District Cooling for Smart Cities

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Conclusions

There are three main conclusions that arose from this study for the energy system of Singapore:

1) The CO2 emissions of the energy system were lowered by 41.5% in the year 2050 in the DC-PV scenario compared to the BAU scenario

2) Primary energy demand in PV and DC-PV scenarios were 15.5% and 19.5% lower than in BAU scenario for the year 2050

3) The total calculated investment cost in district cooling grid amounted to 339 million USD. However this cost was offset by increased energy savings in terms of fossil fuel imports. Thus, the total socio-economic costs of the energy system of Singapore in DC and DC-PV scenarios were 32.7% and 38.4% lower than in BAU scenario.

Introduction

- Tropical climate: humid air and high temperatures throughout the whole year (difference between the maximum and minimum temperature during the year ≈ 6 °C)
- Steady and constant cooling demand on a daily basis
- Lack of free cooling sources: small temperature differences of seas, ground and air
- No rivers, no differences in altitudes
- Current cooling system dominated by individual split systems and electric chillers
- A lack of systematic research of district cooling in tropical regions

Methods:

1) Locating potential sources of energy and calculating cold potential

2) Calculating cooling energy demand of the considered area for utilization of district cooling potential

3) Establishing initial grid layout, calculating cold flows, heat and pressure losses in the grid and establishing piping diameters needed to meet the peak cooling energy demand

4) Calculating socio-economic costs of different scenarios utilizing district cooling energy and comparison with business-as-usual (BAU) scenario

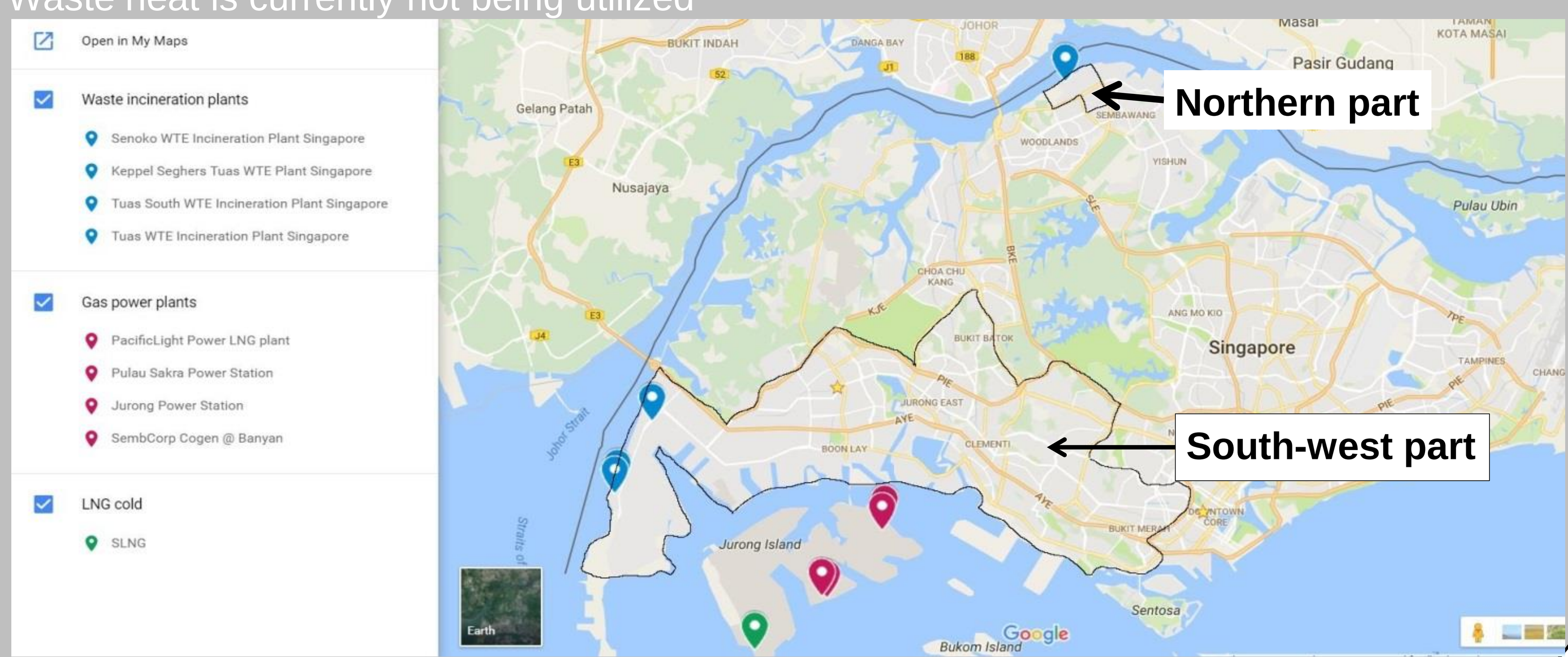
Roadmaps for other sectors for the year 2050 were taken into account

→ a holistic approach to modelling energy system

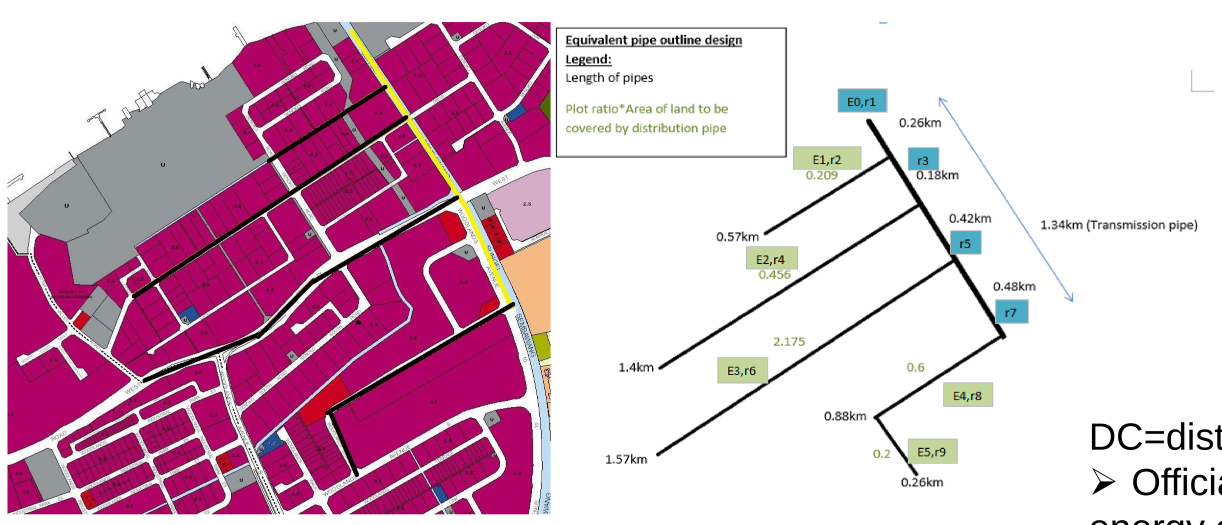
Combination of EnergyPLAN and Matlab algorithms used for modelling

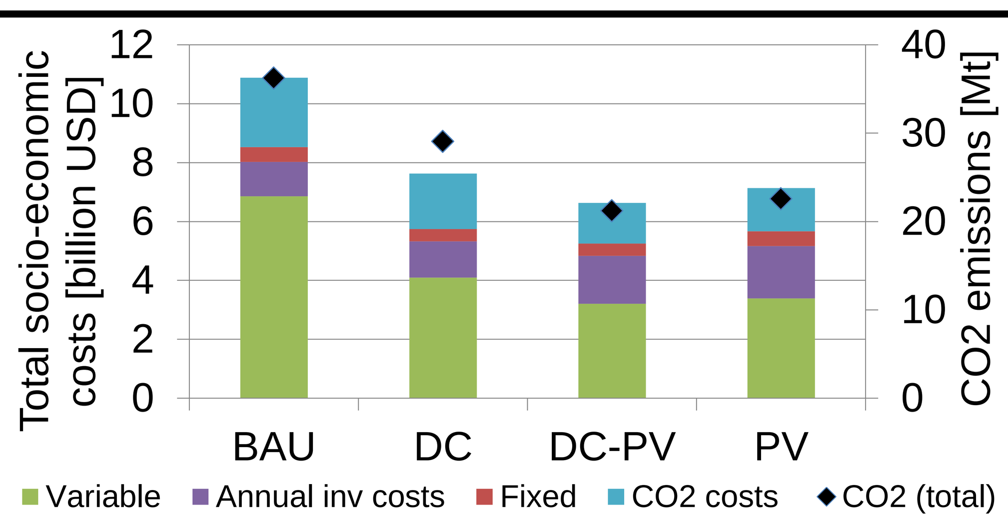
Case study:

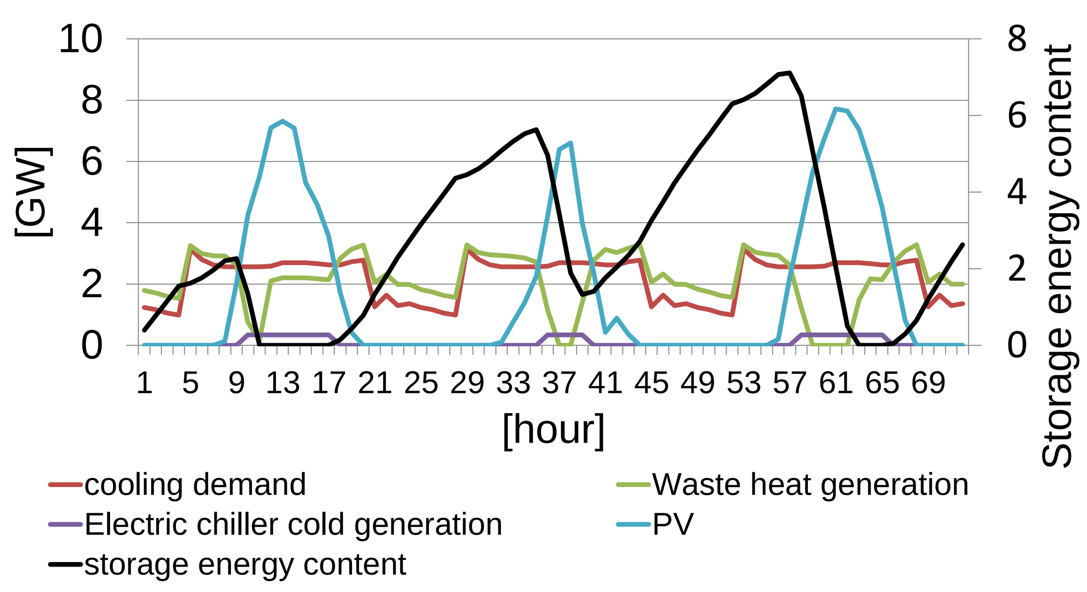
Singapore
Population: 5.5 million
Area: 719.1 km²
Population density: 7,987.5 people/km² (3rd highest country in the world)
Share of natural gas in electricity generation: >95% (remaining share mostly waste incineration)
Regasification LNG terminal: liqefying from -162 °C
Waste heat is currently not being utilized



Results:

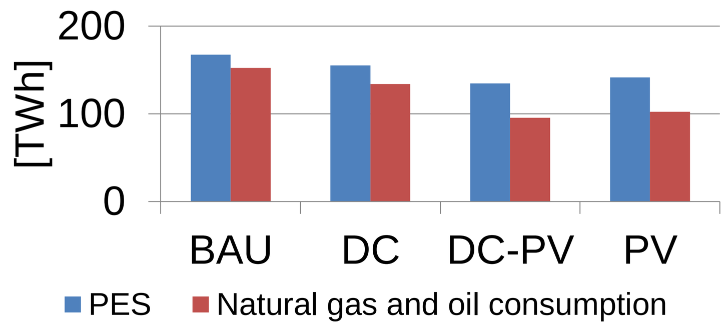






DC=district cooling; PV= photovoltaics; DC-PV= both DC and PV

- Official technology roadmaps for CCS, PVs, Building and industry energy efficiency, Waste management and E-Mobility were taken into account



	Demand [GWh] - weekly	*Demand* [GWh] - yearly	*Supply* [GWh] - weekly	*Supply* [GWh] - yearly	*Theoretical supply potential* [GWh] - yearly	Grid cost [mil. USD]
Northern part	15.01	782.6	15.80	823.9	1,238	8
South-west part	322.07	16793.5	338.17	17633.2	21,609	331

Acknowledgements:

- This work was financed as a part of the CITIES project nº DSF1305-00027B funded by the Danish Strategic Research Council and the Smart Multi Energy Systems (SMES) project funded by the National Research Foundation in Singapore.
- Moreover, a guest research stay of the first author at Energy Research Institute at Nanyang Technological University (ERI@N) was financed by the EliteForsk grant for young talented researchers awarded by Danish Ministry of Higher Education and Science.
- The presented research is a result of the newly established cooperation between the ERI@N in Singapore and Technical University of Denmark (DTU). We appreciate the engagement and the work from all the involved stakeholders.

The authors are thankful to all the involved parties.