# District Cooling

potential of district cooling in hot and humid climates

**Dominkovic, Dominik Franjo; Rashid, K. A. Bin Abdul ; Romagnoli, Alessandro ; Pedersen, Allan Schrøder; Leong, K.C.**

*Publication date:*
2020

*Document Version*
Publisher's PDF, also known as Version of record



*Citation (APA):*
Dominkovic, D. F., Rashid, K. A. B. A., Romagnoli, A., Pedersen, A. S., & Leong, K. C. (2020). District Cooling: potential of district cooling in hot and humid climates. Technical University of Denmark.

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# District Cooling - potential of district cooling in hot and humid climates

BY D.F. DOMINKOVIĆ[1], K.A. BIN ABDUL RASHID[2], A. ROMAGNOLI[2], A.S. PEDERSEN[1], K.C. LEONG[2], G. KRAJAČIĆ[3], N. DUIĆ[3]
[1] Technical University of Denmark, Denmark; [2] Nanyang Technological University, Republic of Singapore; [3] University of Zagreb, Croatia

*First published in November 2018*

## Introduction

Actions are needed to mitigate global warming by well under 2°C, such as a significant reduction in greenhouse gas (GHG) emissions following signing of the Paris agreement. Furthermore, it is expected that 2/3 of the world population will live in cities by the year 2050, increasing the complexity of energy supply.

In order to have a significant increase on energy efficiency of the energy system, as well as to reduce the carbon footprint, the energy that is currently being wasted can be utilized efficiently. For instance, in hot climates with large cooling demands, excess waste heat can be utilized via absorption chillers to generate cold. In this paper we first identify all possible sources of natural cooling, and then second we locate the waste heat potential.

There is no country in a tropical region that has adopted **district cooling (DC)** on a wide scale. Therefore we also research the potential of widely adopted **DC** in regions with steady cooling demand, in order to assess the interactions between different energy sectors, its impact on energy demand and $CO_2$ emissions. Finally, we also model costs of establishing such systematic networks, as well as dimensioning it, as this has not been part of any previous research.

## Primary aim and objectives

1: To address the feasibility of utilizing waste heat for cold and liquefied natural gas cooling sources at a high rate

2: To compare the socio-economic costs of the system with high penetration of **DC** versus the business-as-usual system.

3: To expand the existing model for hourly energy balancing with more detailed **DC** algorithms.

## Scenarios

Singapore was chosen for a case study because it represents a tropical region – a hot and humid climate. The country is economically developed with a high cooling energy demand. Therefore, this paper developed five scenarios to be analysed and compared using the EnergyPLAN model.

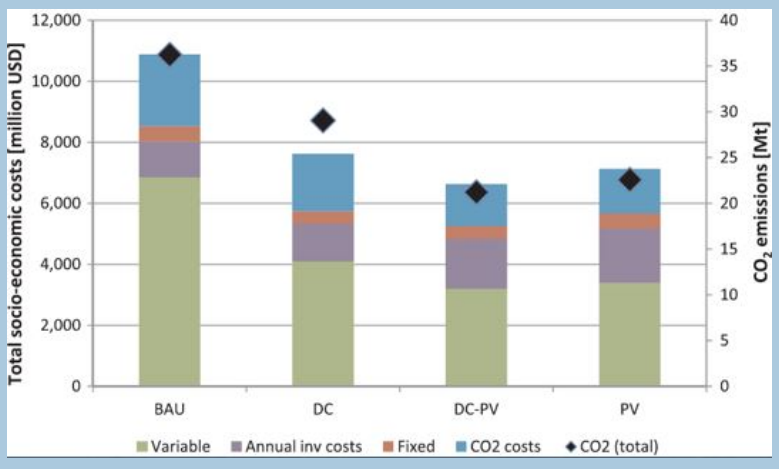
| | Reference scenario (REF) | Business as usual (BAU) | District cooling (DC) | DC and increased PV penetration (DC-PV) | Increased photovoltaics penetration (PV) |
|---|---|---|---|---|---|
| Year | 2014 | 2050 | | | |
| Features | Developed using official statistics from different sources | Scenarios representing normal progress of the system without major incentives for change | BAU + the application of district cooling system | BAU + DC + rapid penetration of PV systems | BAU + rapid penetration of PV systems |

# Results

Total socio-economic costs and $CO_2$ emissions for the BAU and alternative scenarios for the year 2050 can be seen in the figure below. The study shows that the variable costs in the BAU scenarios are much larger than in alternative scenarios, making alternative scenarios less volatile and less prone to changes in import prices of the fuels.

**In order to check the robustness of the results**, a sensitivity analysis was carried out. The analysis was carried out for a DC-PV scenario and the influences of gas price, PV panels price, gas PP efficiency and PV efficiency on the total socio-economic costs and $CO_2$ emissions were assessed. The gas price has the most significant impact on the total socio-economic costs.

Economic and environmental results of different scenarios for the year 2050




**The results** of this paper show that there is a significant potential of waste heat that can be utilized via absorption chillers to produce cold. However, due to the nature of the sources, which are highly concentrated at few sites, a district cooling network needs to be established in order to connect the customers demanding the cooling energy with energy sources. Moreover, the total investment is offset by total socio-economic savings, making the potential future energy system of Singapore cheaper, more energy efficient and less harmful to the environment.

**Finally**, this study successfully showed that the implementation of district cooling system in hot and humid climate is economically sound, environmentally beneficial and a technically feasible investment.

# Discussion

There are **three main conclusions** that rose from the case study with the implementation of **DC**:

**First,** there are significant benefits for the environment

$CO_2$ emissions were lowered by 41.5% in the year 2050 comparing DC-PV scenario and BAU scenario.

**Second**, energy system efficiency significantly raises

Primary energy consumption was 19.5% lower than in the business-as-usual scenario for the year 2050.

**Third**, economic side of the energy system can be positively impacted

Socio-economic costs were 38.4% lower in the DC-PV scenario than in the BAU scenario for the year 2050.

# About the authors

**D.F. Dominković (dodo@dtu.dk),** Post Doc in Department of Applied Mathematics and Computer Science at DTU Compute, Technical University of Denmark
**A.S. Pedersen: Retired**, Head of division at Department of Energy Conversion and Storage at DTU
**K.A. Bin Abdul Rashid (khai0033@e.ntu.edu.sg), A. Romagnoli (a.romagnoli@e.ntu.edu.sg), and K.C. Leong (mkcleong@e.ntu.edu.sg)**, School of Mechanical and Aerospace Engineering at Nanyang Technological University, Singapore
**G. KRAJAČIĆ (goran.krajacic@fsb.hr ) and N. DUIĆ (neven.duic@fsb.hr):** Faculty of Mechanical Engineering and Naval Architecture at University of Zagreb, Croatia

Acknowledgments: Innovation Fund Denmark. Grant 1305-00027B