

# CHIP CORE HEAT DIRECTLY APPLICABLE AS DISTRICT HEATING

***DC'S SUPPLYING SUSTAINABLE HIGH QUALITY  
ENERGY | DR. C.ROPS & ING. P.BOERBOOM, TNO***



**TNO** innovation  
for life  
[www.tno.nl/en/](http://www.tno.nl/en/)

## INTRODUCTION TNO

- > TNO is the Dutch #1 research organisation for applied scientific research
- > Established by law and started in 1932
- > TNO assists companies in innovation projects by
  - > Doing contract R&D
  - > Consultancy
  - > Knowledge development programs
  - > Licencing out IP
- > Independent of public and private interests
- > 3000FTE, >4500 Projects/ year
- > 47 Professors, 12 Lecturers
- > 2188 Publications, > 900 Patents
- > <https://www.youtube.com/c/tno>

### LOCATIONS IN THE NETHERLANDS

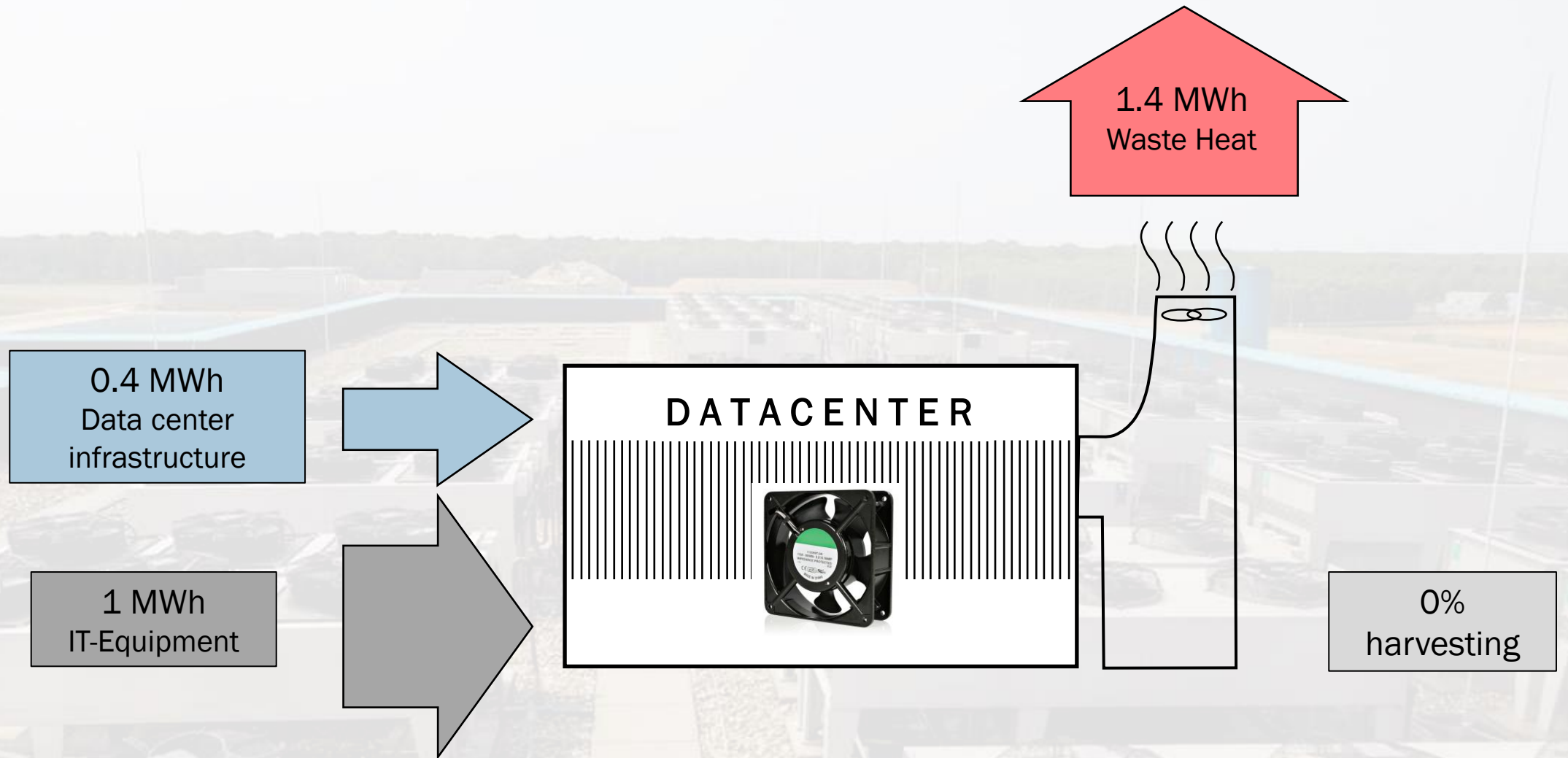




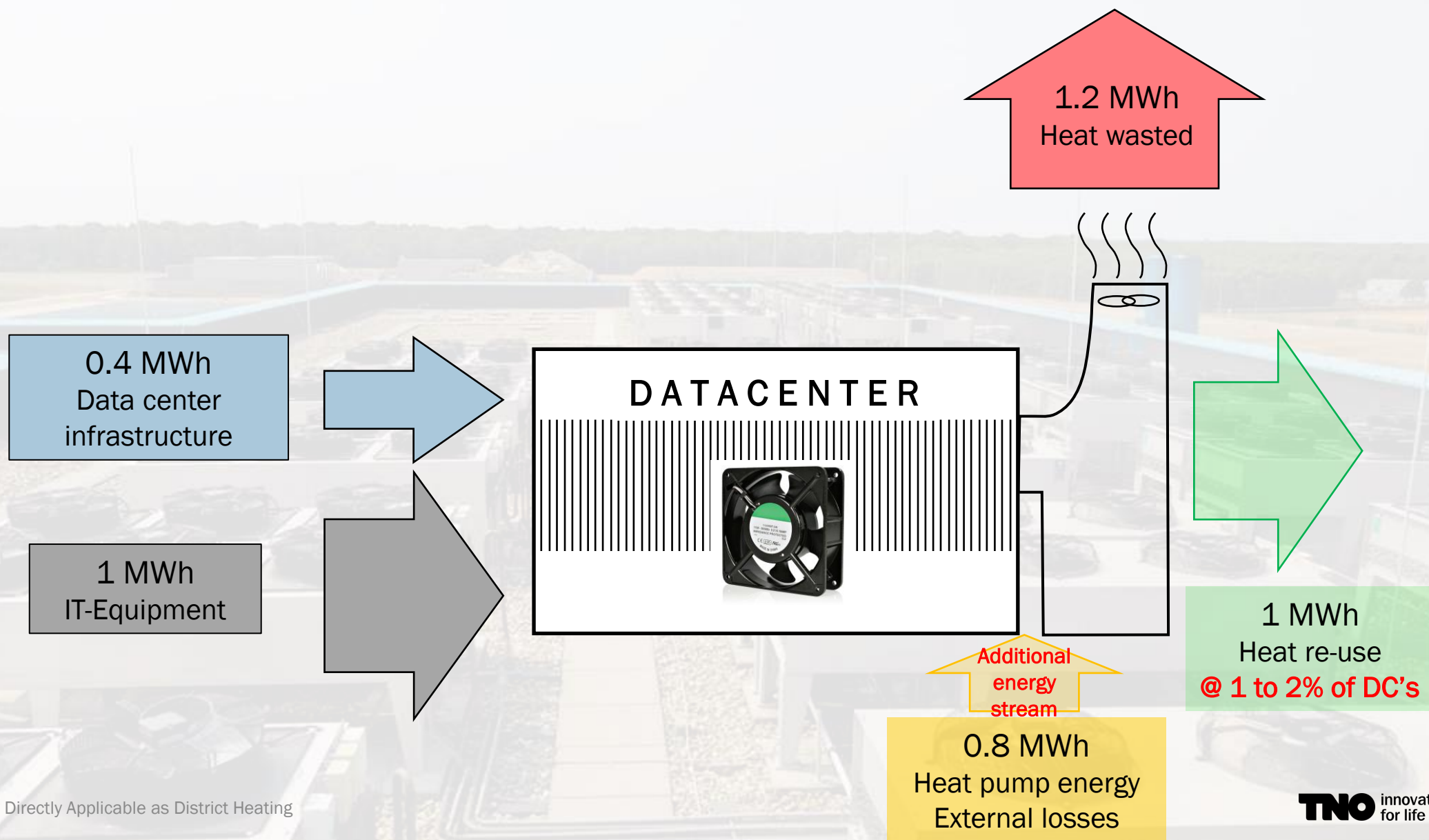
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- 02. HT WASTE HEAT RE-USE POTENTIAL
- 03. IN-CHIP MICROFLUIDIC COOLING – HOW DOES IT WORK?
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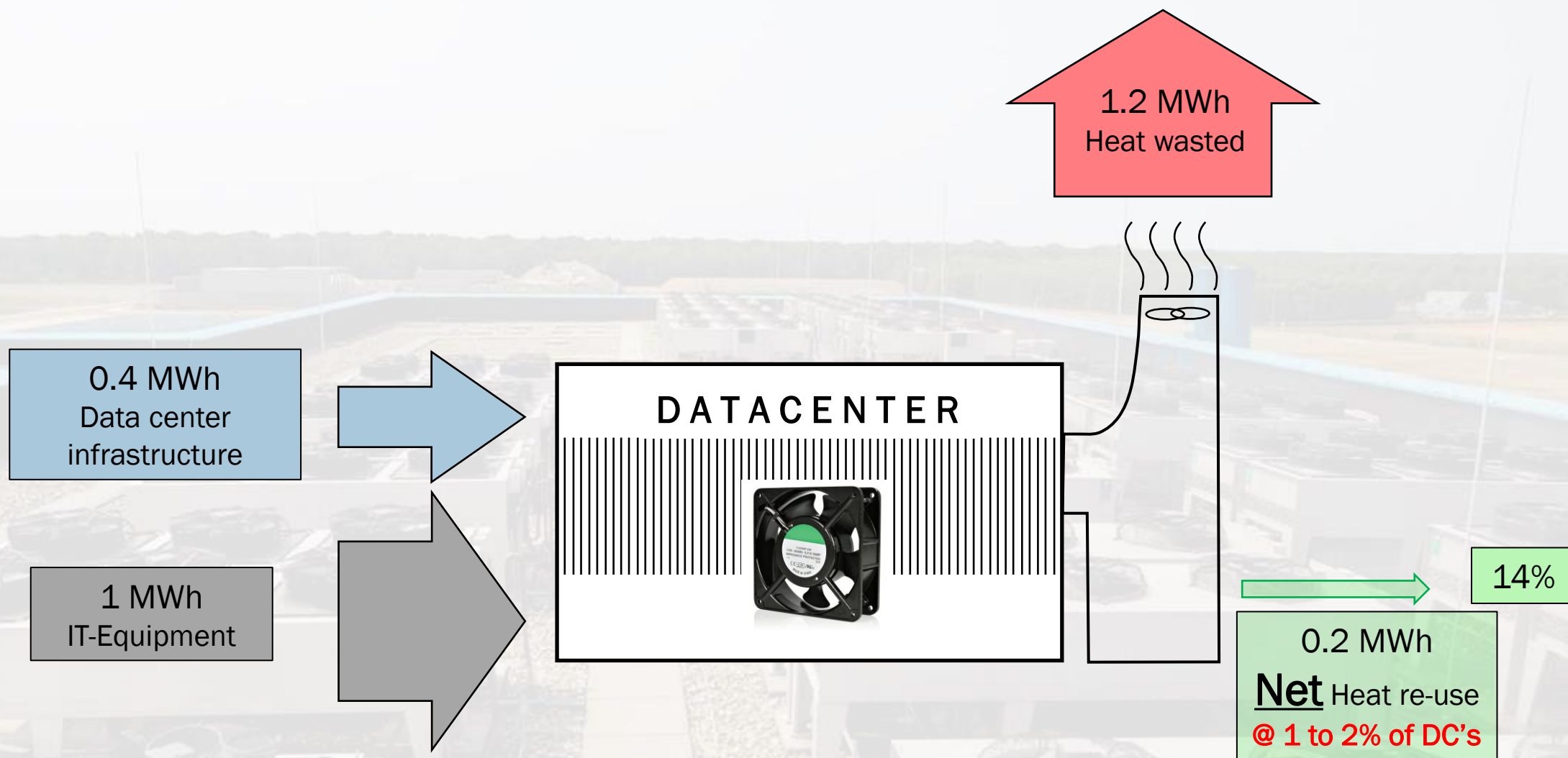
## › **CURRENT AIR COOLED DATACENTER**



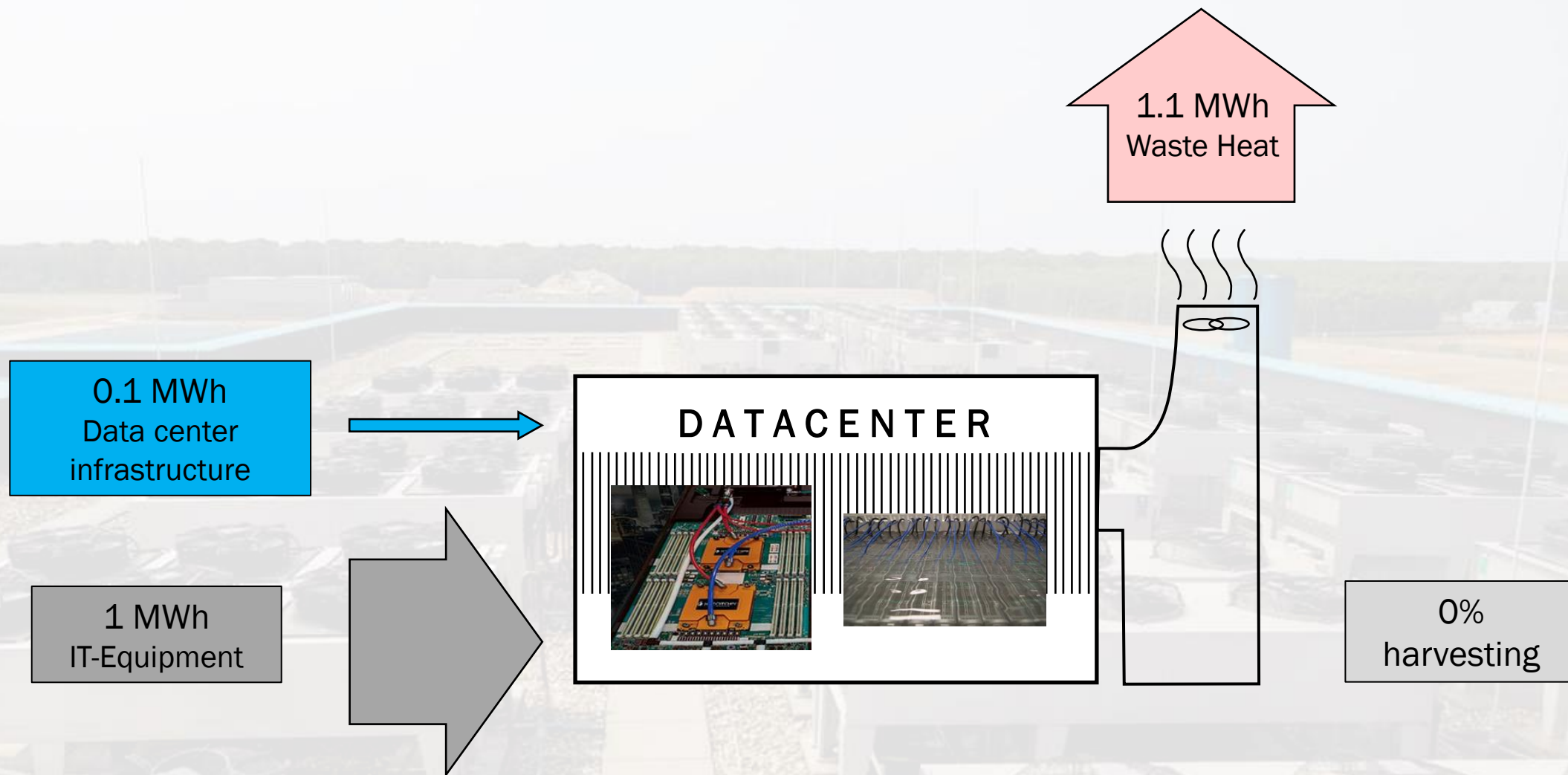
# › CURRENT AIR COOLED DATACENTER



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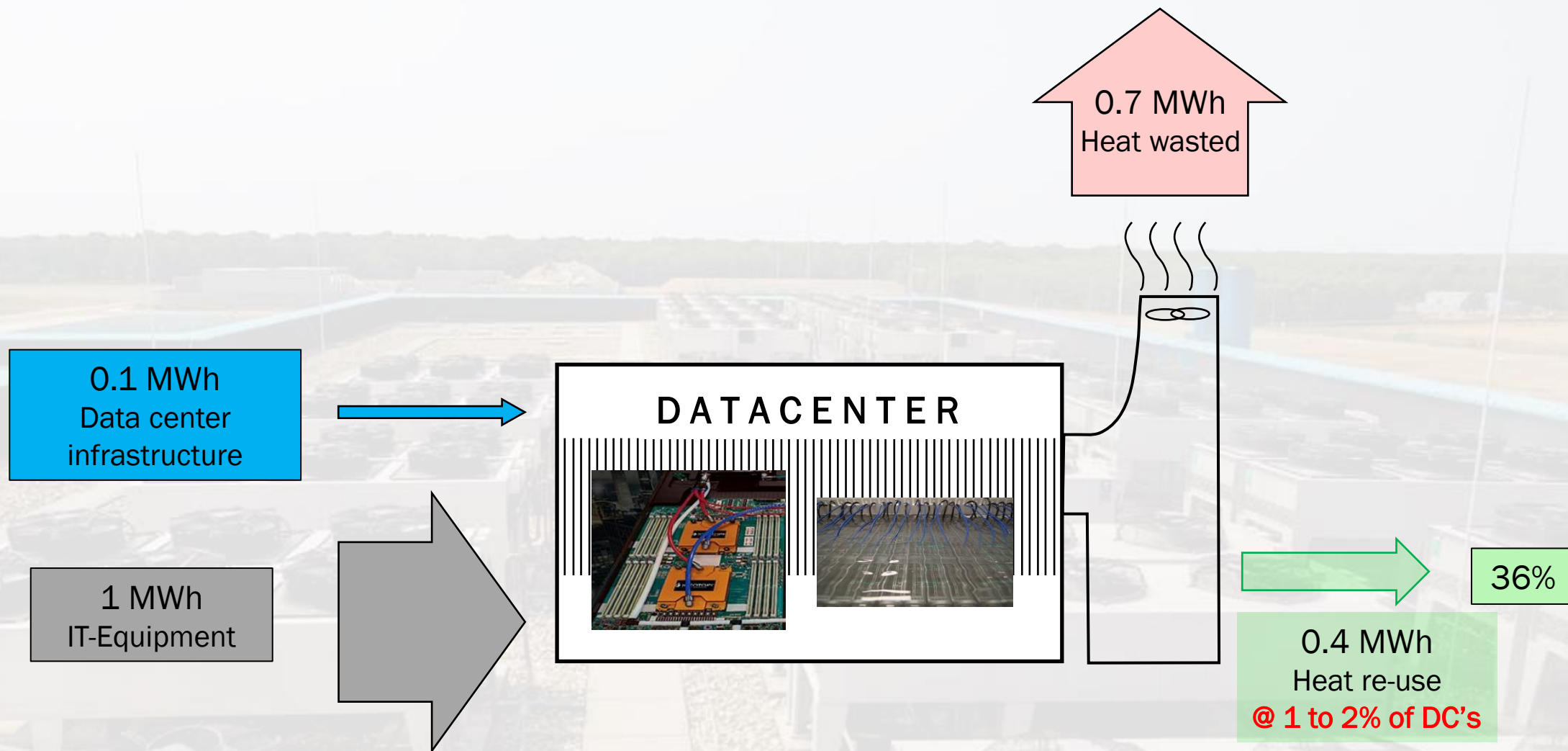


# › **CURRENT LIQUID COOLED DATACENTER**



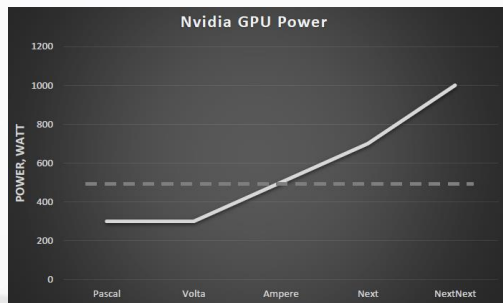


# › CURRENT LIQUID COOLED DATACENTER



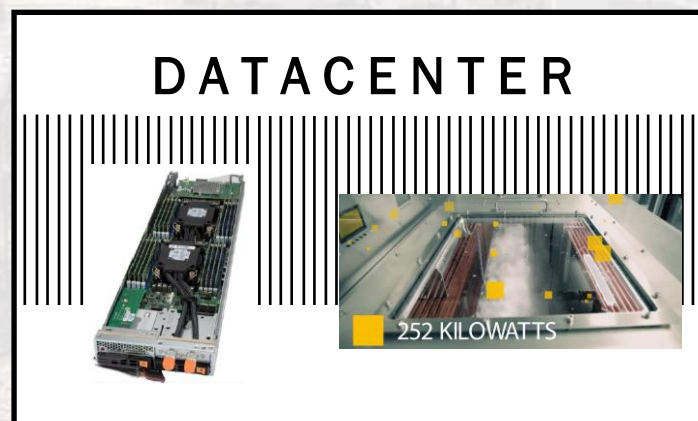


# › FUTURE LIQUID COOLED DATACENTER



0.15 MWh  
Data center  
infrastructure

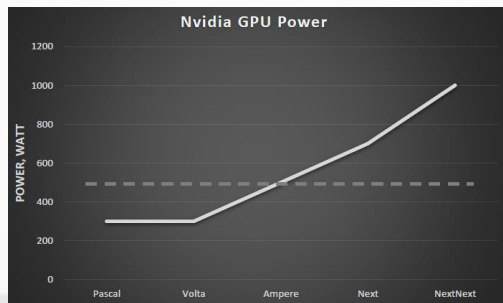
1.5 MWh  
IT-Equipment



1.65 MWh  
Waste Heat

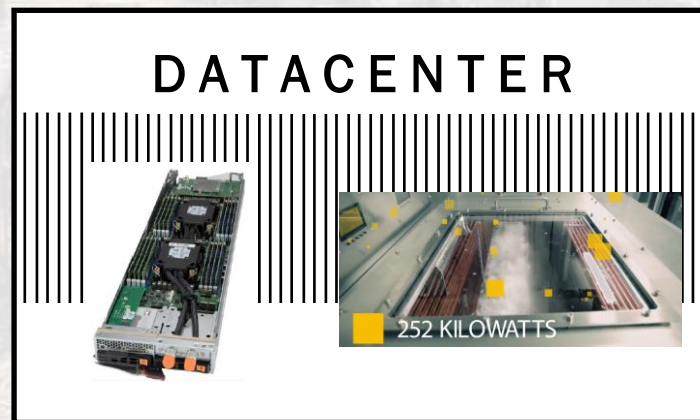
0%  
harvesting

# › FUTURE LIQUID COOLED DATACENTER



0.15 MWh  
Data center  
infrastructure

1.5 MWh  
IT-Equipment



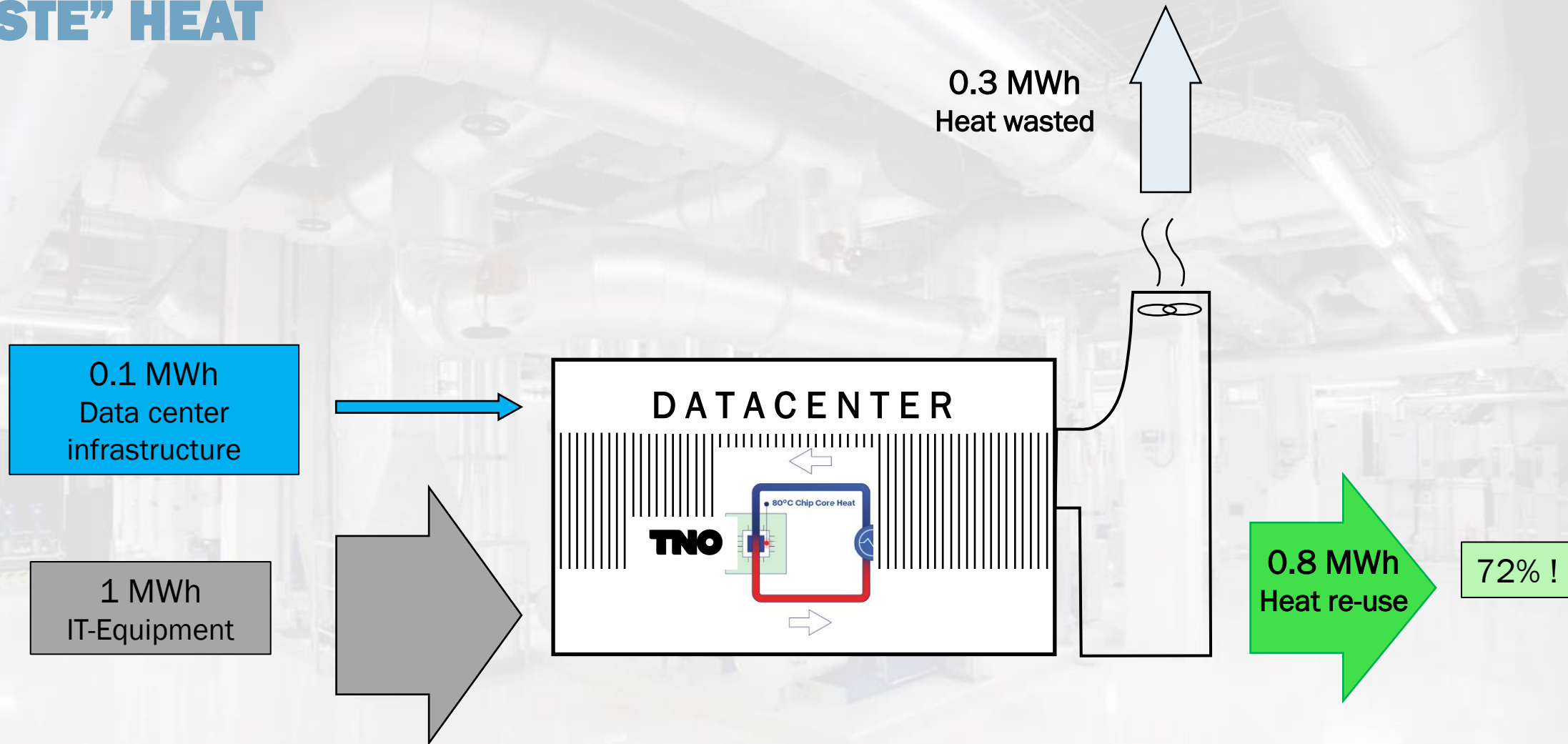
1.05 MWh  
Heat wasted



36%

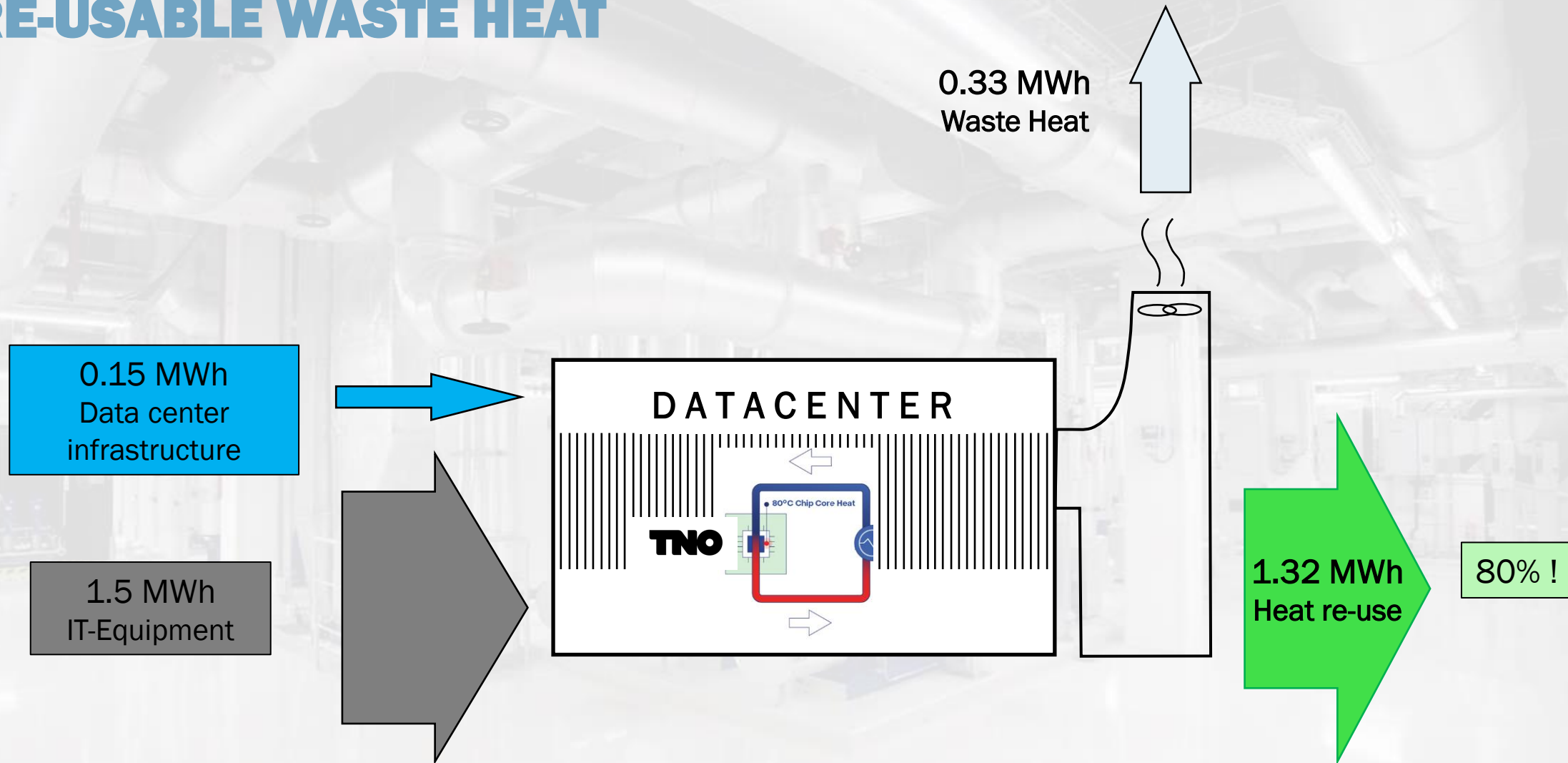
0.6 MWh  
Heat re-use  
@ 1 to 2% of DC's

# WHAT IF... TNO COULD INTEGRATE THE COOLING CHANNELS IN-CHIP? UNLOCKING/ HARVESTING HIGH QUALITY “WASTE” HEAT

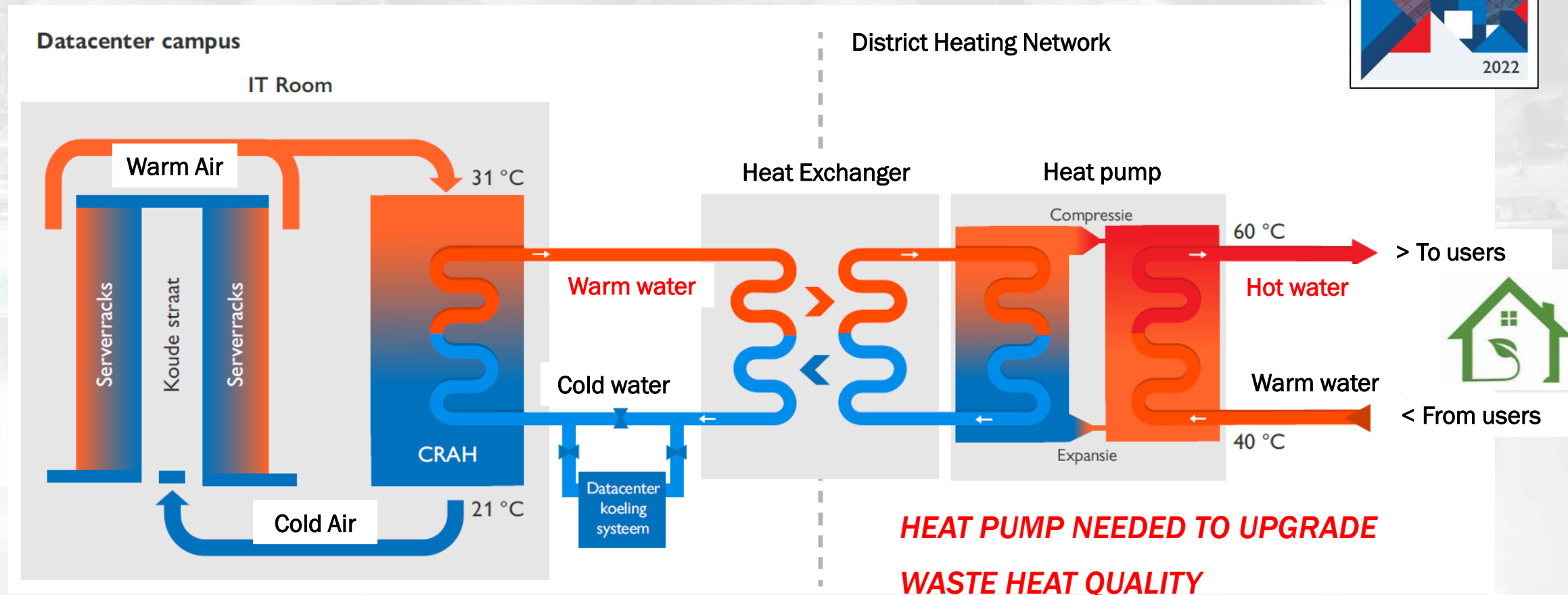




# › FUTURE INCREASE IN WORKLOAD WILL INCREASE AMOUNT OF RE-USABLE WASTE HEAT

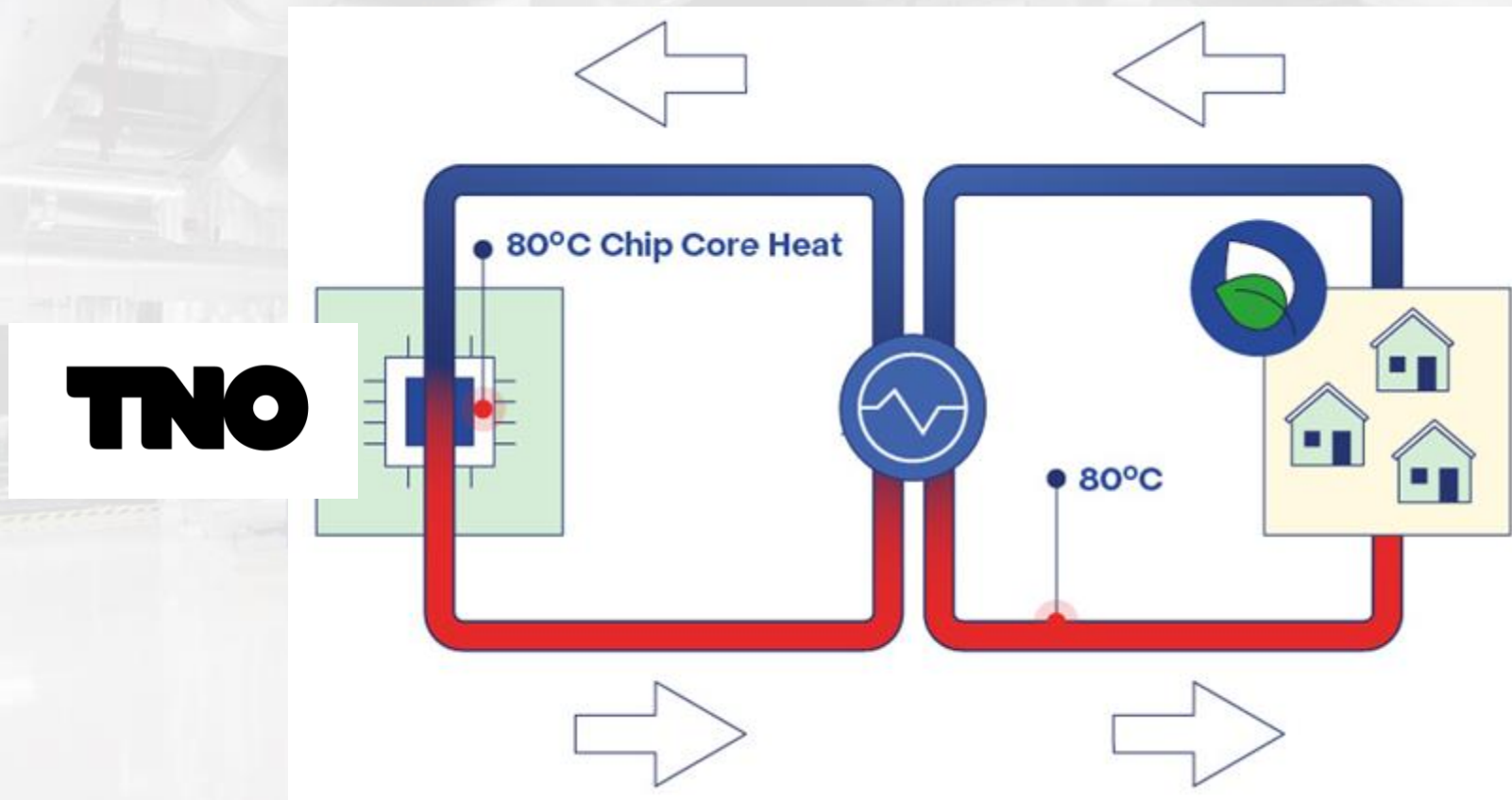


## CLASSIC LOW TEMPERATURE WASTE HEAT RE-USE (AIR)



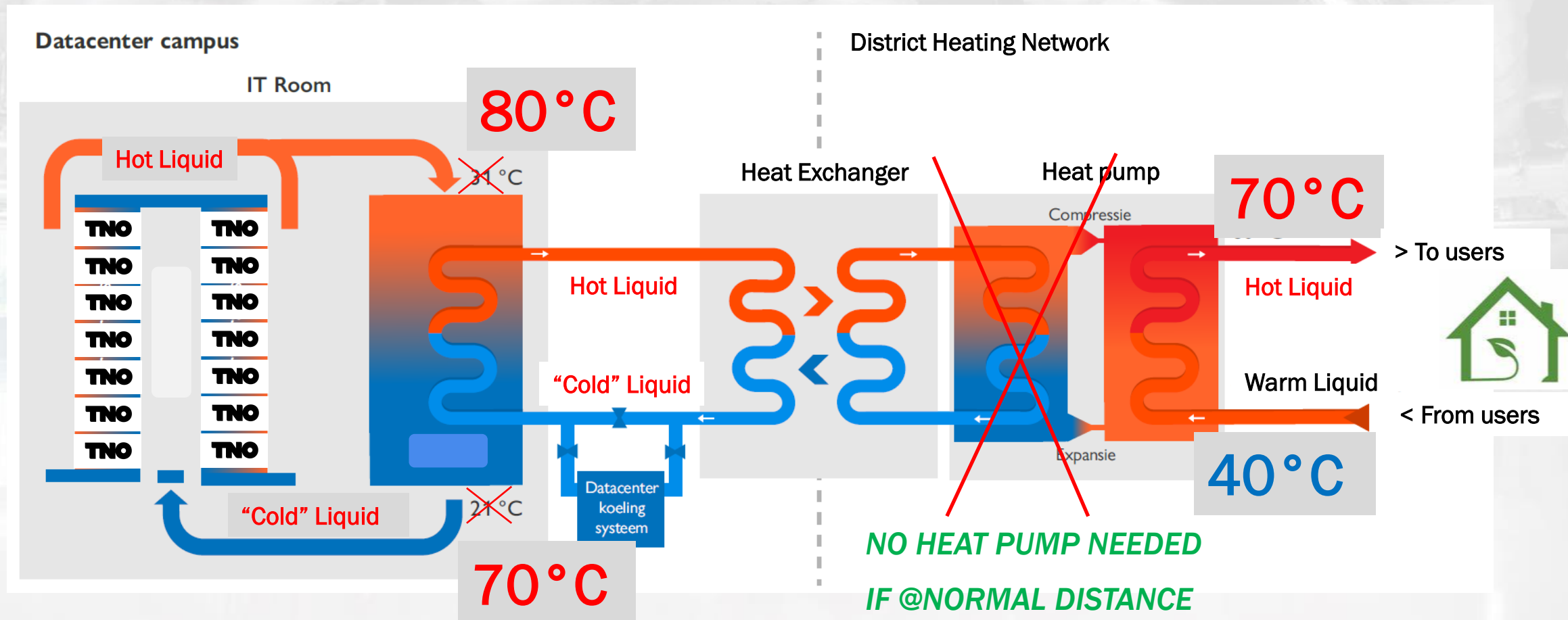
# › INTEGRATING THE TNO COOLING STRUCTURE IN THE CHIP UNLOCKING/ HARVESTING HIGH QUALITY “WASTE” HEAT

**THE PRINCIPLE: IN-CHIP MICROFLUIDIC COOLING**

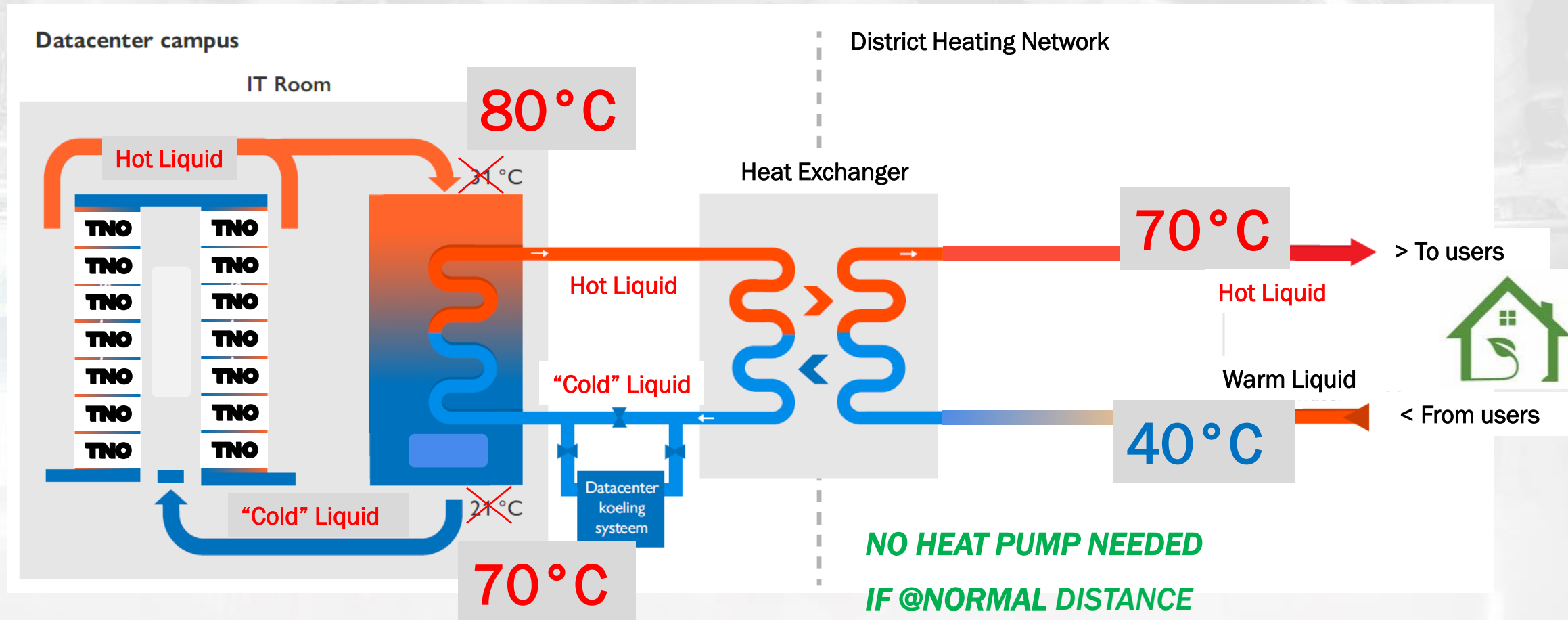




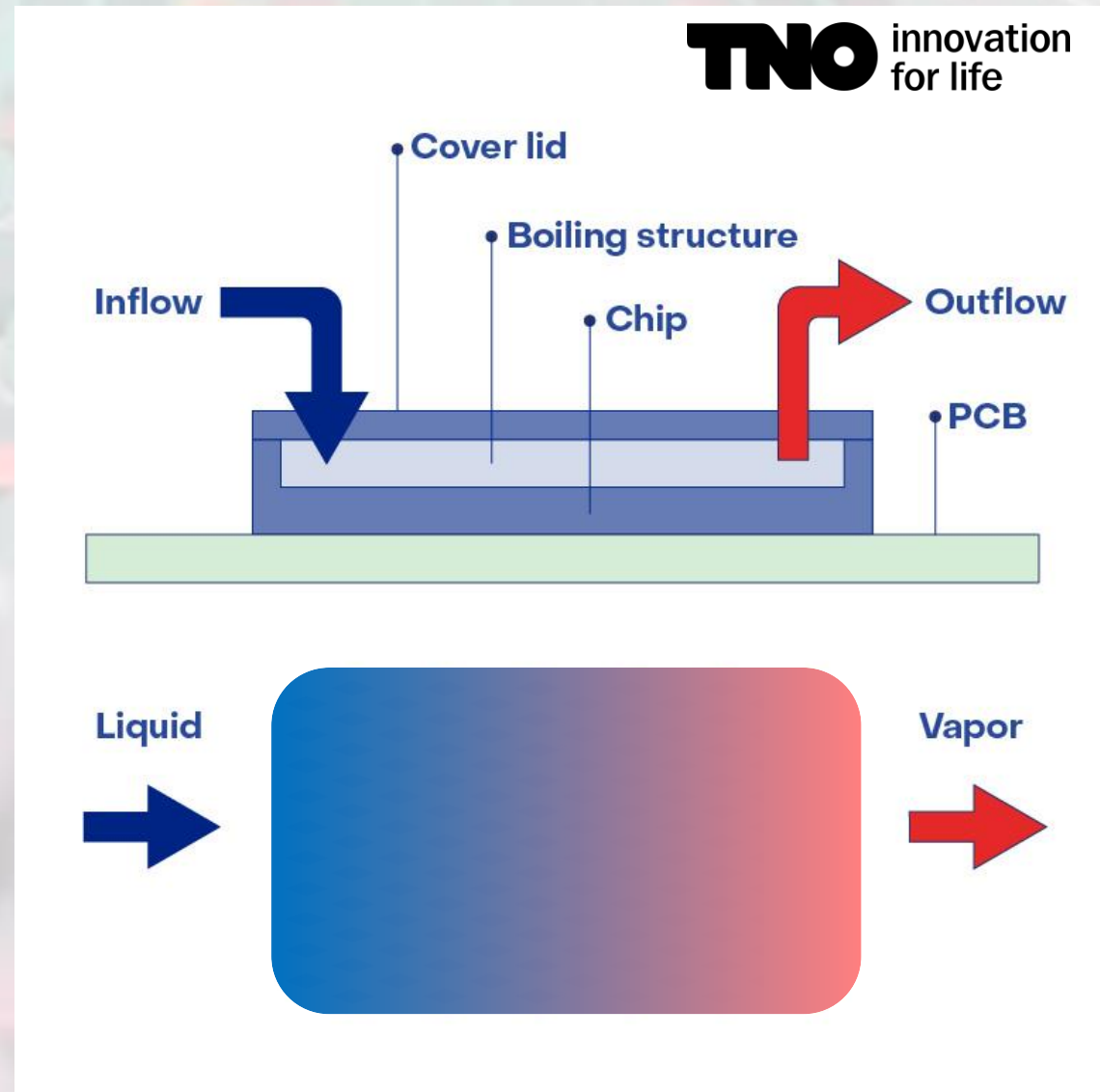
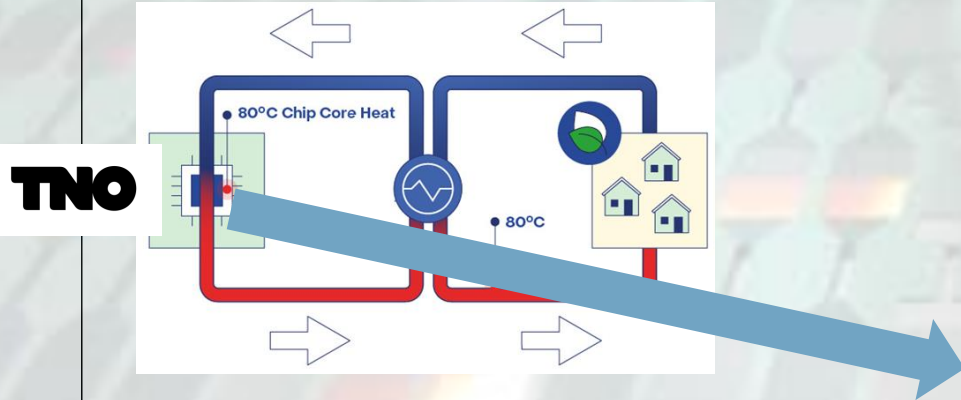
# › TNO HIGH TEMPERATURE WASTE HEAT RE-USE (HOT LIQUID)



## › TNO HIGH TEMPERATURE WASTE HEAT RE-USE (HOT LIQUID)



# TNO IN-CHIP MICROFLUIDIC COOLING – HOW DOES IT WORK?

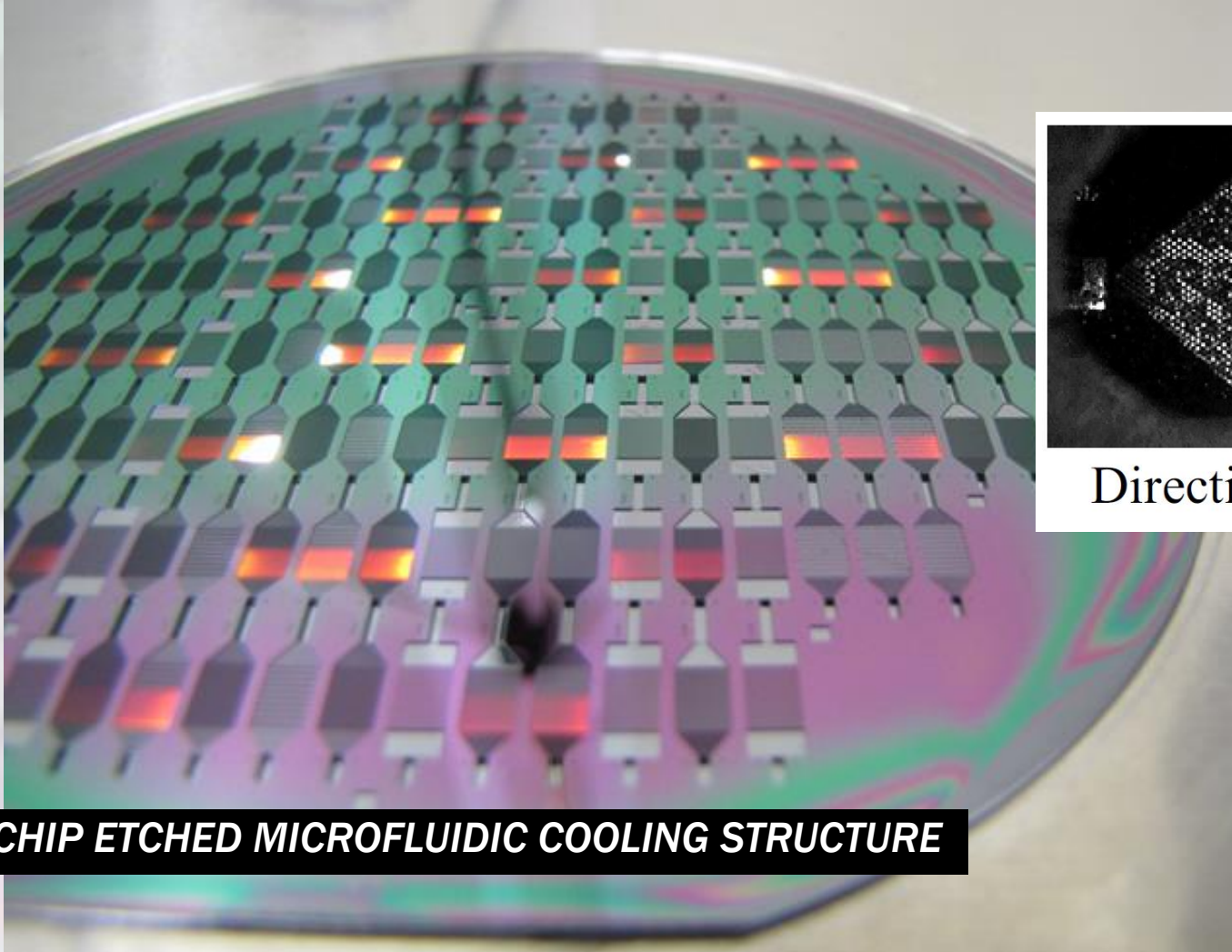


[TNO Thermal Management webpage:](https://tno.to/0qz)

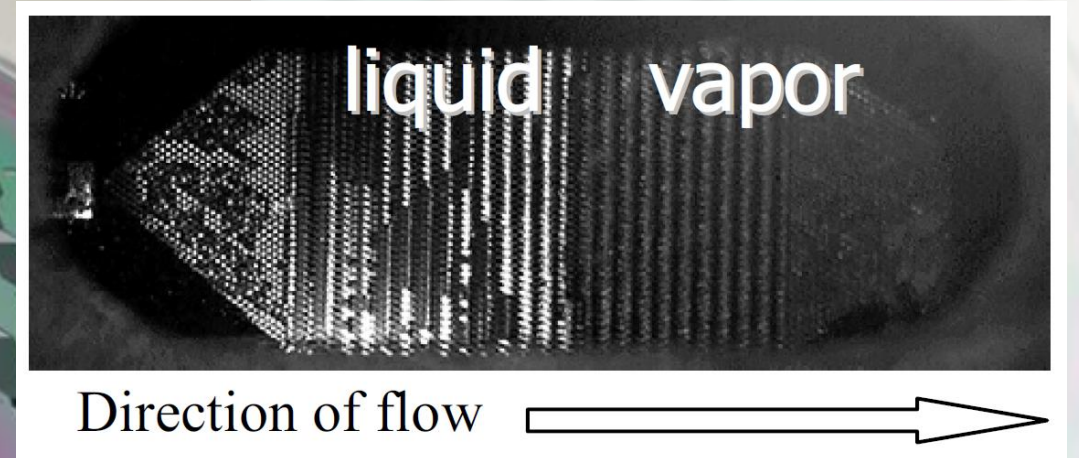
<https://tno.to/0qz>



# › TNO IN-CHIP MICROFLUIDIC COOLING – THE DEMONSTRATORS



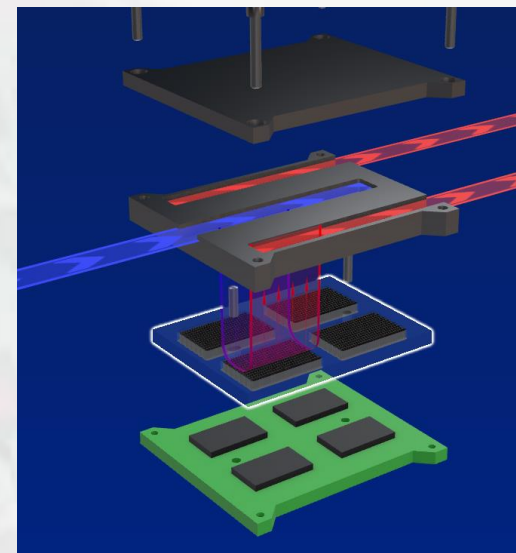
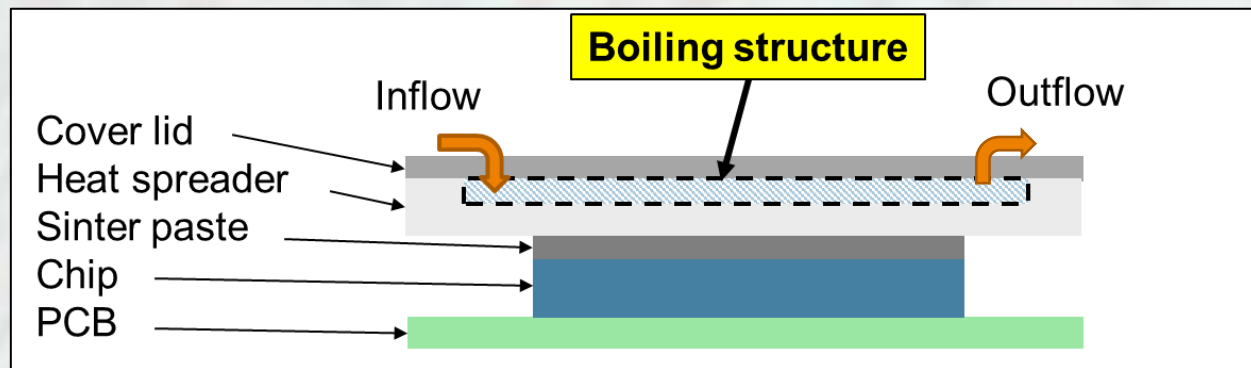
**IN-CHIP ETCHED MICROFLUIDIC COOLING STRUCTURE**



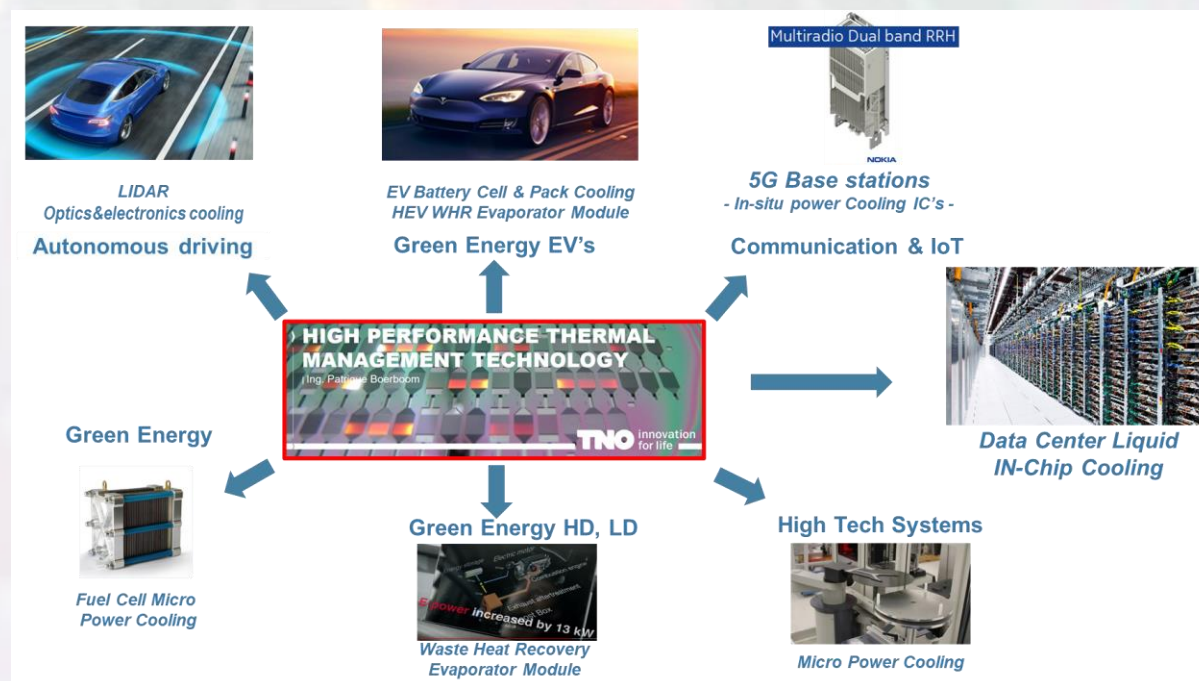
## › **ADDED VALUE WHEN INTEGRATED IN DATA CENTERS**

- › Unlocking high quality “waste” heat due to high outflow temperature (70-80 °C), enabling community re-usage
- › Inherently stable cooling process, due to huge boiling heat flux increase with little wall temperature increase
- › 2P MicroFluidic Cooling (heat dissipation  $>500\text{W}/\text{cm}^2$ ) enables higher computing performance, increasing hardware yield
- › Scale down of cooling hardware and infrastructure, flat cold plates, factor 10 less liquid required, smaller reservoirs/pipes/pumps
- › Noise reduction in data centers due to reduction of main fans
- › Datacenters can be located anywhere, irrespective of local (hot) climate

# ALTERNATIVE DIRECT TO CHIP (D2C) SOLUTION



## TRACK RECORD IN MULTIPLE APPLICATION FIELDS





## › CONCLUSIONS

### TNO MICRO FLUIDIC COOLING TECHNOLOGY:

- Is compliant with future high heat fluxes due to the high evaporative heat transfer coefficient method
- Enables heterogeneous integration of electronic chip and mechanical cooling architecture
- Provides optimal sustainability and optimal server performance at the same time
- Can transform datacenters from energy consumer to green energy supplier
- Can make, harvesting HT waste heat, significant positive impact on global energy consumption

**#hpc #ArtificialIntelligence #Circularcenter #Districtheating  
#netzerodatacenter #decarbonization #residentialheating**

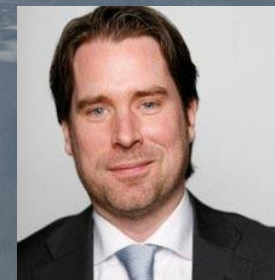


# AS TECHNOLOGY PROVIDER TNO WELCOMES INDUSTRY PARTNERS TO COMMERCIALISE TNO MICROFLUIDIC COOLING IN THEIR FIELD

**TNO** innovation  
for life



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