# Virtual Power Plants

DISSEMINATION PRESENTATION

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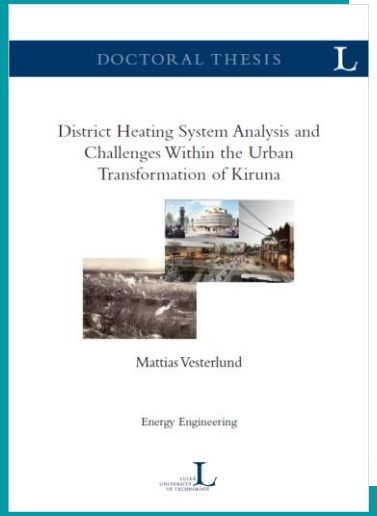
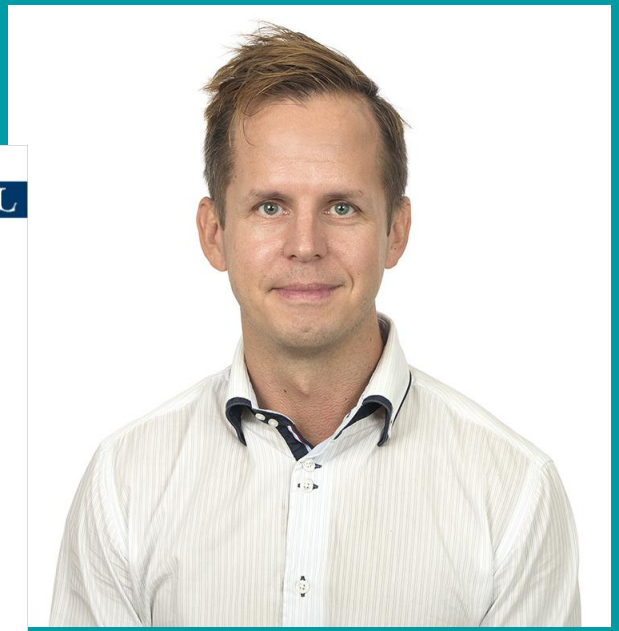
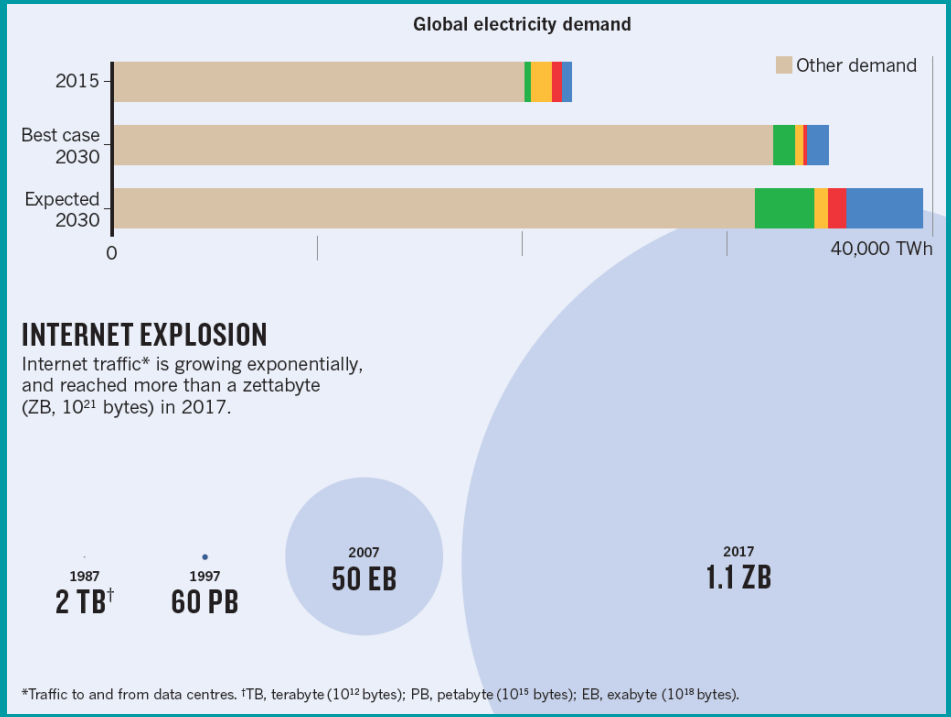


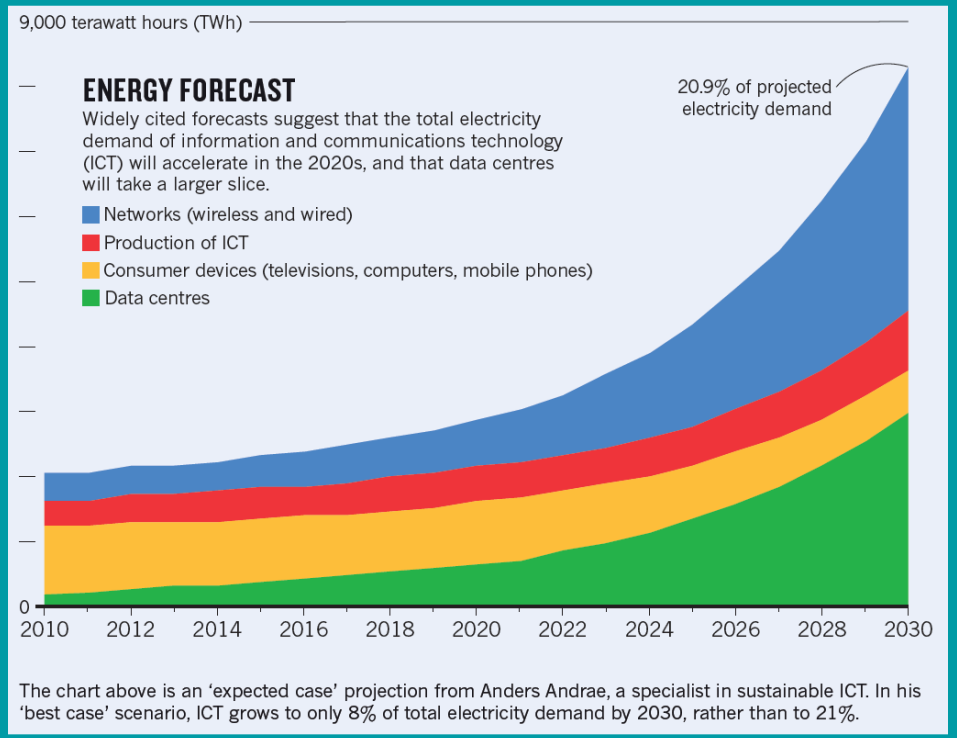



# Internet of Things 5G

RI.
SE

# Internet of Things




Nature 2018

RI.
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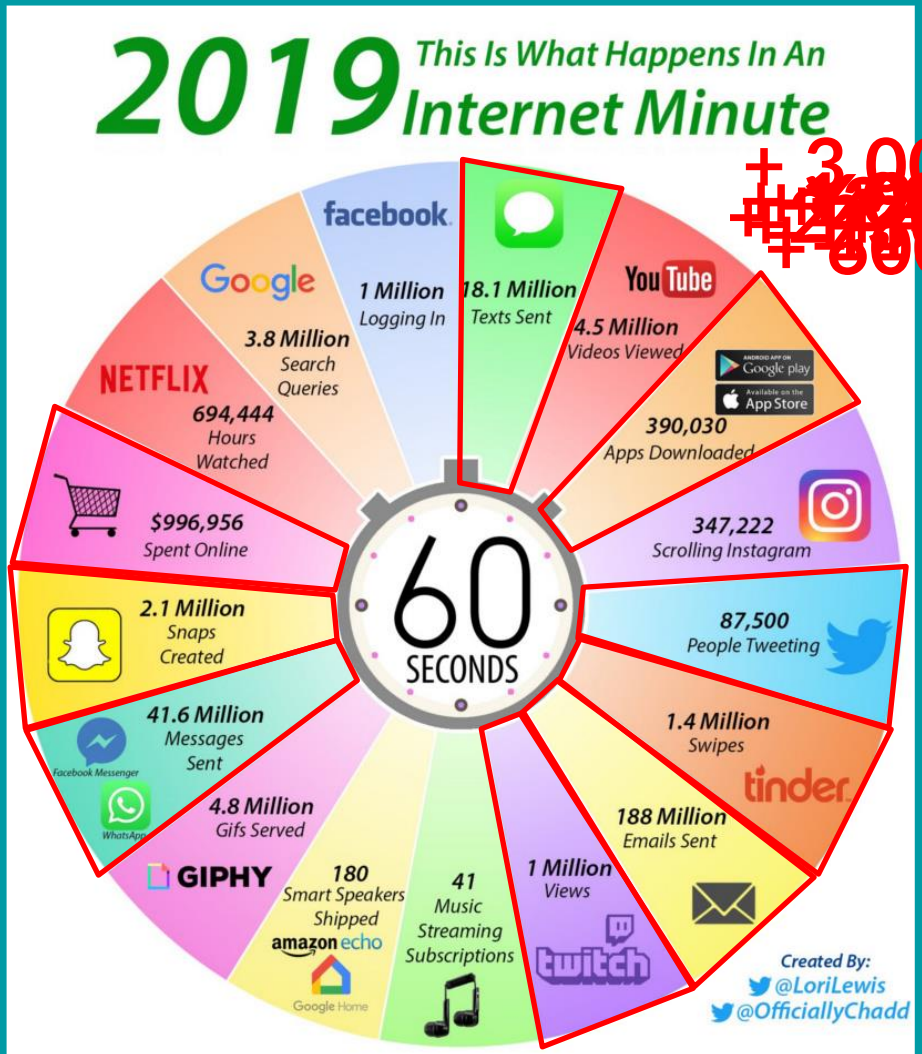
# Internet of Things

Nature 2018

**Figure 1.3** Largest companies by market capitalisation


**Key message:** Digital technology companies have become global leaders by market capitalisation, though energy companies still lead in revenues.

Notes: Rankings are for publicly traded companies; market capitalisations calculated at the end of Q2; circle sizes are relative to market capitalisation.


2019 This Is What Happens In An Internet Minute
facebook
1 Million Logging In
18.1 Million Texts Sent
YouTube
4.5 Million Videos Viewed
390,030 Apps Downloaded
347,222 Scrolling Instagram
87,500 People Tweeting
1.4 Million Swipes
tinder
188 Million Emails Sent
1 Million Views
twitch
41 Music Streaming Subscriptions
180 Smart Speakers Shipped
amazon echo
Google Home
4.8 Million Gifs Served
GIPHY
41.6 Million Messages Sent
Facebook Messenger
WhatsApp
2.1 Million Snaps Created
$996,956 Spent Online
694,444 Hours Watched
NETFLIX
3.8 Million Search Queries
Google
60 SECONDS
Created By:
@LoriLewis
@OfficiallyChadd

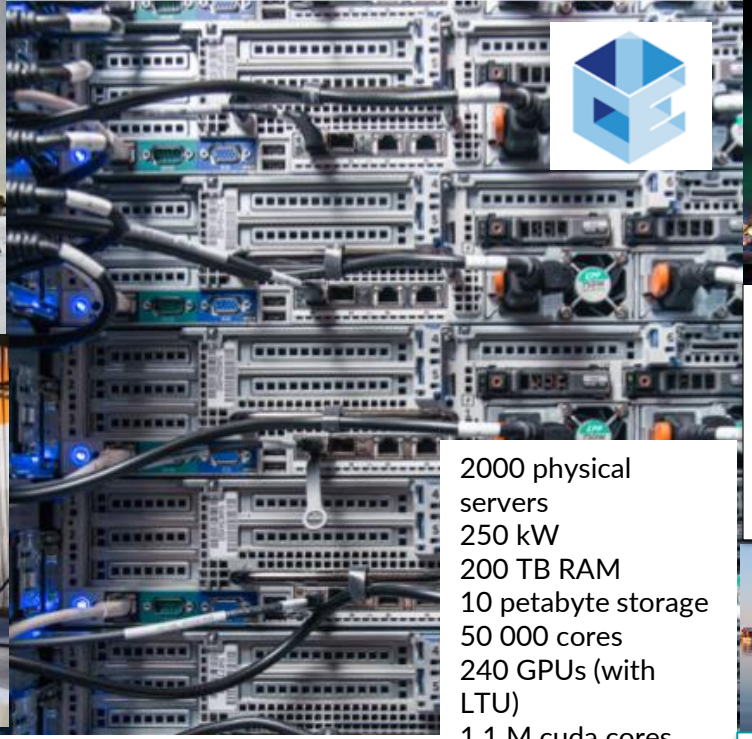
+3,000,000
+[illegible]
+[illegible]


2021 This Is What Happens In An Internet Minute
facebook
1.4 Million Scrolling
21.1 Million Texts Sent
YouTube
500 Hours Content Uploaded
414,764 Apps Downloaded
695,000 Stories Shared
200,000 People Tweeting
2 Million Swipes
tinder
197.6 Million Emails Sent
2 Million Views
twitch
5,000 Downloads
Tik Tok
932 Smart Audio Devices Shipped
amazon echo
Google Home
3 Million Images Viewed
imgur
69 Million Messages Sent
Facebook Messenger
WhatsApp
3.4 Million Snaps Created
$1.6 Million Spent Online
28,000 Subscribers Watching
NETFLIX
9,132 Connections Made
LinkedIn
60 SECONDS
Created By:
@LoriLewis
@OfficiallyChadd

# RISE
# ICE Data Center

# RISE ICE datacenter

https://ri.se/ice

- 30 projects, from the ground to the cloud
- 30 employees
- >4 MEUR turnover
- Established 2016

2000 physical servers
250 kW
200 TB RAM
10 petabyte storage
50 000 cores
240 GPUs (with LTU)
1,1 M cuda cores
12,5 petaflops
HDFS clusters
OpenStack ECC
OCP servers

Stakeholders: Ericsson, ABB, Vattenfall, Facebook, LTU, Region North, Space agency

A full-scale research datacenter and test environment with the objective to increase knowledge, strengthen the AI & DC ecosystems and attract researchers.

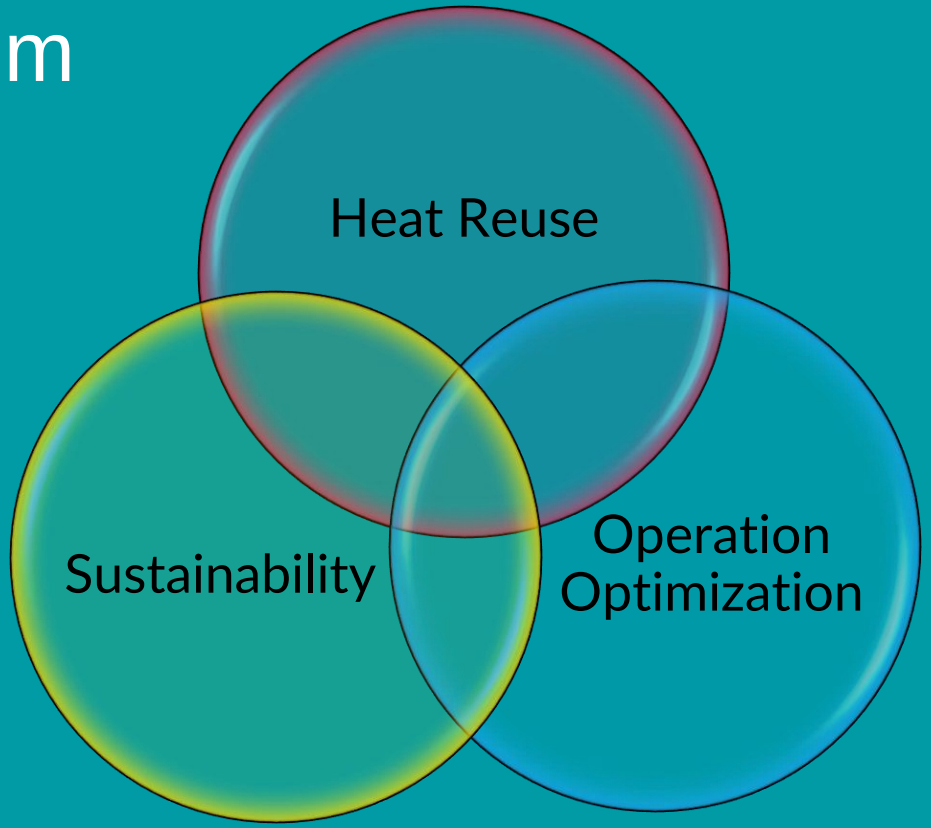
2018, 2019 2020 BDV i-Space GOLD

2016, 2017 BDV i-Space SILVER

DATACLOUD GLOBAL AWARDS 2019

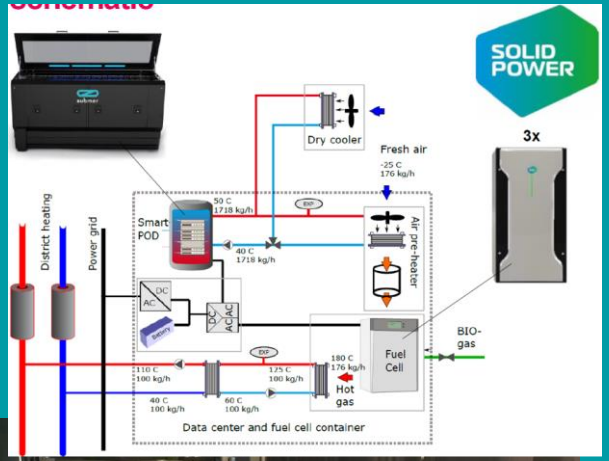
Cluster Management Excellence
STRIVING FOR CLUSTER EXCELLENCE


# ICE Data Center – Data Center System

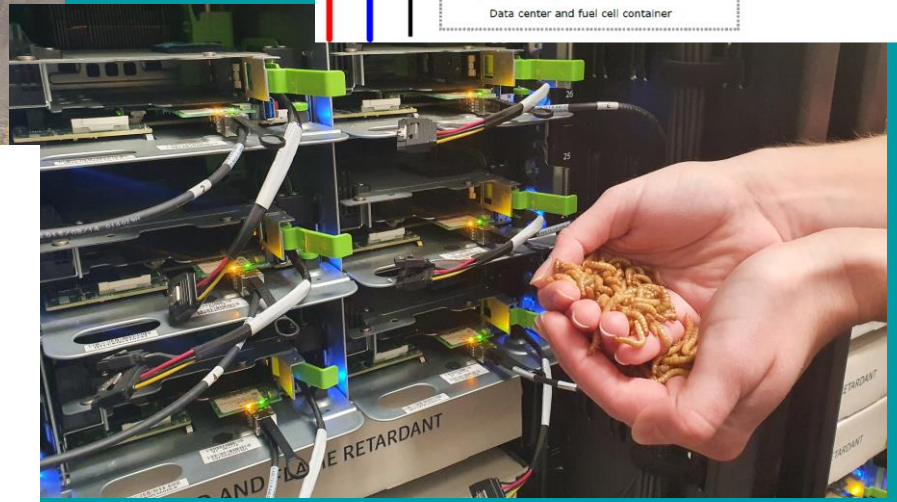


# Data Center Excess Heat

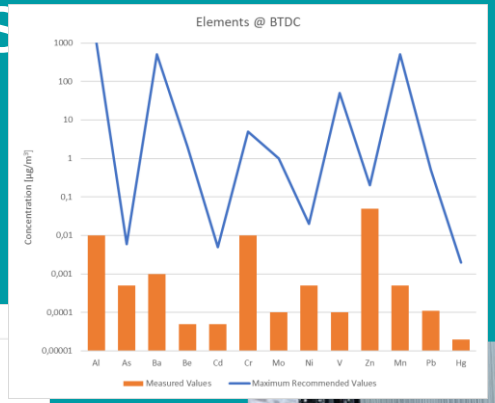
# DC Excess Heat – Various

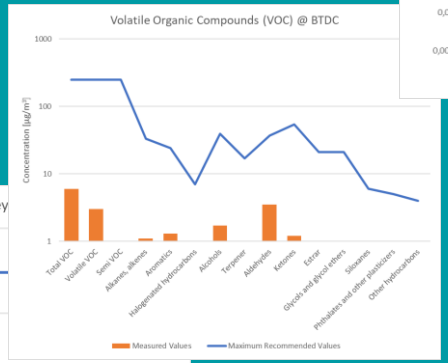



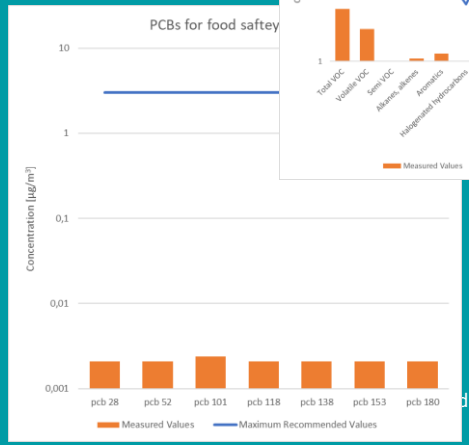




# DC Excess Heat – Various applications

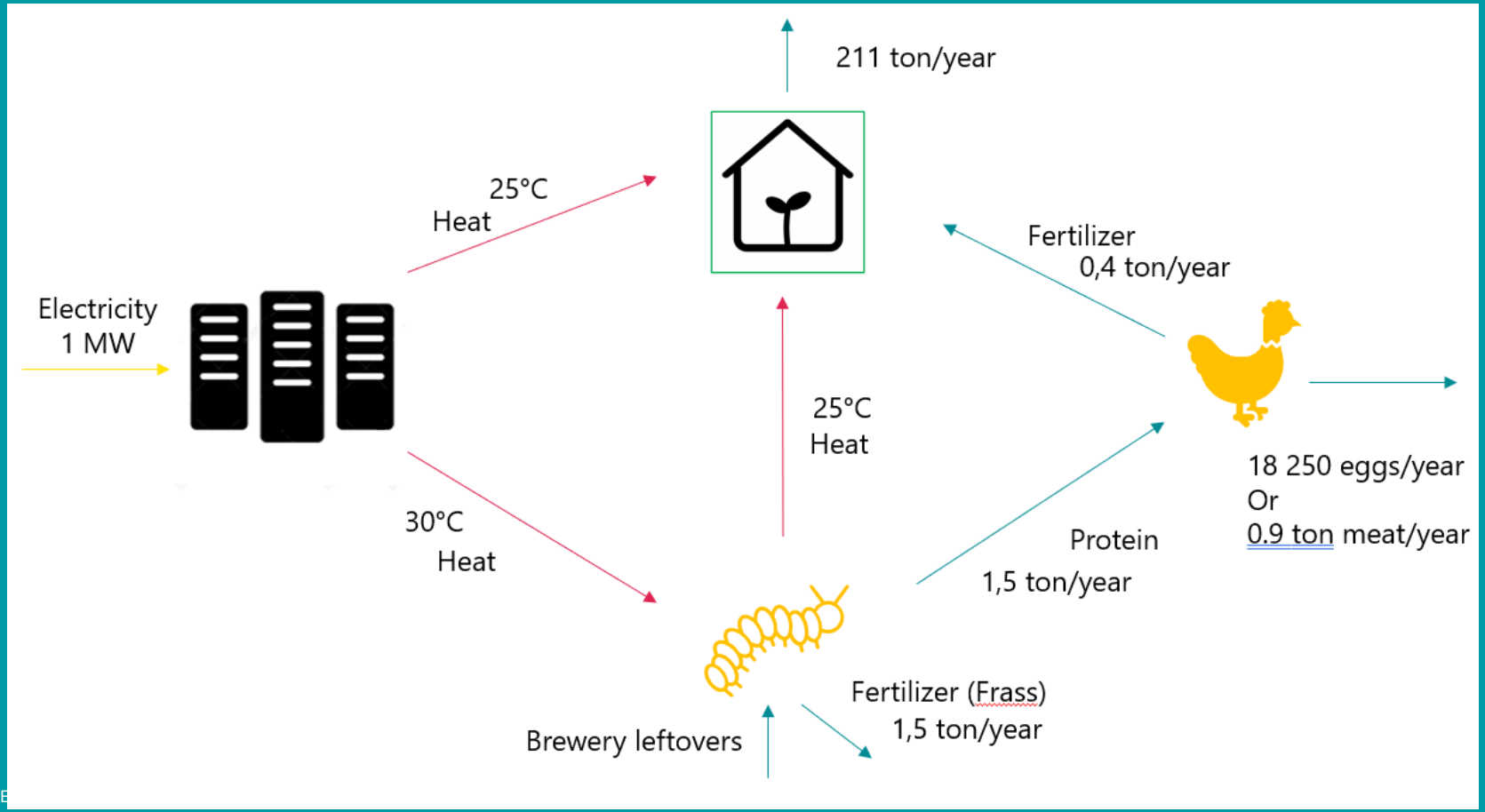


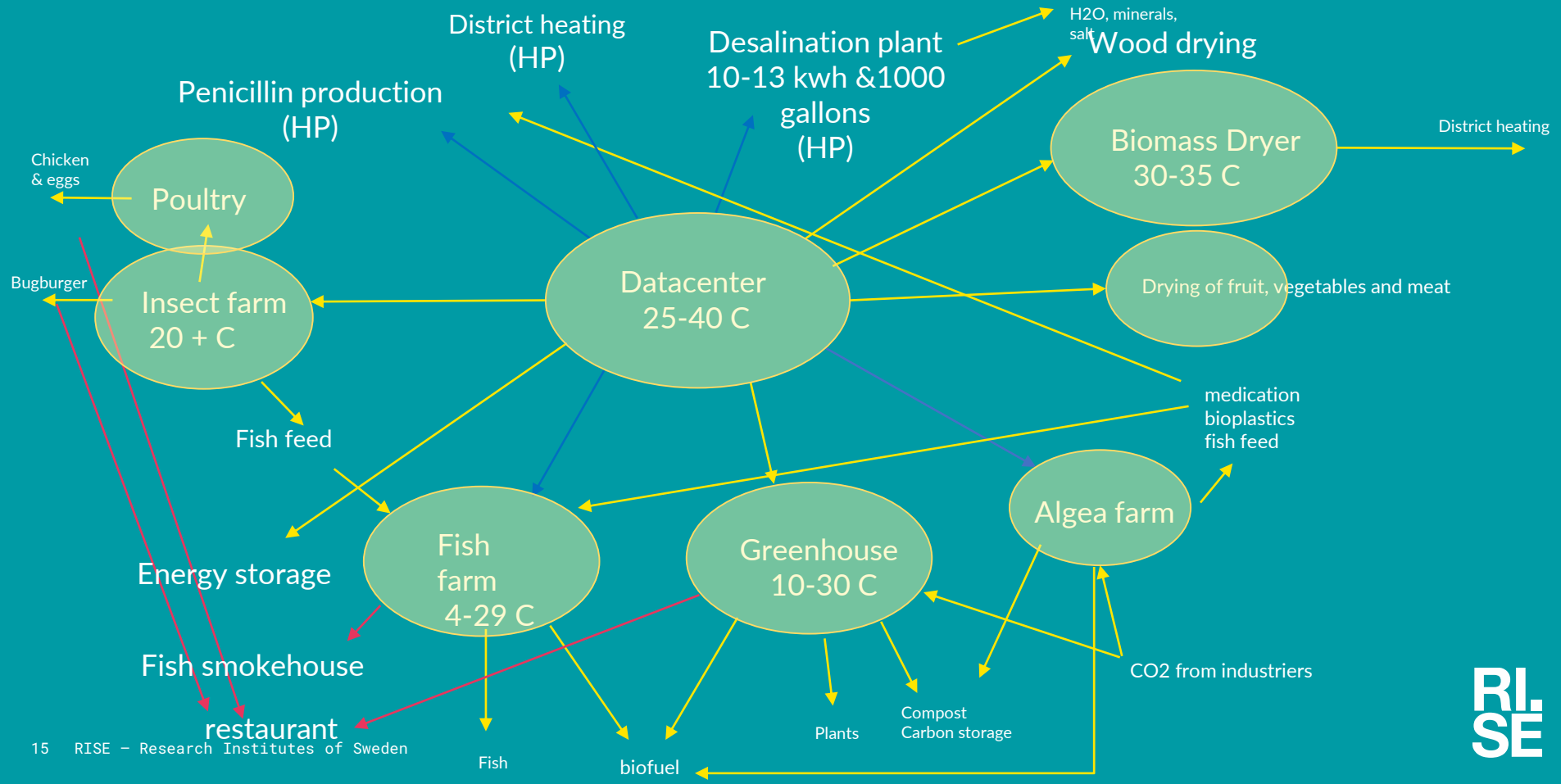




# Industrial and Urban Symbiosis

# DC IUS – Nested Loops



# DC IUS – The Matrix



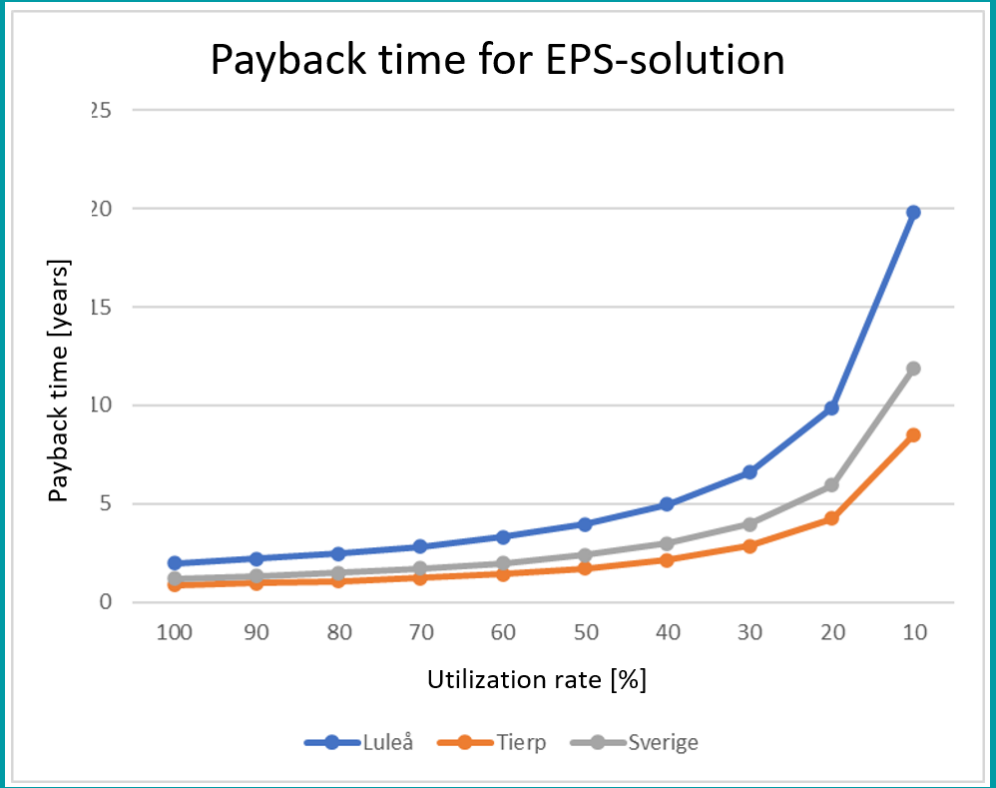
# Virtual Power Plants

# Site study – Power Density

| Fuel | Building area | Plot area | Power | Spec. power intensity | |
|---|---|---|---|---|---|
| | | | | Building area | Plot area |
| | $m^2$ | $m^2$ | MW | $kW/m^2$ | $kW/m^2$ |
| Biogas, oil | - | 22 000 | 450 | - | 20,5 |
| VP, Biomass, oil | - | 25 000 | 355 | - | 14,2 |
| Wood chips | - | 46 000 | 55 | - | 1,2 |
| Bio-oil | 1 100 | 12 000 | 74 | 67,3 | 6,2 |
| Biomass | 5 400 | 128 000 | 75 | 13,9 | 0,6 |
| DC Boden (Mining container 1) | 9 | 45 | 1,8 | 200 | 40 |
| DC Boden (Mining container 2) | 14 | 70 | 0,6 | 45 | 9,0 |
| DC Stackbo (Enterprise) | 24 000 | 226 730 | 500 | 20,8 | 2,2 |
| DC Ersbo (Enterprise) | 24 000 | 174 149 | 290 | 12,1 | 1,7 |
| DC Boden (Mining) | 41 565 | 38 991 | 19 | 0,46 | 0,5 |
| DC Luleå (Enterprise) | - | 325 539 | 212 | - | 0,7 |
| DC Vallentuna (Enterprise) | - | 4 500 | 0,6 | - | 0,1 |

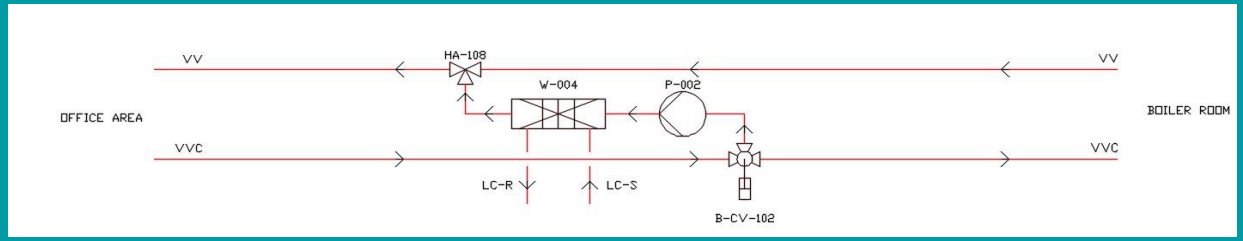
# Cost Comparison – Payback time

| | Asperitas | EPS | Air Cooling |
|---|---|---|---|
| Cost | 511 817: - | 2 352: - | 17 973: - |
| Number of servers | 48 | 2 | 42 |
| Cost/server | 10 663: - | 1 176: - | 428: - |

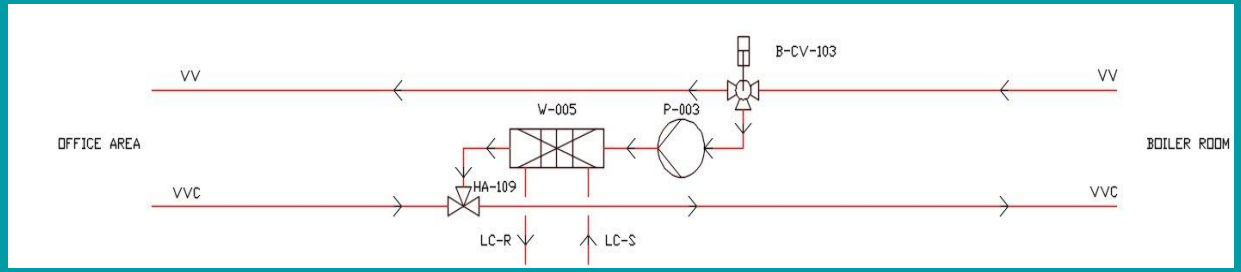


# Liquid Cooling Testbed – LCT

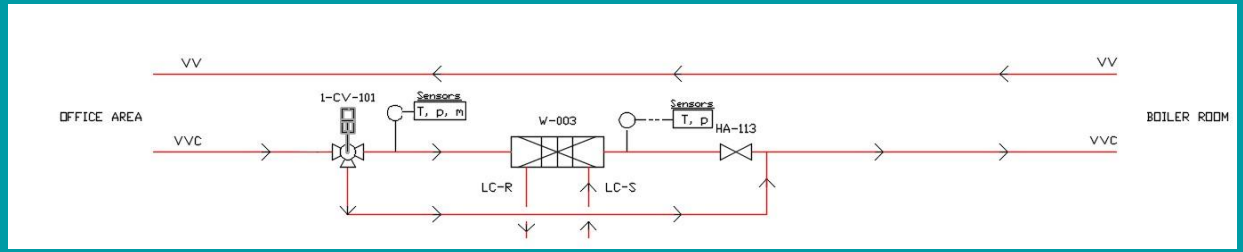
VVC to VV




VV to VVC




VVC or VV



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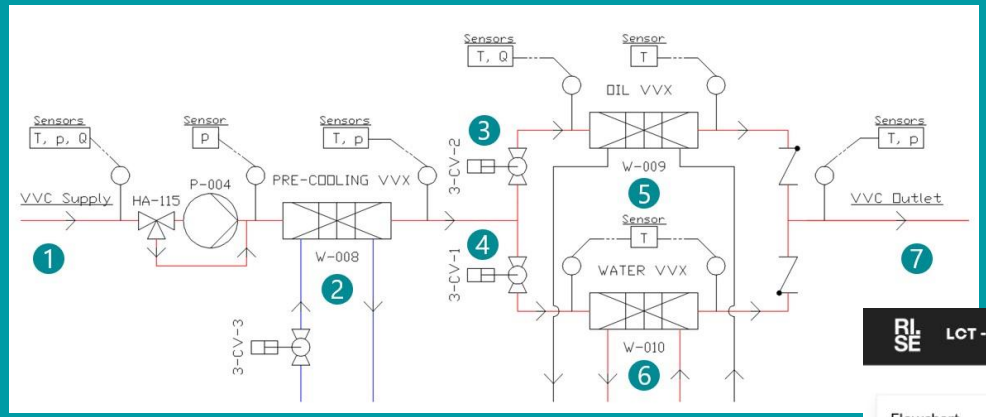


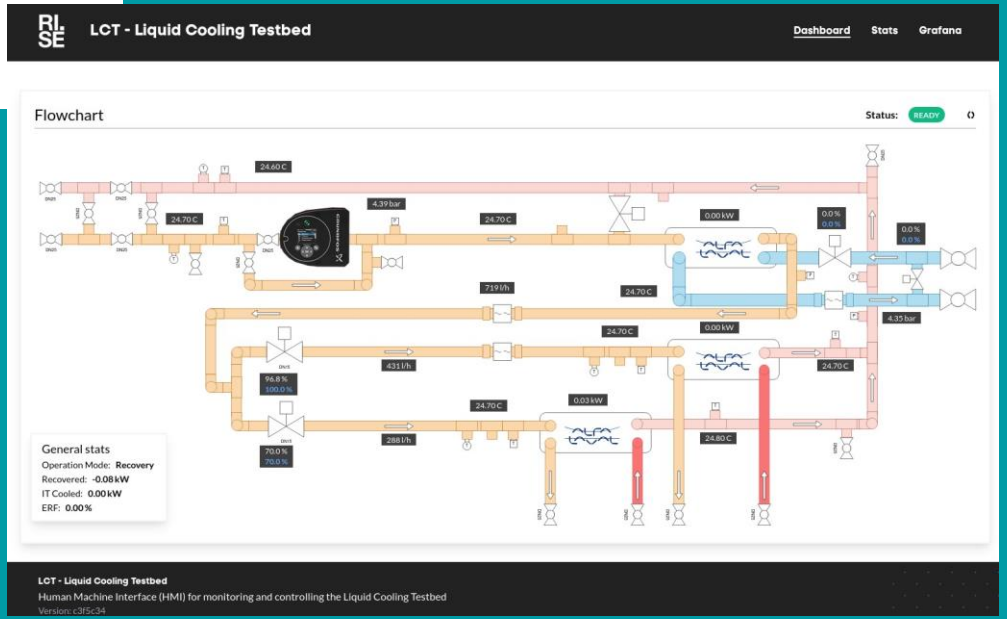

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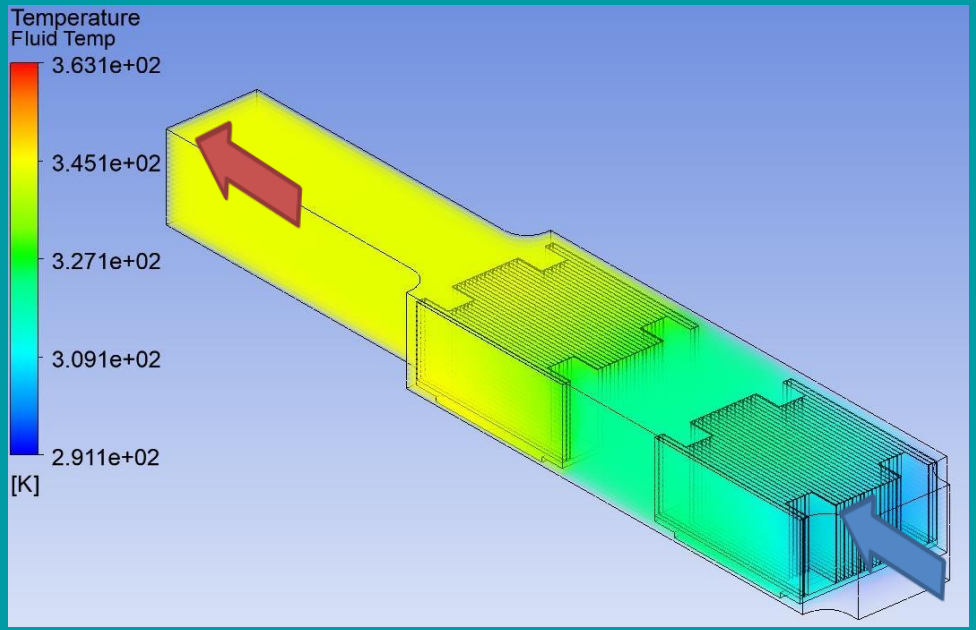


# Summary

# Summary

- 72°C highest extracted temperature at 80°C CPU temperature
- The power density for adata center has could represent as a district heating production site
- The use of liquid cooling is associated with an additional cost, which could be returned as income for selling excess heat
- For heat production the connection from VVC to VV was most favorable
- Immersion easier installation compared with on-chip cooling
- The largest obstacle for implementation of immersion cooling the additional cost

Yes, we where able to produce hot tap water without any support by heat pumps

# Questions or thoughts?

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