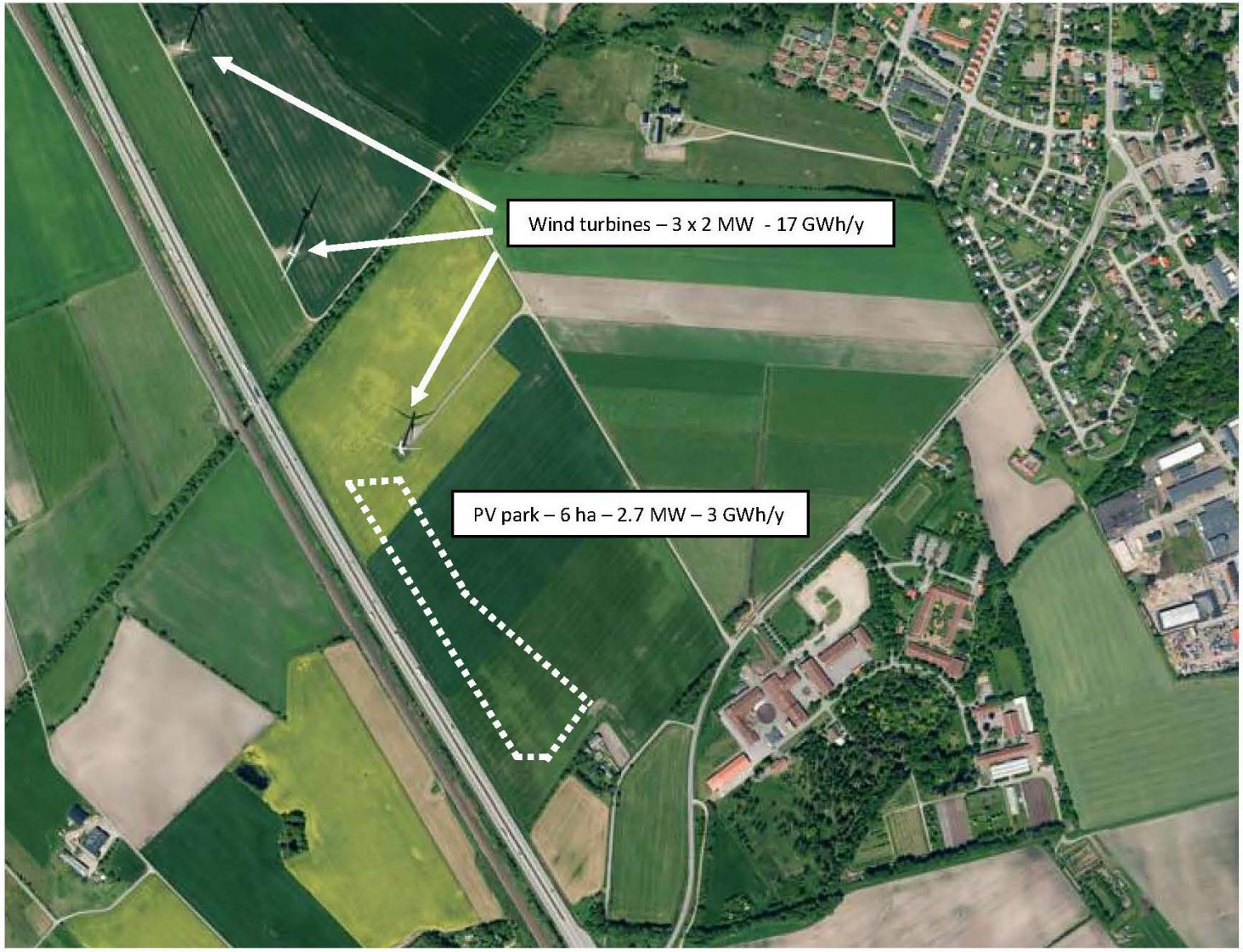


- An industry that makes wood into
- Sawn timber, paper, dissolving pulp ..
- .. energy (electricity, bio fuels, etc),
- .. and heats the City of Varberg

DH IN VARBERG

- **Waste heat from SÖDRA (wood industry)**
- **2 x 10 MW wood chips, 10 MW bio oil (10 MW NG)**
- **3 000 m³ buffer storage (not enough for waste heat)**

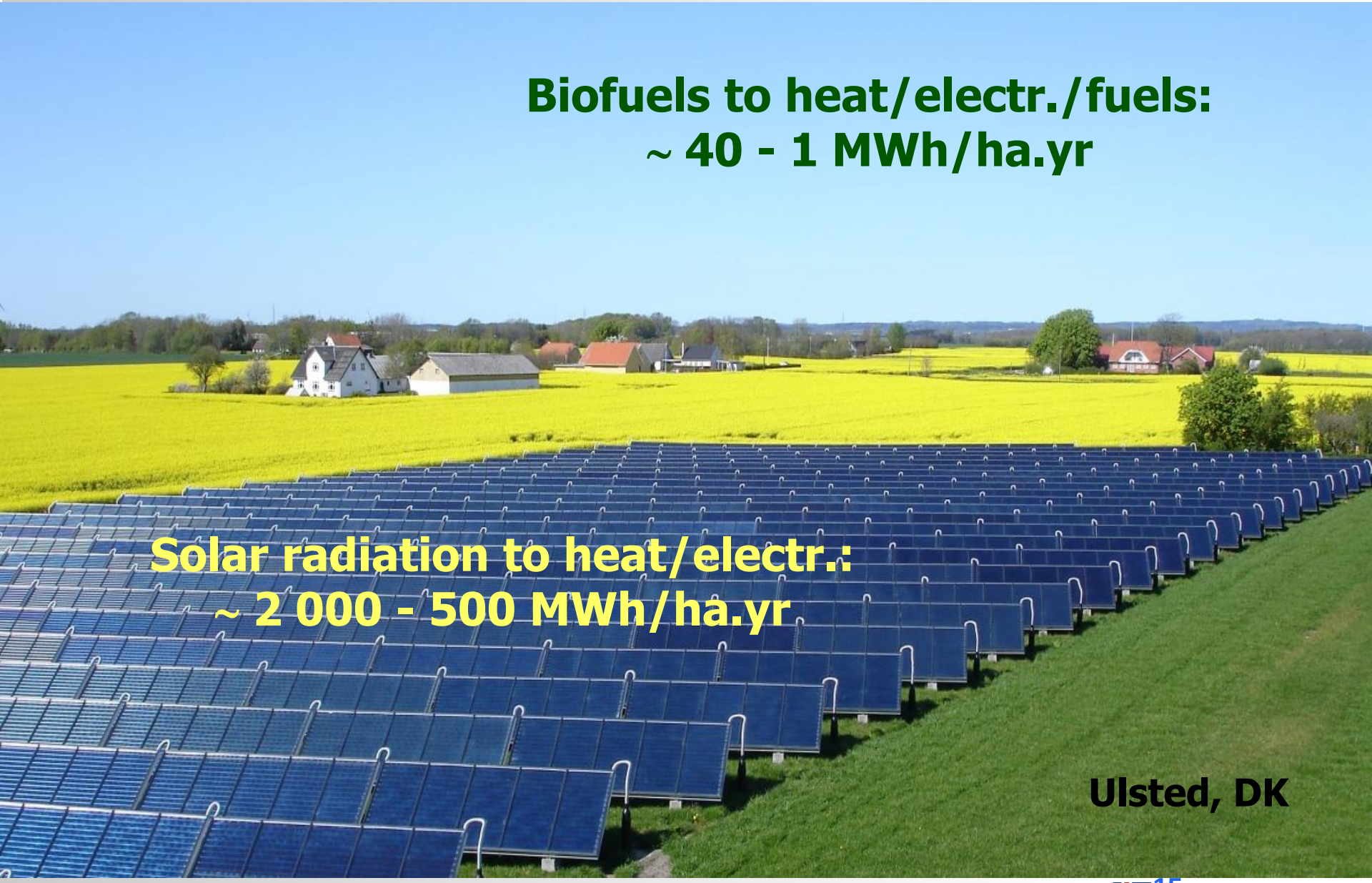

VARBERG ENERGI
02 | Ekologiskt 25
• Hydro, wind and solar power
• First wind power plant in 1991 ..
• First solar power plant in 2016 ..
SOLSIDAN - Sveriges största solcellspark 2016



2017-07-22 / JOD

RENEWABLE ENERGY

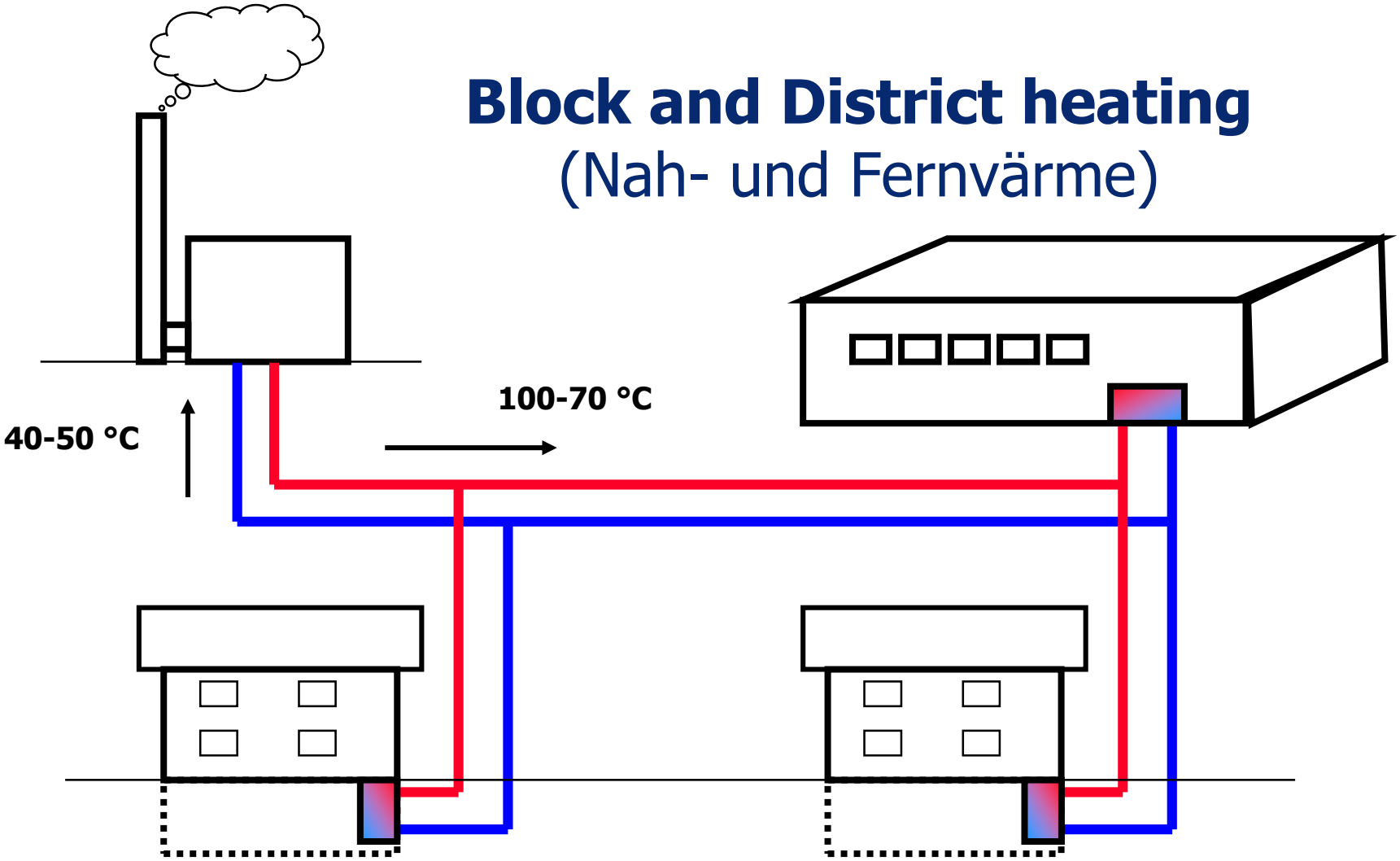
- Origin is solar radiation
- Low density energy ..
- .. transformed into useful energy ..
- Areas !
- Areas !
- Storage !
- Storage !


Biofuels to heat/electr./fuels:
~ 40 - 1 MWh/ha.yr
Solar radiation to heat/electr.:
~ 2 000 - 500 MWh/ha.yr
Ulsted, DK

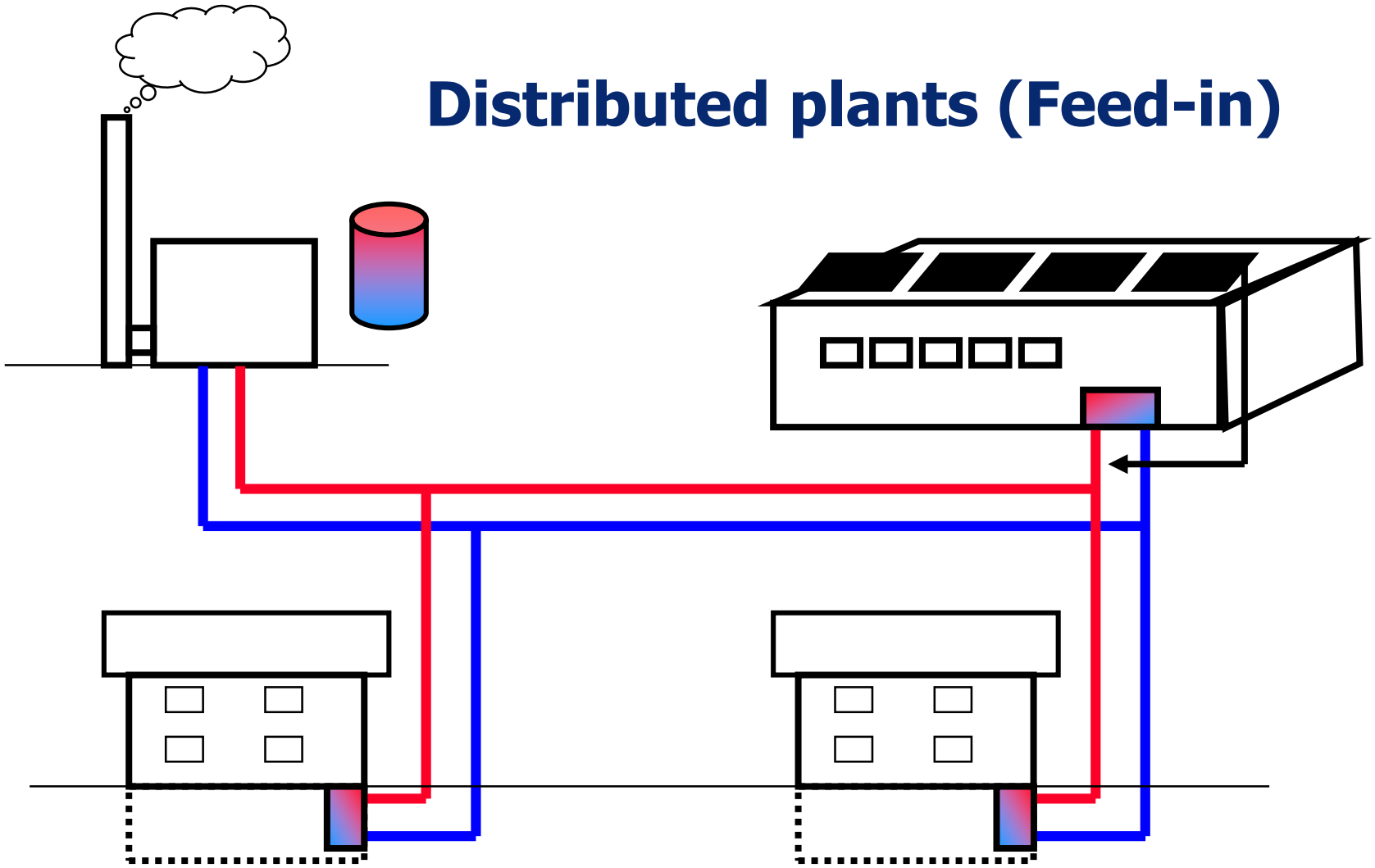
SOLAR DISTRICT HEAT

- **Collector arrays feed into large DH systems (like PV systems)**
  Any type of large DH system
- **Collector array + buffer storage**
  Pref. comb. (Solid) Bio fuel CHP or HOB
- **Collector array + seasonal storage**
  Misc. comb., CHP, HOB, HP, EB, etc.
  Operated based on electricity price i.e. used to **balance electricity market**

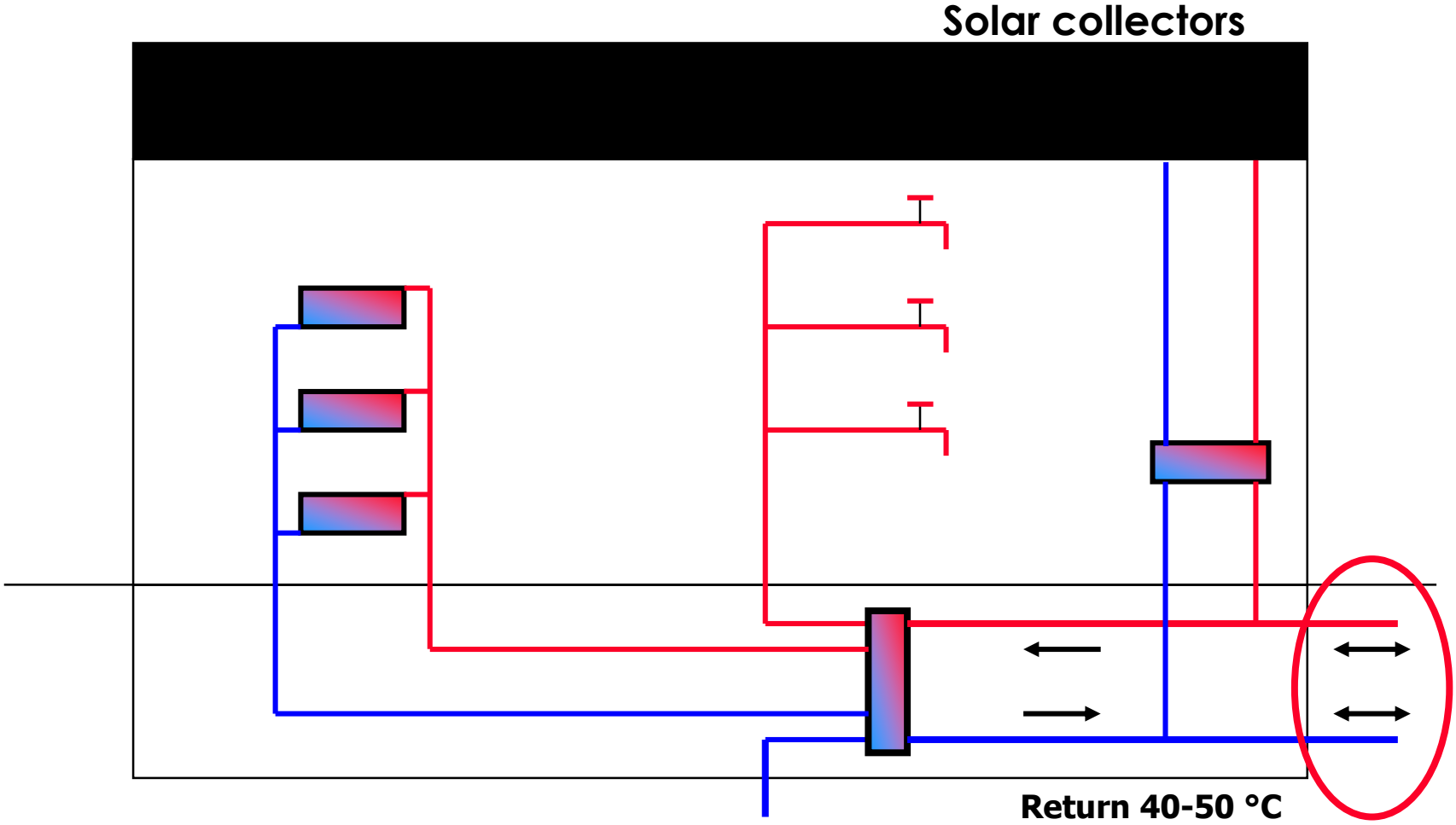
Block and District heating
(Nah- und Fernvärme)



Distributed plants (Feed-in)



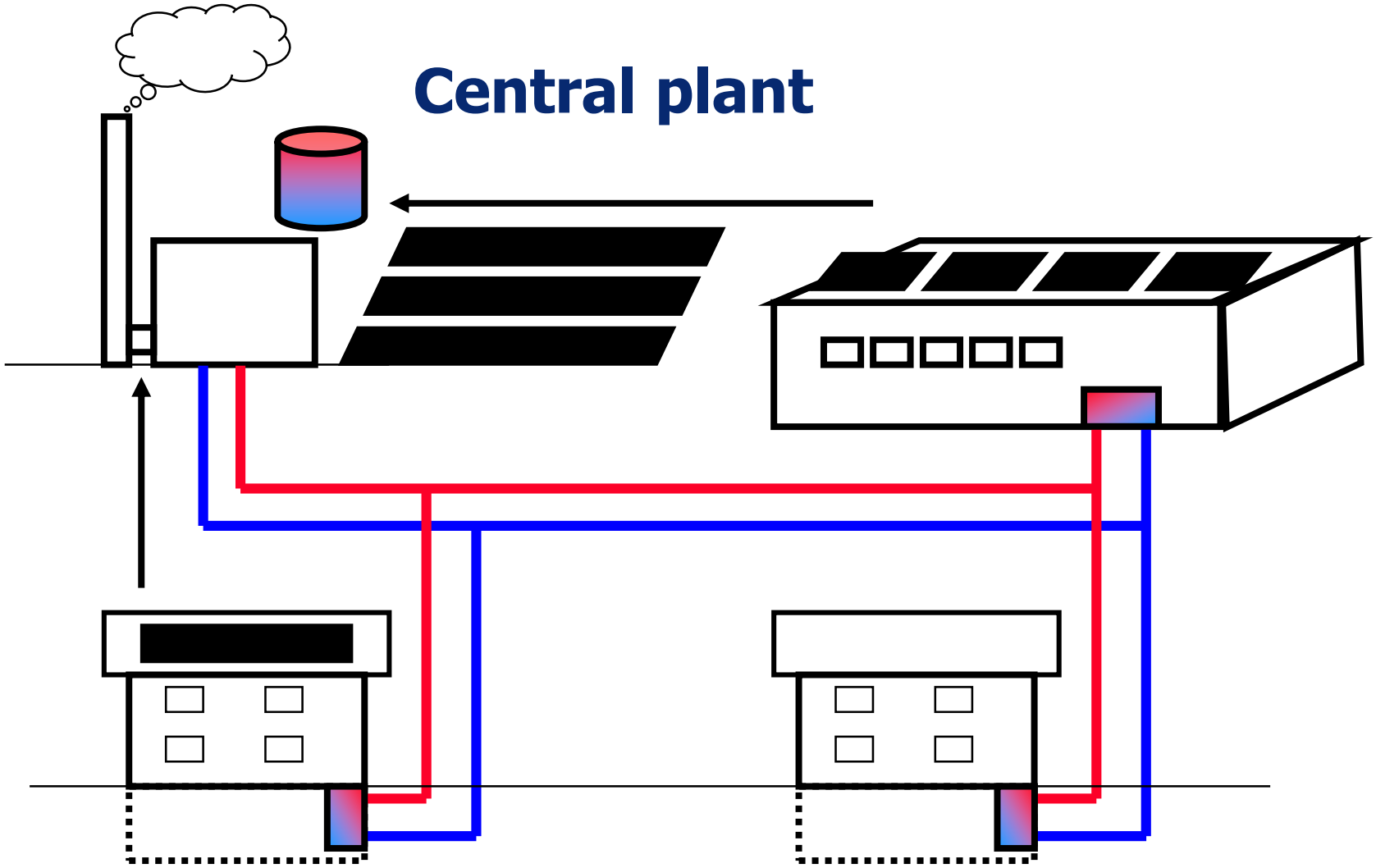
Distributed plant (Feed-in)

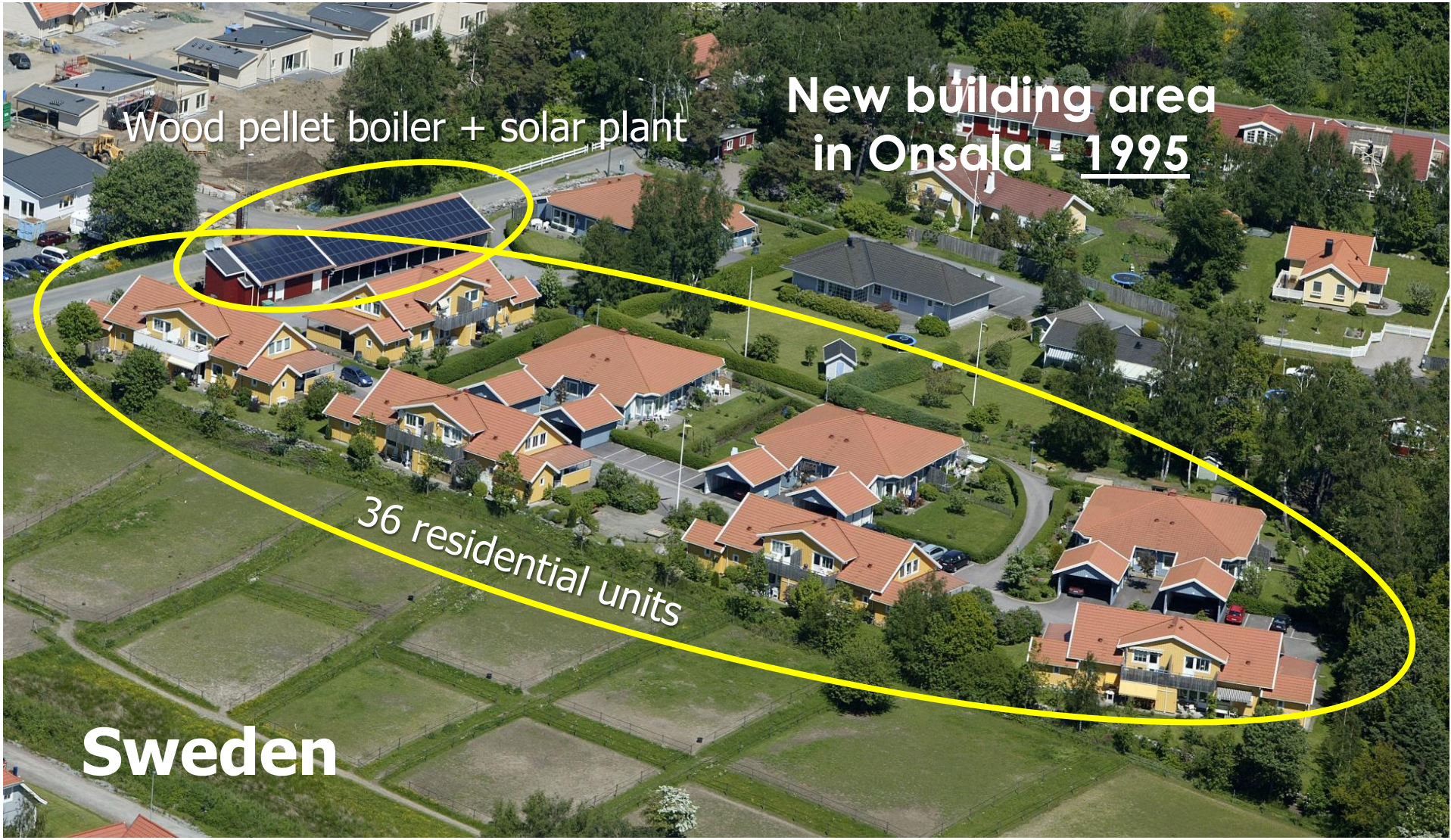


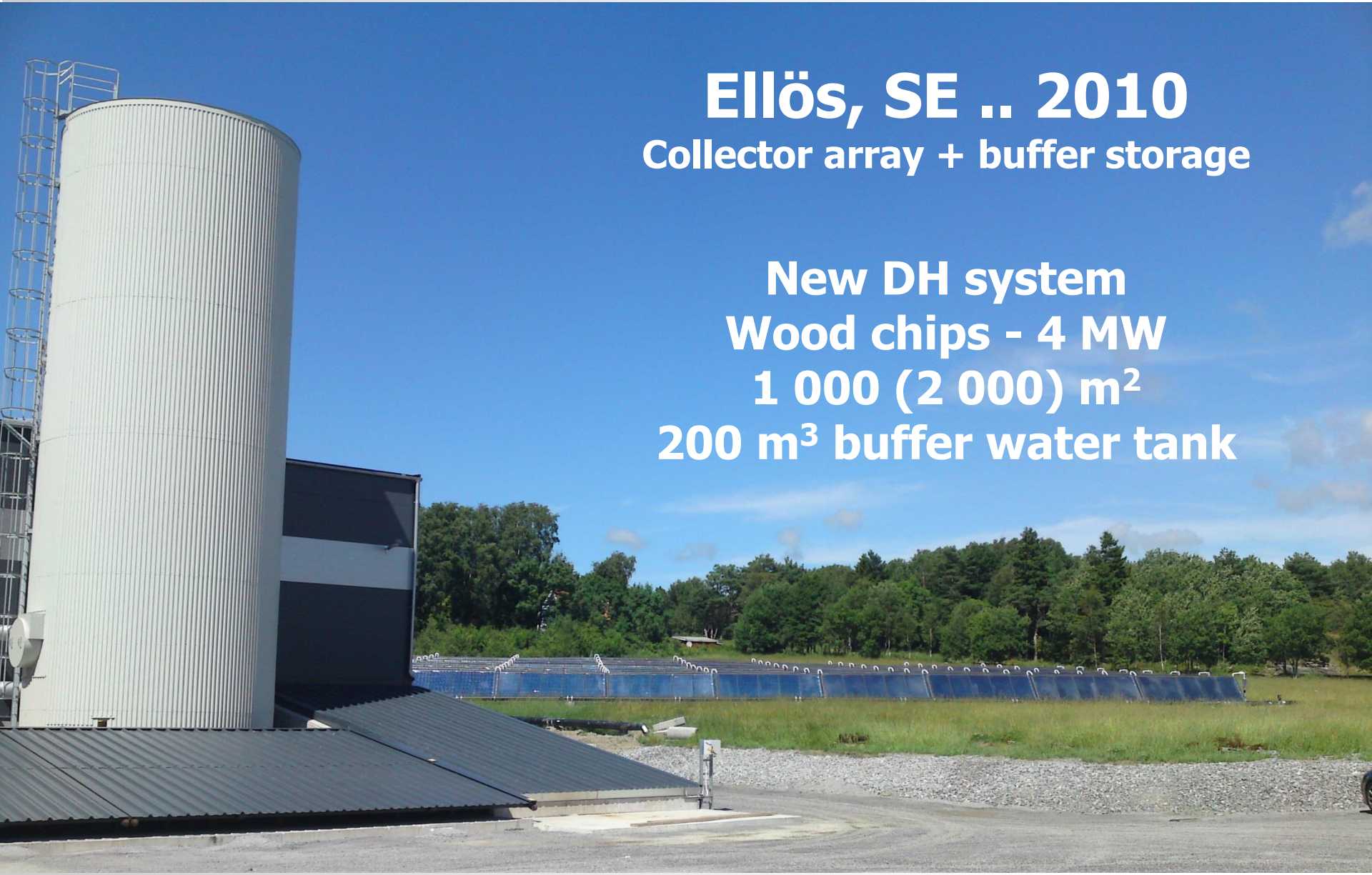
Feed-in .. Graz, AT .. 2006


8 000 m² ETC
Feed-in .. Seftenberg, DE .. 2016

Central plant




Wood pellet boiler + solar plant
New building area
in Onsala - 1995
36 residential units
Sweden



Ellös, SE .. 2010

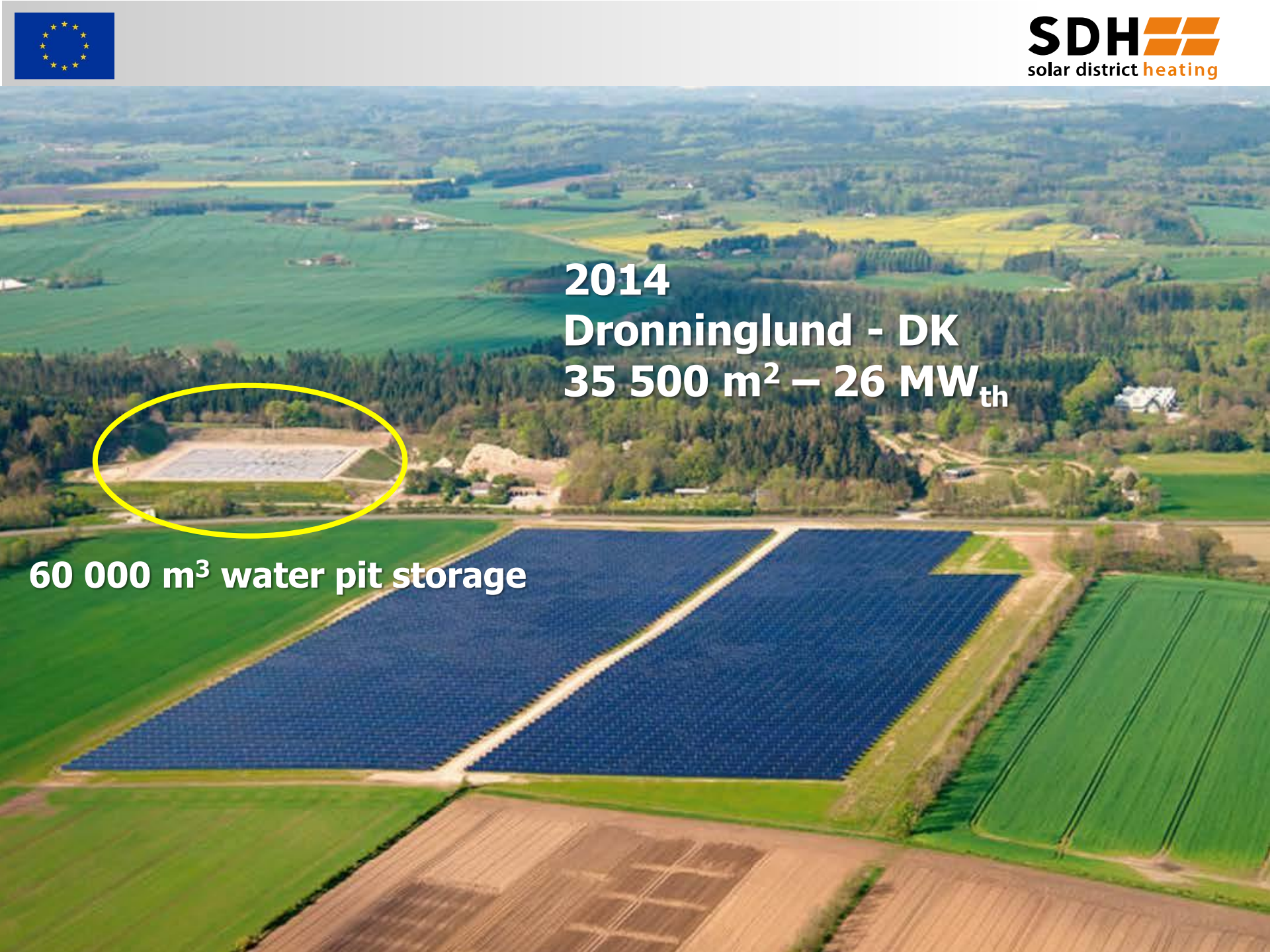
Collector array + buffer storage

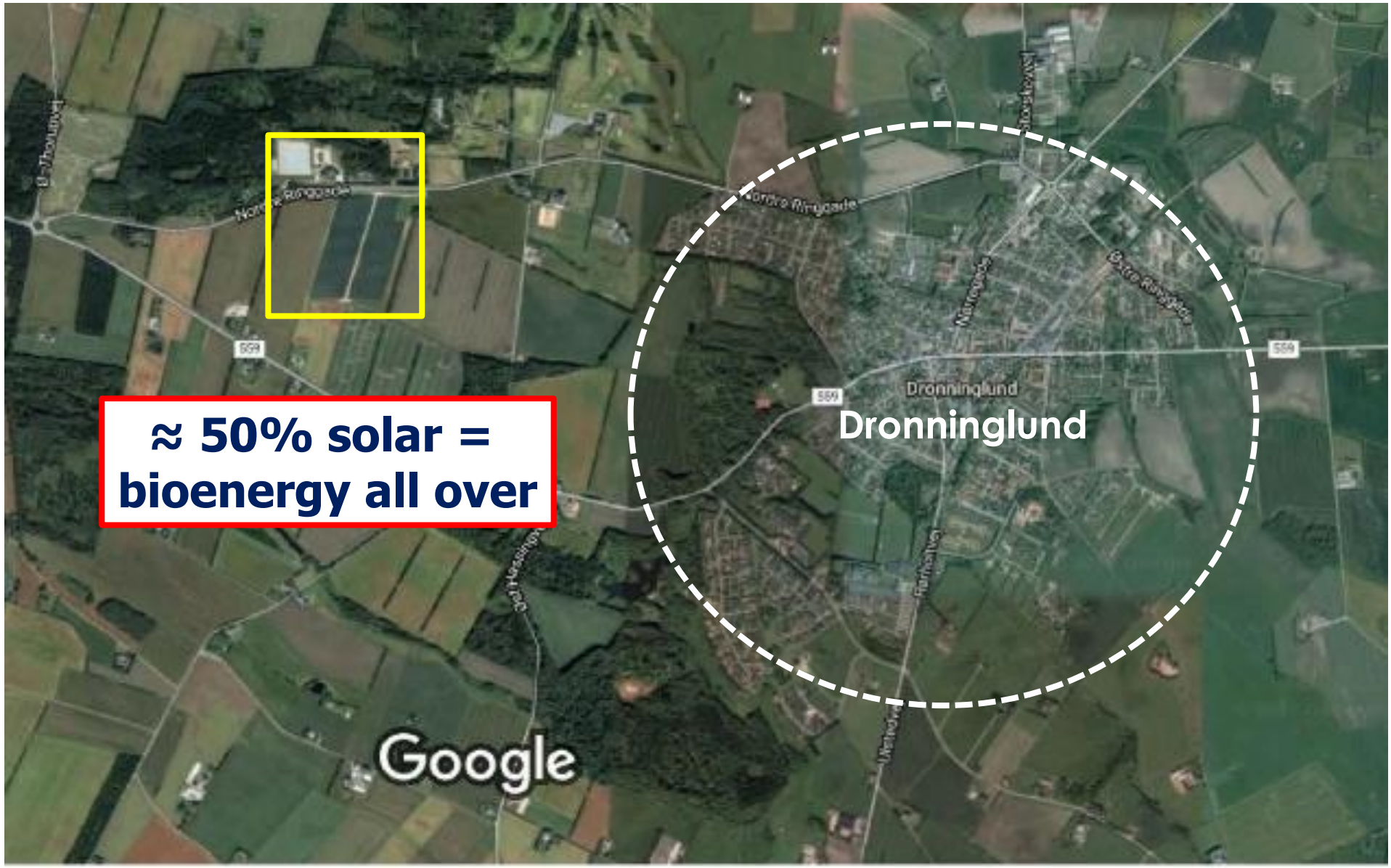
New DH system
Wood chips - 4 MW
1 000 (2 000) m^2
200 m^3 buffer water tank

SE - Lyckebo 1983

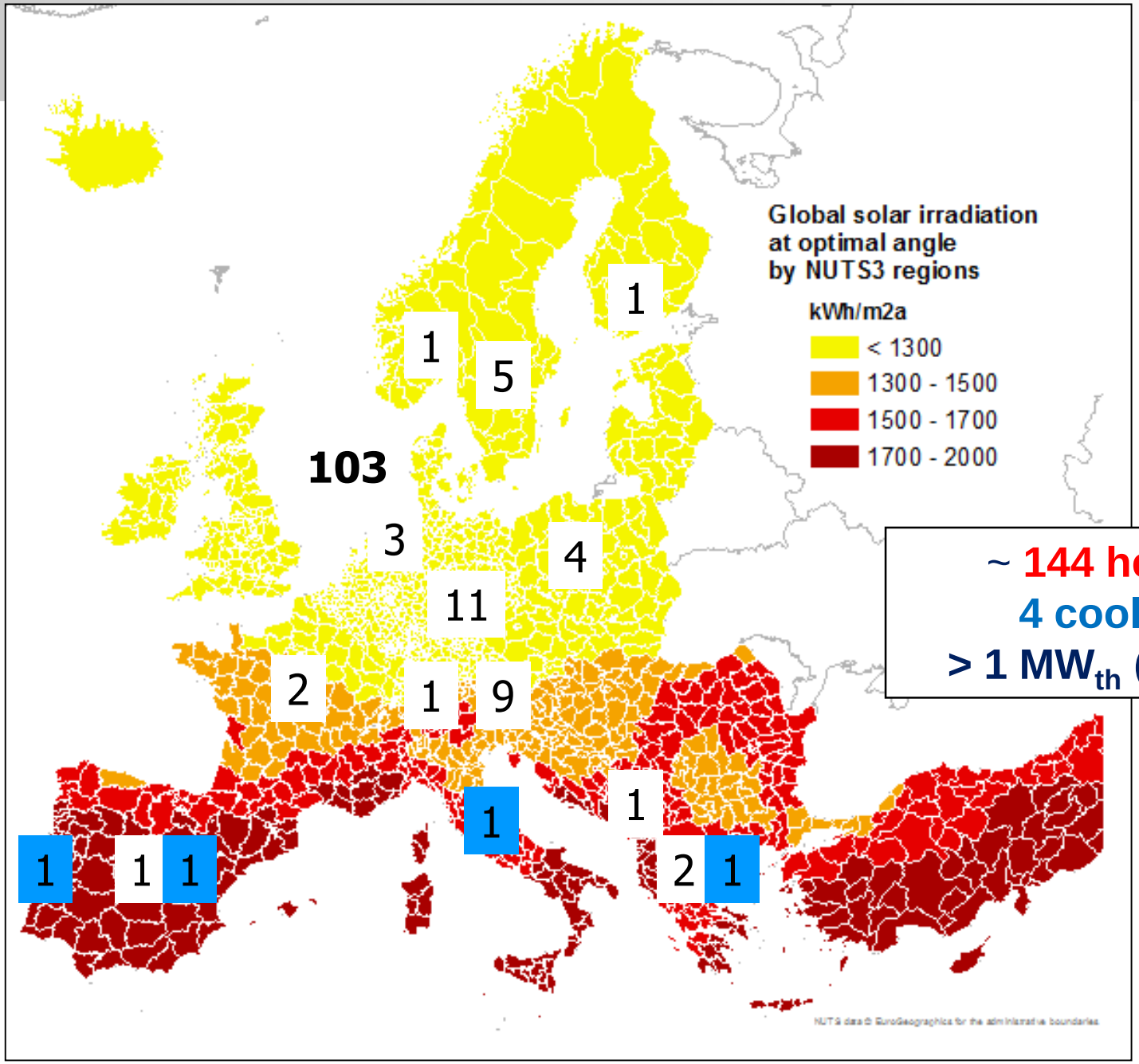
2013
Marstal District Heating - DK
33 000 m^2 – 23 MW_{th}

75 000 m^3 water pit storage


2014
Dronninglund - DK
35 500 m² – 26 MWth
60 000 m³ water pit storage


≈ 50% solar =
bioenergy all over
Dronninglund
Dronninglund
Google

Status 2016



~ **144 heating** and
4 cooling plants
> 1 MW_{th} (> 1 400 m^2)

SDH - SWOT

- **S: Renewable heat ... everywhere ...**
  (Fixed heat cost .. !)
- **W: Low energy density (& utilization time) ..**
  (Bio fuels 30-50 times the land area !!)
- **O: RE district heat in villages and cities ....**
  RE district cooling .. RE balancing ..
- **T: Lack of incentives, knowledge and interest**
  (Policy, desision makers, utilities, etc.)
  Gas network infrastructure ...

OPPORTUNITIES

- Mature and operational technology !
- EU and city planners can (should) consider DH and SDH ..
- DH developers can (should) use solar heat as driver / complement ..
- Solar heating developers can (should) increase their market by developing DH applications .. !

RECOMMENDATIONS

- **Knowledge dissemination**
  www.solar-district-heating.eu
- **Develop regional/national plans**
  Land for solar energy << Golf courses
- **Develop appropriate incentives**
- **”Learn to crawl in order to walk”**
- **Develop appropriate storage applications for local conditions ..**

QUESTIONS ?

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www.solar-district-heating.eu

www.solvarmedata.dk

www.rhc-platform.org