Smart Cooling – Singapore, Grinsted and the future

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Outline

- Singapore – district cooling potential
- Smart Energy Systems: Flexible Cooling of Data Centers
- Future: Cool-Data project

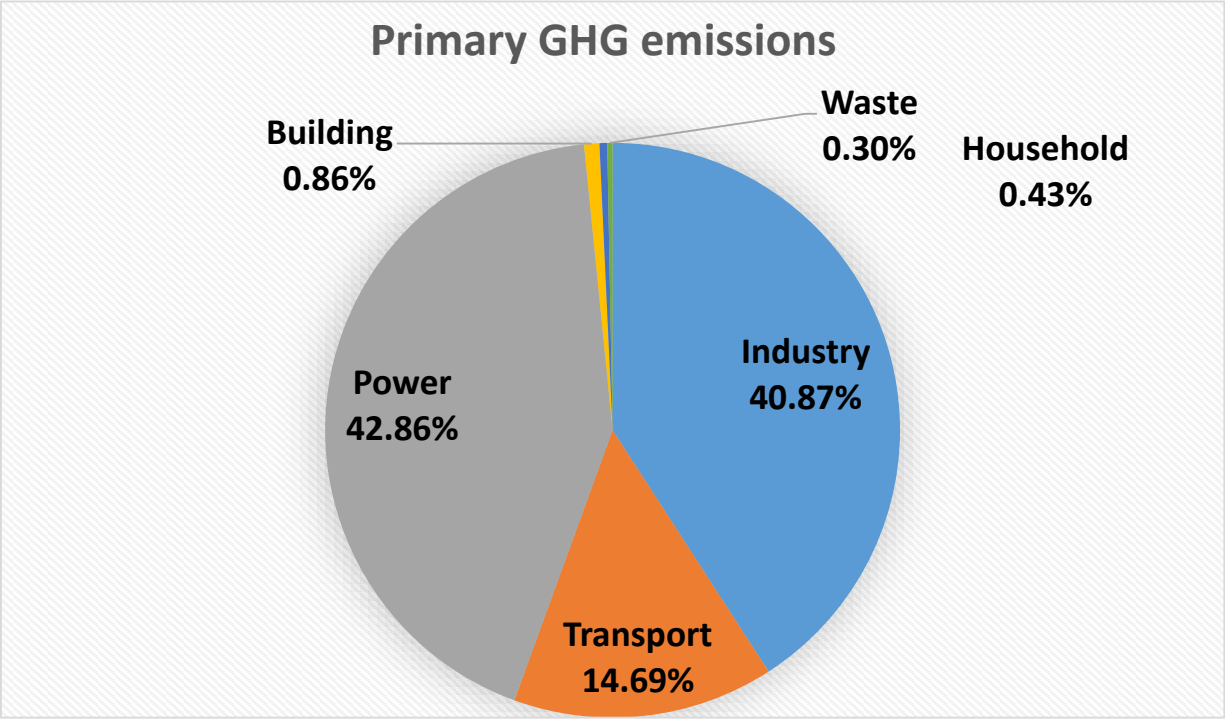
Singapore

Work carried out in collaboration with Energy Research Institute at the Nanyang Technological University (Singapore)

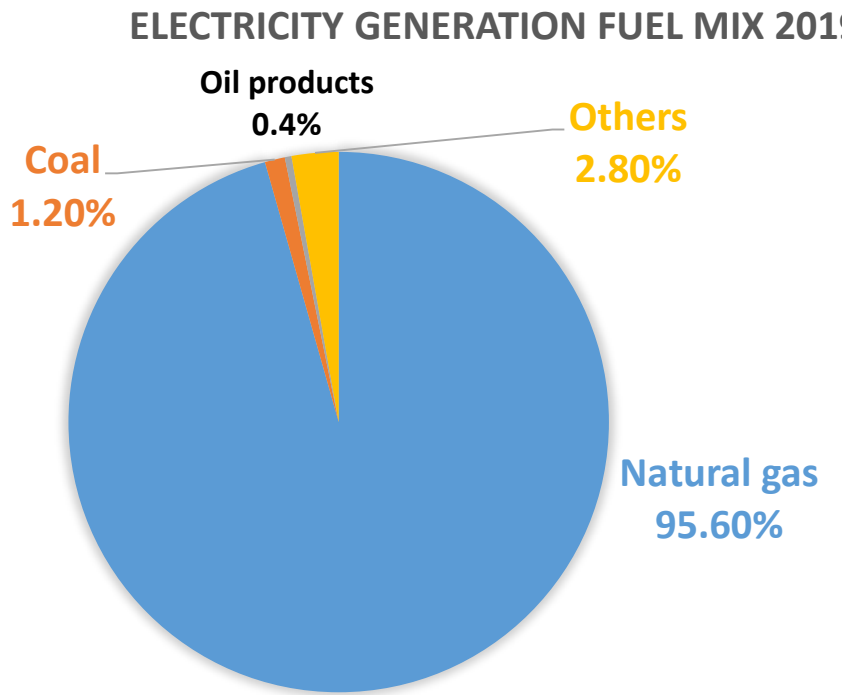
- 6.5 mil people
- 720 km2
- PPP GDP per capita: 107,604 USD (2020 estimate), 3rd in the world
- Yearly temperature variation: 24 °C – 32 °C
- Overcast, humid climate

Source: Google Maps

Singapore: the energy system

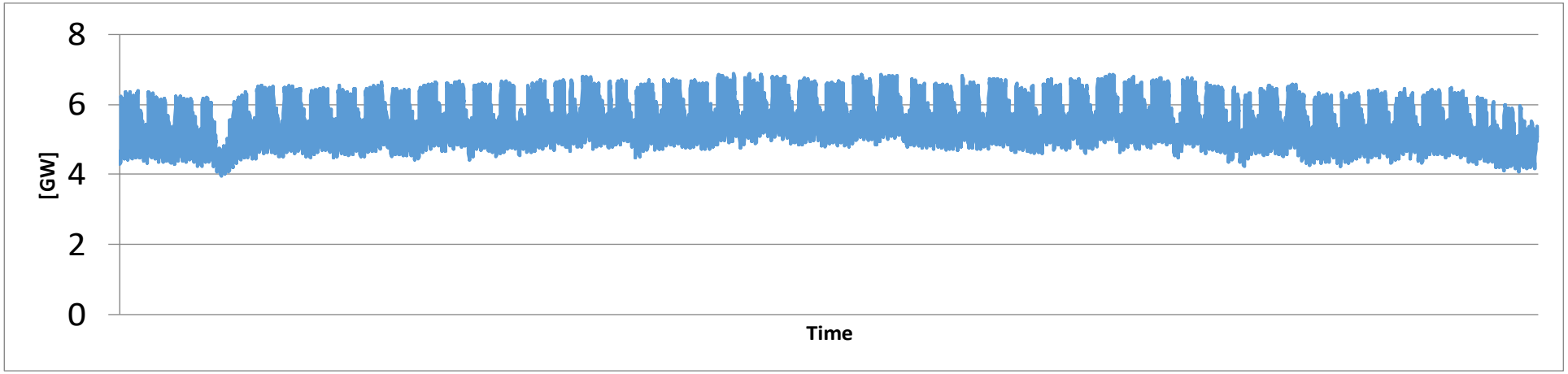


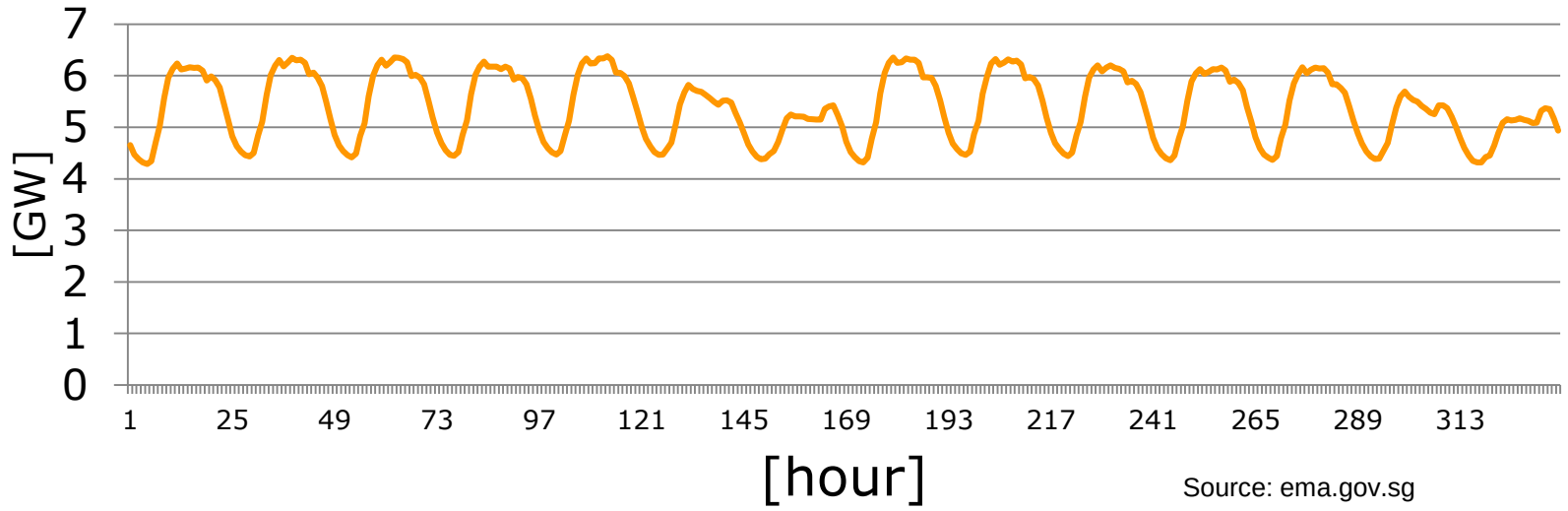
Source: e2singapore.gov.sg



Source: ema.gov.sg

Electricity demand





Source: ema.gov.sg

District cooling

- Central production of cooling energy
- Distribution to the consumers via network
- Supply: 6/12 °C; return:18 °C
- LNG gasification terminal – direct utilization of cold energy

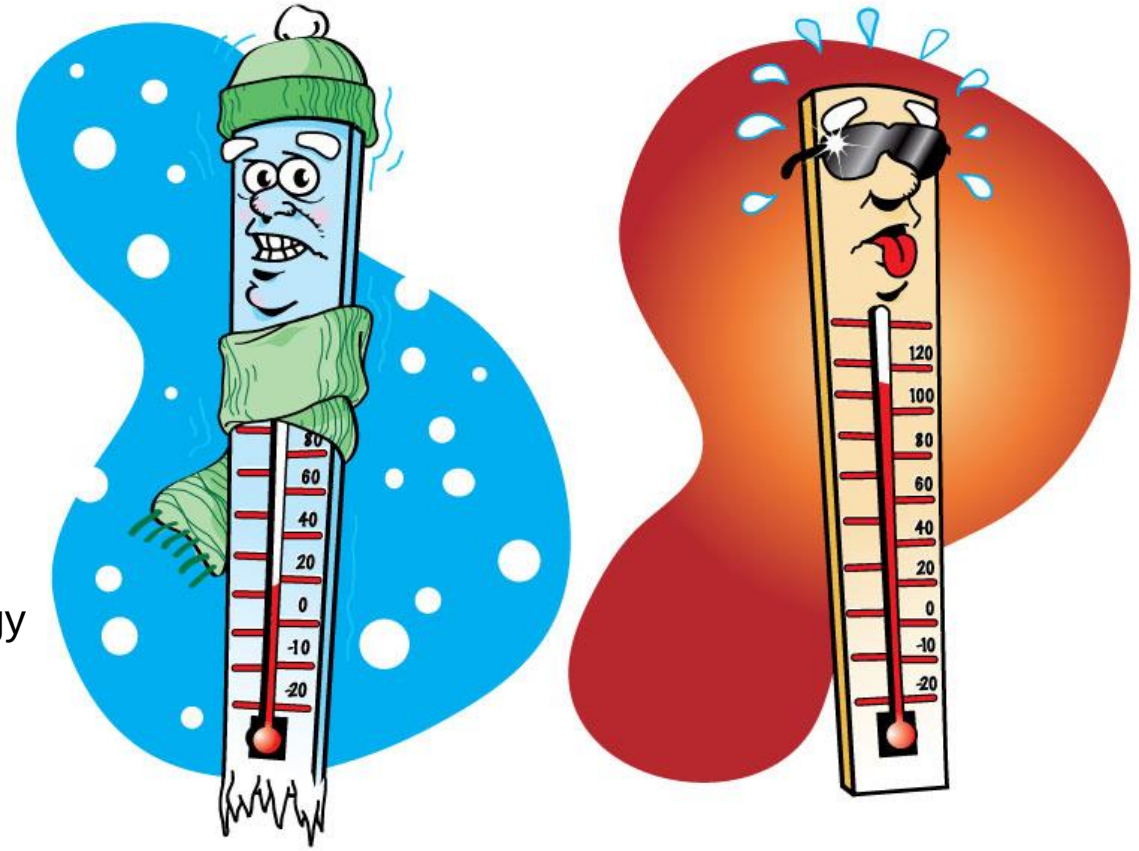
1

- Electric chillers (heat pumps)
  - Heat source and heat sink?

2

- Absorption chillers
  - Single-effect
  - Suitable temperature range
  - Heat supply at 70 °C ⟶ generates chilled water
  - COP – around 0.7

3

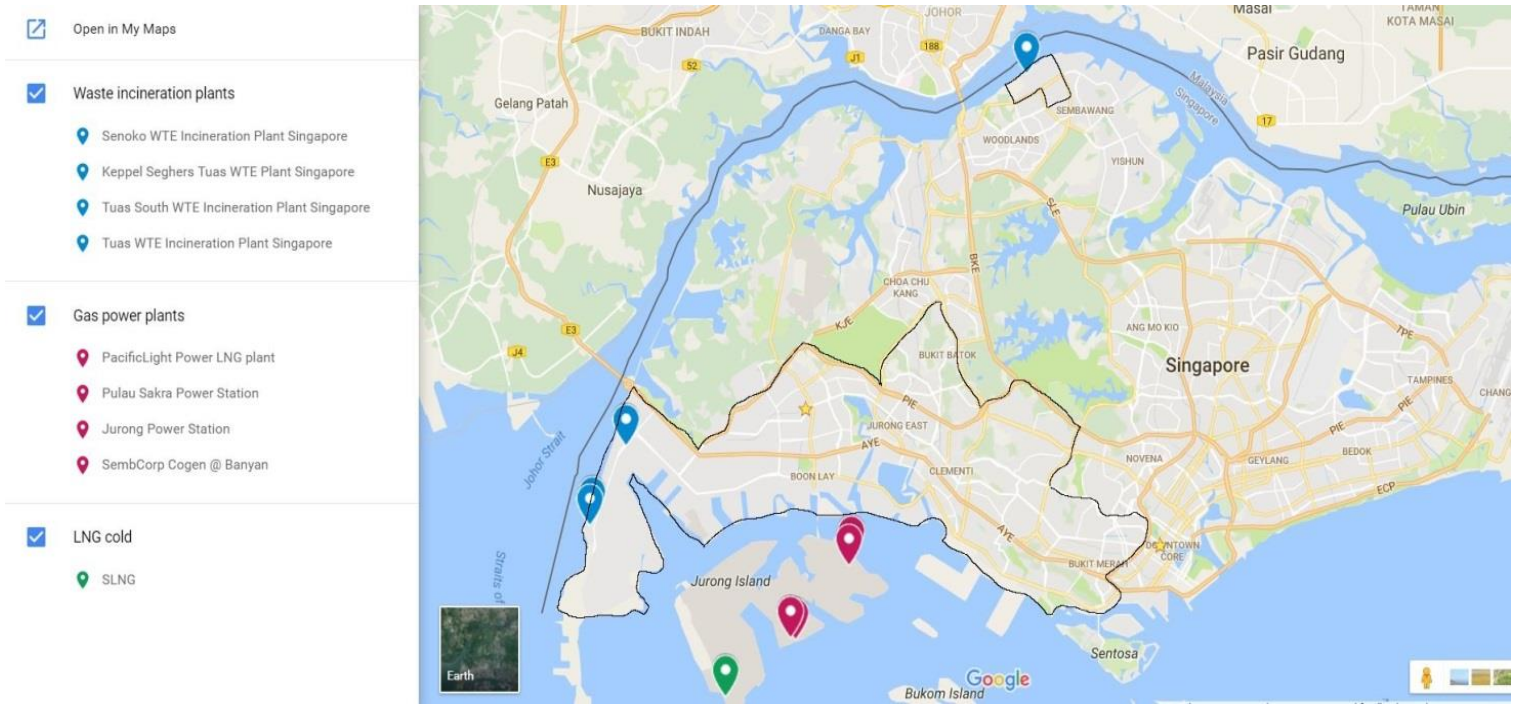


Source: pixy.org

Methods

- 1) Locating potential sources of energy and calculating the cold potential
- 2) Cooling demand of the considered area
- 3) Establishing GIS based grid layour, hydraulic calculation, dimensioning
- 4) Calculating socio-economic costs, comparison with the BAU scenario

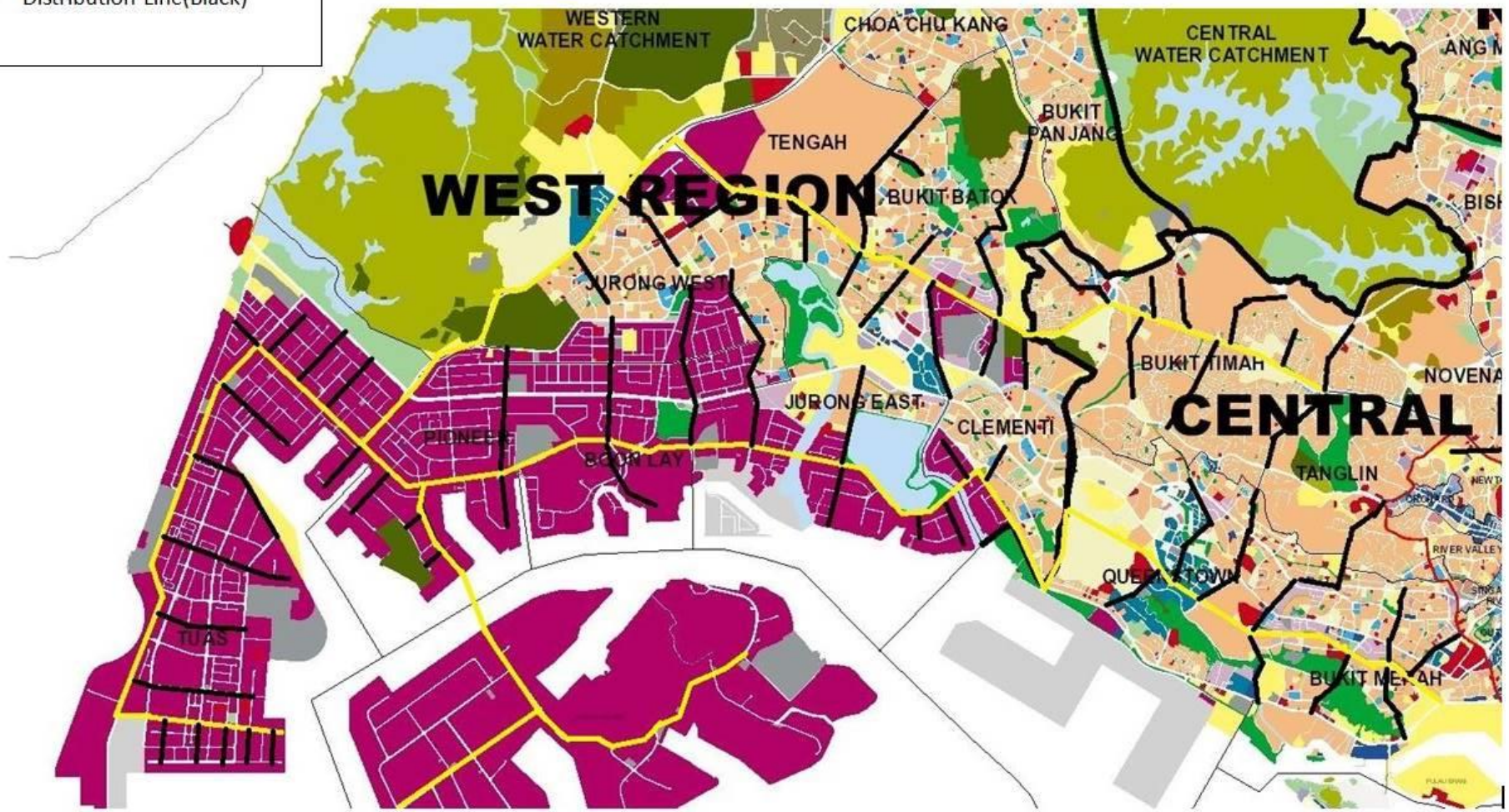
Results: potential cold sources



Source: google maps

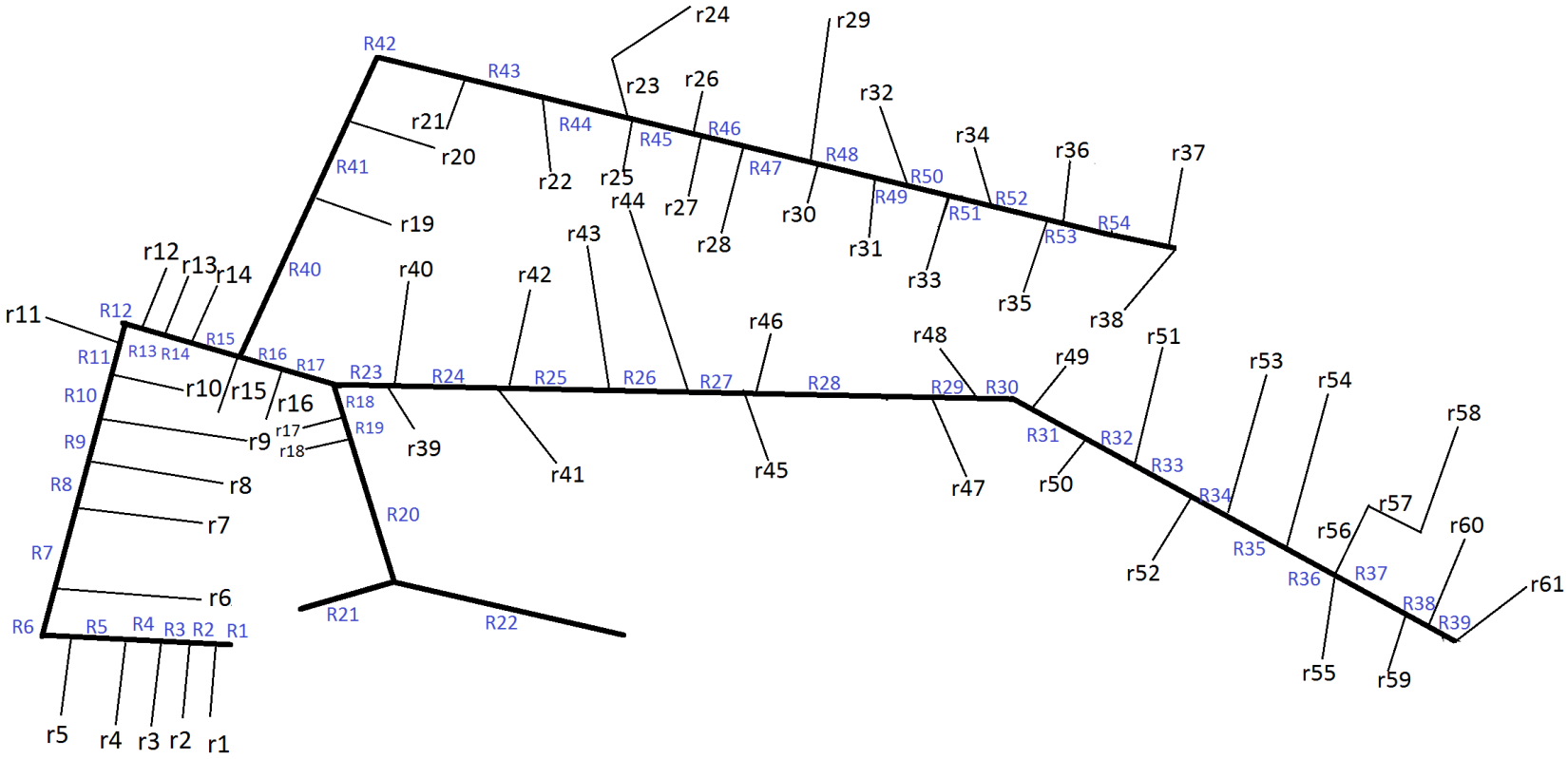
District cooling distribution

- Transmission Line(Yellow)
- Distribution Line(Black)



Source: Urban Redevelopment Authority of Singapore (URA)

Simplified representation



Results

Around 8.8 TWh of saved electricity!

	C_{demand} [GWh] - yearly	E_{supply} [GWh] - yearly	C_{supply} [GWh] - yearly	Grid cost [mil USD]
Northern part	783	824	1,238	8
South-west part	16,794	17,633	21,609	331

- DC could reduce CO2 emissions by 19.8%, reducing the total socio-economic costs by 30%
- DC with massive implementation of PVs would reduce the CO2 emissions by 41.8%

Outcome of the study:

- Alessandro Romagnoli (NTU) works on cryogenic cooling using LNG regasification as a cold source
- Numerous publications on the future of cooling in Singapore

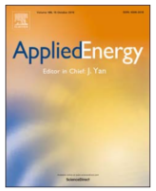
Publications

Applied Energy 208 (2017) 49–61

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy



https://www.sciencedirect.com/science/article/pii/S0306261917313351

(open access)

Potential of district cooling in hot and humid climates

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https://www.sciencedirect.com/science/article/abs/pii/S0360544218308260

Energy 155 (2018) 592–609

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Energy

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Modelling smart energy systems in tropical regions

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Smart Energy Systems: Flexible Cooling of Data Centers

Demo case

- Purix Absorption chiller – being tested at GEV Grinsted
  - 1-stage absorption chiller (LiBr-H2O), air cooled
  - 2.5 kW

- Other partners involved:
  - EnergyCool
  - DTU Compute

Smart Energy Systems: Flexible Cooling of Data Centers

- Goals:
  - Flexible operation based on price and CO2 signals
  - Potential of using electric and absorption chillers dynamically
- Currently being tested in the two meeting rooms
- Ongoing

Future: Cool – Data project

Cool-Data

- AI-based, modular, flexible, secure and reliable integrated cooling energy system for data centres
- Focus on small and medium sized data centers
- Funded by the Innovation Fund Denmark
- 18.4 mil. DKK total project funding
- 8 Partners
- https://cool-data.dtu.dk/ (soon to be set up)

GEV Vi møder dig med go' energi · PURIX · ENERGY COOL more cooling - less energy · NAVIAIR · centerdenmark intelligent energy

Innovation Fund Denmark

DTU Compute
Department of Applied Mathematics and Computer Science

DTU Management Engineering
Department of Management Engineering

DTU Civil Engineering
Department of Civil Engineering

Cool - Data

- Two case studies: GEV Grinsted and Naviair

Cool-Data

PURIX
Distric heating to
cold water

Buffer
tank

Hot water

District Heating

Cold water system

Fan coils | Fan coils

Office building

Free coolers

Data center

Energy Cool system with AIR PCM

Duct 34 kW
Waste heat (air)

Heat-exchanger

Storage building

Questions?

- Contact: dodo@dtu.dk

Thank you!