Green Energy and Technology

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Sea Water Desalination in Microgrids

Springer

Green Energy and Technology

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Preface

The synergies between water, energy, and food sectors are obvious—although often planned independently—that is one of the identified catalysts for achieving the United Nation's Sustainable Development Goals. This fact lowers the opportunity to maximize the positive impacts when developing joint solutions of companies or legislators. Climate change conditions are especially dramatical in islanded and water-scarce environments, where the restrictions of water, energy, and food provoke shortages and high costs.

The book explored the feasibility of a dual microgrid based on energy electricity from renewable energies joint to a desalination plant to offer a sustainable-oriented solution to tackle water scarcity in isolated regions. This book proposes innovation approaches to improve the economic competitiveness of the designed microgrid in the liberalized market. The book explored its feasibility and analyzes how to improve desalination process and how to site and size the facilities to maximize the operation. It investigates the microgrid from an economic, environmental, legal, and technological point of view. The aim is not only to feed the desalination process, but also to provide the power grid with clean energy, taking advantage of the electricity production surplus. One of the main matters that the book deals with is to answer how a desalination microgrid scheme is economically and technologically sustainable in a water-scarce region. It developed a method to locate the facilities and used sustainability tools to describe synergies between systems. Alternative renewable-based energy plans affect a designed sustainability index that models how stressed is the related system—in this book, focused in a region at high water scarcity risk.

The results presented have as an aim to be, itself, a technology transfer asset and to provide a potential economic and social benefit by launching to the market either a new product, a new process, or a new service, and opening a wide range of possibilities of new sustainable business models alongside the microgrid. In this sense, results obtained could be useful for companies with a TRL 6—technology demonstrated in relevant environment—by exploring and assessing the technical feasibility and commercial potential of a breakthrough innovation. Those could obtain public funds from SME phase II or similar to include some of the proposed ideas for a rapid

business deployment. Besides, this book generates social value as it is an activity that benefits civil society and its interest groups.

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Contents

Symbols, Abbreviations, and Acronyms

ρ	Water density (kg/m^3)
Δt	Increase of time in hours
a	Depreciation factor
AEU	Acceptable emissions use
AI	Artificial intelligence
As	Alternative scenario
ASAI	Average service availability system
ASR	Acceptable stress resource
AWU	Acceptable water use
BAT	Best available technique
BBGSOTs	Black box global stochastic optimization techniques
BC	Brine concentrate
BCS	Blade control system
BEU	Baseline emission use
BP	Booster pump
BU	Baseline use
BWU	Baseline water use
C(wind)	Interpolation function from the normalized power
C→E	Cost per energy
CAIDI	Customer average interruption duration
CAPEX	Capital expenditure
CCG	Combined cycle gas station
CCs	Capital costs
CCt	Capital costs
CF	Cartridge filter
CF	Conceptual framework
CHEMAD	Chemical addition
CI	Cost index
CLEWS	Climate, land, energy, and water strategy
CO_2	Carbon Dioxide
COE	Energy cost

coeur	Euro cent
COW	Cost of water
COW	Water cost
CR	Country risk
CRF	Cost recovery factor
CS	Compensation scheme
DC	Dechlorination
DER	Distributed energy resources
DP	Desalination plant
dput	Pumping units required for each available power value
DRES	Distributed renewable energy source
DS	Deployment scenario
DWEER	Dual work exchanger energy recovery
DYCORS	DYnamic COordinate search using Response Surface models
E	Energy
E→E	Emissions for energy
EB	Energy balance
EBITDA	Earnings before interest, taxes, depreciation, and amortization
EC	European Council
ED	Energy demand
EEG	Energy electricity generation
EFSA	European Food Standards Agency
EIB	European Investment Bank
EIPF	Economic and industrial policy framework
EP	Entry point
ER	Energy recovery
ERD	Energy recovery device
ES	Energy sector
ESC	Energy storage capacity
ESIF	European Structural and Investment Fund
ESP	Energy storage potential
ETI	Education, training and information
EU	European Union
FB	Financial/budgetary
FCC	Fuel consumption cost
FCI	Fixed capital investment
FE	Food and energy
FIP	Feed-in premium
FIT	Feed-in tariff
FM	Financial market
FP	Feed pressure
FWC	Feed water concentration
G	Gravitational acceleration (9.8 m/s^2)
GA	Genetic algorithm
GC	Geographical coordinate

GCC	Generation control center
GDP	Gross domestic product
GF	General feed
GHG	Greenhouse gas
GIS	Geographic information systems
GVC	Global value chain
GWh	Gigawatts per hour
H	Head (m)
Ha	Hectare
Hm^3	Cubic hectometer
HPP	High pressure pump
i	Each element of each water array Wideal
IC	Interest on capital
ICT	Information and communications technology
IDAE	Institute for the Diversification and the Energy Savings
idx2	Vector indexes of power mismatch
IEC	International Electrotechnical Commission
Ieff	Effective investment rate
IEU	Incremental emission use
Inhab	Inhabitant
Irradiation	Solar irradiation profile
IS	Information system
IWU	Incremental water use
K	Incoming water flow/outgoing water flow ratio of the reverse osmosis process
kcal	Kilocalories
KPI	Key performance indicator
kW	Kilowatts
kWh	Kilowatts per hour
L→E	Earth for energy
LCOE	Levelized cost of electricity
LCW	Levelized cost of water
LEAP	Long-range energy alternatives planning system
LGs	Loan guarantees
LI	Land index
M&S	Marshall and Swift
M€	Million euro
M^2	Square meters
M^3	Cubic meter
MB	Market-based
MED	Multiple-effect distillation
MENA	Middle East and North Africa
MF	Media filter
MFE	Market, financial and economic
MINLP	Mixed integer nonlinear programming

MPHS	Micro Pumping Hydro Storage
MRIT	Maintenance, replacement, insurance and taxes
MS	Member states
MSF	Multistage flash
MuSIASEM	Multi-Scale Integrated Analysis and Ecosystem Metabolism
MW	Megawatts
n	Number of years
n	Plant life
Ndesalination,t	Number (integer) of pumping units
NDP	National development plan
NOH	Number of operating hours
NORAM	North American
NOx	Nitrogen oxide
NPV	Net present value
NQS	Neutral quota scheme
NREAP	National Renewable Energy Action Plan
NS	Nexus sector
NSC	National support scheme
NT	Water, energy, food nexus tools
O&M	Operating and maintenance
OA	Optimization algorithm
OCs	Operating costs
OIC	Onshore installed capacity
OMEL	Iberian Energy Market Operator
P	Pressure
P&DI	Policy and data input
p.u.	Per unit
Paux,t	Power of auxiliary systems
Pavailable,t	Vector of available power
PF	Project financing
PGC	Power generation capacity
PHES	Pumping Hydro Energy Storage
PIF	Private investment fund
Pnaux,t	Rated power of a pump
Pnominal	Power that will be adjusted by the software optimization procedure (desalination plant)
Pnormalized,t	Normalized production
Pnot_used,t	Power surplus vector
PP	Planning phase
ppp	Parts per million
PSI	Policy support instrument
Psolar	Solar production
PTC	Production tax credit
Punitary,t	Minimum unit power that can be processed
PV	Photovoltaic

PW	Potable water
Pwind	Production of electricity due to wind turbines
RBD	Rotor blade diameter
REE	Red Eléctrica España S.A.U. (Spanish Transmission System Operator)
RENS	Reference energy system
REP	Renewable energy production
RES	Renewable energy sources
RO	Reverse osmosis
RODP	Reverse osmosis desalination plant
ROS	Reverse osmosis system
RPPs	Renewable power plants
Rt	Water ratio produced per power unit
SAIDI	System average interruption duration index
SAIFI	System average interruption frequency index
SCM	Supply chain management
SEC	Specific energy consumption
SME	Small and medium enterprise
SoC	State of charge
SS	Single state
SWOT	Strengths, Weaknesses, Opportunities, Threats
SWRO	Sea water reverse osmosis
t	Tones
TCI	Total capital investment
TDC	Total delivery cost
TEC	Ecologic transition
TER	Technical, economic, and regulatory
TFC	Total fixed cost for the annual operation
TGCs	Tradable green certificates
TPP	Total permeate production
TRL	Technology readiness level
TSD	Total solids dissolved
UN	United Nations
US	United States
V	Volume to be stored (m^3)
VC	Vapor compression
VC	Variable cost
VSD	Variable speed drive
VT	Vapor turbine
W	Watts
W&E	Water and electricity
W→E	Water for energy
W→F	Water for food
WACC	Weighted average cost of capital
WB	Water body

WC	Wind class
W_c	Working capital
WCC	Well construction cost
WDC	Waste disposal cost
WEAP	Water evaluation and planning
WEF	Water Energy Food
WEF	Water, energy and food
Wflow	Water flow
WI	Water index
Wideal,t	Water production vector
WLES	Water, land and energy system
WP	Wind power
WPPs	Wind power plants
WR	Water requirement
WSoc	State of charge of the deposit
WT	Wind turbine
Ww	Water withdrawal

List of Figures

List of Tables

Chapter 1
Introduction

To meet the needs of the present without compromising the ability of future generations to meet theirs
Brundtland Commission

Climate change conditions is especially dramatical in islanded environments, where these restrictions to water resources have conducted to an overexploitation of aquifers and wells that desalination plants have become essential. The synergies between Water, Energy, Food sectors are obvious—although often planned independently—is one of the identified catalysts for achieving the United Nation's sustainable development goals. Isolated and water-scarce regions suffer high water and energy costs that itself results in high environmental costs. The book offers a sustainable approach to tackle with water scarcity for regions that need desalted water in isolated regions. Specially in those regions, sustainability must be a key feature that legal and market issues highlight as a parameter to be analyzed in order to improve the deployment of hybrid schemes.

Among the problems that this book intends to help to solve, it highlights tackle the impact and costs of the RO desalination process, proposing improvements to reduce water global costs. The vast deployment of renewable energy technologies of electricity generation face barriers that stresses when it is combined with other sectors, technologies.

This book proposes a methodology for locating and sizing the microgrid to maximize the benefits of the microgrid. The proposed microgrid uses desalted water to develop a water storage pumping scheme, that let the management of the energy surpluses in the system. The desalination microgrid takes advantage of this dual resource to conform rural microgrids that supply water and energy in the surrounding areas. Energy is used in the farms, desalination plant, citizens, and other elements which are part of the microgrid. Water is used in surrounding farms, by citizens, or other uses, of the microgrid. Specially in those regions, sustainability must be a key feature of any action taken that the legal issues highlight as a parameter.

The results in this book provides solutions to increase the performance of RO desalination plants providing water and energy electricity at economic, and environmental affordable cost. The product includes the development of a microgrid

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