Carbon neutral archipelago – 100% renewable energy supply for the Canary Islands

Sonja Simon, Hans Christian Gils,

German Aerospace Center, Stuttgart

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DLR

Objective

Background: Global carbon budget → 70-90% GHG reduction by 2050 is necessary → complete decarbonisation of the energy system

Main objective: Development of consistent and robust transformation concepts towards **100% renewable energy systems**

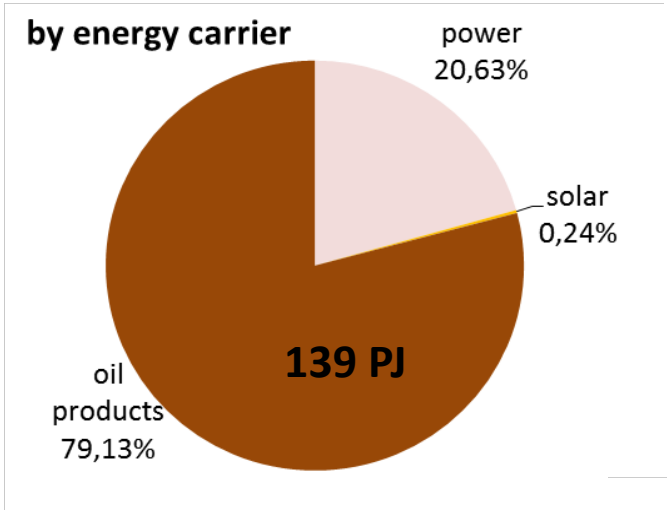
→ Assessing feasibility and viability

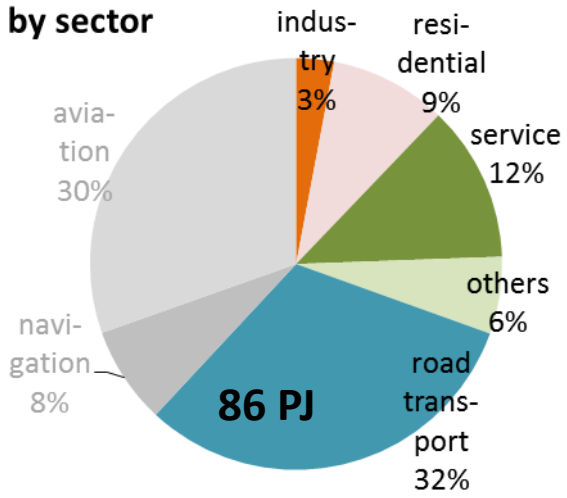
→ Transferrable methodology

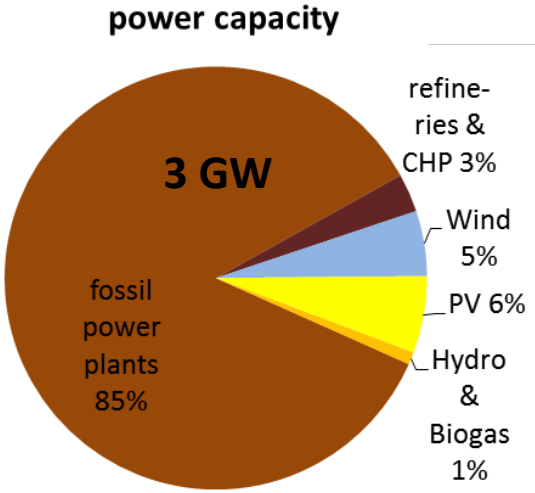
→ Targeting the **Canary Islands**: remote, largely dependent on fossil fuels & mainly on imports

Current status of the energy system on the Canary Islands

Final energy demand (2015)

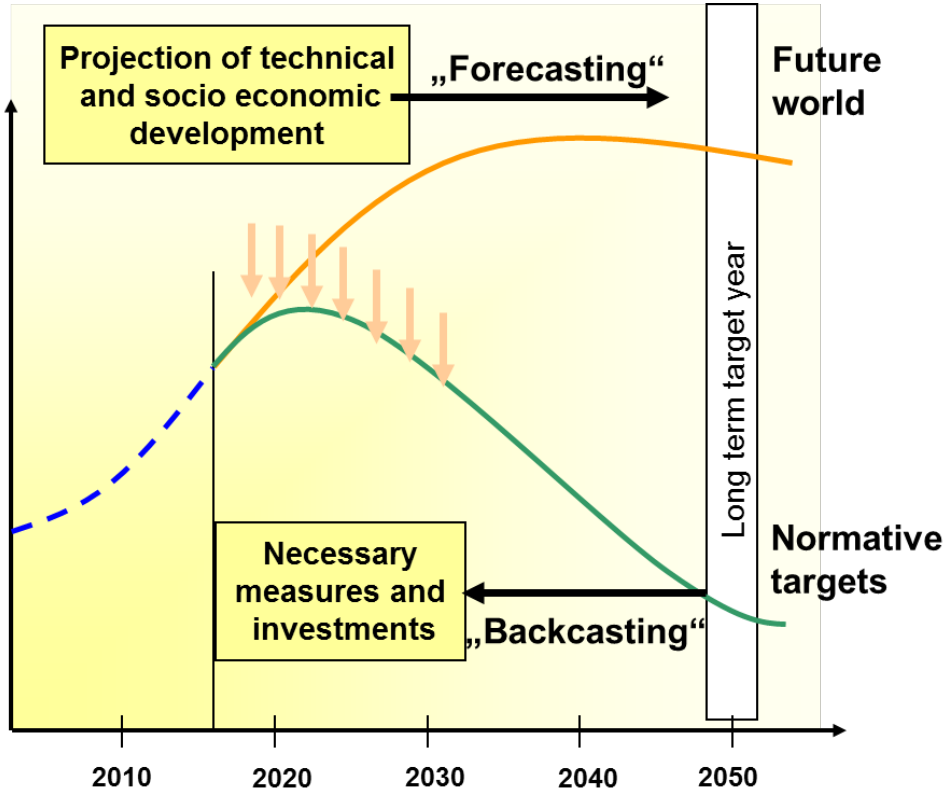






Scenario approach: target orientation and backcasting

- Target: **100%RE** in 2050
- Including only **proven** Technologies
- Assessing effects of **sector coupling** and efficiency targets
- Optimizing demand and supply in power system with high shares of **Variable Renewable Energy** (VRE) in the target year
- **Backcasting** of transformation pathways for the heat, transport and power sectors



Modelling approach: MESAP and REMix

Joint model input and technology representation

Input data: energy statistics, population, GDP, …

Technologies: power, heat & transport technologies (RE & fossil)

REMix-EnDAT

RE potentials

Hourly demand profiles

MESAP-PlaNet

Simulation & Backcasting

Model coupling

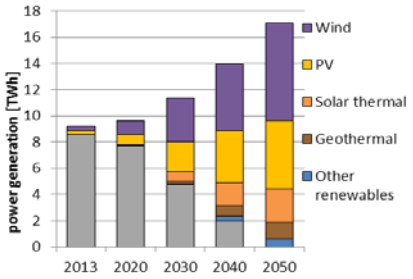
Energy demand development

System configuration at final stage

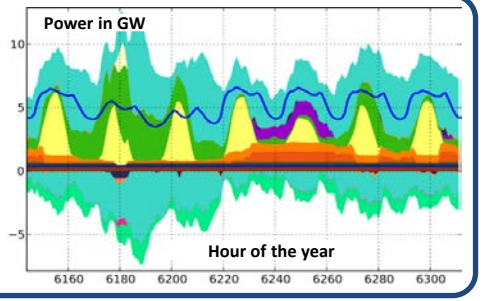
REMix-OptiMo

Least cost optimization of supply
Temporally and spatially resolved

System transformation pathways



Hourly generation, transmission and balancing



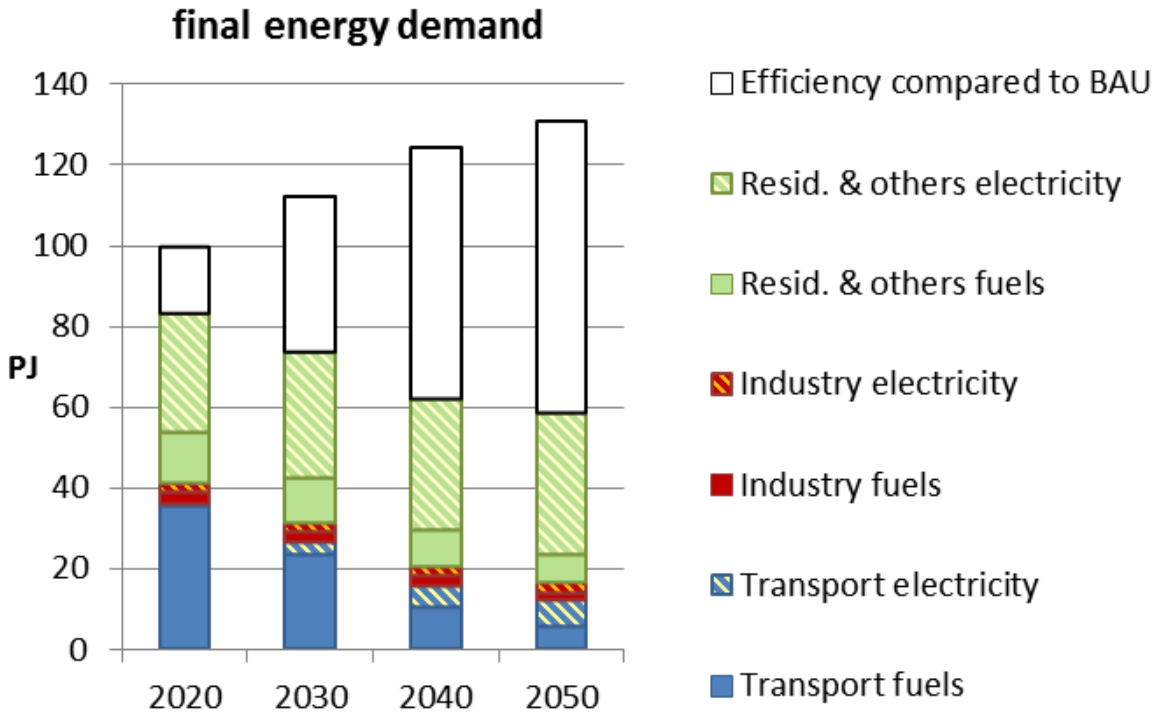
Drivers and input data

- Population development: based on projections for Spain; considering increasing tourism
- Economic growth: Business-as-usual scenario based on developments for Spain

- Renewable energy potentials by island

	Photovoltaics	Concentrating Solar Power (CSP)	Wind onshore	Wind offshore fix	Wind offshore floating
	MW	MW (th)	MW	MW	MW
El Hierro	39	0	58	107	342
Fuerteventura	477	8892	1824	846	2592
Gran Canaria	2205	1523	896	332	1510
La Gomera	67	0	106	139	696
La Palma	224	0	116	171	771
Lanzarote	581	2157	512	589	1660
Tenerife	2876	0	388	428	1414
Total	**6,468**	**12,572**	**3,900**	**2,612**	**8,985**

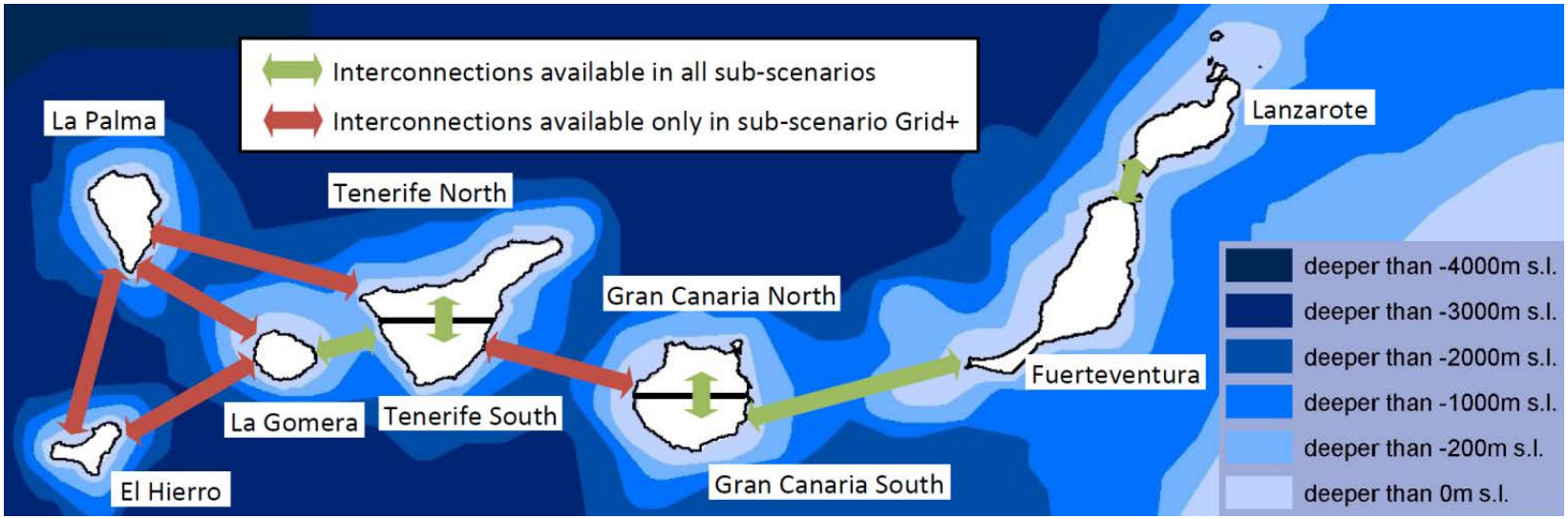
Demand assessment



- Efficiency potentials based on best available technologies & electrification of heat and transport

- Assessing power demand for heat, transport & synthetic H_2

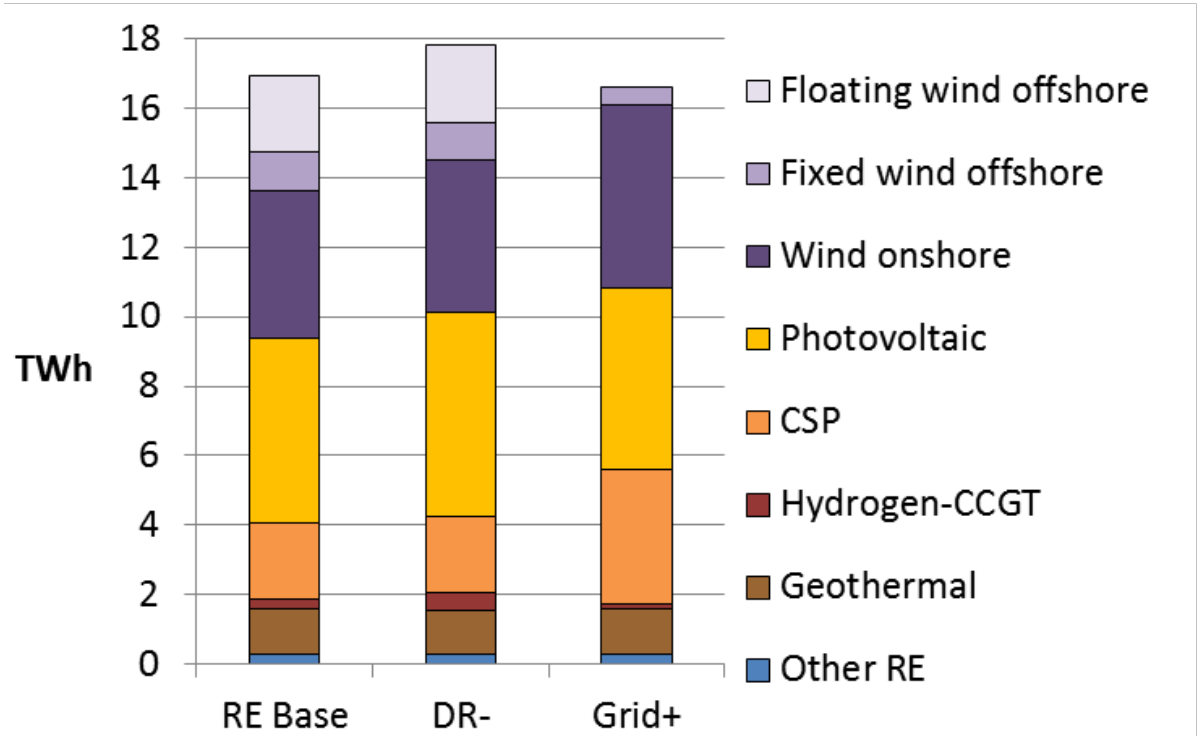
Optimization for the Canary Islands



- Limited potential for hydro, wave, geothermal and biomass (total 2.5 GW)

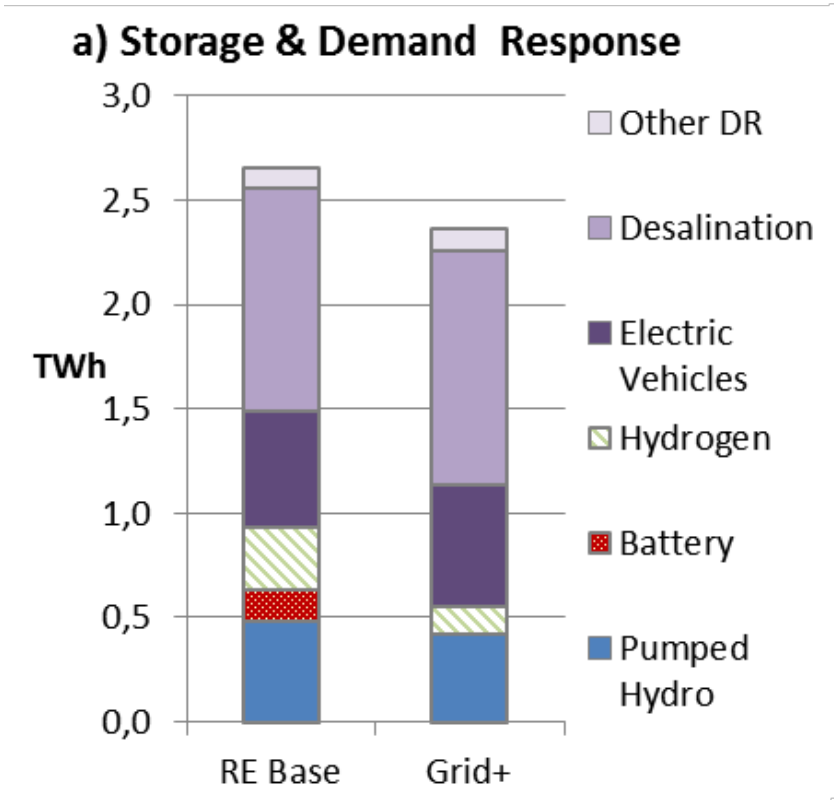
- Sub-Scenarios targeting effects of
  - existing and planned power grid (RE Base)
  - demand response (DR-)
  - additional grid connections (Grid+)

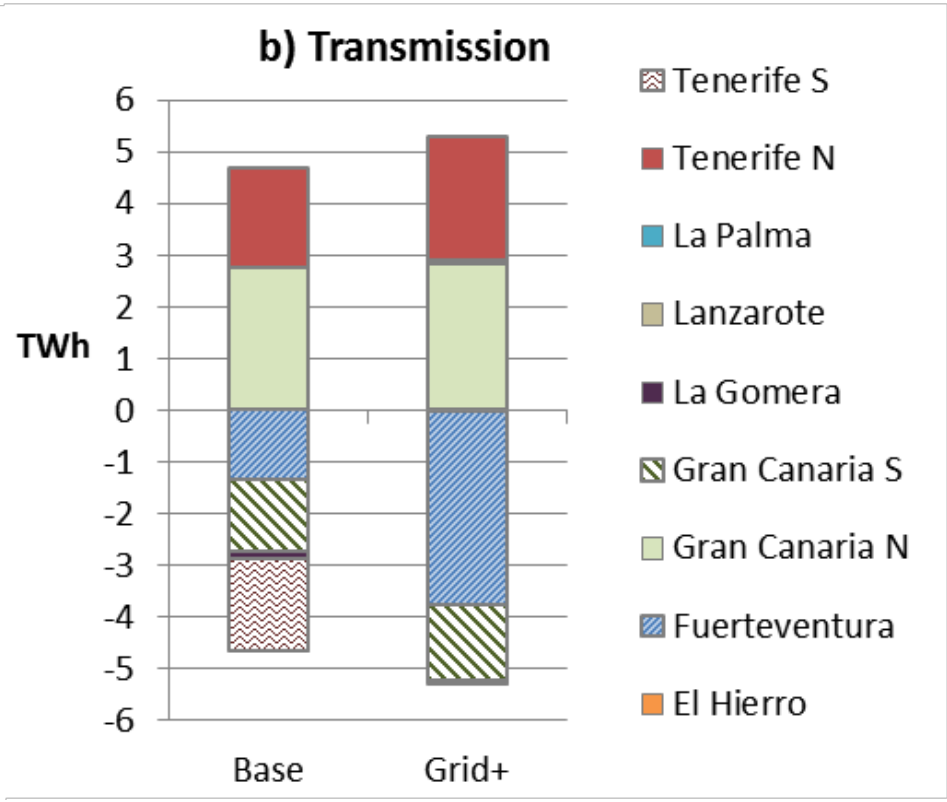
Optimization results power supply for 2050



- PV and Onshore wind potentials are exploited to a large extent
- Additional inter-island grid connections favour CSP & onshore wind and reduce floating offshore wind installations

Results power supply: Canary Islands 2050

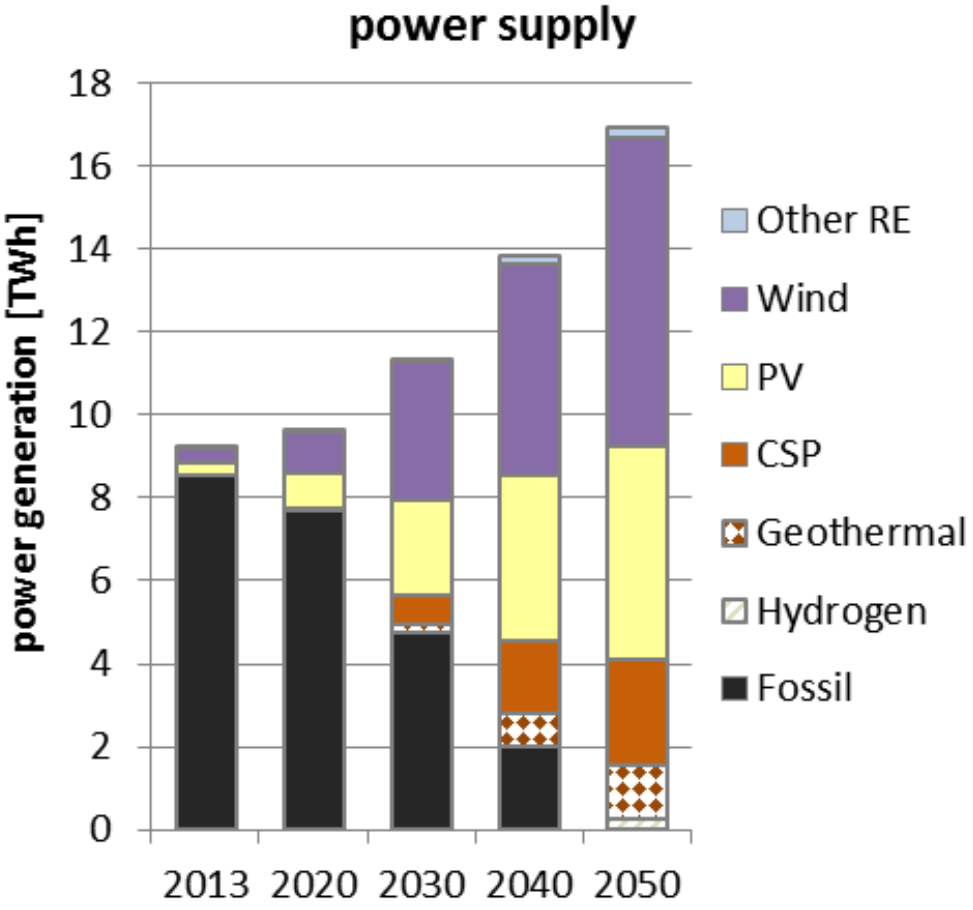




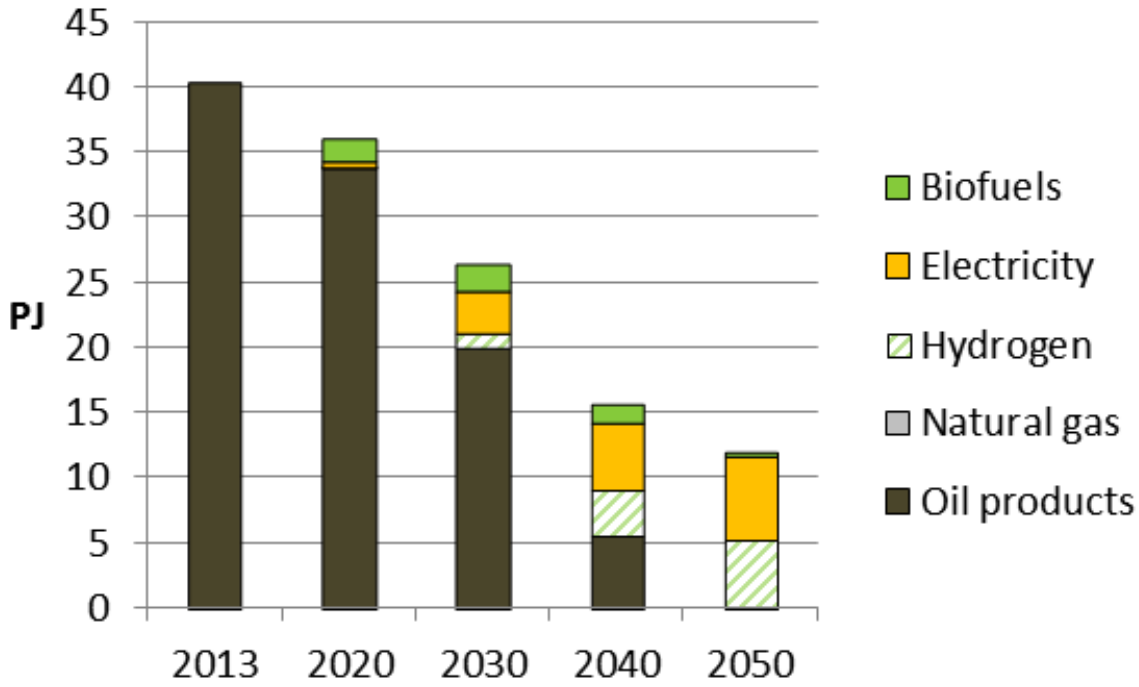
- 25 % of total power production is transmitted to other regions
- Grid expansion taps wind potential in Fuerteventura & provides a potential to reduce system costs by 15%

Transformation pathways for the power sector (RE Base)

- Significant expansion of wind & PV necessary before 2030
- Early diversification is important
- Relevant shares of dispatchable power generation necessary from 2030 on in order to phase out fossil power
  - Geothermal
  - CSP
  - RE Hydrogen



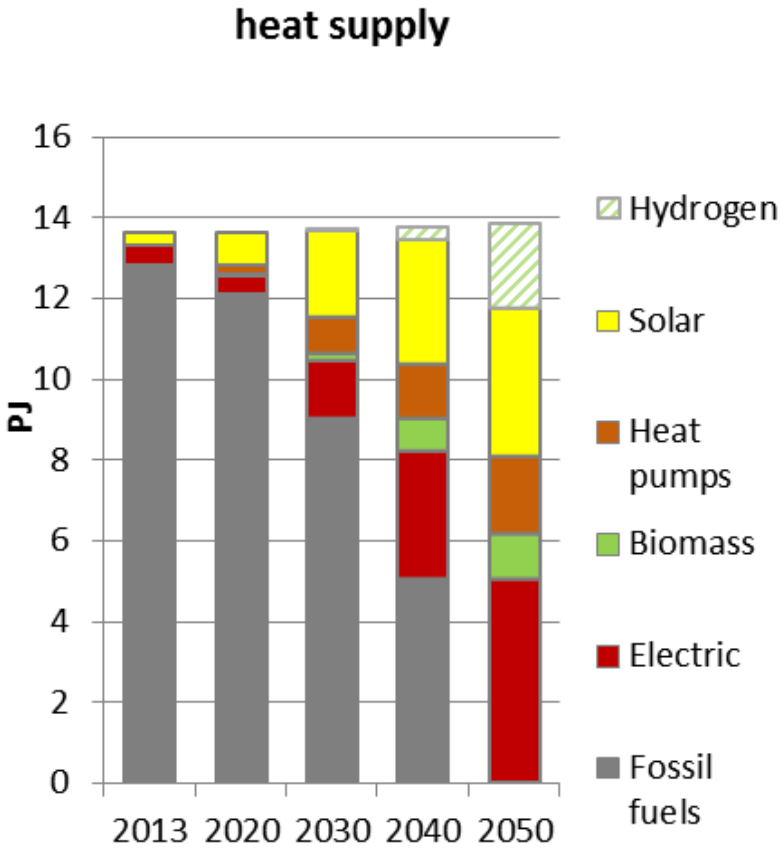
Transformation pathways for road transport



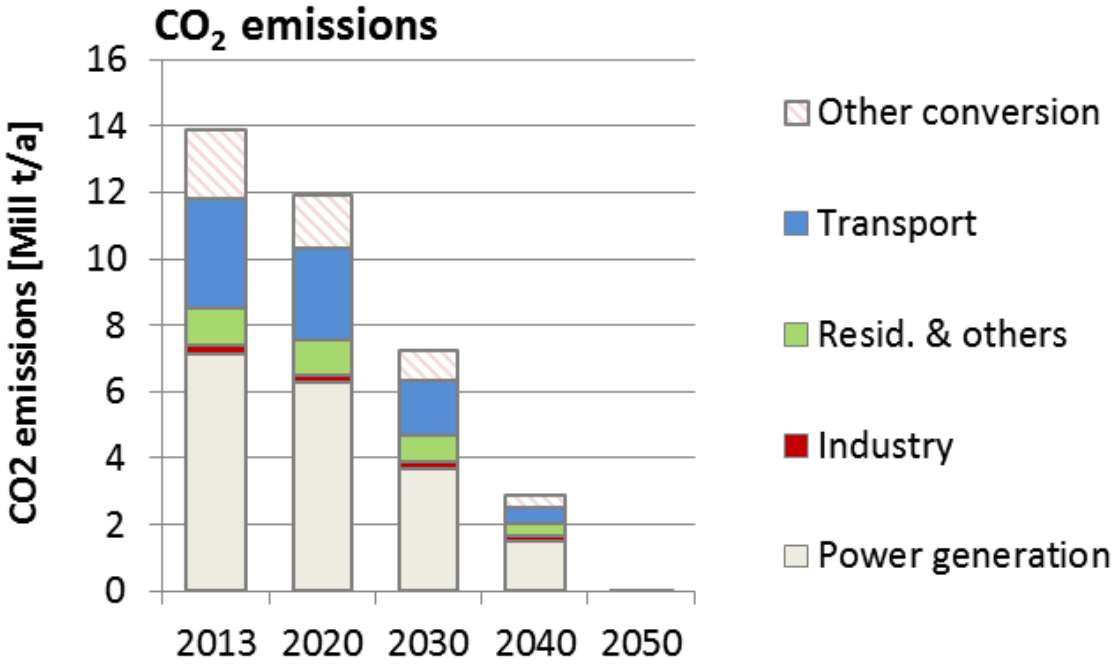
- Reduction of energy demand by electrification
- Short distances on the islands ideal for replacing internal combustion engines (ICE) in individual road traffic with electric vehicles (EV)
- Biofuels (from imports) only for transition
- Hydrogen from VRE for heavy duty vehicles

Transformation pathways for the heat sector

- Electric heat supply necessary to transform the complete system
- Hot water & heating for residential and service: heat pumps and solar
- Efficient CHP from Biomass
- High temperature process heat→ hydrogen, if biomass is not available



Resulting CO_2 emissions and costs



- Phase out of direct CO_2 emissions by 2050
- In the power sector 70% of VRE are backed up by CSP and grid extension at costs of around 17-20 €ct/kWh
- Additional storage and grid infrastructures account for 1/3 of the costs

Conclusions

- Scenarios provide insight, what is necessary to completely phase out CO_2 emissions in Island energy systems
- Sector coupling (EV, hydrogen, heat storage) is essential to tap VRE potential
- Grid extentions are essential for cost efficiency
- Secured capacity from CSP, geothermal and H2 reconversion

Our results show, that the Canary Islands can completely provide their own heat and road transport supply as well as an increase power demand can be securely supplied by RE in 2050

Publications:

Gils, H.C. and Simon, S. (2017) Carbon neutral archipelago – 100% renewable energy supply for the Canary Islands, Applied Energy, 188: 342-355. http://dx.doi.org/10.1016/j.apenergy.2016.12.023

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Krewitt, W., Teske, S., Simon, S., Pregger, T., Graus, W., Blomen, E., et al. (2009) Energy [R]evolution 2008 - a sustainable world energy perspective. Energy Policy;37: 5764-75. http://dx.doi.org/10.1016/j.enpol.2009.08.042

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Contact:

Dr. Sonja Simon
German Aerospace Center, Stuttgart, Germany
Sonja.Simon@dlr.de

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