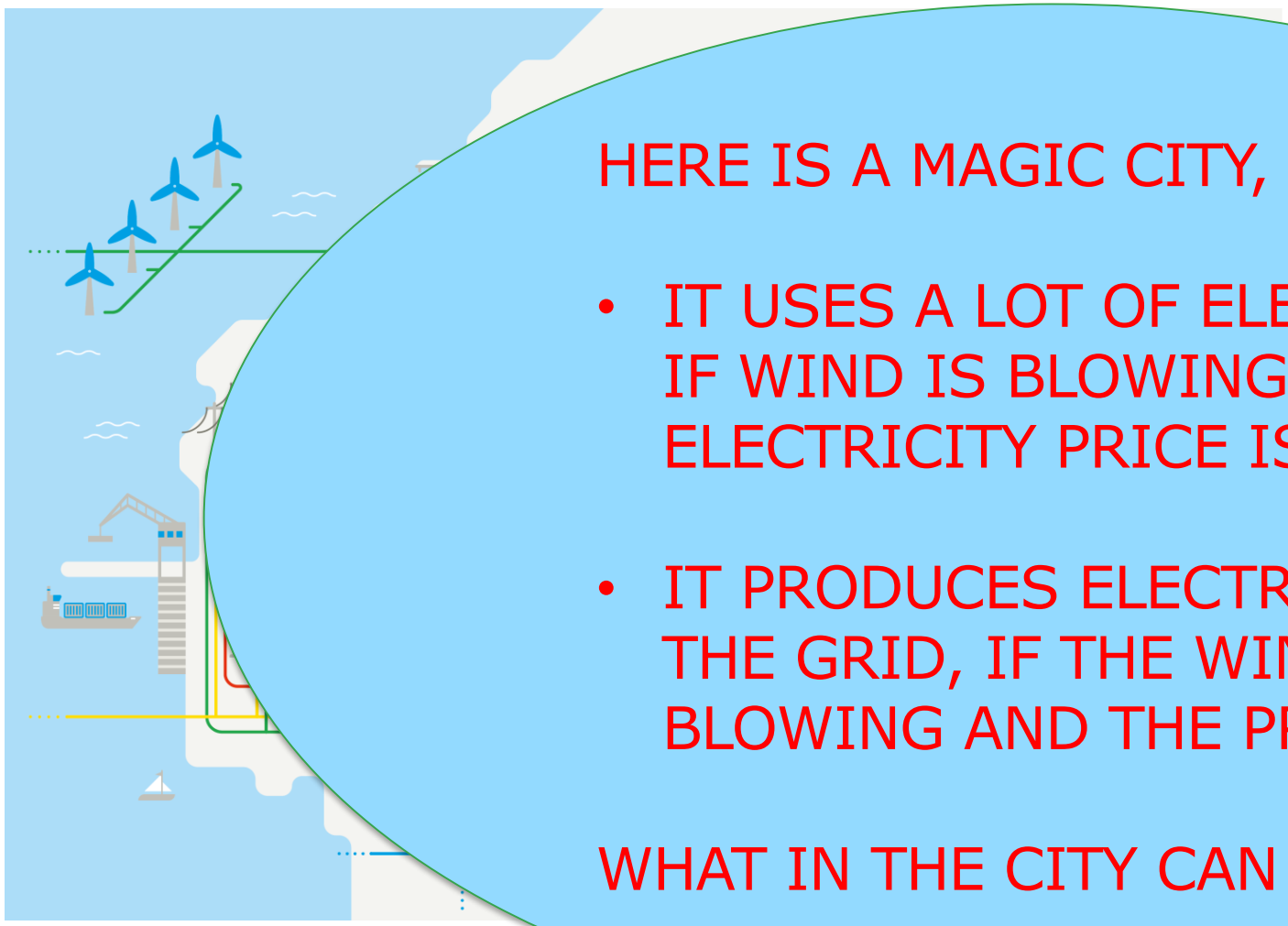
TERMISKE ENERGILAGRE

ATV - NATIONALT CENTER FOR ENERGILAGRING 22.01.19

THE RENEWABLE ENERGY AND IN PARTICULAR WIND ENERGY FLUCTUATES



HERE IS A MAGIC CITY,

- IT USES A LOT OF ELECTRICITY, IF WIND IS BLOWING AND THE ELECTRICITY PRICE IS LOW
- IT PRODUCES ELECTRICITY TO THE GRID, IF THE WIND IS NOT BLOWING AND THE PRICES HIGH

WHAT IN THE CITY CAN DO THIS **?**

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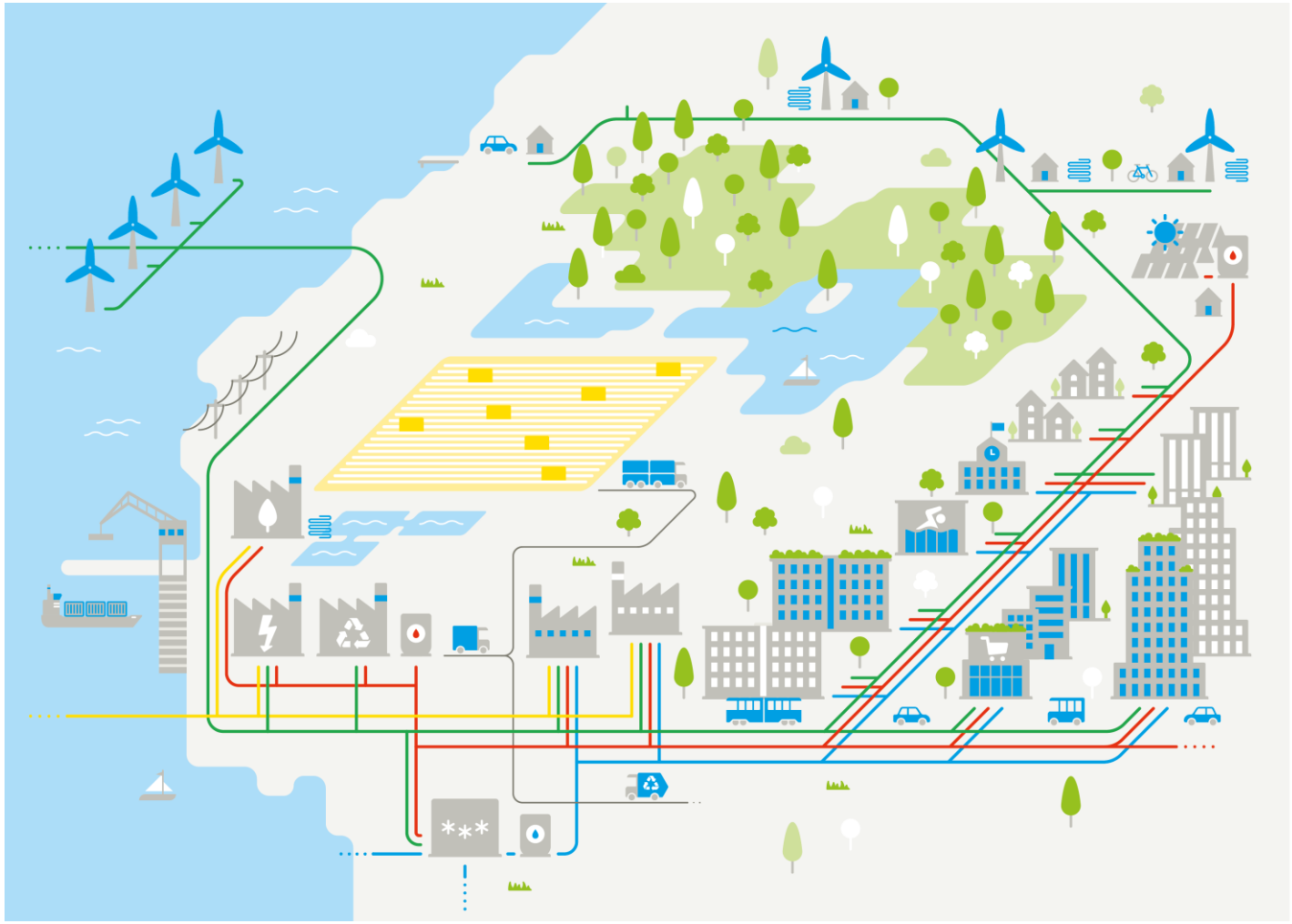
A SMART INTEGRATED ENERGY SYSTEM IN THE CITY
DEMAND RESPONSE LIKE A BATTERY- A VIRTUAL BATTERY



- Surplus biomass for CHP plant
- Surplus straw for CHP plant
- Offshore wind farm
- Large commercial / residential building
- Small residential building
- Harbour, unloading of biomass
- Wastewater treatment, heat pump, biogas and sludge incineration
- Solar heating plant and heat storage
- Solar PV plant
- Distant building w/solar PV
- Outskirt building w/heat pump, solar PV and wind turbine
- CHP plant fuelled by gas, straw, wood, city waste + heat storage
- District heating/cooling plant + cold water storage
- Industry with process energy and surplus heat

- Electricity
- District heating
- District cooling
- Gas

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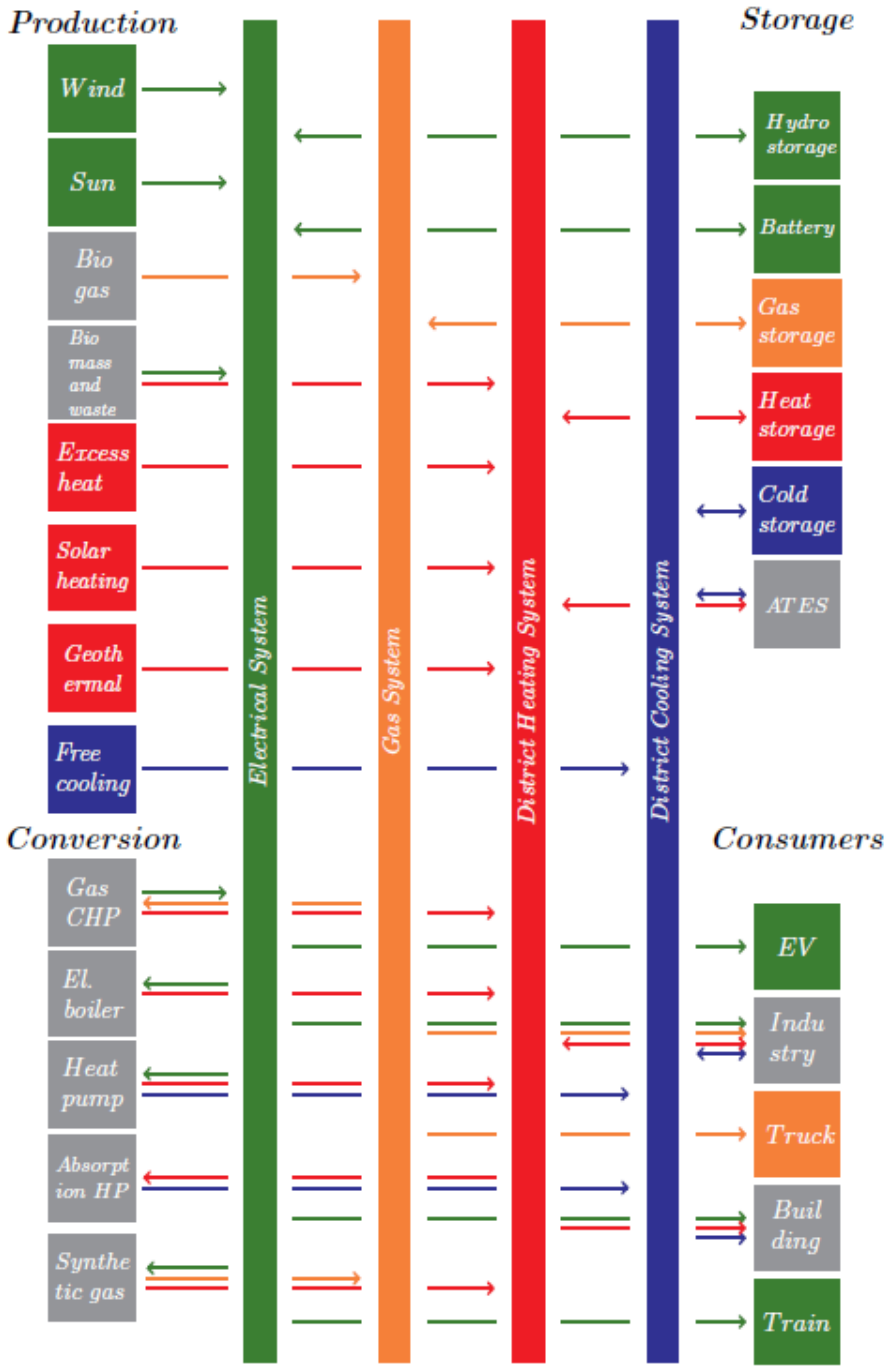
THE SMART ENERGY SYSTEM

- National power grid
- National natural gas grid
  - Gas storage, CHP, P2Gas

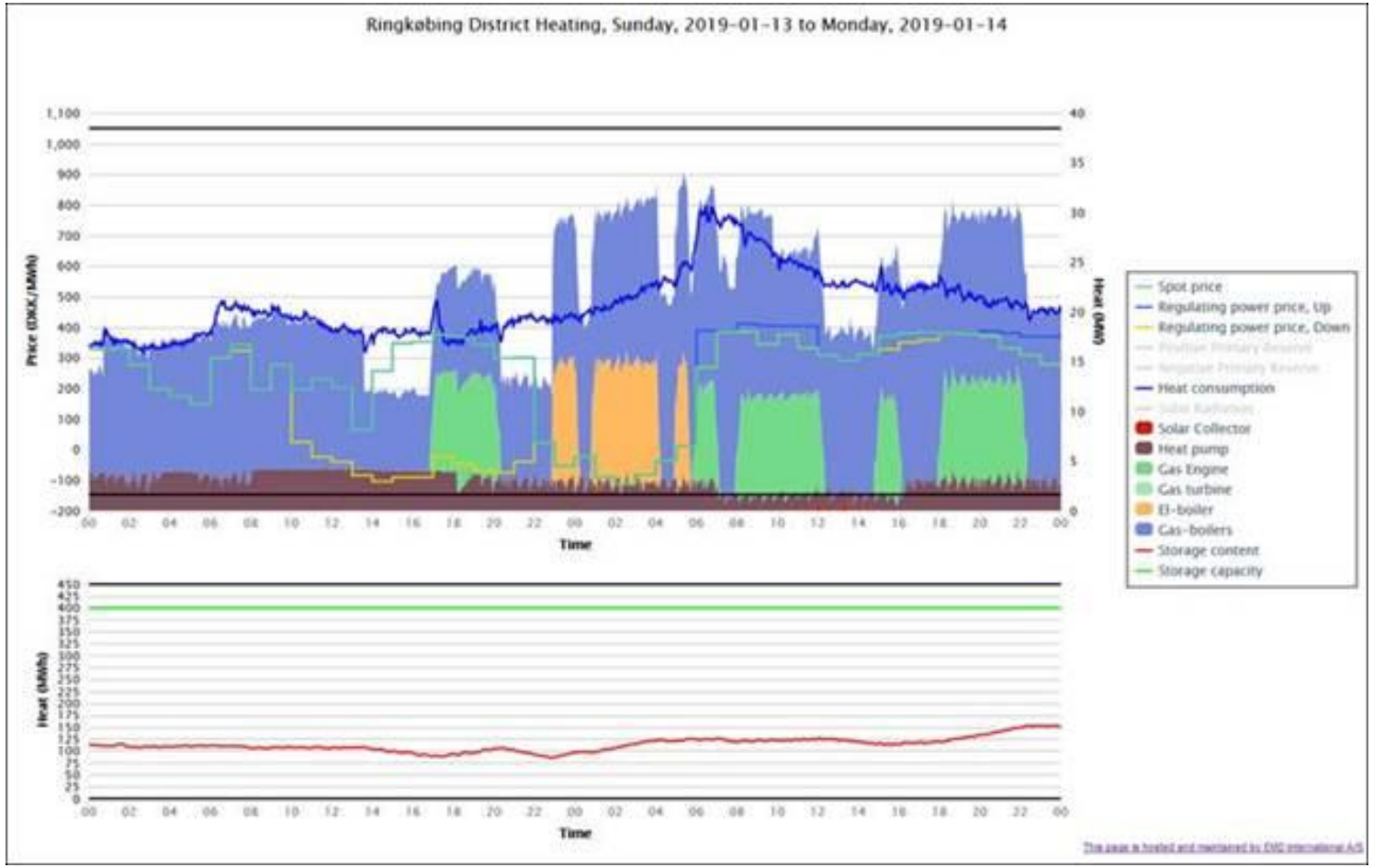
- City-wide district heating grid
  - Storage for CHP and RES
- City district cooling grid
  - Storage and optimal cooling

- Buildings and other end-users
  - Low-temperature heating
  - High-temperature cooling



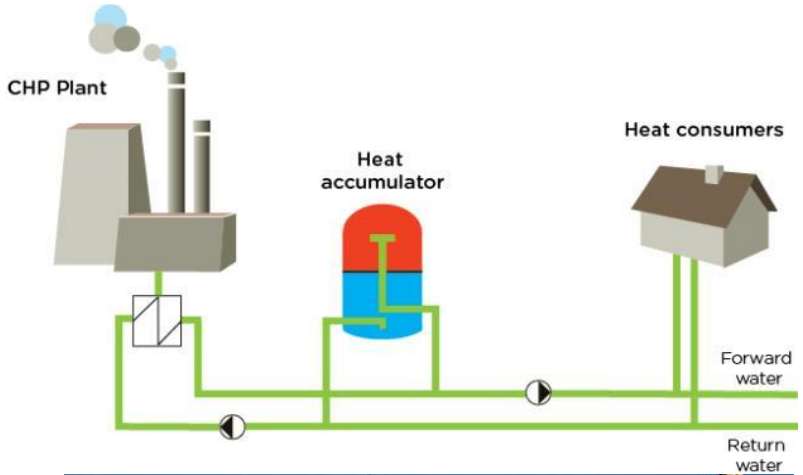
THERMAL VIRTUAL ELECTRICITY STORAGE (LIKE A BATTERY)

- Baseline
  - Small heat pumps without storage or gas boiler back-up
  - Can-not adjust consumption to the fluctuations of the wind
- The virtual electricity storage
  - DH&C grids
  - Large heat pumps, to be interrupted
  - Electric boilers, only at low price
  - CHP plants, only at high price
  - Hot and cold water storage
  - Can adjust consumption, regulate and provide back-up



THE SIMPLE HEAT STORAGE TANKS
PRESSURE-LESS AND DIRECT CONNECTION

- **All CHP plants have heat storage tanks in Denmark**
- Optimize operation of the CHP plant > 8 max load hours
- Can integrate surplus heat from waste, solar, wind etc.
- Optimize the operation of the DH system
- Maintain the pressure
- Provide peak capacity the coldest day
- Fjernvarme Fyn at Fynsværket power plant, Odense
  - 75,000 m^3
  - Direct connection
  - Maximum temp **95ºC**. 90/40
  - Storage capacity, 3,6 GWh, e.g. 300 MW in 12 hours
- An increasing interest from other countries



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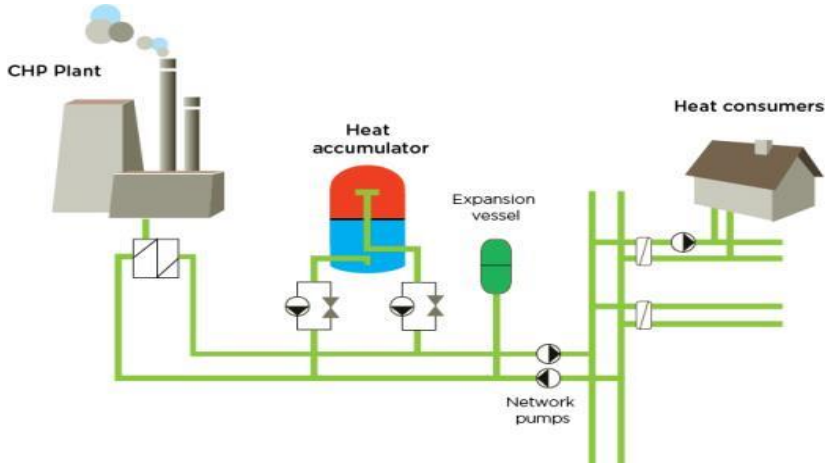
ADVANCED HIGH TEMPERATURE HEAT STORAGE TANKS PRESSURIZED AND PRESSURE SECTIONED

- Temperature **above 100 ºC** can be necessary due to consumer needs (poor heating installations),
- But - the larger temperature - the larger investment.
- Pressure sectioning can be necessary due to the pressure level in the DH grid and due to necessary pressure variations **at a specific location**
- Pressure sectioning increase costs, but is cheaper and more efficient than a heat exchanger connection
- Avedøre CHP plant, Copenhagen
  - 2 x 24,000 m^3
  - Maximal temp **120 ºC** actual temp. 105/50
  - Pressure diff: 10 Bar
  - Storage capacity 2,400 MWh, e.g. 300 MW in 8 hours



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HEAT STORAGE PITS
PRESSURE-LESS AND SECTIONED BY HEAT EXCHANGER

- Heat storage pit, an innovative combination of:
  - Landfills for establishing liners to a water proof pit
  - Heat storage tank for diffusers
  - Off shore technology for diffusers and pipes
  - A floating cover (newly developed, Plastic foam og leca)
- Impossible to avoid oxygen in the water, therefore sectioned by heat exchanger
- Maximal temp **85 °C up to 90** °C
- Storing weekly or monthly fluctuations
- The driver for this development in Denmark has been to increase share of solar heat up to 60%

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HEAT STORAGE PITS
PRESSURE-LESS AND SECTIONED BY HEAT EXCHANGER

- Test plants with subsidy
  - 10,000 m^3 Test plant in 2010 in Marstal
  - 70,000 m^3 Full-scale test plant 2012 in Marstal
  - 62,000 m^3 Full-scale test plant 2014 in Dronninglund
- Commercially, without subsidy, new floating cover
  - 125,000 m^3 Gram district heating 2015
  - 200,000 m^3 in Vojens district heating 2015
  - **70,000 m^3 in Toftlund district heating 2017**

- Several more in the pipeline:
  - May be 100 in DK in 2030 ?
  - First project outside DK, increasing interest
  - Similar storages for cooling in the pipeline

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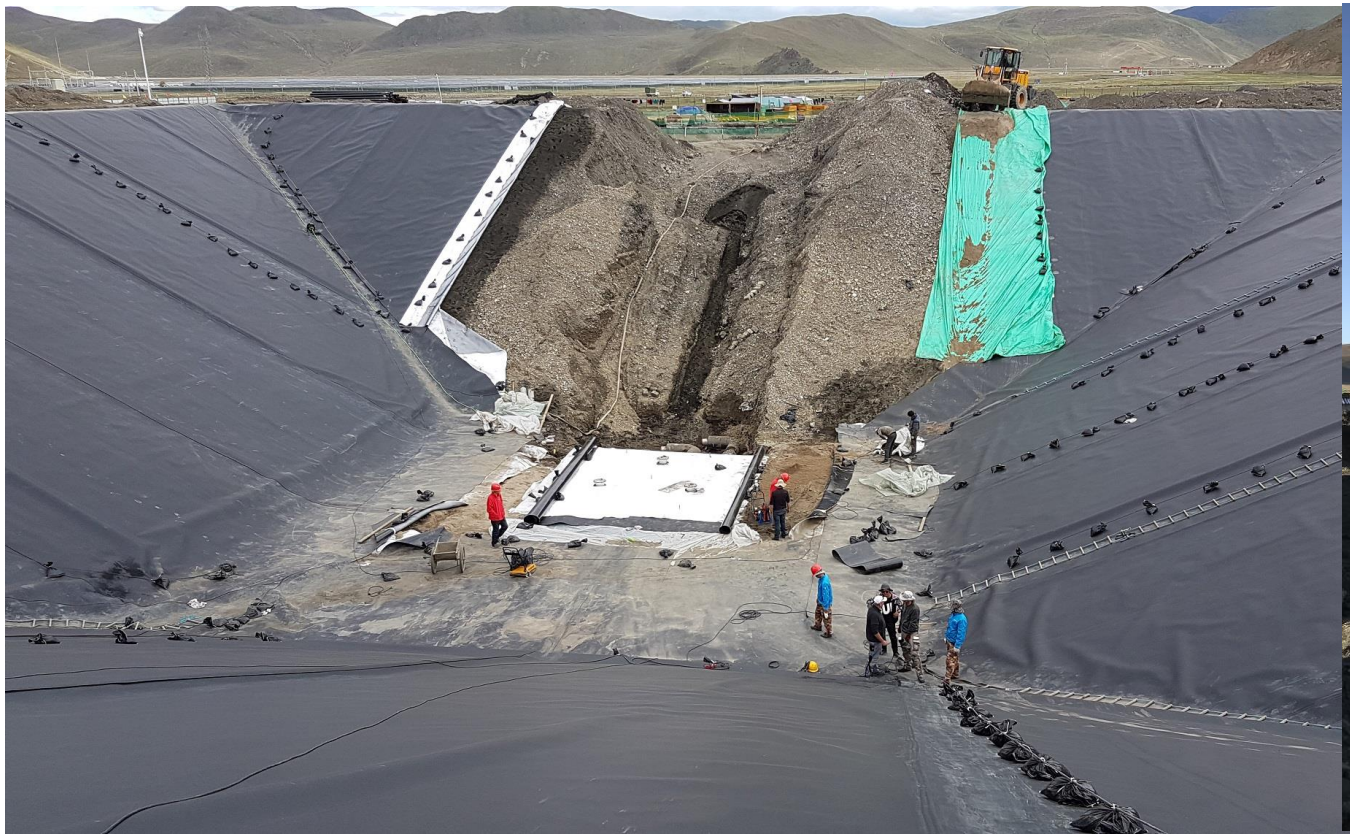
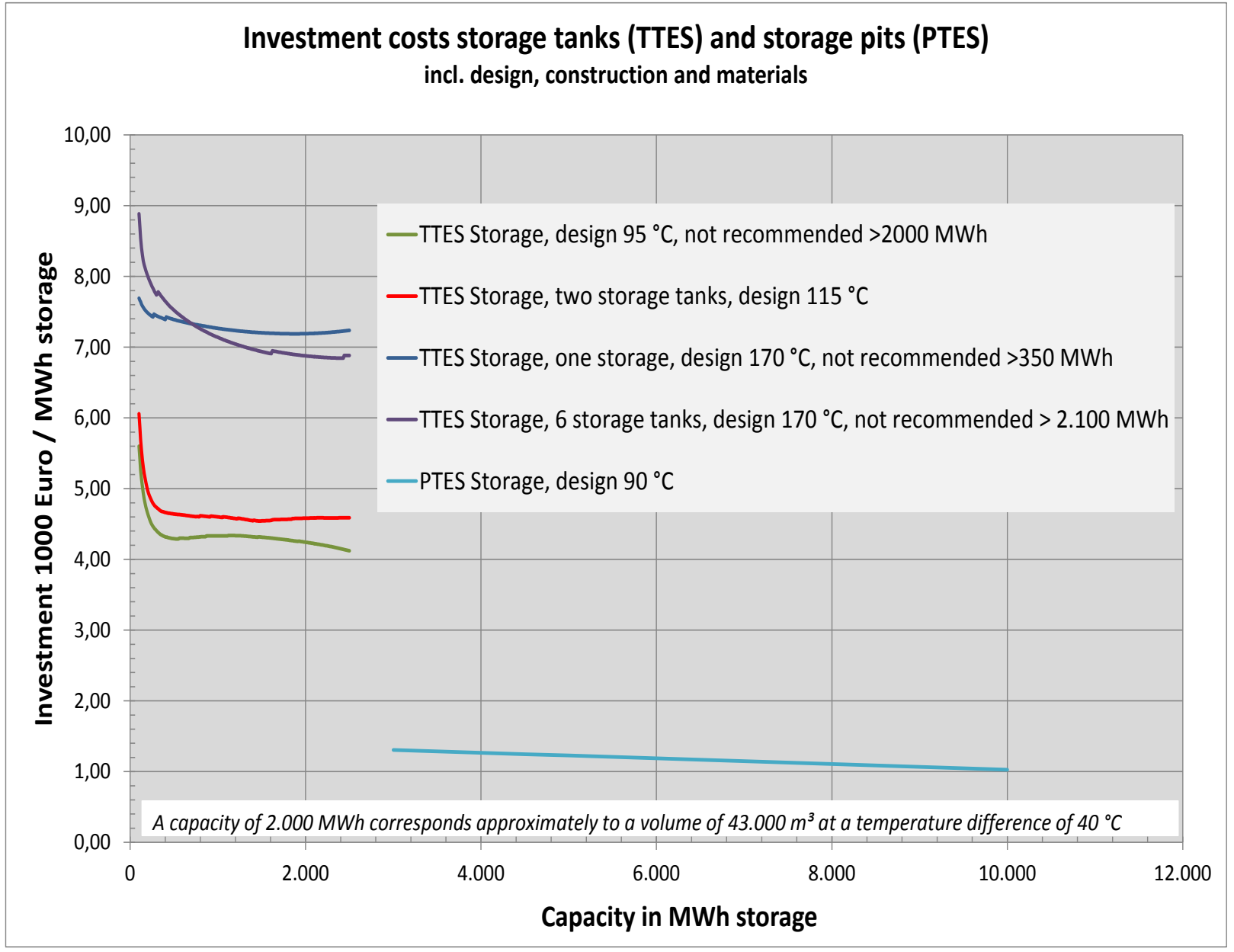
FØRSTE DAMVARMELAGER UDENFOR DANMARK



ECONOMY OF SCALE



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ECONOMY OF SCALE FOR HOT WATER STORAGES
EUR/MWH HEAT STORAGE CAPACITY

- One family house, 0.16 m^3 300,000
- Large building, 4 m^3 40,000
- DH tank, 160°C 7,000
- DH tank, < 95°C 4,000
- Storage pit, 150,000 m^3 800
- Pit alone, 100,000-200,000 m^3 500
- Marginal extension of the pit 200

- Sources: Henrik Lund and Ramboll

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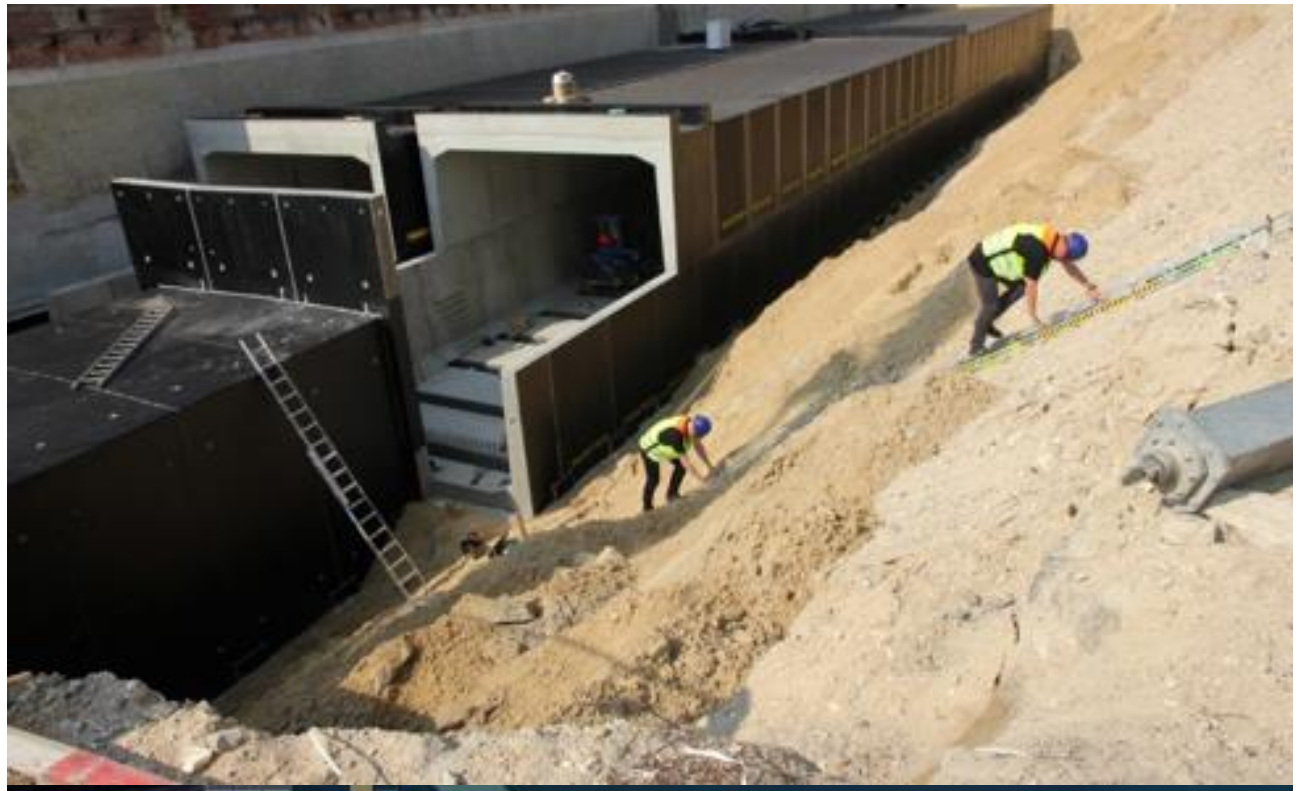
DE FØRSTE FJERNKØLELAGRE I DK

- Fjernkølebetontank I drift i Carlsbergbyen med vandteknologi, gode erfaringer
- Fjernkøleståltank på vej i Tårnby med fjernvarmeteknologi, senere suppleres med ATES
- Vi har de første ATES anlæg i bygninger og Fjernvarme/fjernkøleanlæg
- Mange fjernkøletanke og ATES anlæg i udlandet



PERSPEKTIVERNE FOR VARMELAGRING OM 5, 10 OG 20 ÅR – OG I 2050

Jævn udvikling mod maksimal udbygning i 2035

- I samspil med fjernvarme og fjernkøl den vigtigste komponent i integrering af fluktuerende VE
- Booster den danske eksport i fjernvarme og fjernkøl
- Positiv afsmitning på vindmølleeksport, da udfordringen for vindmøllekunderne er at kunne bruge vindenergien

- Fordobling af tanklagerkapacitet
- Fra 5 til 100 damvarmelagre
- 100 fjernkølelagertanke
- 100 ATES anlæg til fjernvarme/fjernkøl

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HVILKE UDFORDRINGER ER DER, OG HVAD SKAL DER FORSKE I ?

- Information om betydningen af det virtuelle batteri
- Længere levetid af plastic liner ved 80 grader
- At måle lagtykkelse af leca uden at lave huller I lineren (et kusteskaft I stedet for en landmålerstok)
- At 2+2 < 4 m3 leca
- Lavtemperaturbygninger
- "Smart grid" eltariffer, som fremmer det smart energisystem og brug af det virtuelle batteri
- "smarte energiafgifter" som giver incitement til fleksibelt elforbrug

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HVILKE DEMONSTRATIONER OG FORRETNINGSUDVIKLINGER ER DER BRUG FOR? OG KOMMERCIELLE MULIGHEDER

- Power2gas er det manglende link i det virtuelle batteri hvis vi skal være helt uafhængig af fossile brændsler
- DTU Campus er allerede et fantastisk demonstratorium: samkøring med det storkøbenhavnske kraftvarmesystem med lokalt varmelager, kraftvarme og elkedel, fjernkøling – og indenfor 10 år kommer varmepumpe, kølelagertank og ATES
- Mere frihed til fjernvarmeselskaberne til at producere og lagre varme og køl optimalt
- Vi vil styrke vores førerposition på verdensmarkedet
- Tvivlsomt om borehulslagre og højtemperatur lagre, kan blive kommercielt bæredygtige under danske forhold set i forhold til de anlæg, som virker I dag, savner overbevisende forskningsresultater med focus på økonomi og marked

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THANK YOU FOR YOUR ATTENTION!

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