SUMMER 2021 SEMI-ANNUAL ETSAP MEETING

17-18 June 2021

Sustainable energy and climate mitigation pathways in the Republic of Mauritius

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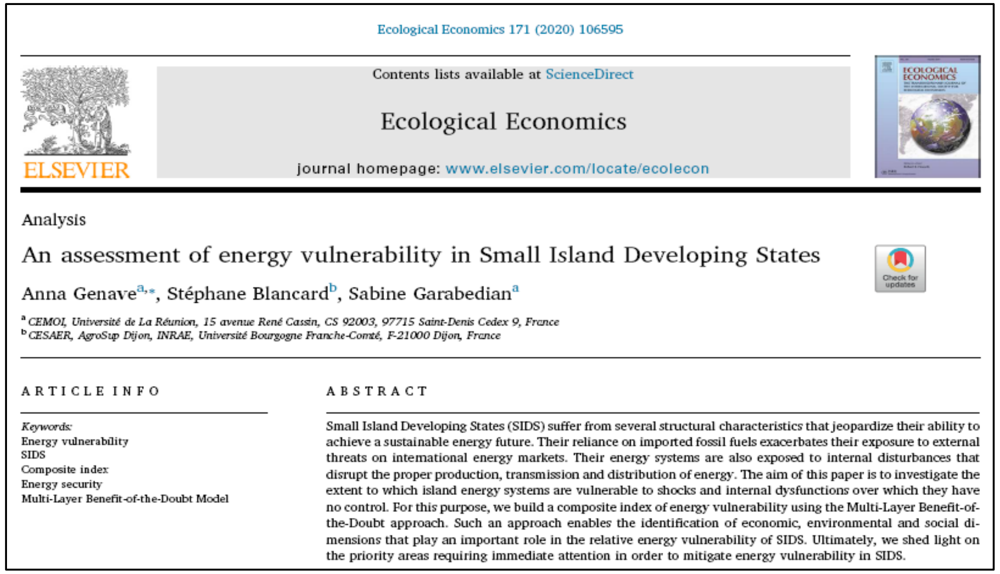
1. Background

What motivated this study?



Ecological Economics 171 (2020) 106595

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

ELSEVIER

Analysis

An assessment of energy vulnerability in Small Island Developing States

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ARTICLE INFO

Keywords:
Energy vulnerability
SIDS
Composite index
Energy security
Multi-Layer Benefit-of-the-Doubt Model

ABSTRACT

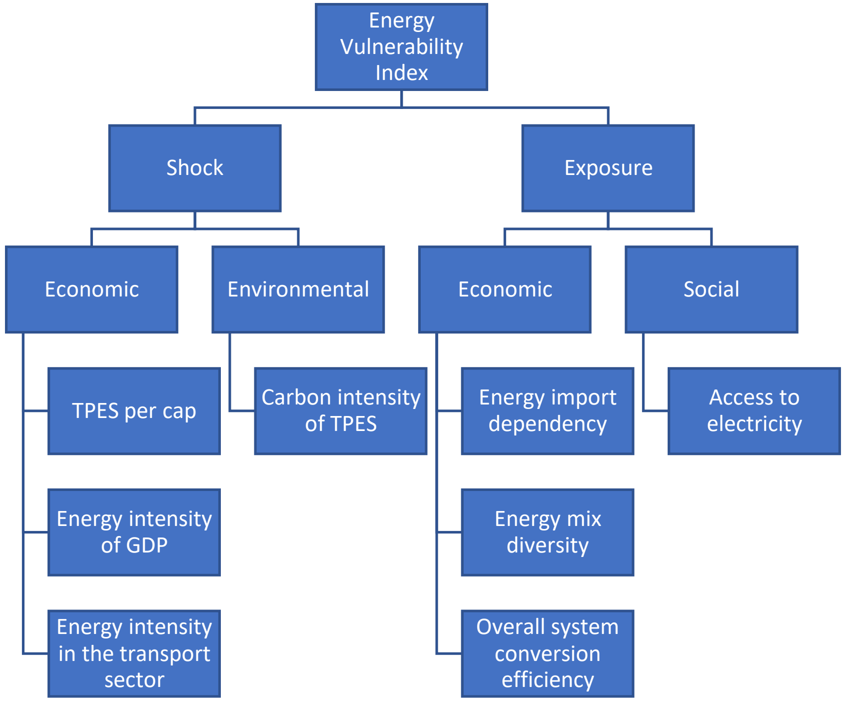
Small Island Developing States (SIDS) suffer from several structural characteristics that jeopardize their ability to achieve a sustainable energy future. Their reliance on imported fossil fuels exacerbates their exposure to external threats on international energy markets. Their energy systems are also exposed to internal disturbances that disrupt the proper production, transmission and distribution of energy. The aim of this paper is to investigate the extent to which island energy systems are vulnerable to shocks and internal dysfunctions over which they have no control. For this purpose, we build a composite index of energy vulnerability using the Multi-Layer Benefit-of-the-Doubt approach. Such an approach enables the identification of economic, environmental and social dimensions that play an important role in the relative energy vulnerability of SIDS. Ultimately, we shed light on the priority areas requiring immediate attention in order to mitigate energy vulnerability in SIDS.

From **energy vulnerability** to **energy transition**

Mitigating vulnerability to energy system external shocks and internal disturbances

+

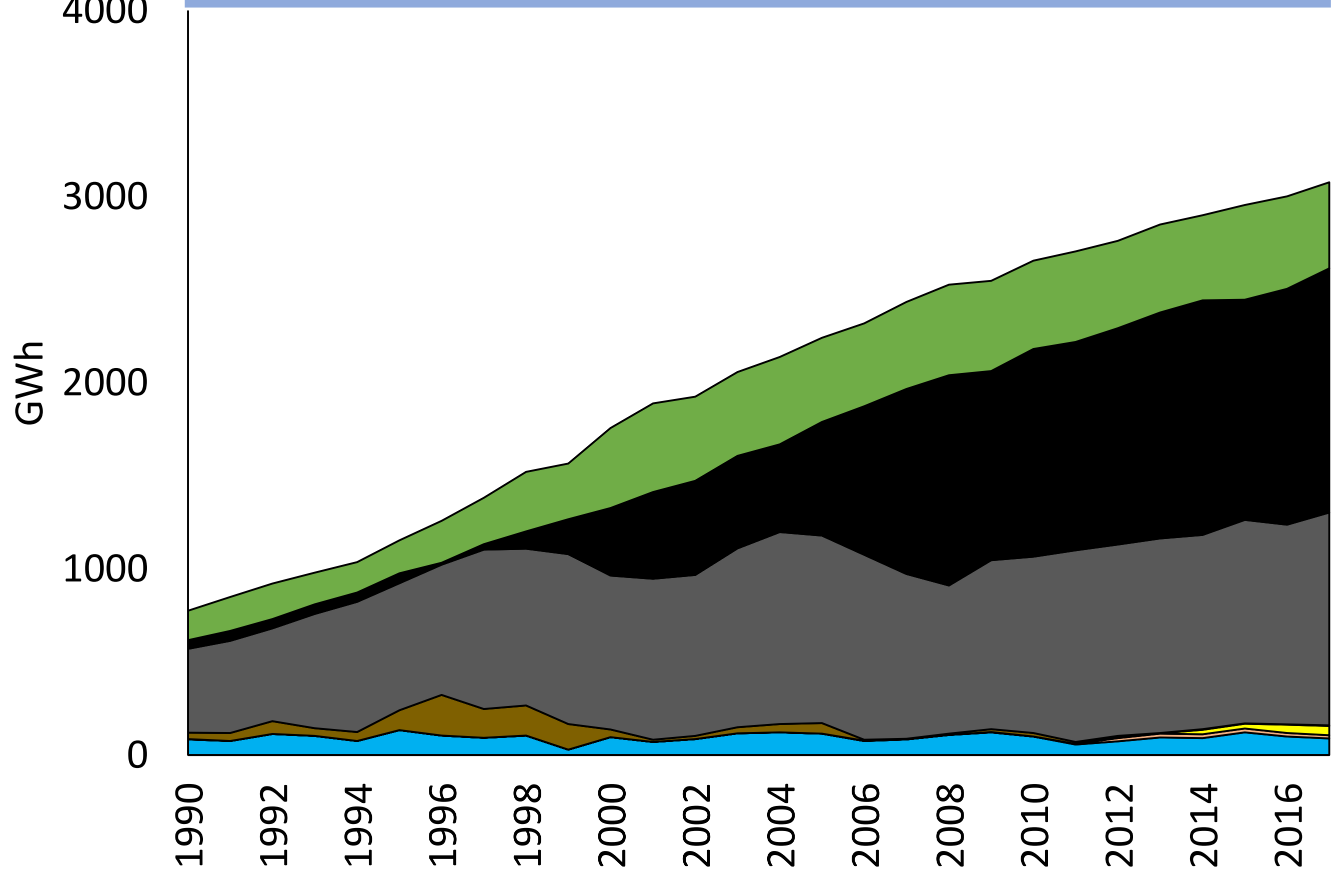
Mitigating climate change through GHG emissions reduction



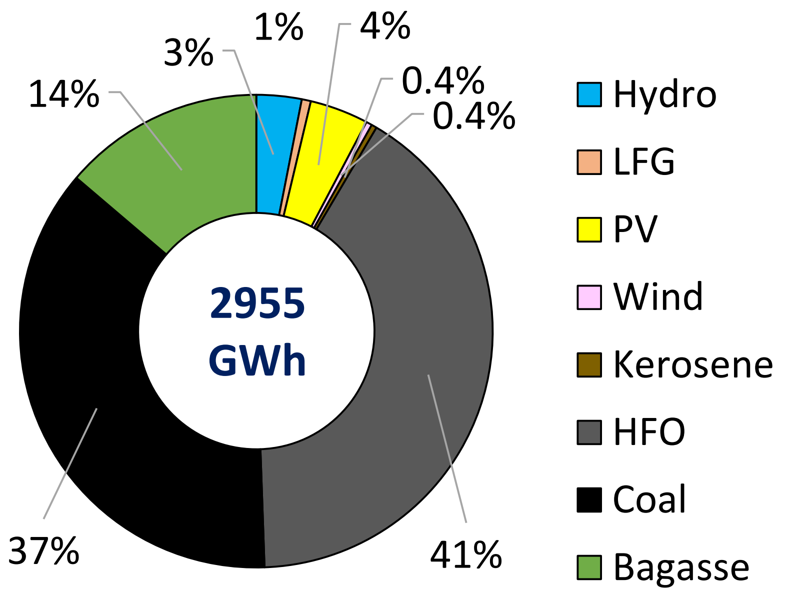
Source: Genave et al. (2020)

Evolution of power generation by source - Mauritius

Power generation (GWh) between 1990 and 2017



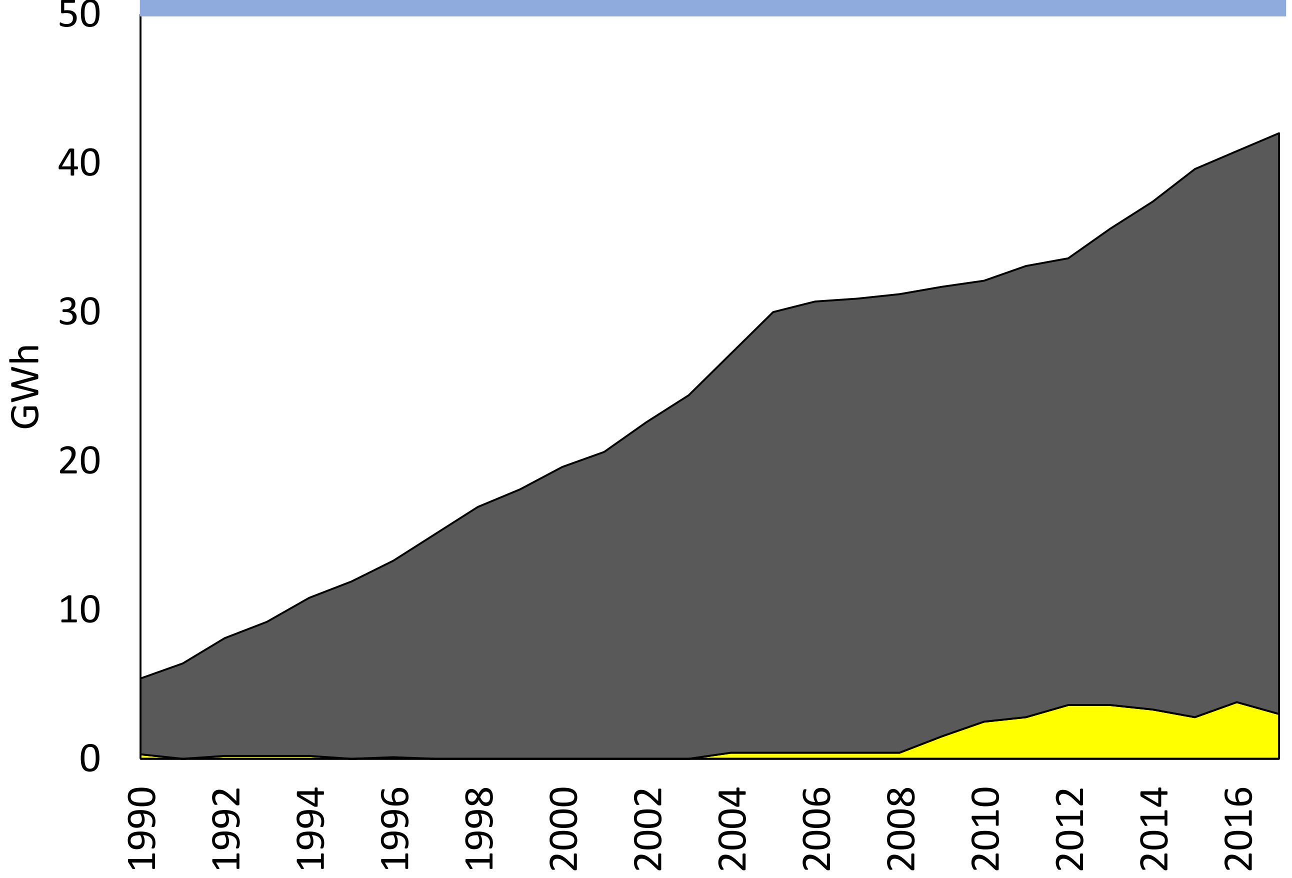
Generation (%) in 2019



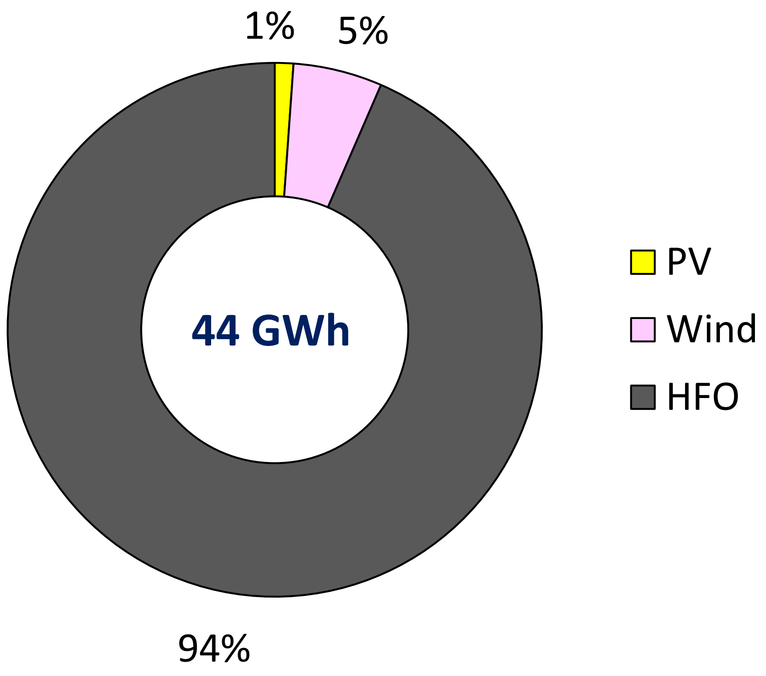
830 MW of installed capacity

Evolution of power generation by source - Rodrigues

Power generation (GWh) between 1990 and 2017

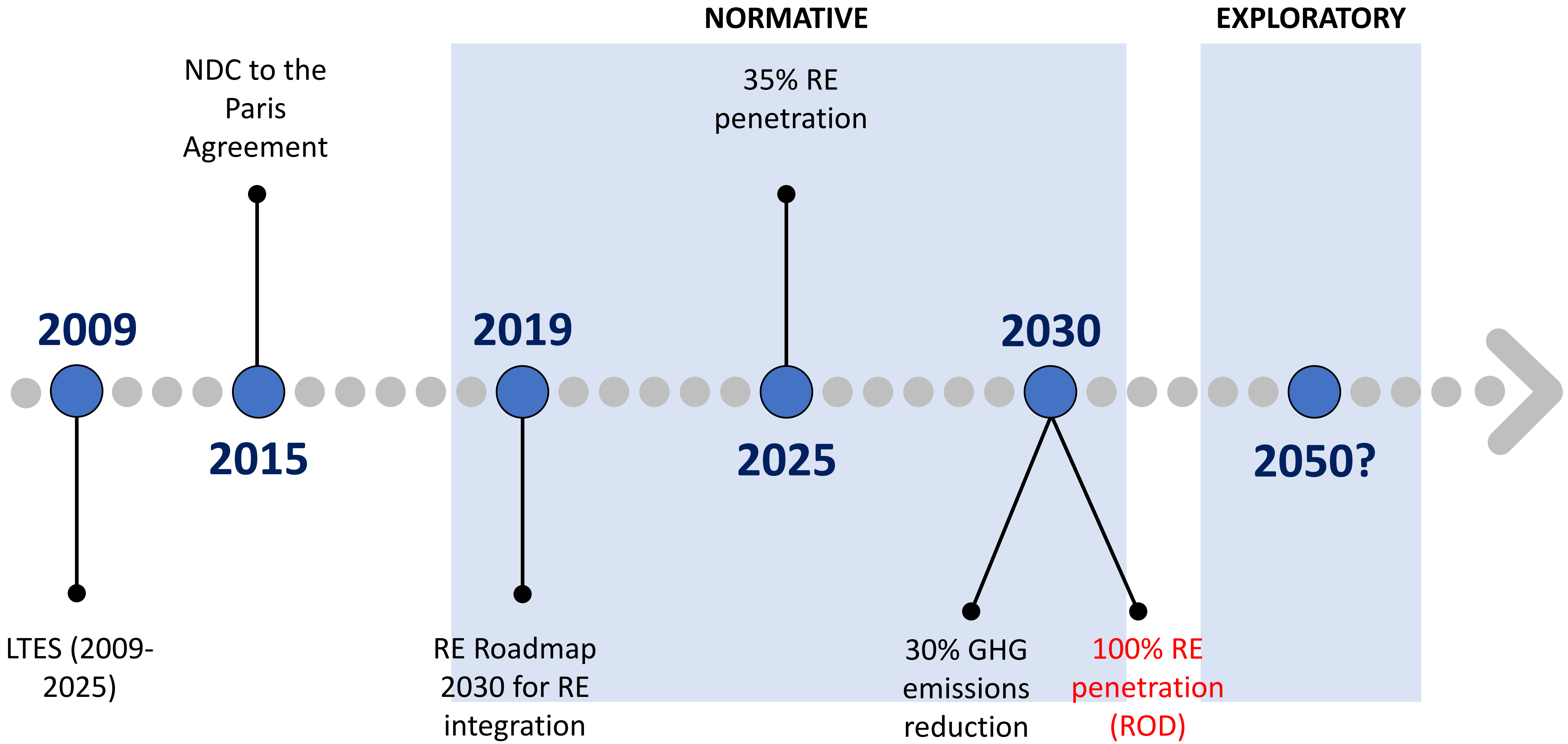


Generation (%) in 2019



14.1 MW of installed capacity

Policy milestones in the RoM



Research question

Which policy target is most likely capable of shaping a secure and sustainable energy future for the two island power systems in the Republic of Mauritius?

Earlier literature

Existing studies on the RoM	
Weisser (2004)	Assess the long-term costs of various electricity generation choices using Discounted Cash Flow analyses based on NPV and LCOE
Shea and Ramgolam (2019)	Identify local renewable resource potential and island specific costs to determine the LCOE of various technologies.
Timmons *et al.* (2019)	Adopt a cost-effectiveness approach to identify the least expensive way to obtain electricity from renewable sources using the OSeMOSYS model
Edoo and Ah-King (2020)	Identify the major technical challenges with respect to achieving 35% RE by 2025, as outlined in the Long-Term Energy Strategy (2009-2025) of the MEPU (2009) using the EnergyPLAN software.

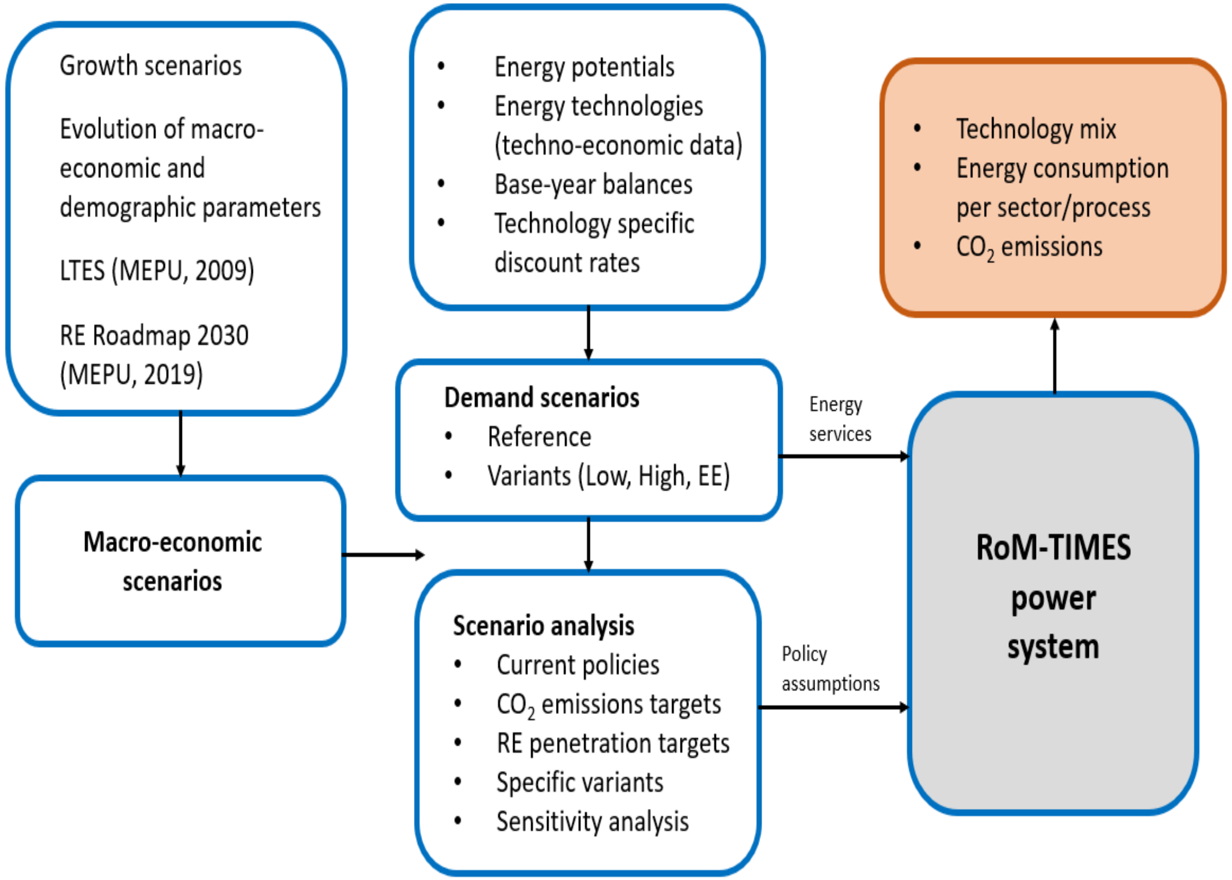
- Solar PV and biomass play a major role in the energy transition
- Storage technologies are seen as enabling technologies

Contributions

- Insights into long-term power system modelling for Rodrigues Island
- Modelling of power sector specificities
  - Supply side
  - Demand side
  - Network density
- Extend the discussion beyond policy milestones to 2050
- Investigate CO_2 emissions trajectories

2. The RoM-TIMES Model

RoM-TIMES model: power-sector scenarios to 2050



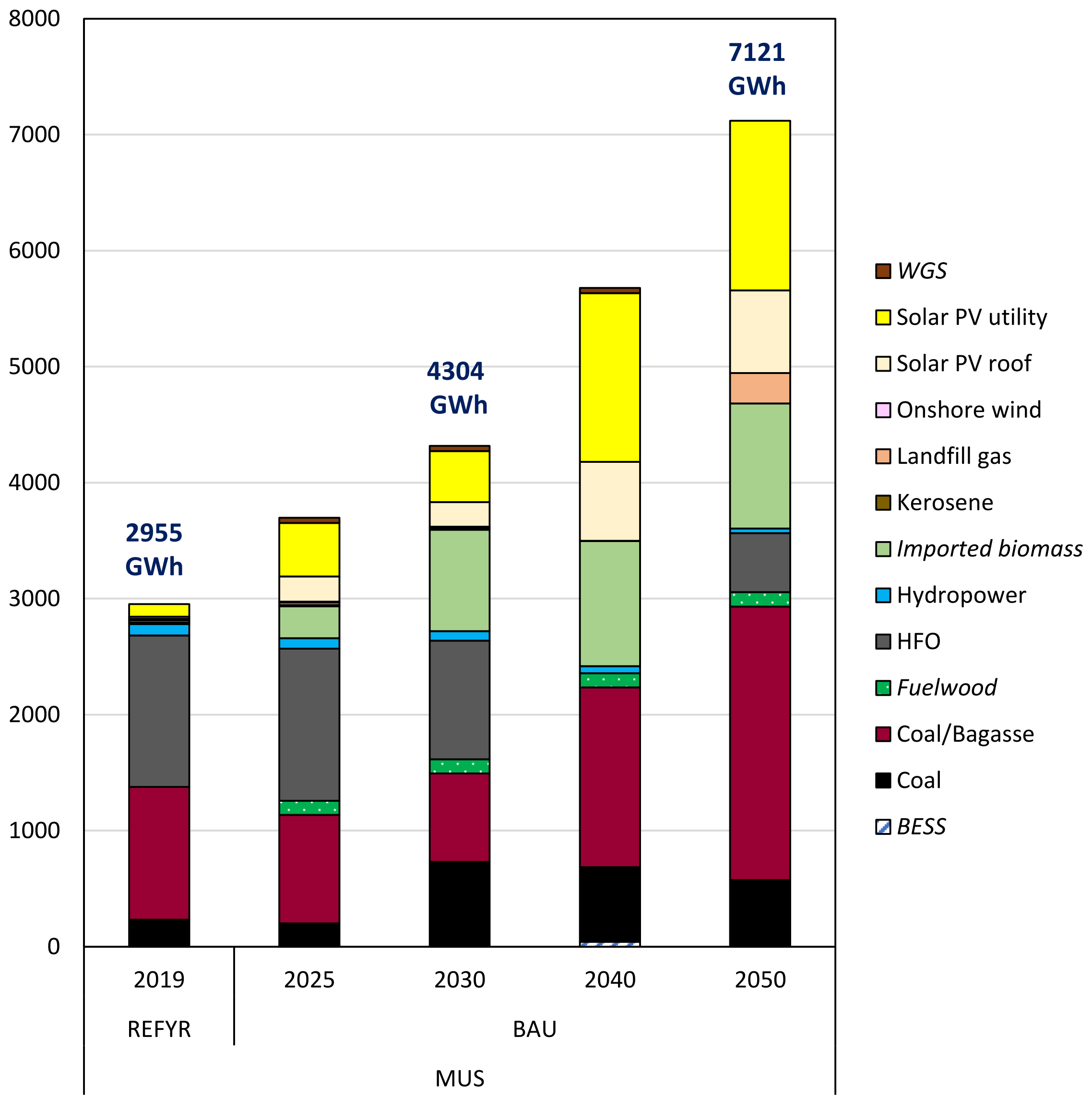
- Two regions - Mauritius (MUS) and Rodrigues (ROD)
- Modelling horizon: 2019-2050
- Granular representation of generating units
- Time slices: 20 for both MUS and ROD
- Electricity demand is exogenous
- Policy focus: LTES (2009-2025) and NDC
- Model discount rate of 8%

Scenarios

BAU	35RE	30GHG
• NDC targets not reached • No policy intervention to correct current trends	• Development of renewables as per RE target **Normative** **Exploratory** • Additional 15 *pp* RE penetration by 2050	• 2030 NDC target achieved • CO_2 emissions growth slow-down **Normative** **Exploratory** • Additional 20 *pp* reduction in CO_2 emissions by 2050

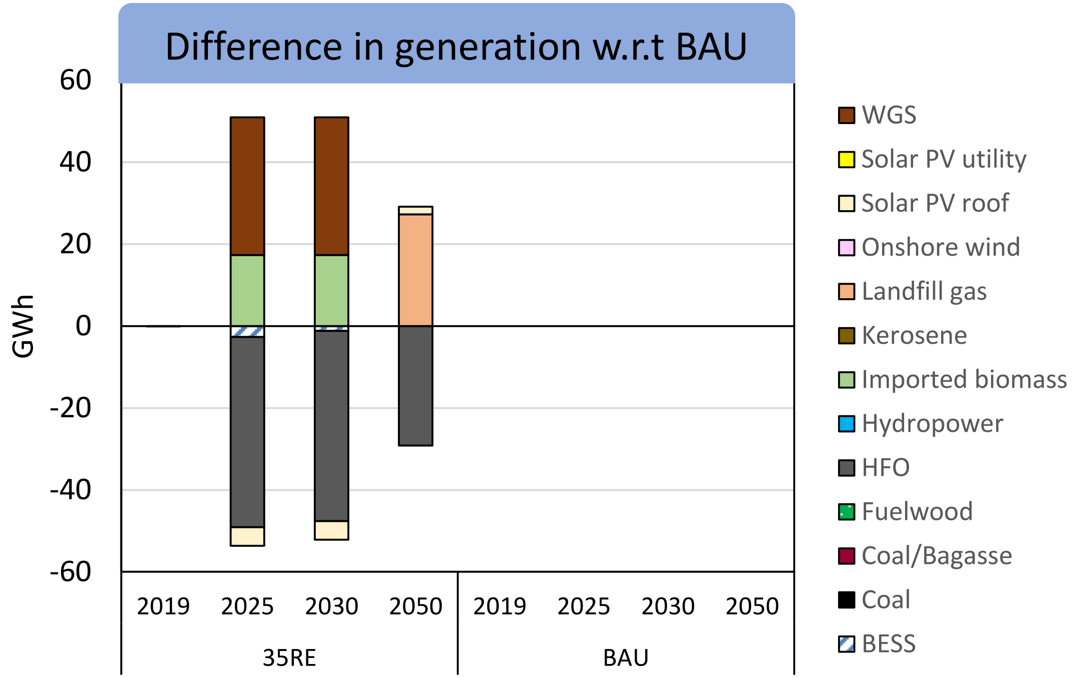
3. Results

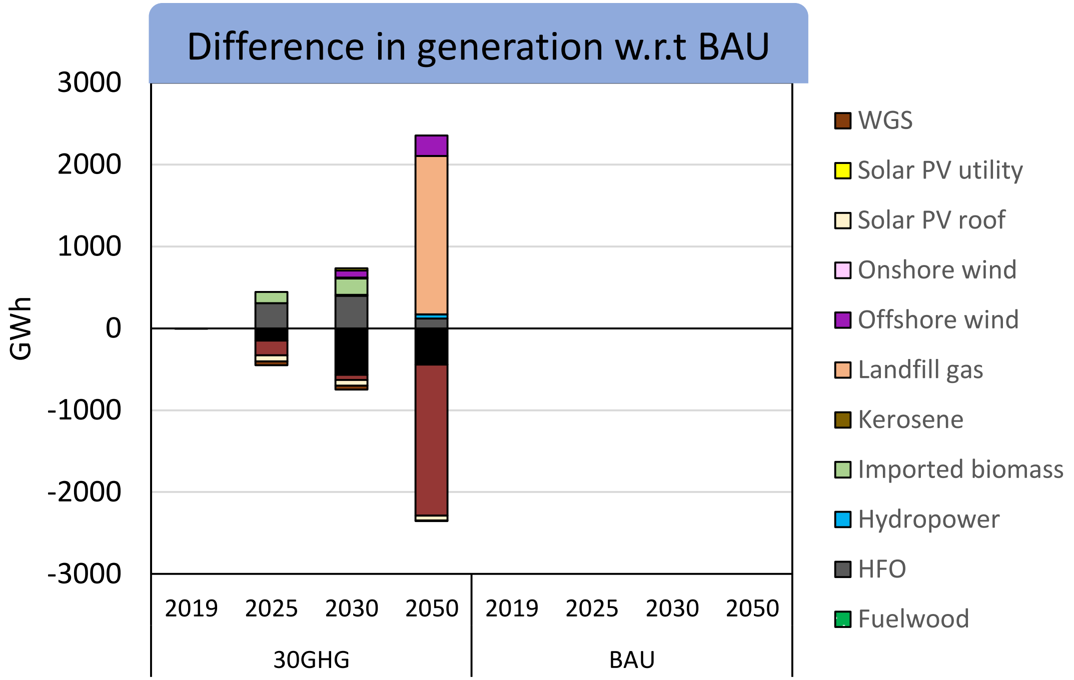
Power generation mix evolution - Mauritius



- BAU naturally integrates RE
- Coal still plays an important role at the end of the modelling horizon
- Fuel switch between HFO and LFG + imported biomass

Power generation mix evolution - Mauritius





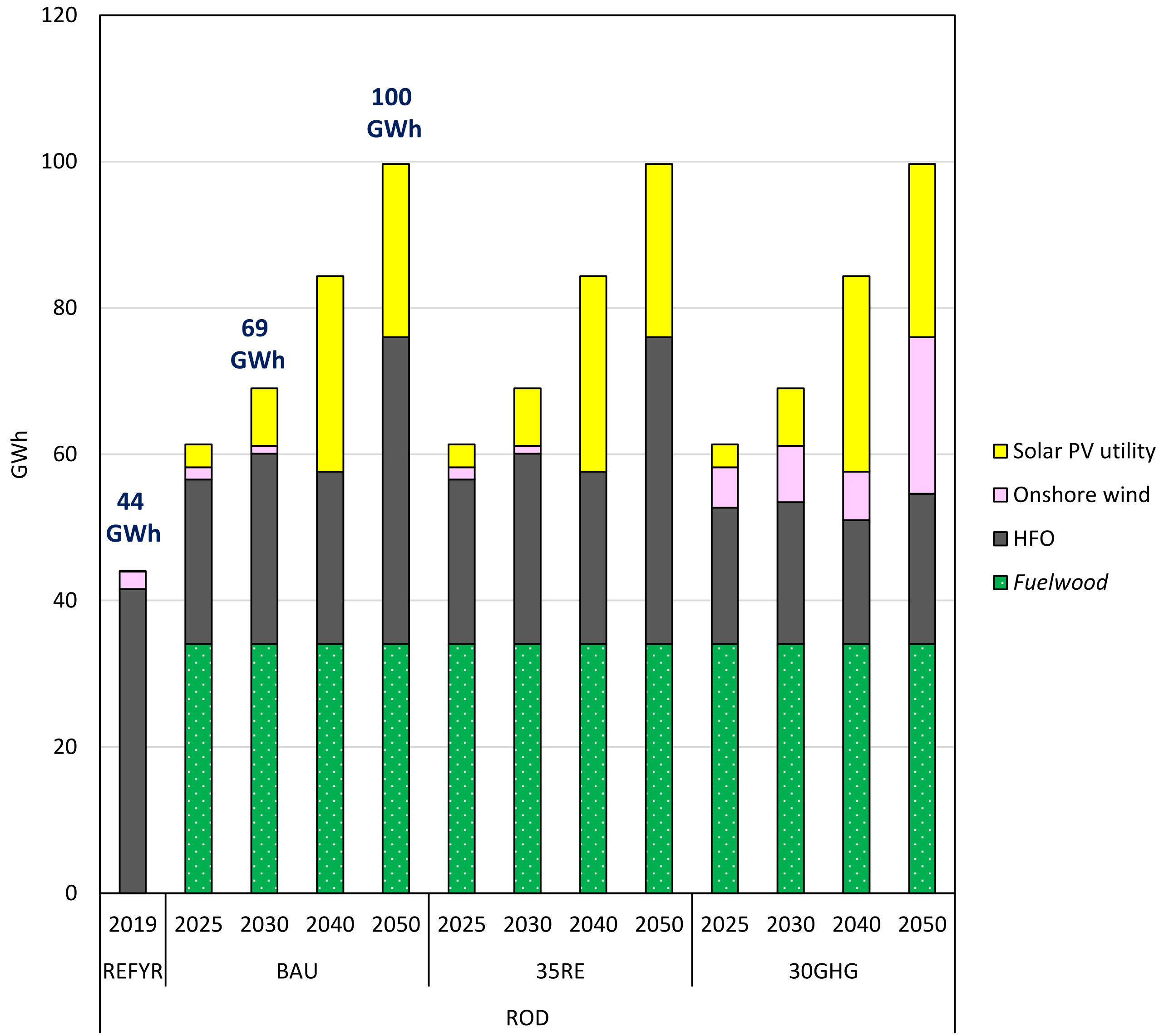
35RE

- Earlier phase-out of HFO to integrate imported biomass and WGS
- More integration of LFG at the end of the horizon

30GHG

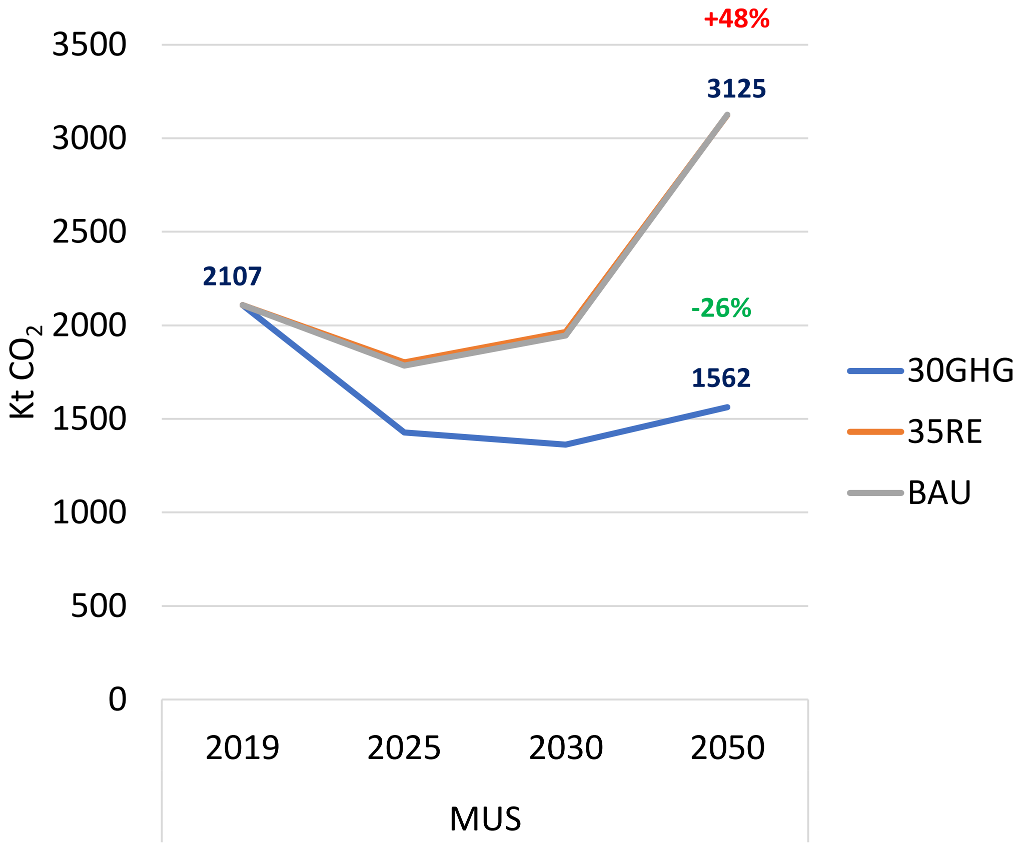
- Deeper cuts in fossil production than in the 35RE scenario
- Coal production is replaced by more renewable (LFG and offshore)

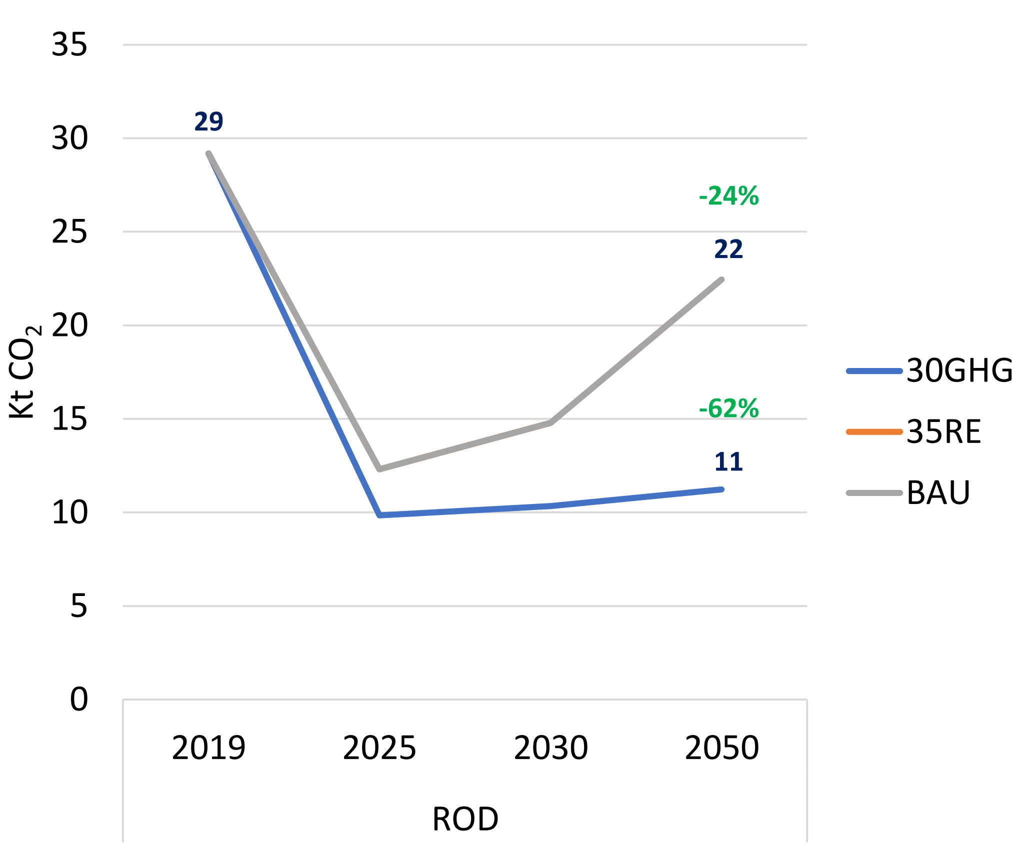
Power generation mix evolution - Rodrigues



- BAU naturally integrates RE thanks to fuelwood and solar PV
- Fuelwood plays an important role in replacing HFO
- Fuel switching between HFO and onshore wind to achieve emissions reduction targets
- 45% VRE penetration at the end of the modelling horizon in 30GHG

CO_2 emissions trajectories



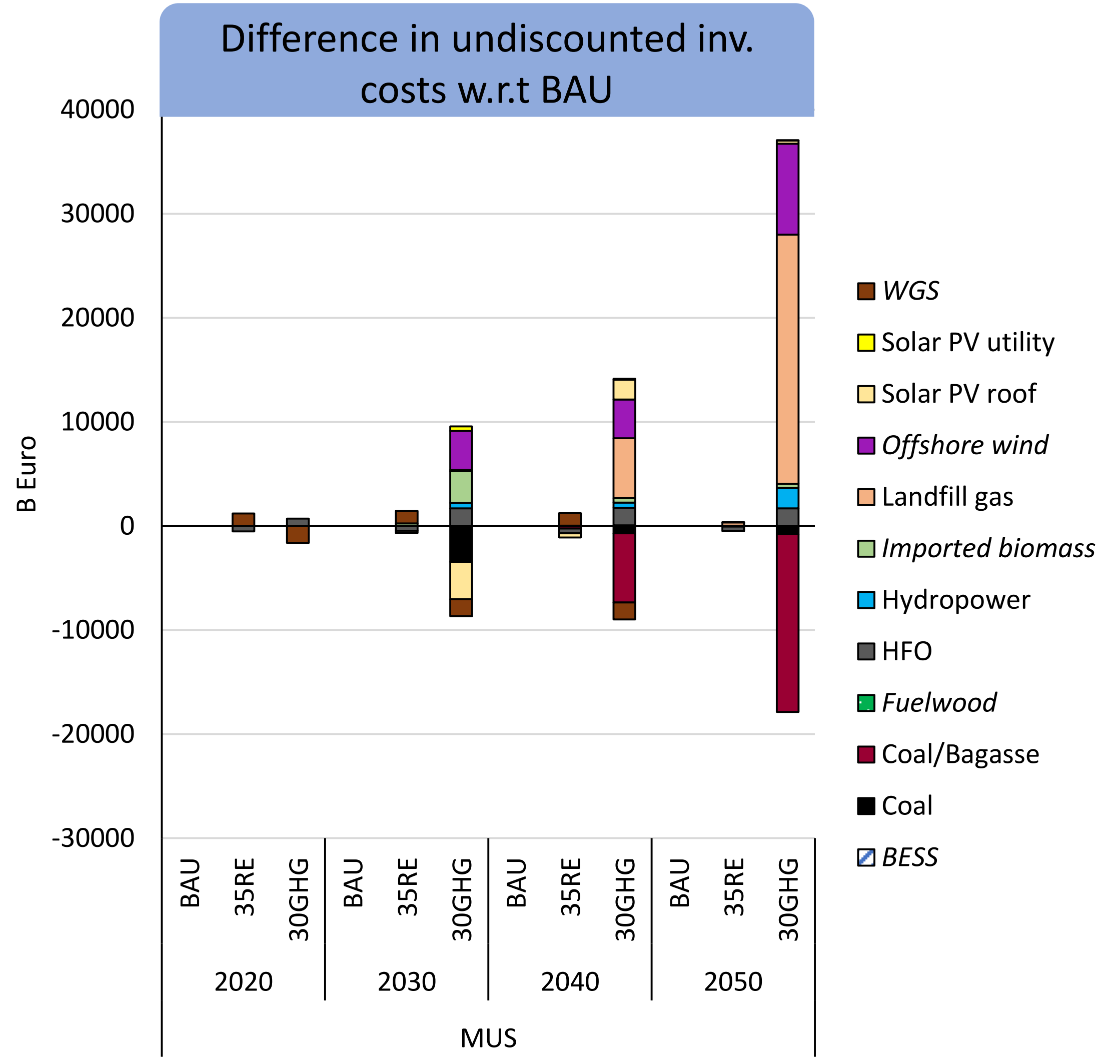


RE targets not compatible with NDC pledges of the RoM

30GHG results in more stringent emissions reduction

Economic impacts - Mauritius

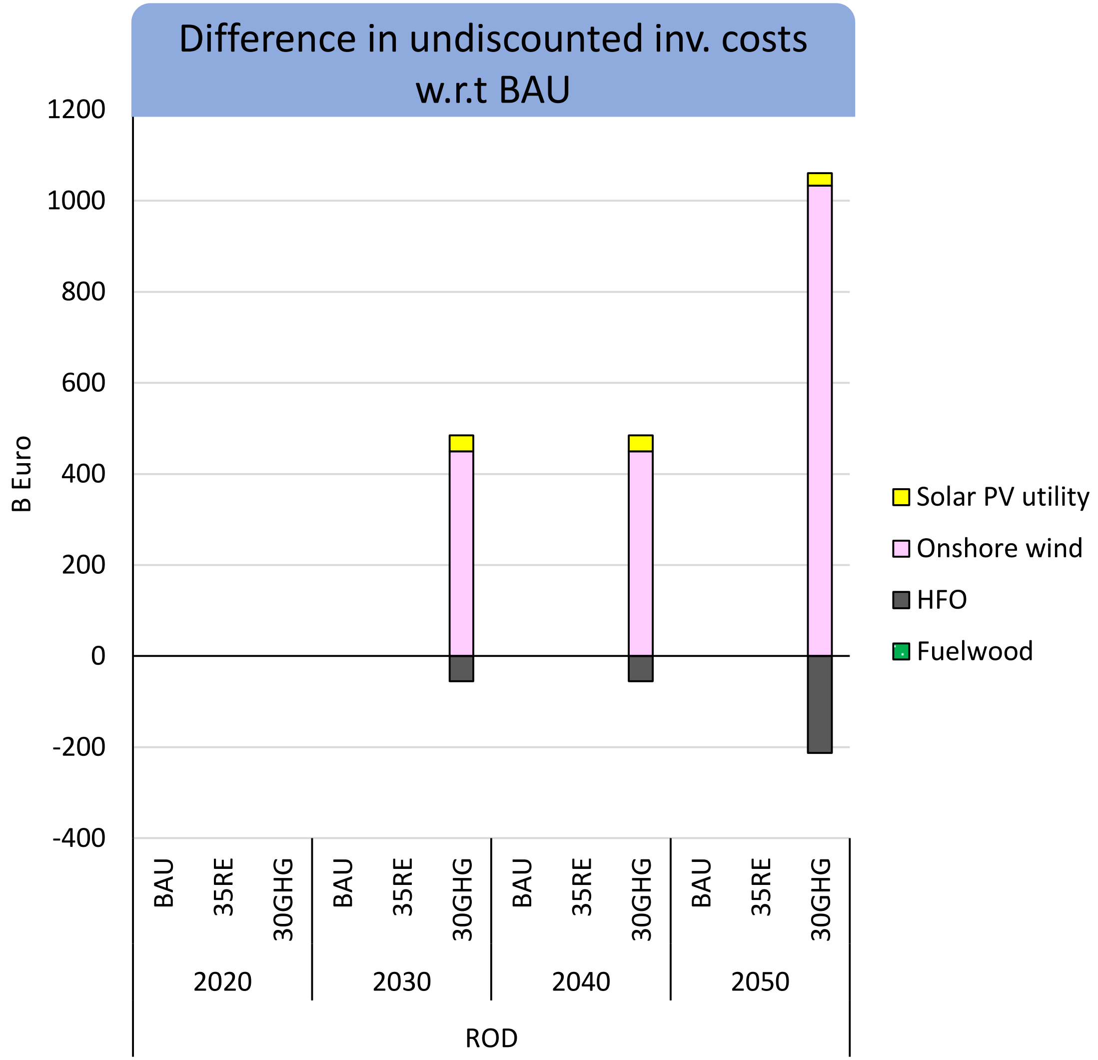
NPV (B Euro)			
Region	BAU	35RE	30GHG
MUS	3606	-	+6%
ROD	77	-	+3.5%



- 30GHG scenario is sensibly more capital-intensive than BAU due to the deployment of LFG and offshore wind

Economic impacts - Rodrigues

NPV (B Euro)			
Region	BAU	35RE	30GHG
MUS	3606	-	+6%
ROD	77	-	+3.5%



- Investment requirements in BAU and 35RE similar
- 30GHG scenario is substantially more capital-intensive than BAU due to the deployment of onshore wind turbines

4. Conclusion

Concluding remarks

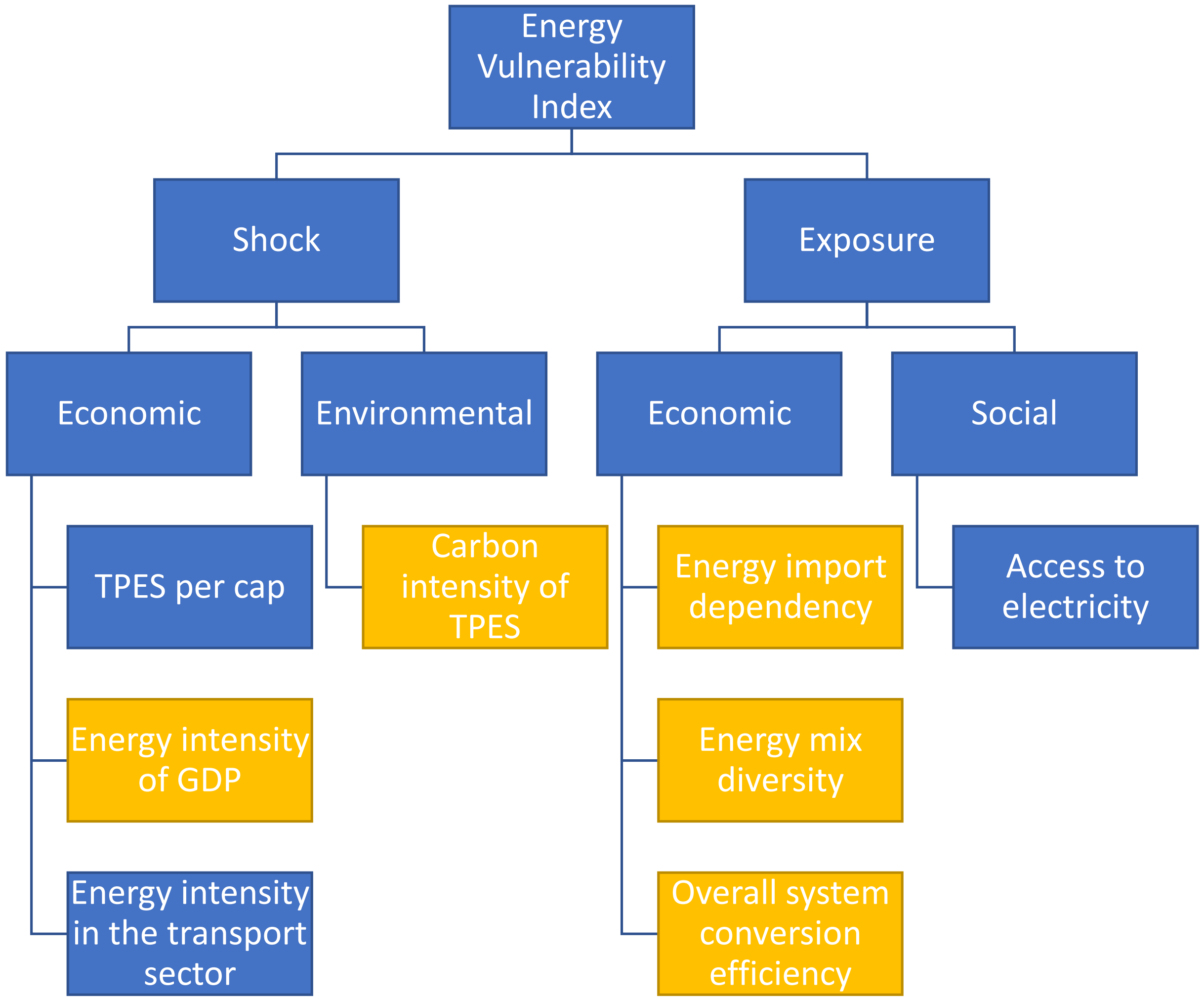
- RE targets are not compatible with the RoM’s commitment to the Paris Agreement (could be revised upwards)
- Solar PV, biomass, LFG and wind are critical energy technologies for the clean energy transition in the RoM
- Emissions reduction targets require more capital-intensive investments
- The RoM should focus on CO_2 emissions reduction efforts and design adequate policy packages for climate mitigation

What's next? (1)

Comprehensive sensitivity analysis on key parameters to deal with uncertainty

- Price of fossil fuels
- Biomass potential → land usage, non-CO_2 emissions
- Technology specific rates + SDR
- Electricity demand scenario variants (HIGH and EE)

What's next? (2)



The role of energy transition in energy vulnerability mitigation?

- ↓ CO_2 emissions
- ↓ fossil imports
- More diversified mix
- More efficient system

Thank you for your attention!

Any questions?

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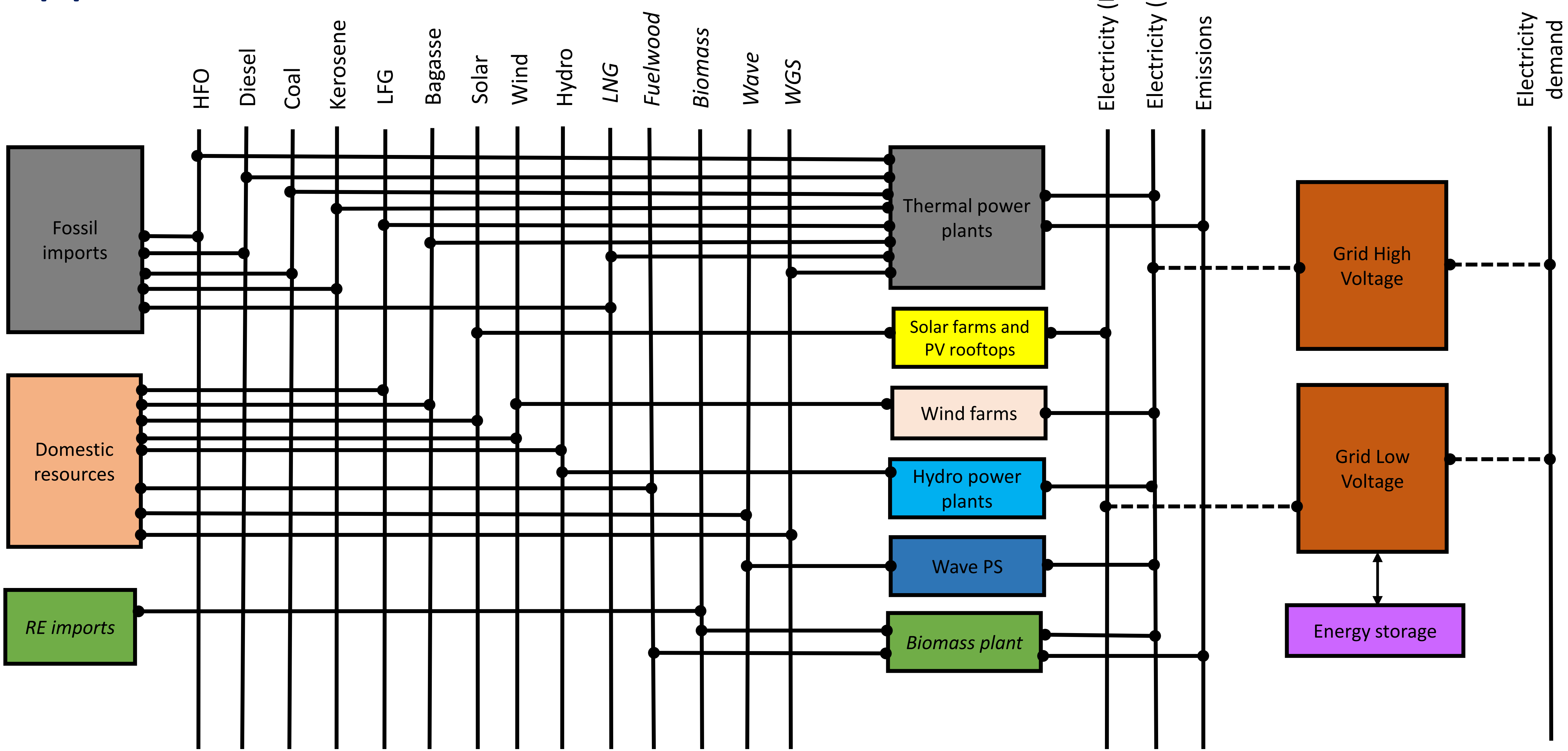
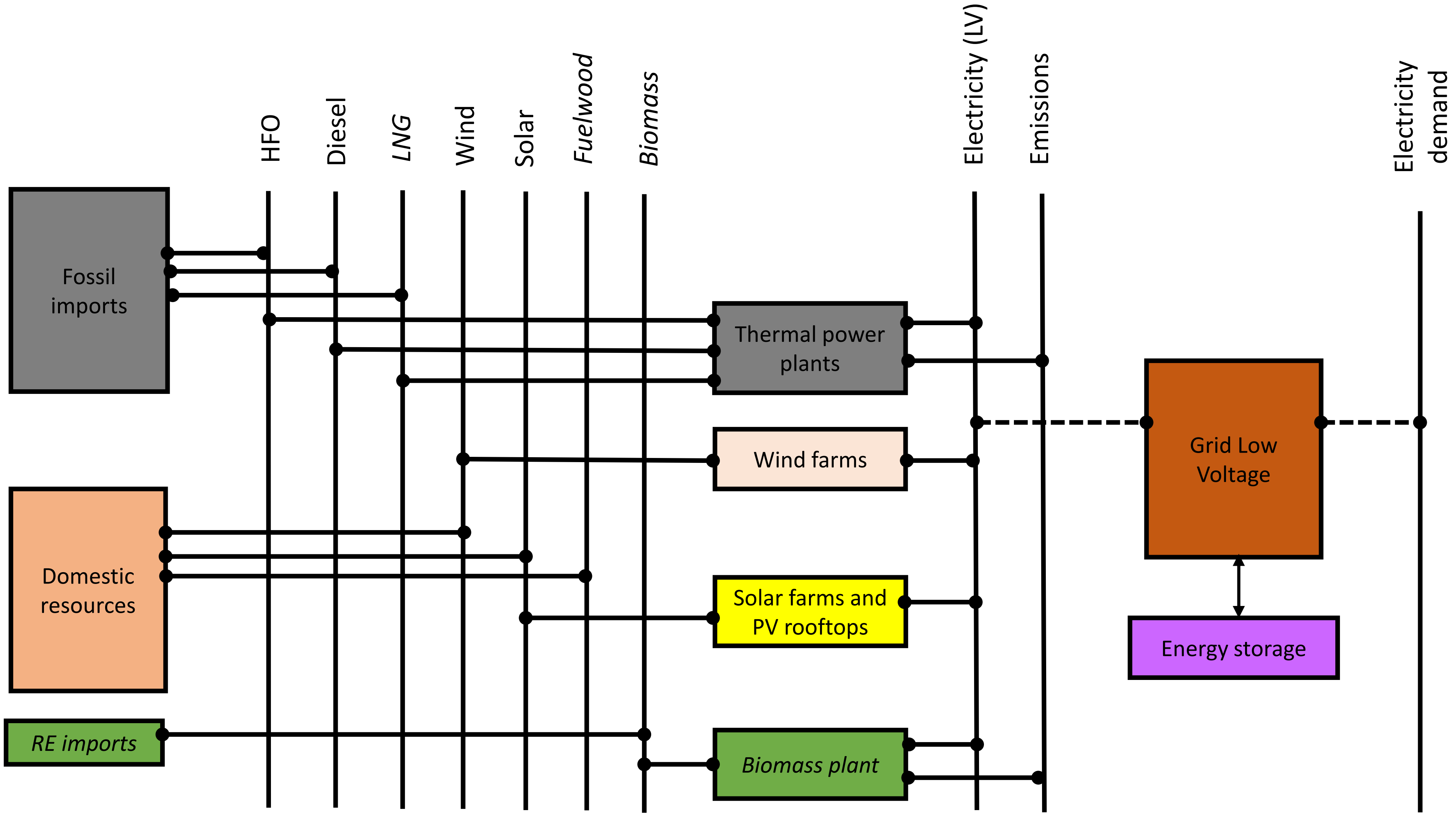
Appendices

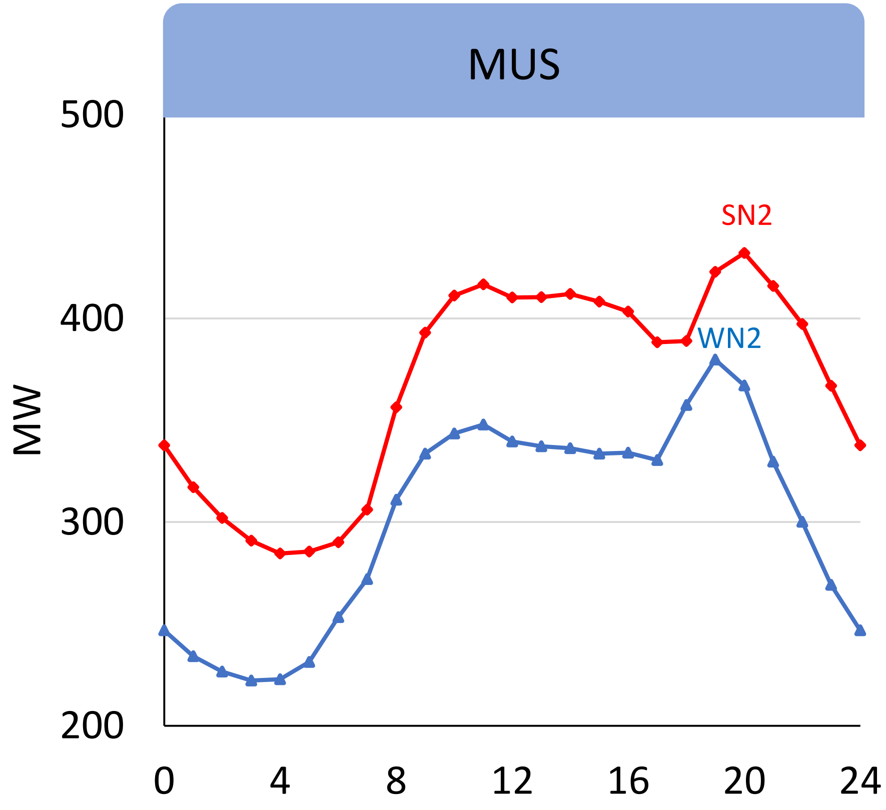
Appendix A.1: RES-MUS

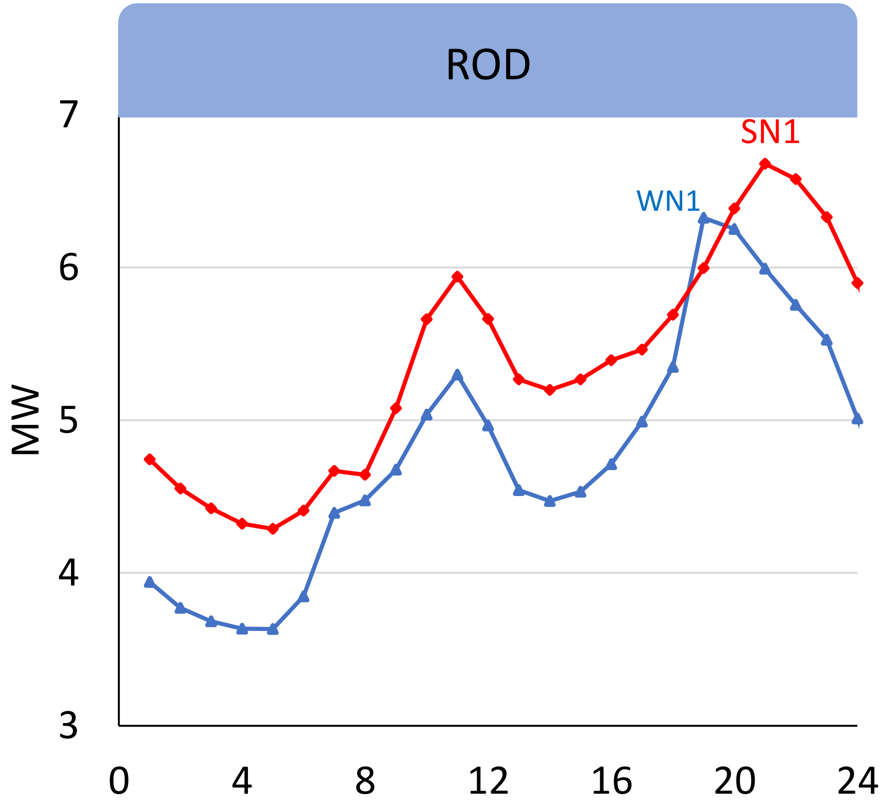


Appendix A.2: RES-ROD



Appendix B: Load profiles





Appendix C: Techno-economic parameters

Techno-economic parameters in the RoM-TIMES									
Energy source	Life	AFA	EFF		CAPEX (k€/MW)		OPEX (k€/TJ)		Import price/Extraction cost (k€/TJ)
			Existing	New	2030	2050	Fixed	Variable	
Hydro	50	[0.13 - 0.39]	1	1	4807.08	3605.31	[50.28 – 62.85]	0	-
Solar PV Roof	25	[0.10 - 0.18]	1	1	1881.44	496.7	5.42	0	-
Solar PV Utility	25	[0.13 – 0.21]	1	1	1188.17	313.68	10.84	0	-
Wave	20	0.29	-	1	4451	3115.70	178.04	0	-
Wind Onshore	20	[0.14 – 0.22]	1	1	2134.7	1183.48	52.97	0	-
Wind Offshore	20	0.5	1	1	4005.90	2220.87	214.63	0	-
Landfill gas	13	0.66	0.33	0.4	1503.55	845.75	271.51	0	-
WGS	28	0.79	-	0.25	5875.32	3304.87	235.9	3.56	-
Coal	33	0.82	0.26	0.31	1585.45	-	62.35	4.46	0.00127
HFO	33	[0.30 - 0.54]	0.44	0.53	1924.61	-	67.21	15.04	0.01409
LNG	25	0.5	-	0.4	1090.90	531.81	19.95	23.96	0.000018
Coal/bagasse	33	[0.54 - 0.68]	0.26/0.24	0.31/0.28	1554.29	-	62.95	4.46	-
Kerosene	25	0.02	0.26	-	-	-	6.70	0.47	0.02248
BESS	15	0.25	-	0.94	771.36	289.76	2.05	0	-
Fuelwood	33	0.5	-	0.4	1650	928.13	41.69	0.12	0.00000
Imported biomass	33	0.5	-	0.4	1650	928.13	41.69	0.12	0.00025

Appendix D: Capacity installations - Mauritius