in collaboration with

Reesbe
Resource-Efficient Energy Systems in the Built Environment

MÄLARDALEN UNIVERSITY SWEDEN

HEAT TO POWER

– techno-economic assessment of heat-to-power use in district heating networks

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RISE Research Institutes of Sweden
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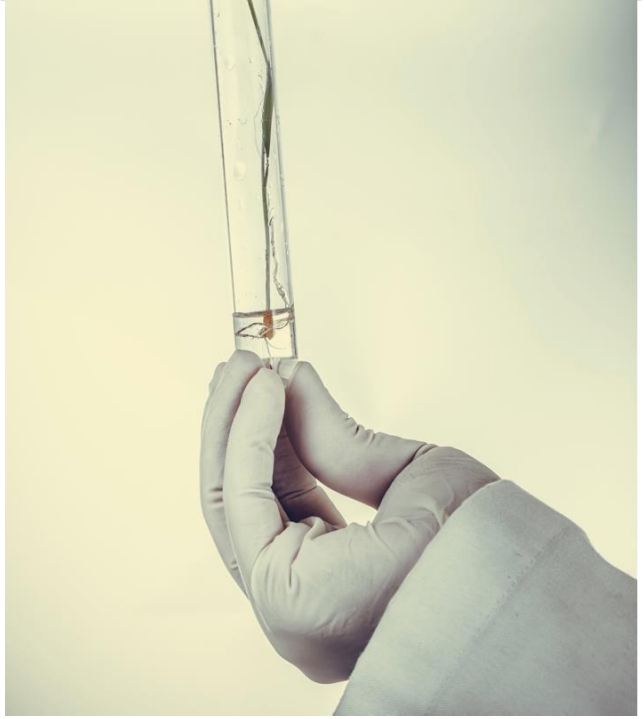
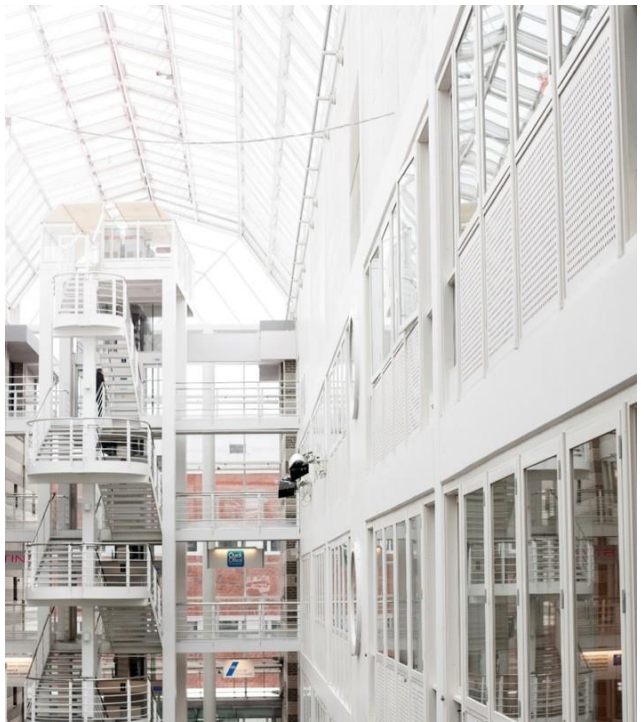
Energy and circular economy

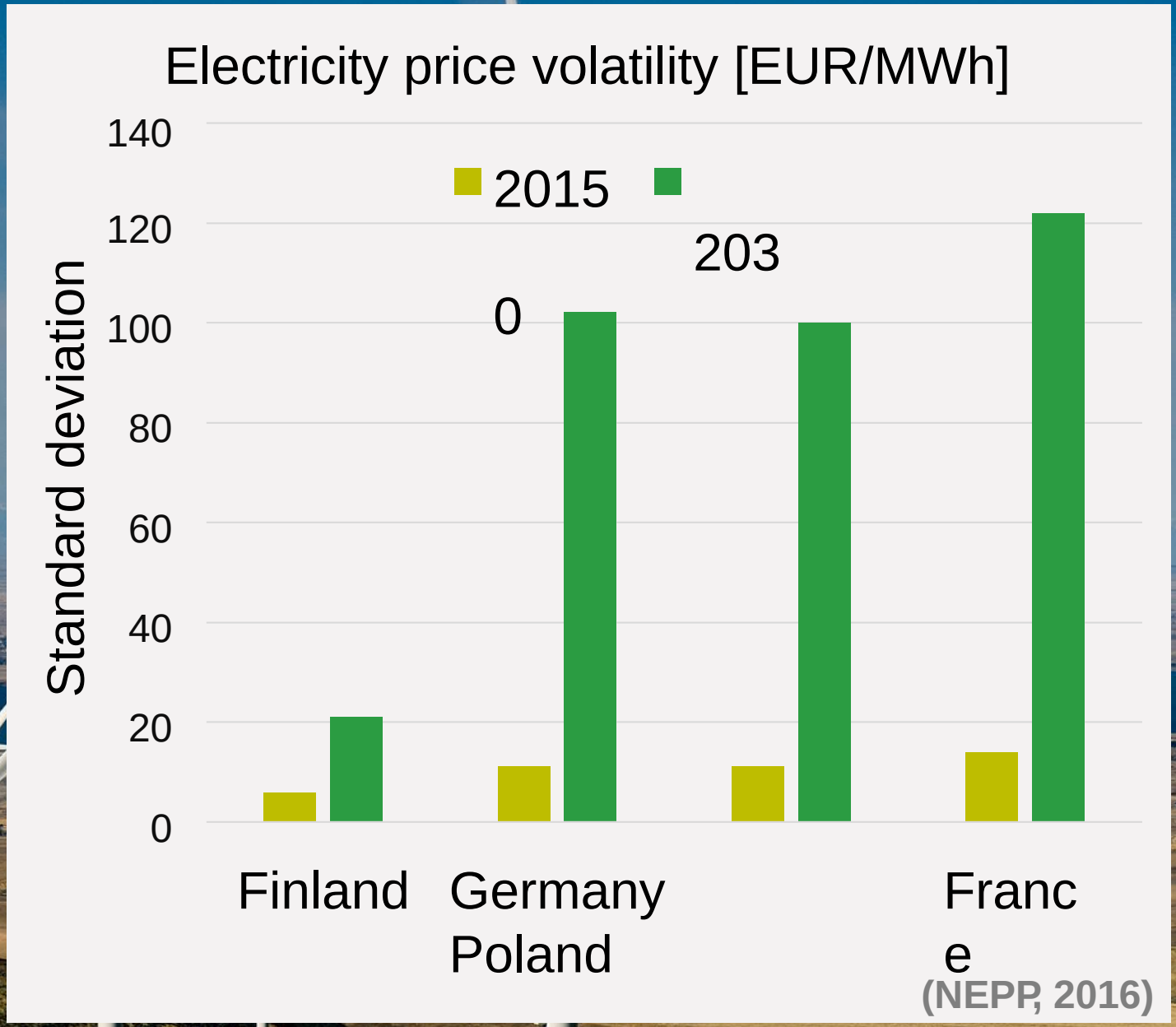




30 %

2014 – 2020

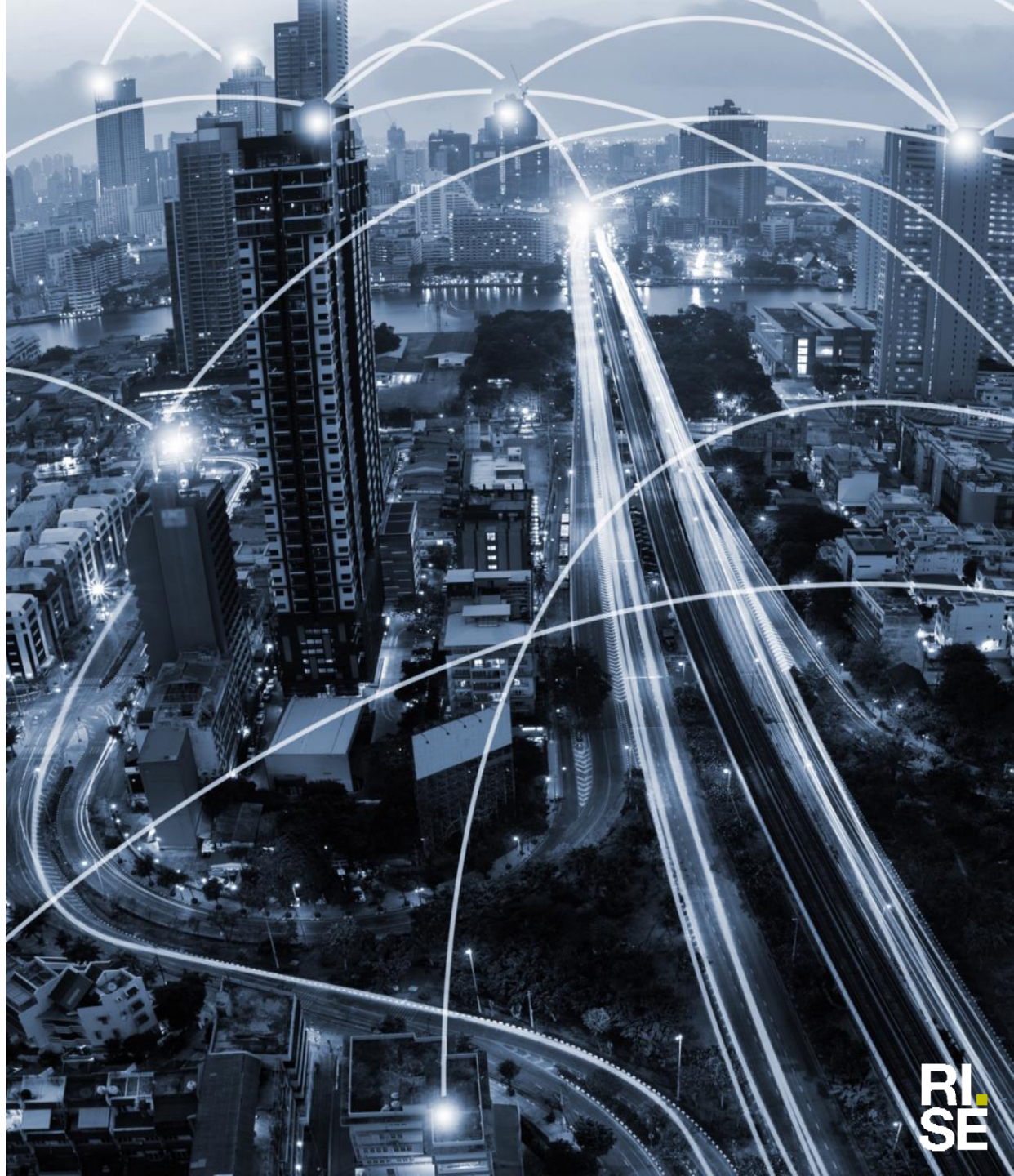
(IEA, 2016)



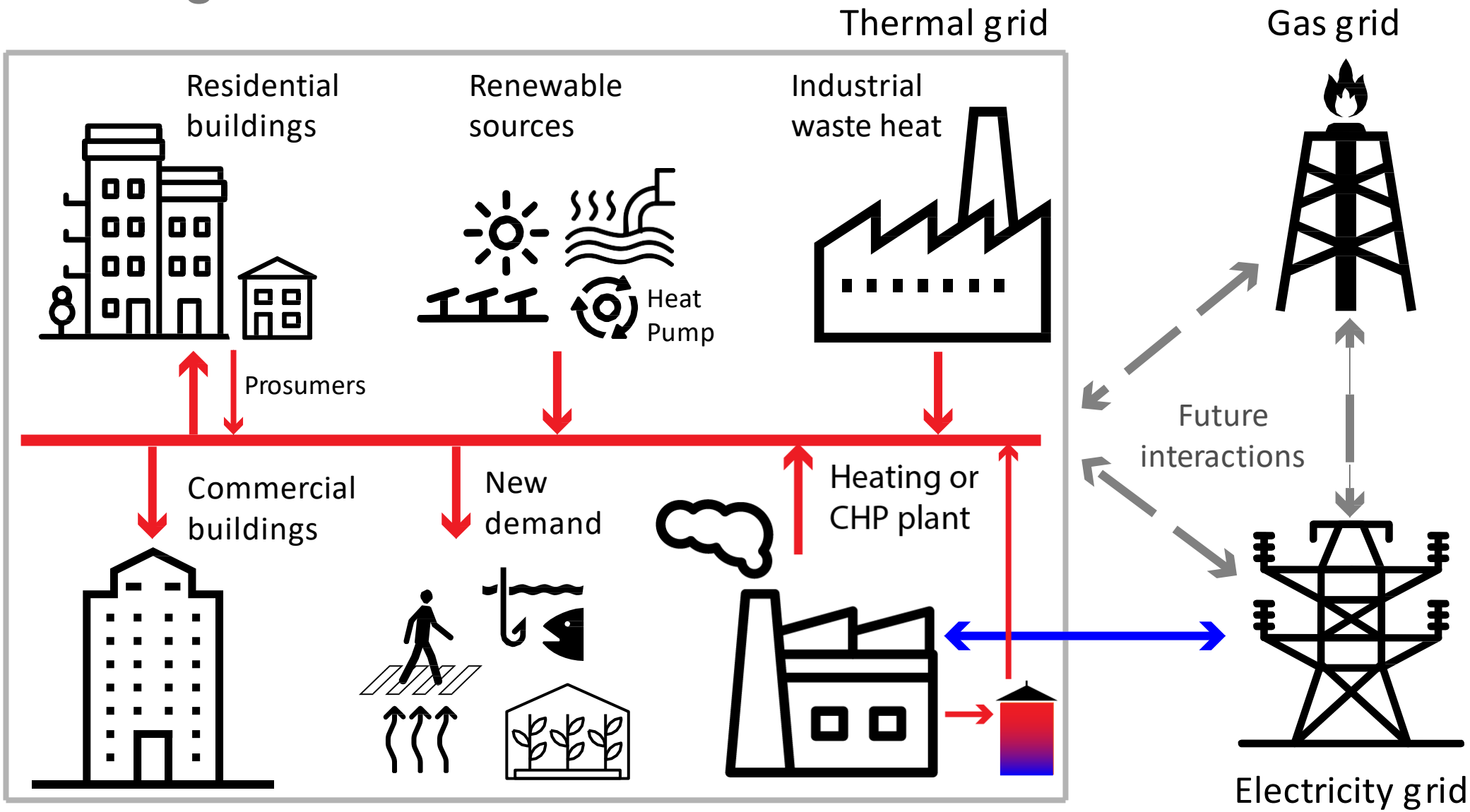
(NEPP, 2016)

Coming up…

- Thermal grids vision
- Heat to power
- Levelised cost of electricity (LCOE) from thermal grid heat



Thermal grids future

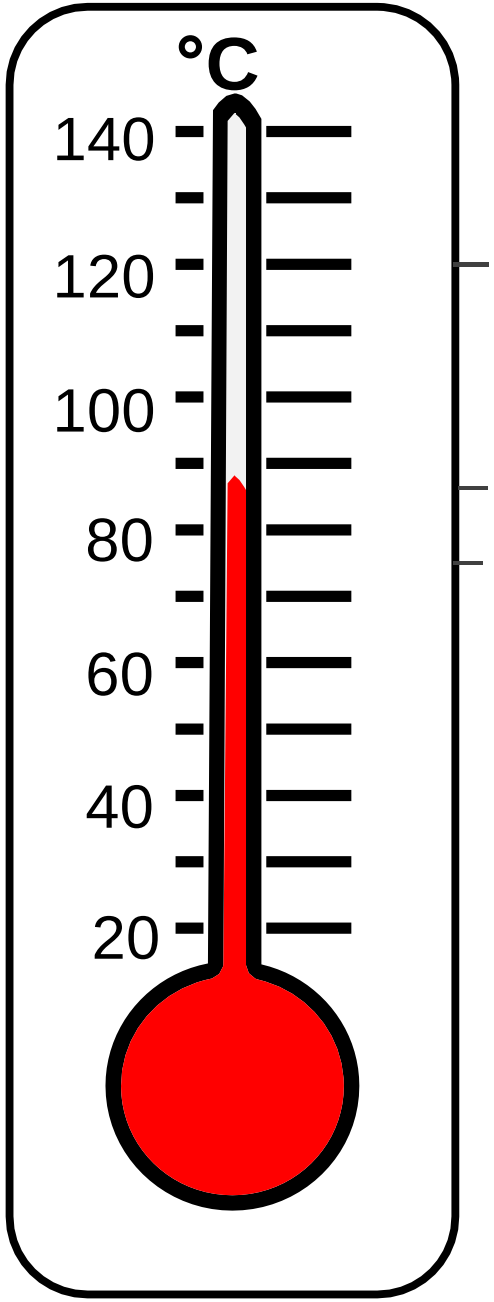


Temperatures

2nd gen: High temp.

3rd gen: Medium temp.

4th (next)gen: Low temp.



– Max. peak Europe: **120 °C**

Annual average…

– Sweden 86 °C

– Denmark 74 °C

…**80 °C**

(Lund et al., 2014; Østergaard and Svendsen, 2017)

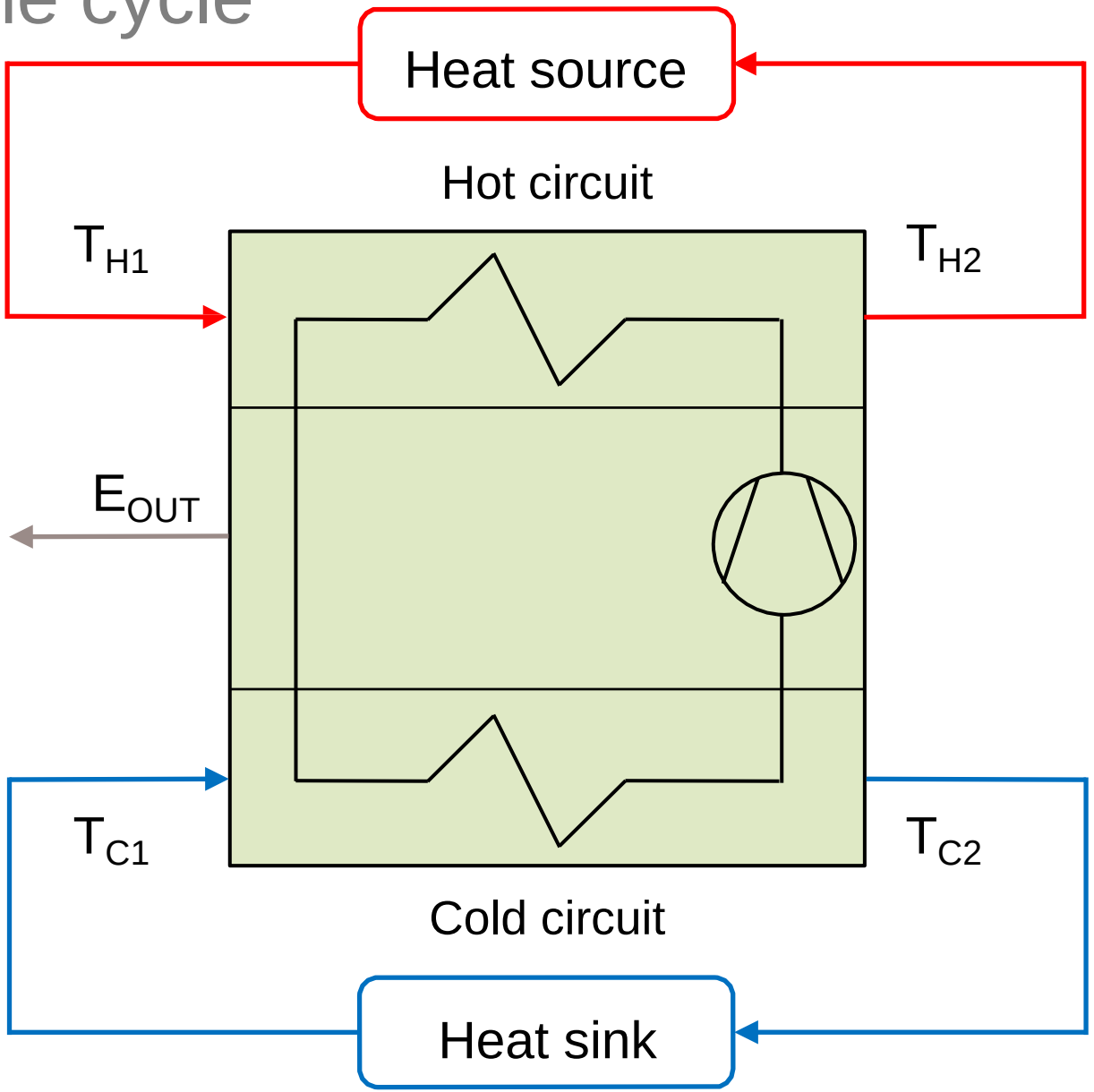
(Dansk Fjernvarme, 2016; Frederiksen and Werner, 2013)

Technology selection

- Thermodynamic power cycles
  - **Organic Rankine cycle (ORC)**
  - Kalina cycle
  - Goswami cycle
  - **Commercial ORC-like cycles**
- Direct processes
  - Thermoelectric
  - Piezoelectric
  - Thermionic
  - Thermo-photovoltaic

- Appropriate operating temperature and power demand
- Competitive cost
- Efficiency
- Commercially available
- **Selected: ORC and commercial cycles**

Organic Rankine cycle



Levelised Cost of Electricity (LCOE)

the net present value of the unit-cost of electricity over the lifetime of a generating asset

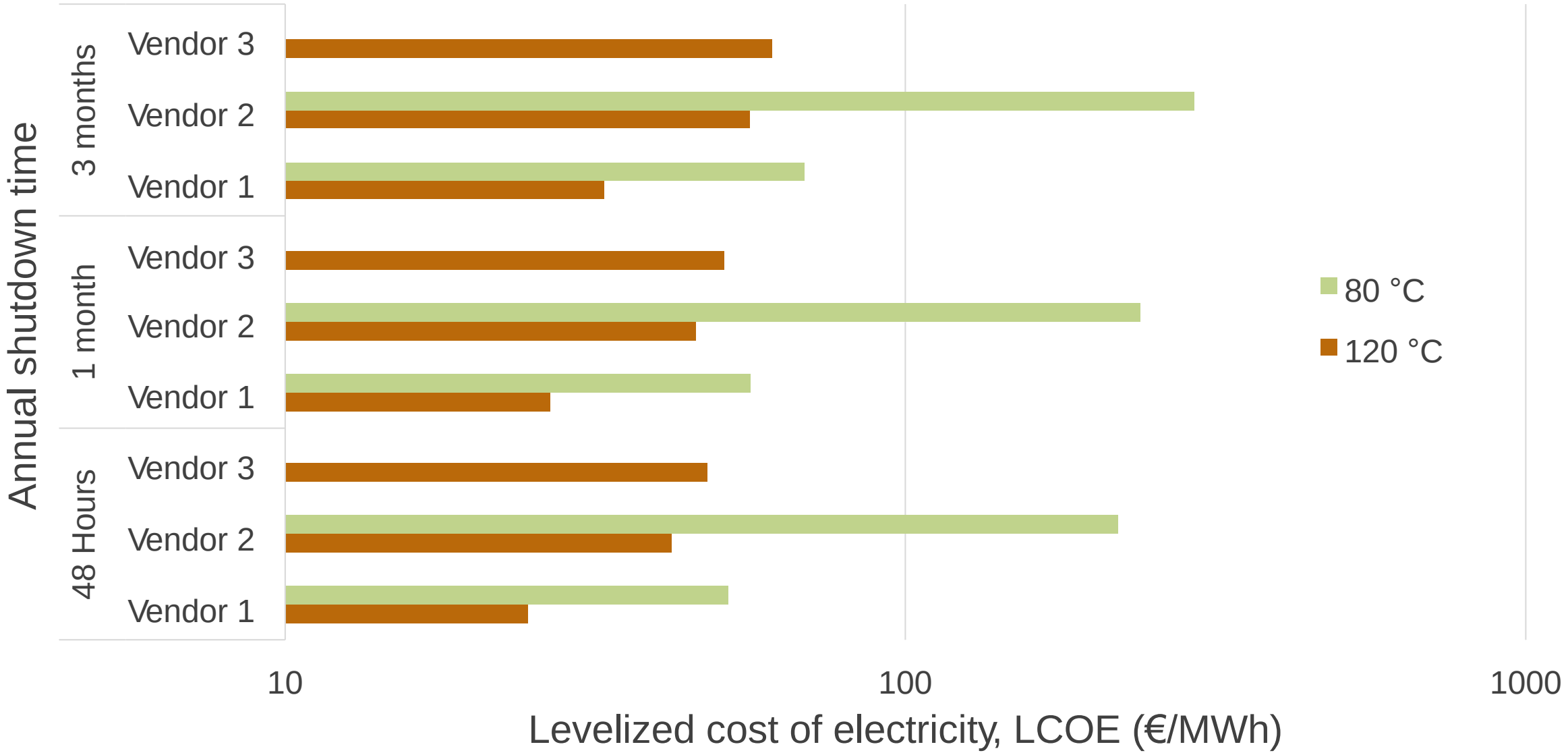
$$LCOE = LFC + LVC = \left[\frac{TIC \times r}{1 - (1+r)^{-T}} \right] \div Q + \left[\frac{M}{Q} \right]$$

(Blumsack, 2014)

- Heat source temperatures: 80 °C and 120 °C
- Heat sink temperature 20 °C
- Shutdown time: 48 hours, 1 month, 3 months
- Heat has zero cost
- Pump electricity not included
- Data from 3 heat to power vendors

LFC = Levelised Fixed Cost
LVC = Levelised Variable Cost
TIC = Total Installed Cost
r = discount rate (6 %)
T = technology lifetime (years)
Q = annual energy output
M = operational costs

Calculated LCOE



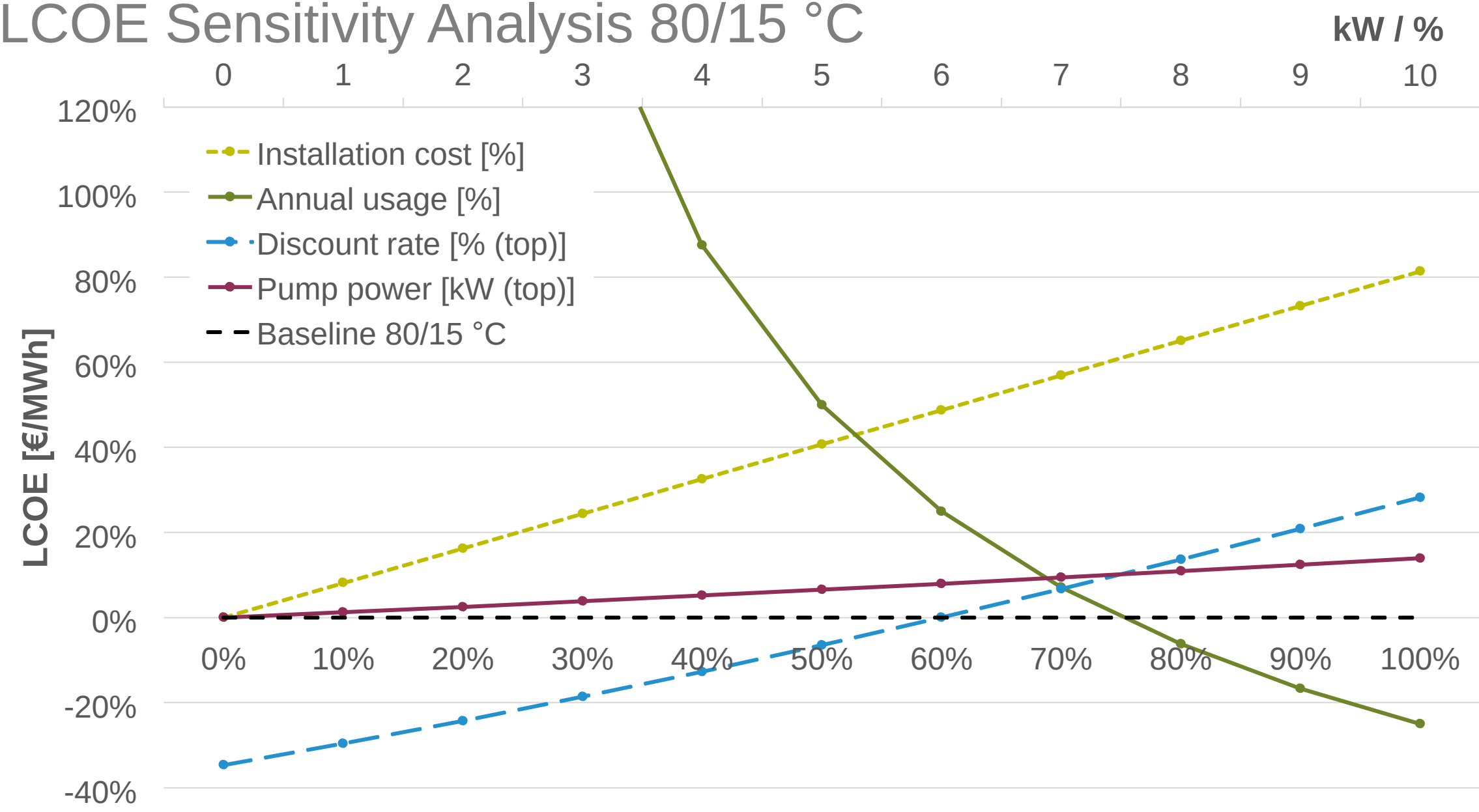
69 € /MWh in context…

54 € /MWh UK
annual average (peak 75 €)

121 € /MWh New York
annual average

63 € /MWh UK offshore wind

LCOE Sensitivity Analysis 80/15 °C



Conclusions

Levelized cost of electricity

- Most sensitive to:
  - Installation cost
  - Heat availability / annual operation time
- Cold sink source important

Upcoming analysis

- LCOE sensitivity to hot / cold temperature
- Test case with district heating network data
- Include levelized cost of heat
- Scenarios economically & technically feasible

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THANKS!

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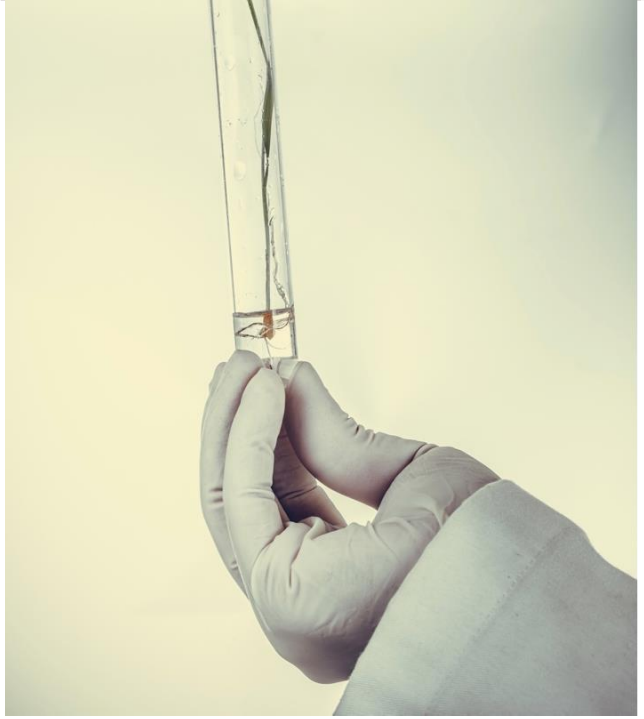

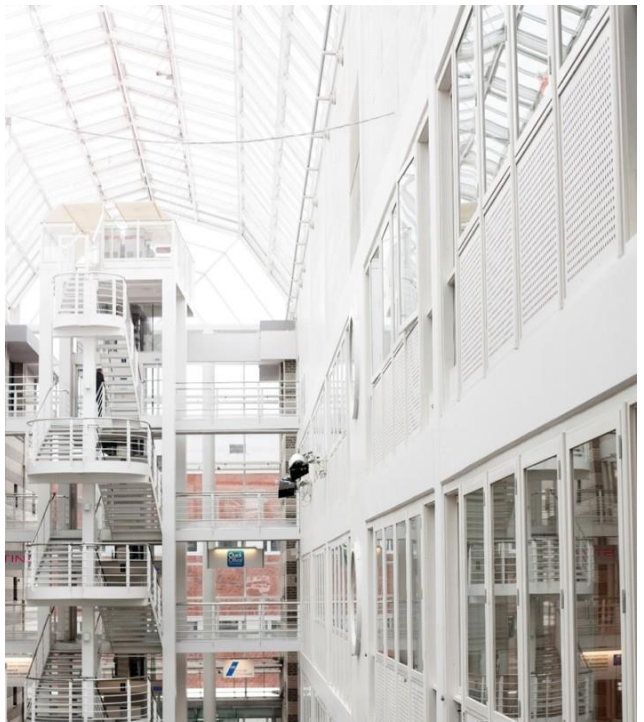

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