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The Dynamics of the Water-Electricity Nexus

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The dynamics of the Water-Electricity Nexus

**How water availability affects electricity
generation and its water consumption**

Santiago D. Vaca Jiménez

Colophon

The research was carried out at the Center for Integrated Research on Energy, Environment and Society (IREES), which is part of the energy and Sustainability Research Institute (ESRIG) of the University of Groningen in the Netherlands.

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university of
 groningen

The dynamics of the Water- Electricity Nexus

How water availability affects electricity generation and its water
consumption

PhD thesis

to obtain the degree of PhD at the
University of Groningen
on the authority of the
Rector Magnificus Prof. C. Wijmenga
and in accordance with
the decision by the College of Deans.

This thesis will be defended in public on

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Work willingly at whatever you do,
as though you were working for the
Lord rather than for people.

Colossians 3:23

This work is dedicated to both of my grandfathers that saw me start this journey but could not see me finish it. Germánico and Byron, this work is dedicated to you. Thank you for all your hard work and for giving me so many wonderful memories throughout my childhood.

Before starting my PhD, my academic life was straightforward: register for a program, fulfil the requirements to pass, and at the end of the program, receive my diploma. However, this was not the case for this PhD. The journey until this day has been long, full of turnarounds and unexpected events. Everything has been so unpredictable, that until recently, I was under the impression that this day would never come.

I also thought that after my PhD, I would only gain academic knowledge. In reality, this whole process helped me gain knowledge in every area of my life. Besides the knowledge in the subject, this whole experience taught me two main things: 1) to understand and embrace criticism, and 2) to carry on despite the adversities.

During my PhD, I had to change my research topic and my supervision team twice and to change countries three times. I struggled to find the proper topic of each paper. I endured the loss of Gerard Dijkema, my initial promotor. Recently, I had to change the plans of my defence ceremony because of the Coronavirus Pandemic. Nevertheless, thanks to God, I managed to move through the obstacles, and I have finally finished my PhD.

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Santiago D. Vaca J.
Quito
September 24, 2020

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Acronyms

BPP Biomass power plant

CWR Crop Water Requirement

DC Dry cooling system

DEM Digital Elevation Model. 3D model of the Open Water Surface

DH Dam height, considered from the base to the top of the dam (in m)

GHG Greenhouse gases

GSH Gross Static Head (in m). The vertical distance from the open water surface to the top of the water in the tailrace (discharge)

HFL Dammed hydropower plant with flooded lake reservoir

HFR Dammed hydropower plant with flooded river reservoir

HNR ROR hydropower plant without reservoir

HPP Hydropower plant

HRR ROR hydropower plant with reservoir

ICE Internal Combustion Engine Thermal power plant

IDC ICE power plant with dry cooling

IOT ICE power plant with once-through cooling

IWT ICE power plant with wet-tower cooling

MEHP Most water-efficient hydropower plant

NC No cooling system

NO_x Nitrous oxide

OPP Other renewable power plants (including solar fields and wind farms)

OT Once-through cooling system

OWS Open water surface

PP Power plant

RES Renewable Energy Systems

ROR Run-of-the-river

ROT Rankine TPP with once-through cooling

RWT Rankine TPP with wet-tower cooling

TPP Thermal power plant

WEN Water-electricity nexus

WF Water Footprint

WFA Water Footprint Assessment

WT Wet-tower cooling system