

Overview of the

ENERGY RESEARCH AT LEIBNIZ UNIVERSITÄT HANNOVER

EnergyResearch@LUH – Vision/Mission (1/2)

Vision

- Affordable and Clean Energy (SDG 7)
- Climate Action (SDG 13)



Mega trends

- Decentralised, volatile energy sources
- Change in transportation, electromobility
- Digitization
- Sustainable heat supply

Observations

- Need for action in the context of climate change is growing
- Social discourse on the energy transition is increasing
- Complexity increases
- Sustainable energy supply is gaining importance for innovations

EnergyResearch@LUH – Vision/Mission (2/2)

Mission

Enabling transformation ...

- of energy systems,
- mobility
- and material value chains towards the use of renewable energies,

through ...

- basic research,
- research in practice and
- science communication



EnergyResearch@LUH – Faculties/Infrastructure

Faculties involved

- Architecture and Landscape Sciences
- Civil Engineering and Geodetic Science
- Economics and Management
- Electrical Engineering and Computer Science
- Law
- Mathematics and Physics
- Mechanical Engineering
- Natural Sciences

Research infrastructure

- Dynamics of Energy Conversion Research Building
- Generator Converter Lab
- Large Wave Flume with MarTech
- Test Centre Support Structures Hannover
- Calibration and Test Centre (ISFH-CalTeC)
- Solar Technology Centre (ISFH-SolarTeC)



EnergyResearch@LUH – Cooperations/Networks



EnergyResearch@LUH – Research focus areas

Components

- Wind energy
- Solar energy
- Electrical energy technology
- Thermal and electrochemical energy technology
- Sustainable drives

System

- Overall system and transformation
- Digitization of the energy system



Energy-research@LUH – Numbers, data, facts (4/4)

- Third-party funding annually
 - 15-20 million € energy research projects
 - 8-12 million € solar energy projects at ISFH

- Funding
 - National (Lower Saxony, Germany, DFG/ Programmes)
 - European Programmes

SFB 1463
Offshore-
Megastrukturen



Gefördert durch
DFG Deutsche
Forschungsgemeinschaft



Sustainable and Energy-
Efficient Aviation

Study programs in the field of sustainable energies

Bachelor of Science

- Energy related
 - Power Engineering
- Engineering
 - Electrical Engineering and Information Technology
 - Civil and Environmental Engineering
 - Sustainable Engineering
 - Mechanical Engineering
- Other with energy topics
 - Environmental Meteorology
 - Engineering and Business Administration
 - Production and Logistics



Study programs in the field of sustainable energies

Master of Science

- Energy related
 - Power Engineering
 - [Energy Technology](#) (Double Degree together with Lappeenranta, English)
- Engineering
 - Civil Engineering
 - Electrical Engineering and Information Technology
 - Environmental Engineering
 - [Environmental Planning and Territorial Development - Major Territorial Development](#) (English)
 - Mechanical Engineering
- Other with energy topics
 - Meteorology
 - Production and Logistics



Mission 2031 – Sustainable Development Goals (SDG)

Focus on SDG 7 and SDG 13

- Climate neutrality by 2031
- Climate protection concept

Coordinated by

- Vice President for International Affairs and Sustainability, Prof. Nogueira
- Green Office, Dr. Mittrach

Steering Group

- Senate Working Group on Sustainability, Prof. Braun



Further reading in the Research Journal „Transformation of energy systems“



Till Bruckermann | Sascha Schanze |
Katharina Müller
50**Energy research boosts schools**
The Leibniz4U Student Research Centre as
an educational transfer measure

Margit Seckelmann
52**Recursive norm formation in the energy
transition**
Project examining social and legal
negotiations

Christina von Haaren | Hans-Peter Braun |
Stephanie Mittrach
54**Energy transition in practice:**
Photovoltaics on the campus of Leibniz
University Hannover

Raimund Rolfes | Jan-Hendrik Piel |
Tobias Bohne
56**WindGISKI**
WindGISKI – Can Artificial Intelligence find
new areas for wind turbines?

58**The authors**

Richard Hanke-Rauschenbach |
Völker Schöber
4**Transformation of energy systems**
A compact overview of energy research at
Leibniz University Hannover

Raimund Rolfes | Clemens Hübler |
Andreas Ehrmann
8**Towards the realisation of mega wind
turbines at sea**
Collaborative research centre develops
digital twin

Bernd Ponick et. al
12**Airborne Wind Energy**
Airborne wind energy systems for the use
of high-altitude wind

Raimund Rolfes | Michael Breitner |
Clemens Hübler
14**What should we do with old wind turbines?**
Sustainable end-of-life strategies for
onshore and offshore wind turbines

Raimund Rolfes et. al
16**How does noise arise from wind turbines?**
Studies on sound propagation and sound
perception

Rolf Brendel et. al
18**Gigawatt photovoltaics with nanometre
structures**
Research for mankind’s most important
energy source

Marcus A. Horn | Nadine Rüppel
22**Life always finds a smart way**
Production of hydrogen by microorganisms

Axel Mertens et. al
24**No fear of the blackout**
A decentral black start is feasible!

Jörg Seume et. al
28**Aviation of tomorrow**
Energy-efficient and sustainable flying

Stephan Kabelac | Rolf Brendel |
Gunther Seckmeyer
32**The heat pump**
The linchpin of the heat transition

Jörg Seume | Hans Jürgen Maier et. al
36**Appreciate instead of throwing away**
Saving energy and resources by repairing
capital goods

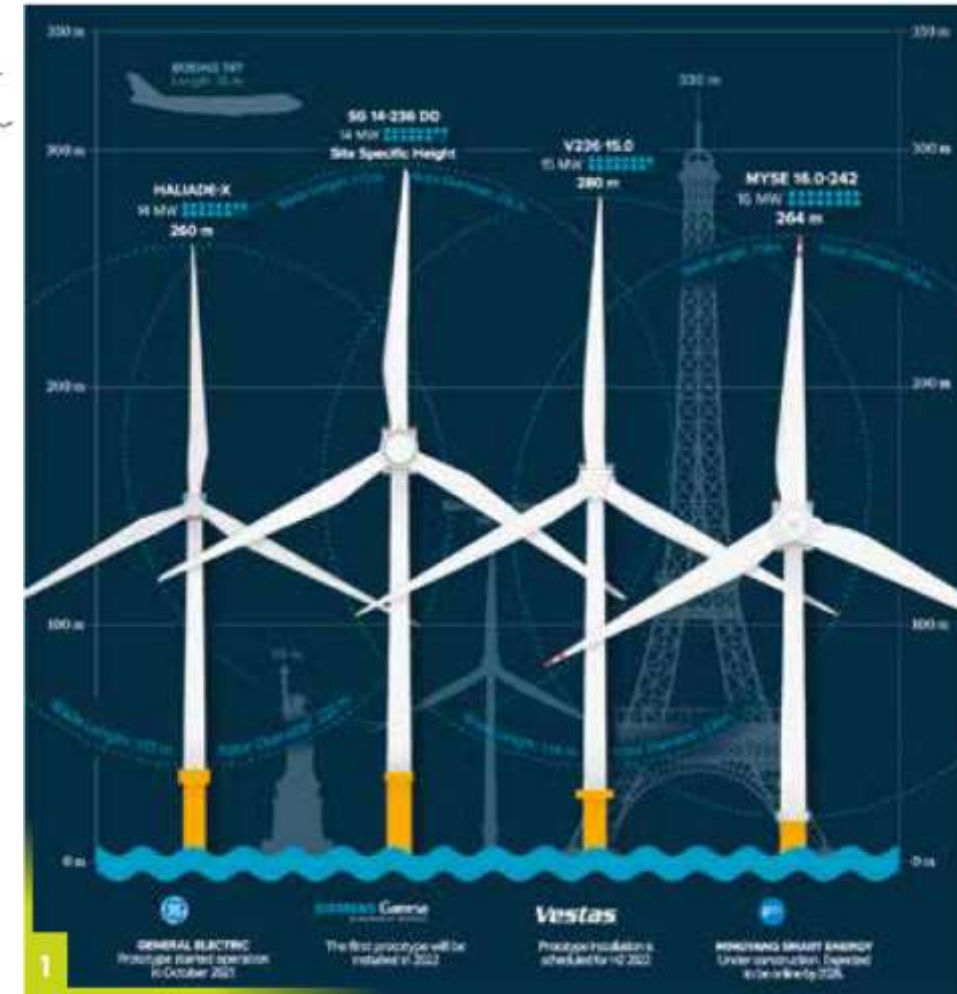
Richard Hanke-Rauschenbach et. al
40**Hydrogen: An Enabling Force for Sector
Coupling**
Saving energy and resources by repairing
capital goods

Michael H. Breitner | Monika Sester et. al
44**Delivering goods efficiently and sustainably:**
The USEFUL web application

Rolf Brendel et. al
46**Flexible and robust pathways to the energy
transition**
New transformation routes to a sustainable
energy system

Towards the realisation of mega wind turbines at sea

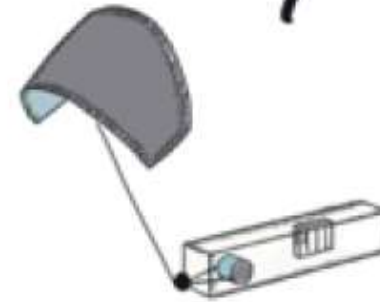
- Collaborative Research Centre Project
 - CRC 1463 "Offshore Megastructures"
 - Research for future trends towards larger turbines with 20-30 MW capacity and beyond
 - Integrated design and operation methodology for offshore megastructures
 - Concept of the digital twin
 - Control and Structural Monitoring



SkyPower 100 – Airborne wind energy systems

- Wind energy at higher altitudes between 300 metres and 1000 metres to generate electrical energy through a winch
- Fully automatic operation to navigate the kite for power generation
- LUH: Demonstration of the electrical generator
- Start-up Skysails
 - <https://skysails-power.com/>

AIRBORNE
WIND
ENERGY

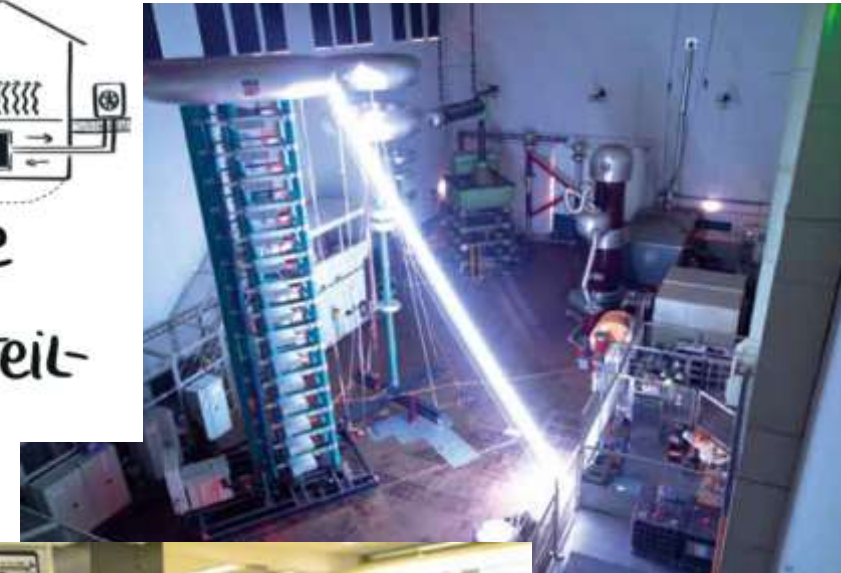


RuBICon – Resilient grids, No fear of blackout

- RuBICon – Rule Based Initialization of Converter Dominated Grids
 - To develop and validate robust procedures for the grid restoration of small island grids
 - Rule-based, decentralized process for power converters, batteries, smart consumers etc.
 - Local distribution grids can operate self-sufficient
- In the event of a grid failure ...
 - a local grid is isolated, larger consumers are switched off and then ...
- the grid is gradually restarted with ...
 - existing energy storage, generation facilities based on renewable energy sources as an island grid.
- In the last step ...
 - the isolated local network is synchronized with the electricity network and reconnected to it.



DEZENTRALE
STEUERUNG
ENERGIEVERTEIL-
NETZE



WindGISKI - Can Artificial Intelligence find new areas for wind turbines?

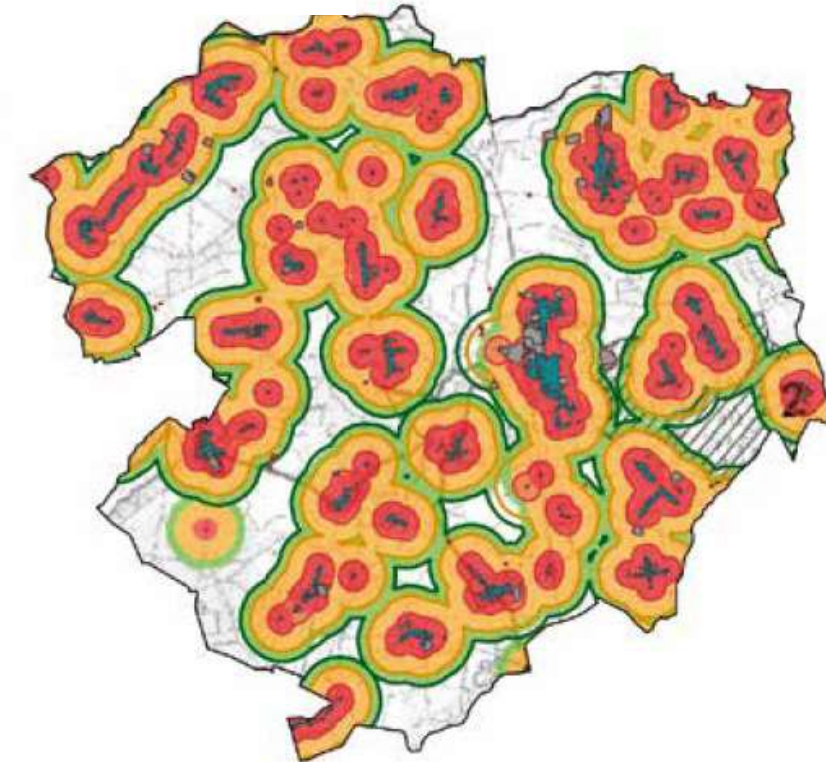
- [WindGISKI](#) focuses on an AI-based GIS for the selection of wind energy potential areas
 - Conflict solutions between species, environmental and climate protection
- [Nefino](#): Startup of LUH
 - Offers powerful GIS solutions for the planning of renewable "power plants"



ENTWICKLUNG EINES
KI-INFORMATIONSSYSTEMS
FÜR DIE AUSWAHL VON
WINDENERGIEPOTENZIAL-
FLÄCHEN

LEGENDE

- Gemeinde Karstädt
- Siedlungsstruktur
 - Siedlungsgebäude im Innenbereich
 - Siedlungsgebäude im Außenbereich
 - Gewerbe- und Industrieflächen
- Tabuzonen
 - Harter Tabuzone Siedlung
 - Weiche Tabuzone Siedlung
 - Restriktionszone Siedlung



Green hydrogen generation at international airport sites

RES potential analysis



- protected areas
- water depth

- topology
- land classification
- farmland
- protected areas

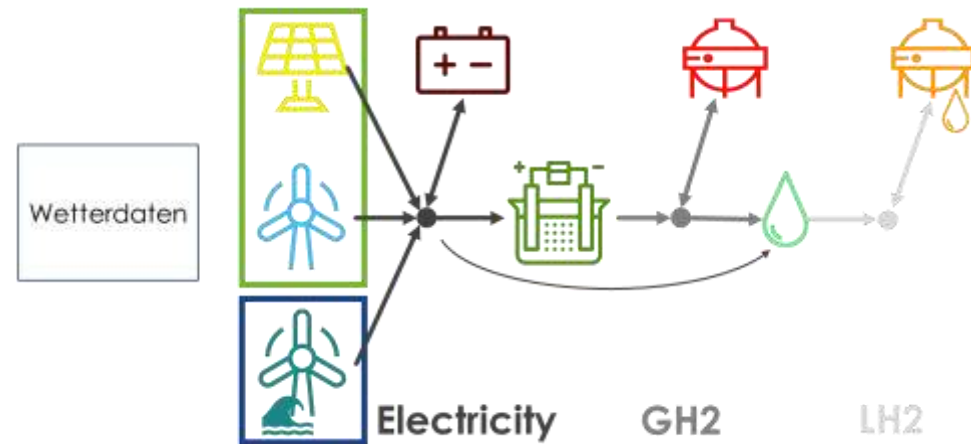
water surface area

land surface area



50 km radius

energy system



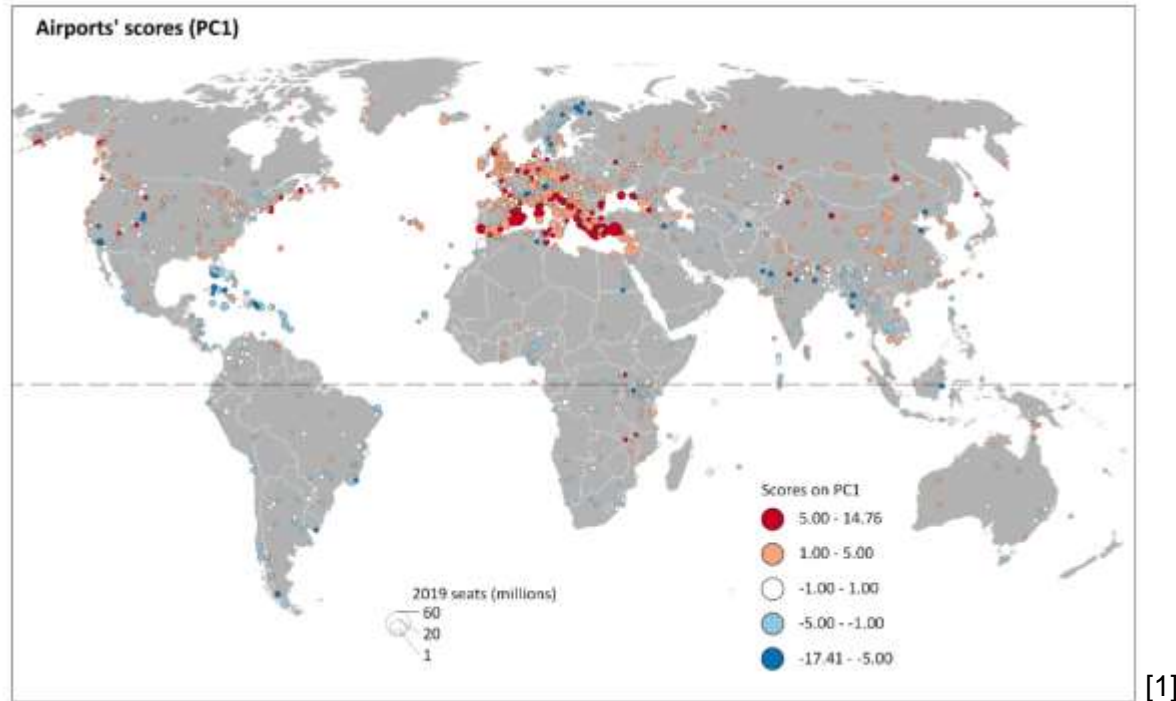
Solar	Liquification
Wind On	Battery Storage
Wind Off	H2 Storage
Electrolysis	LH2 Storage

½ yearly demand
Hamburg airport

yearly demand
100 kt LH2

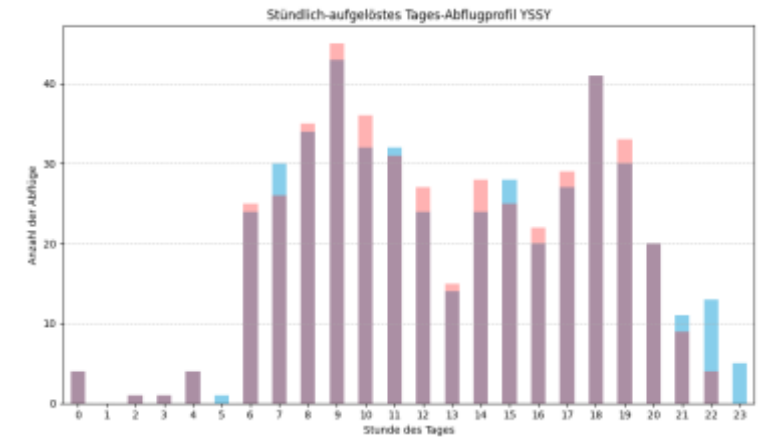


monthly profiles



[1]

daily profiles



daily profiles by
Flightradar24

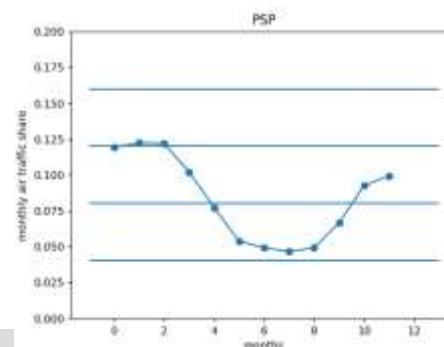
not implemented yet



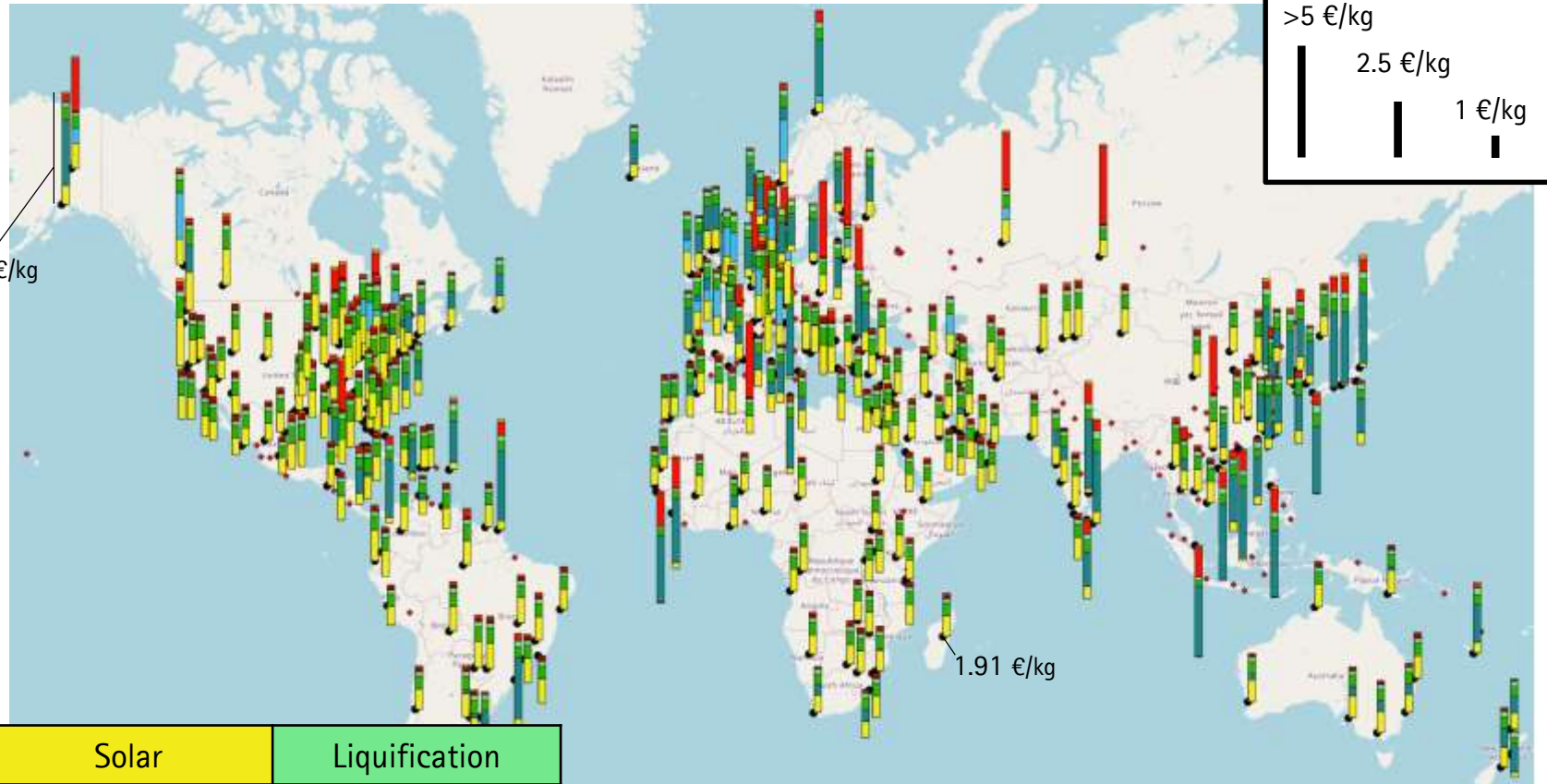
[1]

← measured profile

reproduced profile →



Global LH2 production cost compositions



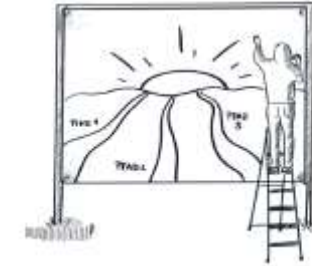
- mostly solar dominated energy systems
- wind onshore mostly in europe
- wind offshore expensive -> increased lcoh
- Down to 1.5 €/kg LH2 at sites with sufficient land surface area and matching seasonality of airport demand and pv feedin
- Up to 13 €/kg LH2 due to area restrictions and/or low RES feedin
- expensive H2 storage requirements if seasonality of airport demand and RES feedin does not match
- *offshore floating PV not included*
- *constant capital costs (wacc)*

◆ RES potential not sufficient

Solar	Liquification
Wind On	Battery Storage
Wind Off	H2 Storage
Electrolysis	LH2 Storage

ESTRAM – Energy System TRAnsformation Model

NESSI - Nano-Energy System Simulator



- ESTRAM - Energy system modelling software
 - Design and optimisation of transformation paths
 - Transition pathways to a sustainable and climate-neutral energy system
 - Planning the demand for renewable energies, synthetic hydrogen, eFuels etc. and their import and export quotas
 - Exploiting regional opportunities
- NESSI
 - Calculates investments, costs and contributions to climate protection
 - For building owners and tenants, tradespeople, energy consultants and political decision-makers
 - Web-based & open access
 - Enables the quantification of sustainability (ecological, economic and social)

<https://nessi.iwi.uni-hannover.de/de>

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