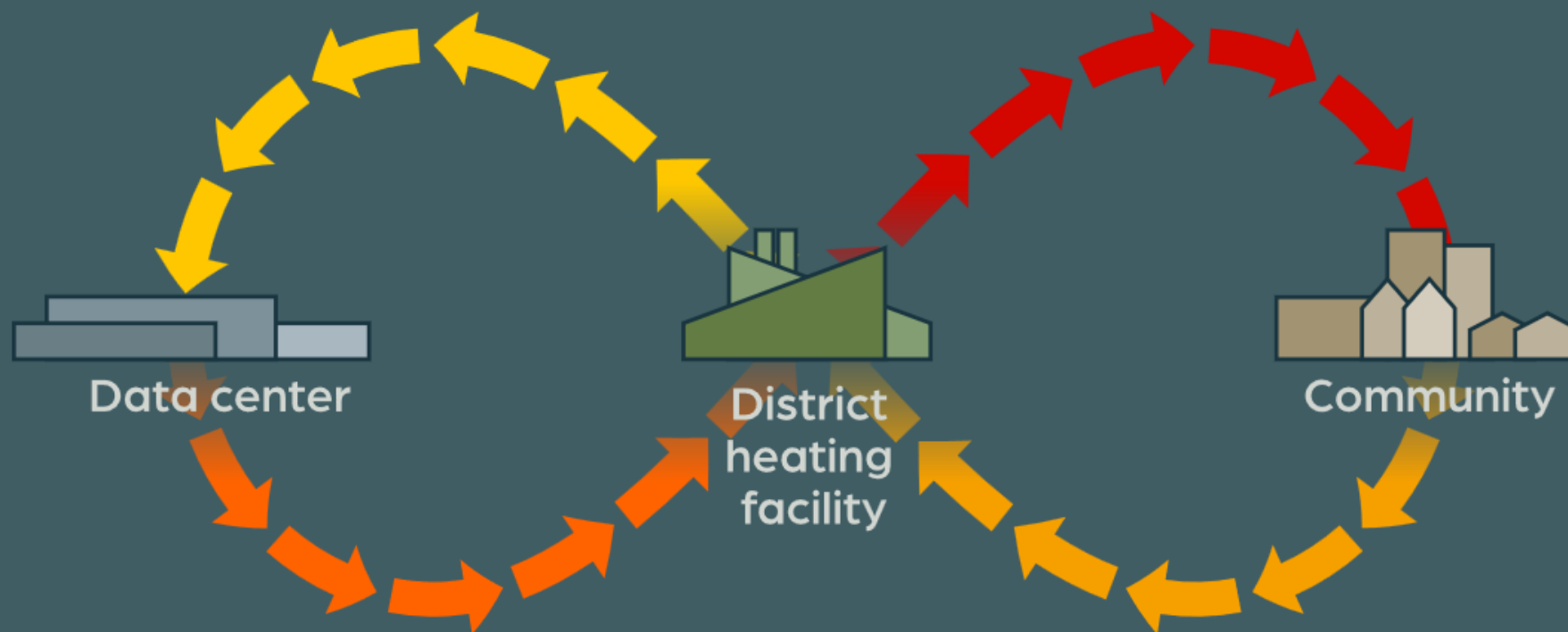


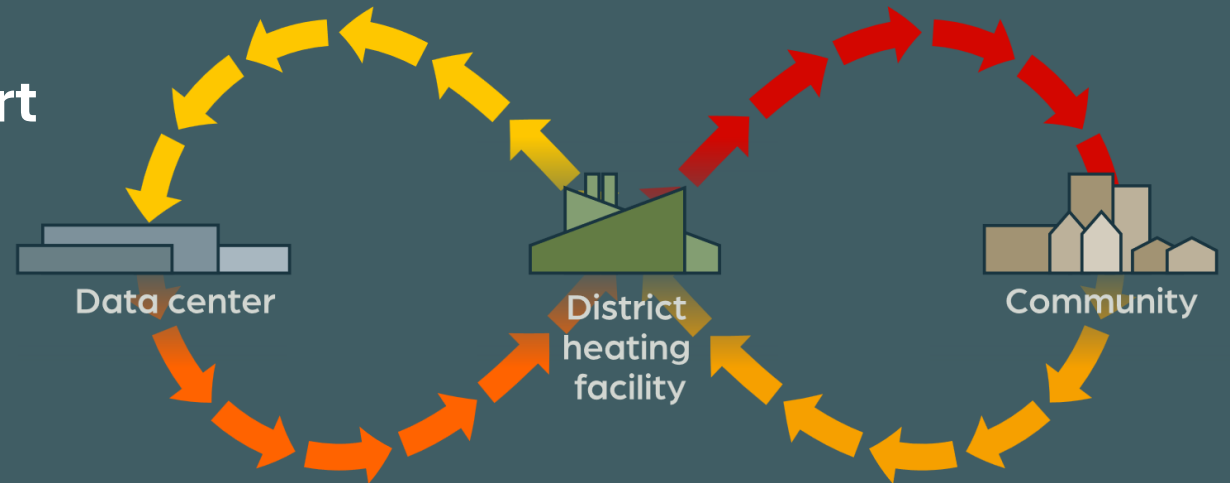
The Value of Hot Water

for Next Generation Data Center Cooling



Agenda

- The Market and The Setup
- Cost of boosting T; Cost of transport
- Temperature and Value
- Next generation cooling
- Cases
- Design vs Reality
- Retrofit



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DIN Forsyning



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Next Generation Cooling

Din Forsyning
connects

25,000

households

through

1000 km

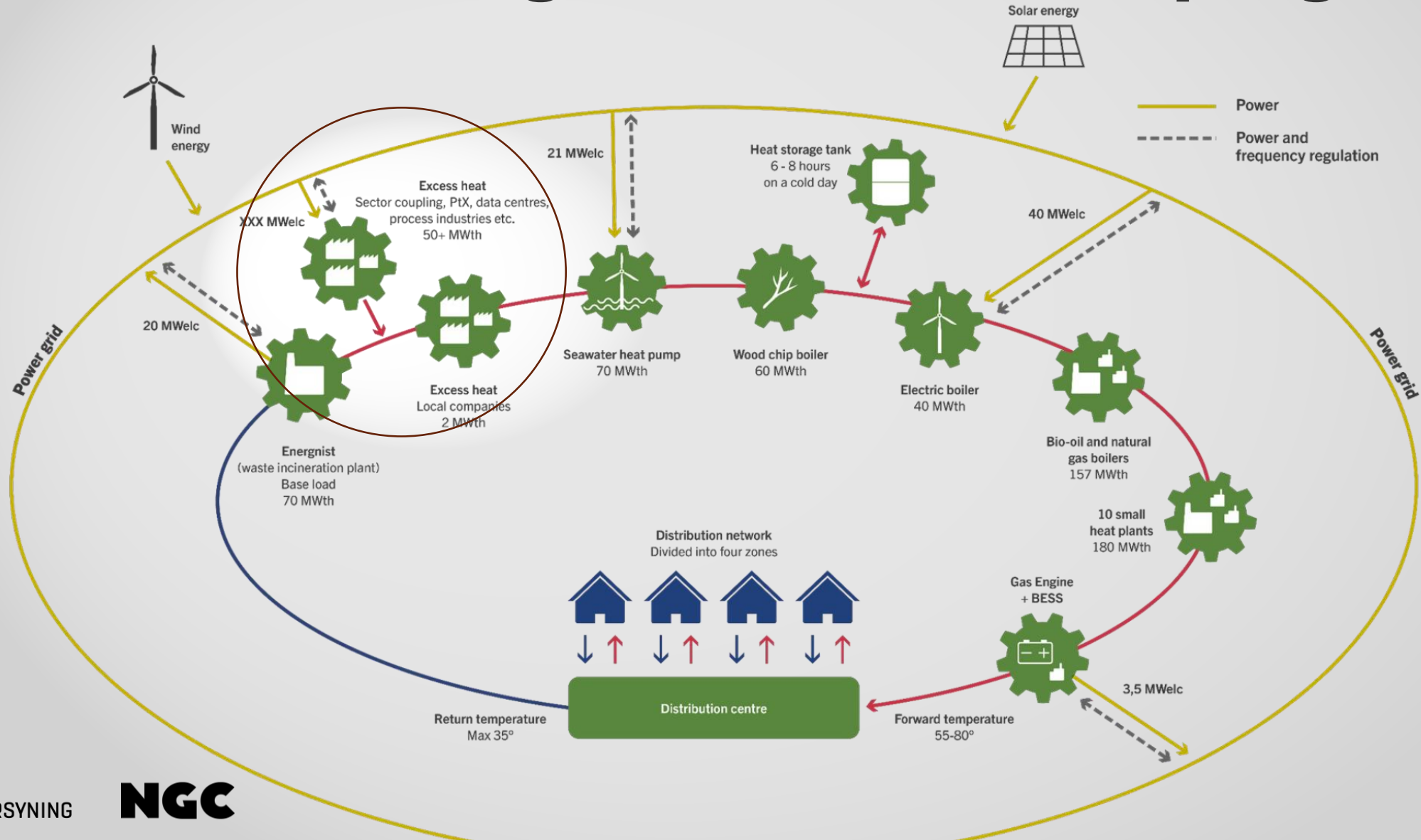
of district heating
creating the
infrastructure to
integrate surplus heat
from data centres into
the energy system.



**DIN
FORSYNING**



Heat & Power integration – Market coupling



Datacenters are a **large and stable** heat source.

The value depends on **how** it can be integrated.

Waste Heat from Data Centers Matters

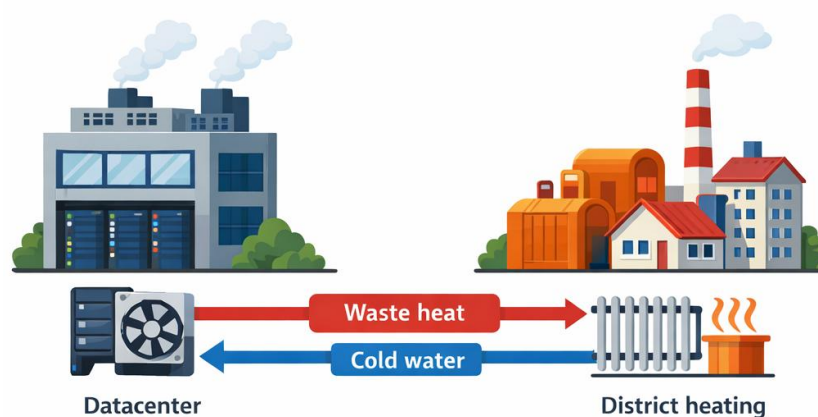
- **Denmark has district heating in 65-70% of households;** annual heat supply equal 125-130 PJ, comparable to waste heat from more than 22 datacenters of 200MW each
- **Waste Heat Recovery delivers low-carbon,** local heat supply alongside cooling for the datacenters
- **Large datacenters create steady waste heat**
- Value of waste heat depends on:
 - Temperature levels
 - Distance
 - Required infrastructure and operation
- **Waste heat utilisation is an integrated energy system,** not just heat sale or purchase — heat of waste heat is not “free”

Datacenters deliver **low to medium temperature heat**.

Usable heat requires **temperature upgrading**.

Utilisation of Datacenter waste heat

- **Typical available waste heat temperature: ~20-30°C** (potential to reach 40-60°C depending on cooling design)
- **Different utilisation for Waste Heat Recovery:**
 - 50°C → low-temperature applications (e.g. greenhouses, aquaculture)
 - 85°C → mid-temperature - district heating / process heat
 - 150°C → high-temperature industrial processes



Cost of Heat Upgrade

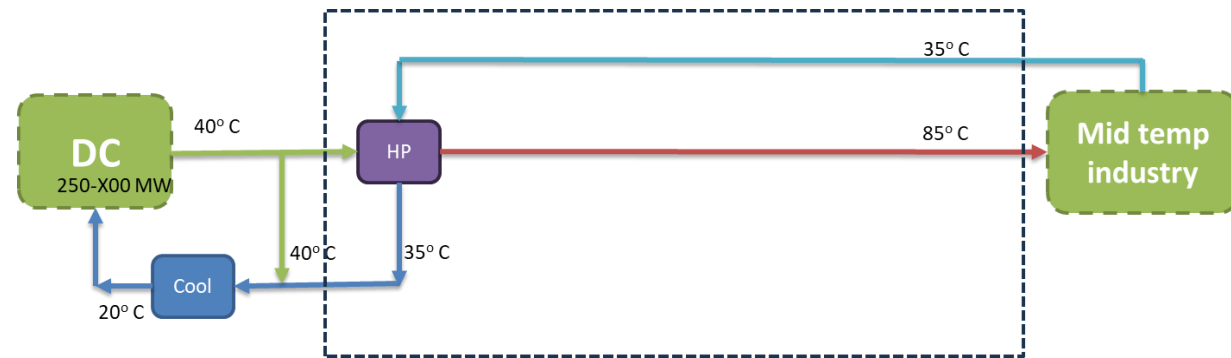
Before heat transport, **waste heat with heat pump boost is generally feasible**

Average heat production cost (DKK/MWh, excl. transport):

Delivery temperature	System COP	Boost of 40°C Waste heat	Air-to-water HP	Electric boiler	N-Gas boiler
°C	-	DKK/MWh	DKK/MWh	DKK/MWh	DKK/MWh
85	4,9	435	673	850	884

Assumptions:

- 10 MW heat,
- 4,000 h/year operation,
- Power price 680 DKK/MWh,
- 20-year lifetime,
- 5% financing rate,
- 7% IRR



Design implications:

- Delivery temperature - **lower temperature lower CAPEX and OPEX**
- Operation hours - **more hours lower total cost**
- Waste heat temperature - **higher temperature = lower OPEX**

Heat Transport can be a Deal-Breaker

Distance and temperature difference (ΔT) determine **pipe size, CAPEX and total heat price.**

Cost of infrastructure and transport (DKK/MWh)

Temperature district heat / pipe diameter	1 km	2 km	4 km	12 km
35->85 °C DN200	62	124	248	743

Total cost of heat incl. Infrastructure and transport (DKK/MWh)

Temperature district heat / pipe diameter	1 km	2 km	4 km	12 km	Alternative local TCOH
35->85 °C DN200	498	559	683	1,178	673 – 884

Design implications:

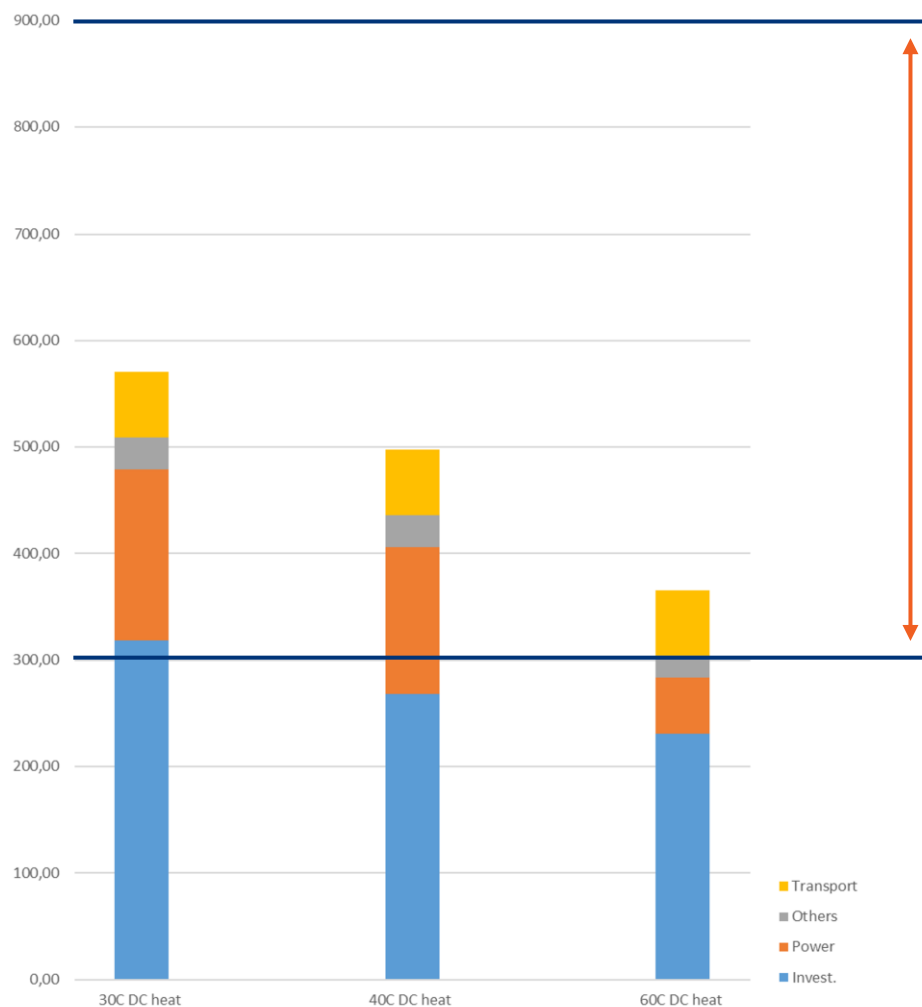
- Maximise ΔT - lower flow and smaller pipe size
- Boost temperature close to the datacenter
- Heat off-taker must cool heat as much as possible (low return temperature)

DC temperature makes a difference

Waste heat is competitive, but must be evaluated as part of the whole heat system.

Cooling design directly determine waste heat value and feasibility.

Total cost (DKK/MWh) of 85°C heat @ 1 km distance



District heating production prices varies from 300 to more than 900 DKK/MWh depending on technology, fuel/power prices, and season (winter higher than summer).

Higher waste heat temperature is crucial.

- Rear-door heat exchangers with **distributed intelligence**
- Coolant Distribution Units that **simplify and separate** hydraulic circuits
- **System-wide optimisation** of cooling performance and energy use
- Delivering return temperatures that improve both **efficiency** and **reuse potential**

DK company

CZ production

EU components

Founded to Rethink How Cooling Systems Behave



Up to 90% Cooling Energy Reduction

Enables pPUE levels below 1.1



< 0.5 s Response Time

From idle to maximum cooling
in less than one second.



High Efficiency Across the Operating Range

Efficiency and precision from low-load
operation to full-load conditions.

We do not begin with assumptions. We begin with physics.

A case story

Room:

25° C

Fluid supply:

22° C

Server air:

60° C

Starting point

A standard rear door cooling solution from a well-established cooling company

- Fluid: 22/32°C.
- 1MW: 100 m³/h

NGC Rear door cooling solution

- Fluid: 22/52°C
- 1MW: 33 m³/h

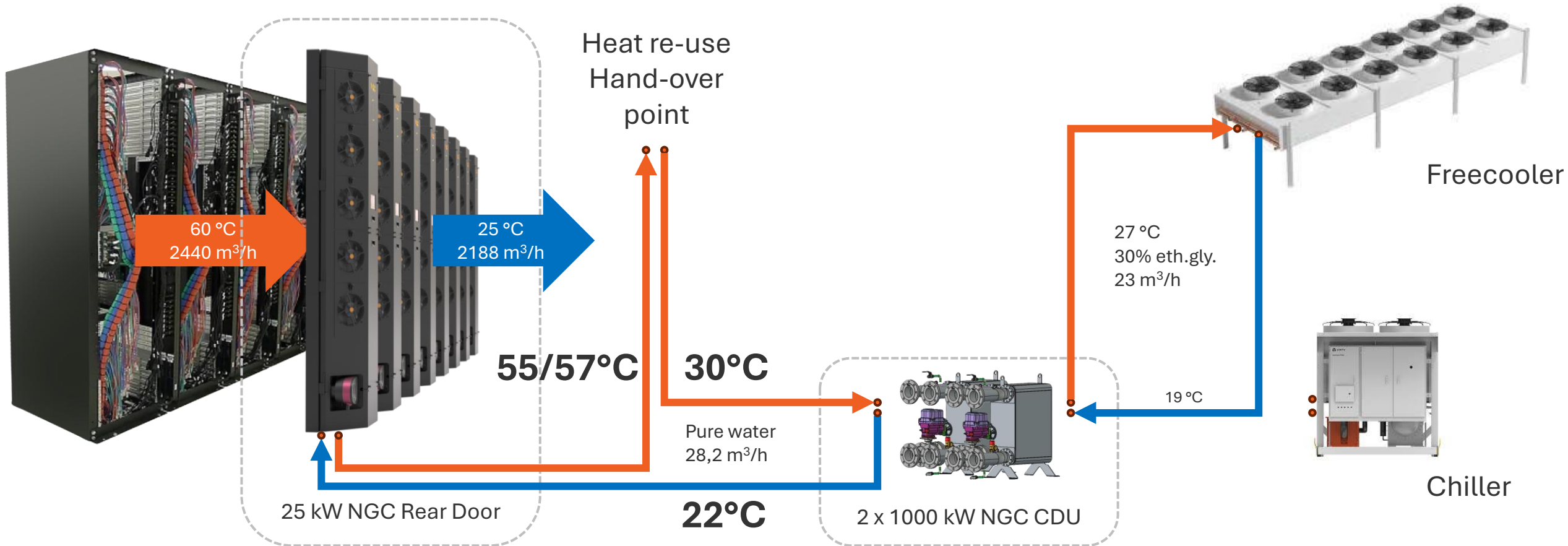
Benefits

- CAPEX: smaller pipes, valves, hoses, freecoolers and chillers
- OPEX: 99,2% freecooling (in Aarhus Tirstrup temperature profile)
- Cooling sub-system pPUE = 1,0071



CASE 1:

Solution with secondary circuit (1,2 MW modules)

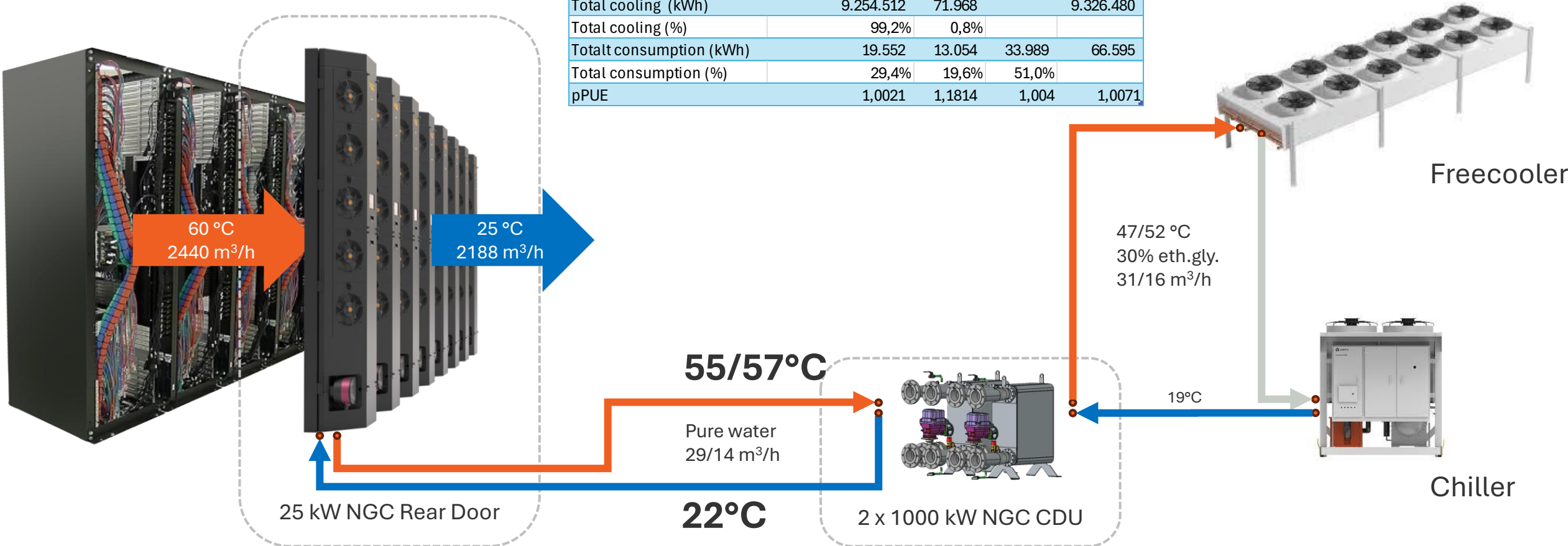




CASE 2:

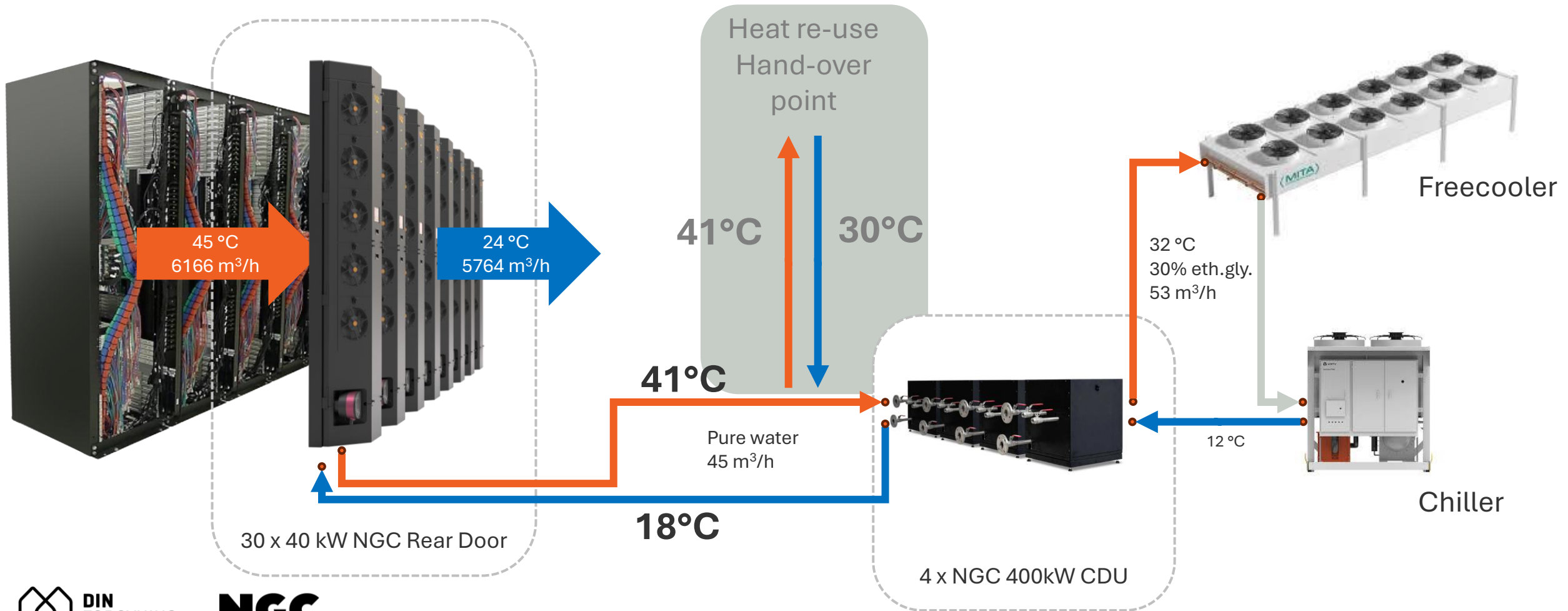
Solution with secondary circuit (1,2 MW modules)

Full load 24x7 51,8°C	Drycooler	Chiller	Rear D	Total cool
Total cooling (kWh)	9.254.512	71.968		9.326.480
Total cooling (%)	99,2%	0,8%		
Totalt consumption (kWh)	19.552	13.054	33.989	66.595
Total consumption (%)	29,4%	19,6%	51,0%	
pPUE	1,0021	1,1814	1,004	1,0071



CASE 2:

Solution with secondary circuit (max load)



How about the real world? (a [LinkedIn](#) article)

🎯 Design PUE vs Operational PUE

The difference between design-stage efficiency claims and real-world performance in data centers.



Partial performance load analysis

Performance overview

Load	Profile % of time	Load kW	hot air flow m ³ /h	cool air flow m ³ /h	air PD Pa	Fan sound dB(A)	fluid return °C	fluid flow m ³ /h	fluid PD kPa	laminar flow compensation	Fan Power (W)	Pump Power (W)	Drycool Power (W)	Chiller Power (W)	Total Power (W)	Partial PUE	EER kW/kW
100%	40%	40	6.166	5.764	122	68	40,4	1,50	68.300		454	73			527	1,013	76
80%	20%	32	4.933	4.611	85	64	41,5	1,18	42.200		268	39			307	1,010	104
60%	14%	24	3.699	3.458	54	59	42,4	0,85	23.700		144	20			164	1,007	146
50%	12%	20	3.083	2.882	40	56	42,9	0,69	16.600		96	14			110	1,006	182
40%	9%	16	2.466	2.306	28	52	43,3	0,55	1.100	23%	60	10			70	1,004	228
20%	5%	8	1.233	1.153	9	41	44,0	0,26	2.800	63%	14	9			23	1,003	347
0%	0%	0		-											-		

Maximum load 25-100	45,59	7.000		149			39,8	1,80	88.900			124,5					
Maximum load 25-120	49,53	7.600		170			39,4	2,00	107.100			164,3					

Room T	24,0 °C
Server air T	45,0 °C
Primary fluid supply T	12,0 °C
Secondary fluid supply	18,0 °C

#rows in coil	6
injections	7
Finn spacing	18 FPI

Coil:	W 3S9 E 06 66 0510 141 007 1 A L
Fans	2214
Pump:	MAGNA3 25-100N

Average PUE	1,0093
Average ret T	41,2 °C
Average flow	1,1 m ³ /h

Cost per kWh	DKK	0,00 €
Average p	302 W	
OPEX	- kr/year	- €/year

Max total flow	45,0
Average total flow	33,0
Average load	30 kW
Total average load	900 kW

1
High fluid return
temperature

2
Low pPUE

3
Fast

4
Precise

Have hot water need savings

We can deliver water at **2-3 degrees below server air out temperature**

- 22°C/42°C is good for heat-reuse
- 22°C/42°C will enable 99% free-cooling in the Nordic countries (DMI data for Aarhus airport)
- Pump reaction time < 0,5 sec
- Feed forward regulation with continuous calibration



Hot water and retrofit

Rear-door cooling is good for retrofit:

- 30cm whitespace behind rack, can swing out of the way
- DN15-25 hoses to connect fluid
- Cooling sub-system pPUE as low as 1,005 (RDHx, pumps, freecooler and chiller)
- Fluid return up to 42°C (or even 56°C)

Pump is integrated in door, installation consists of

- Mounting frame on rack
- Hanging door on frame
- Connecting hoses (drip free option)

Existing “cold” cooling ring – **not a problem**

Passive CDU
300/500/1000kW

Including room
temp
compensation





**DIN
FORSYNING**

NGC

Next Generation Cooling

DINForsyning.dk

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6715 Esbjerg N
Denmark

NextGenerationCooling.com

Delta 6
8382 Hinnerup
Denmark