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## Sustainable energy and climate mitigation pathways in the Republic of Mauritius

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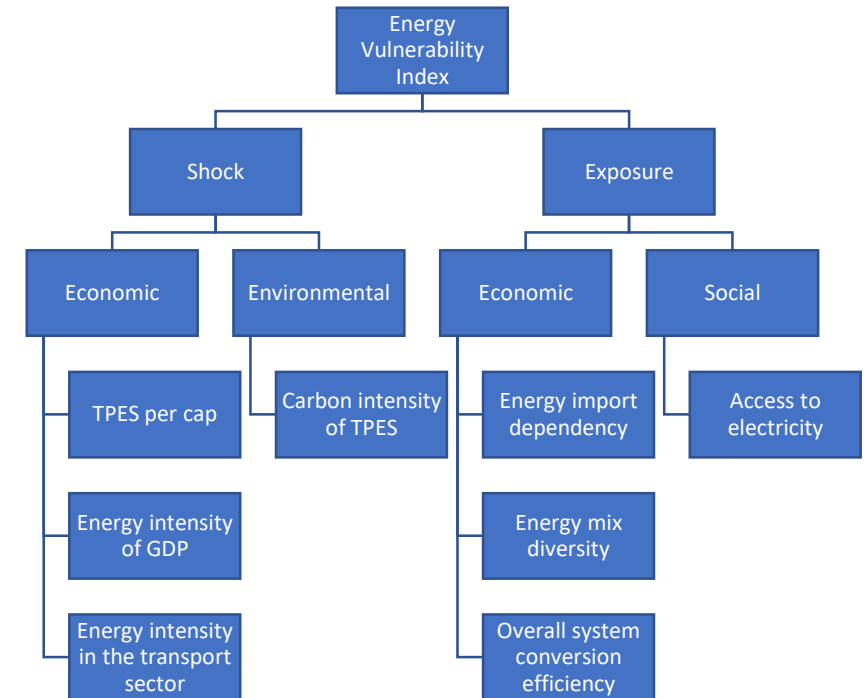
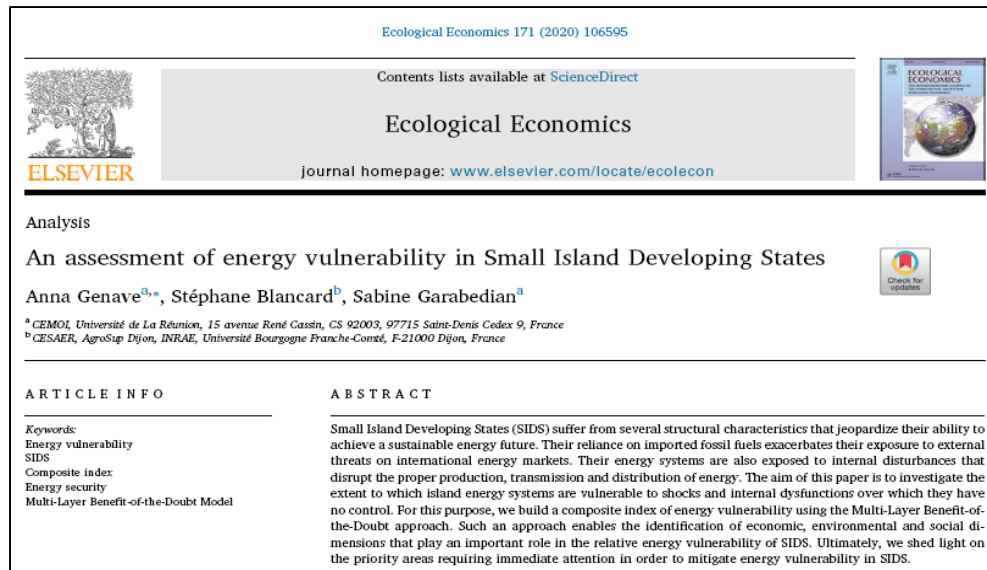
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# 1. Background

# What motivated this study?



Source: Genave et al. (2020)

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

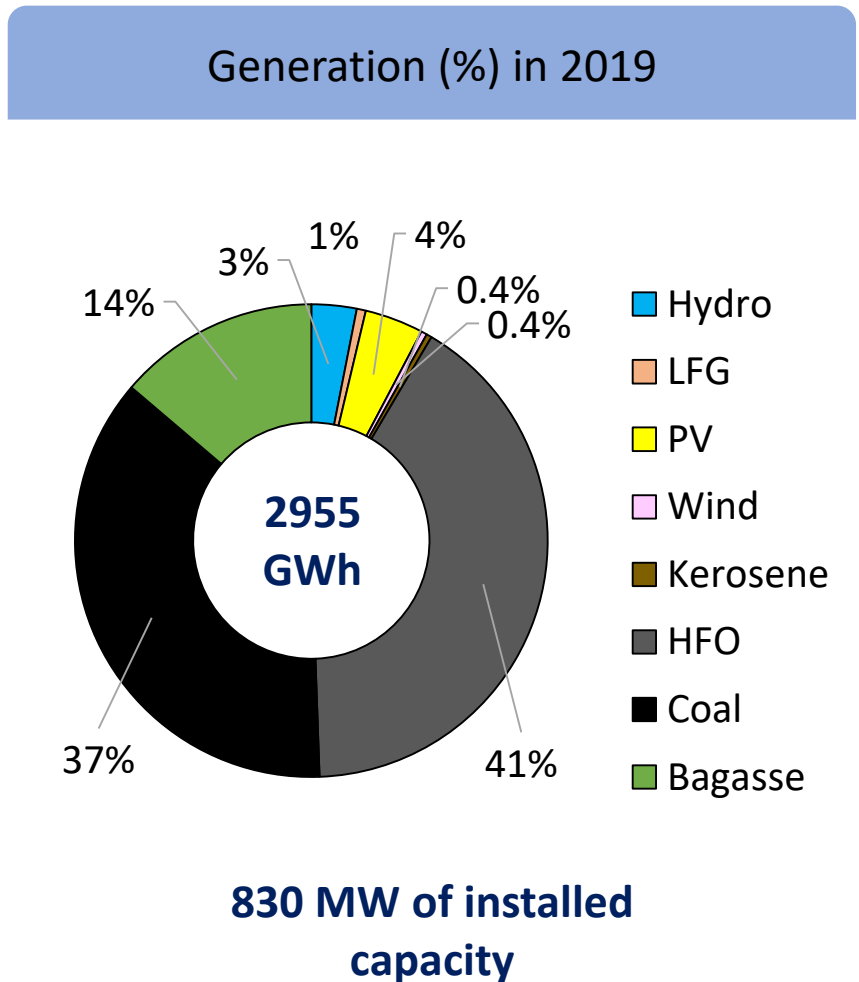
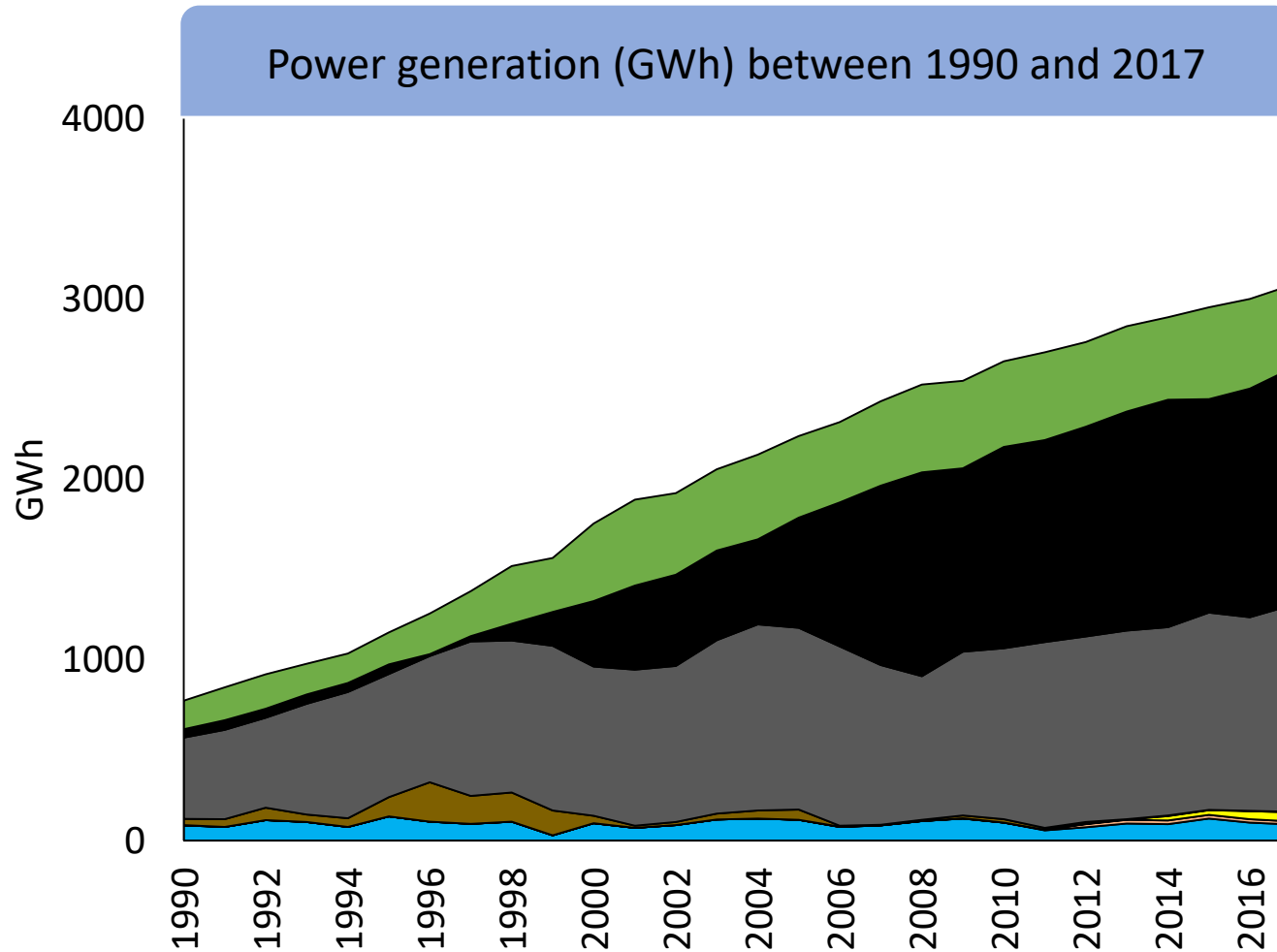


**Mitigating vulnerability** to energy system external shocks and internal disturbances

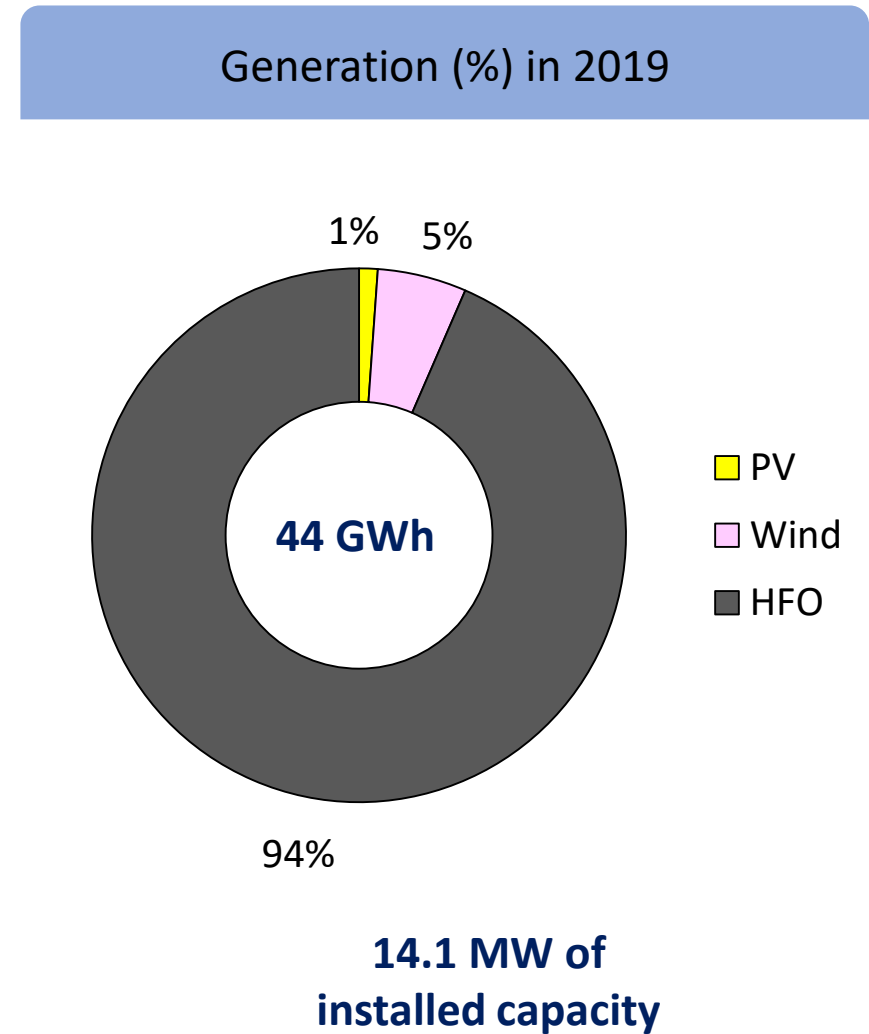
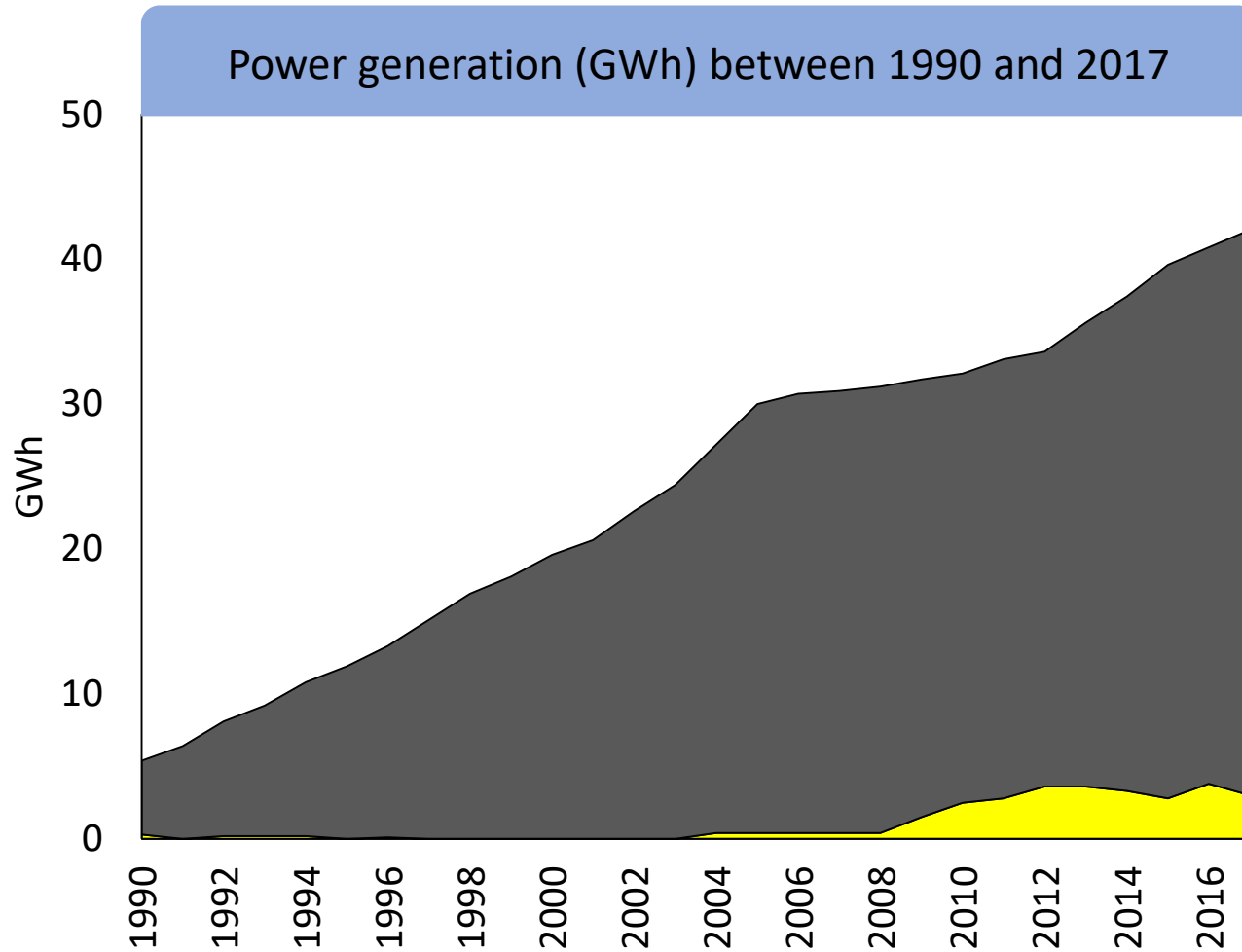
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**Mitigating climate change** through GHG emissions reduction

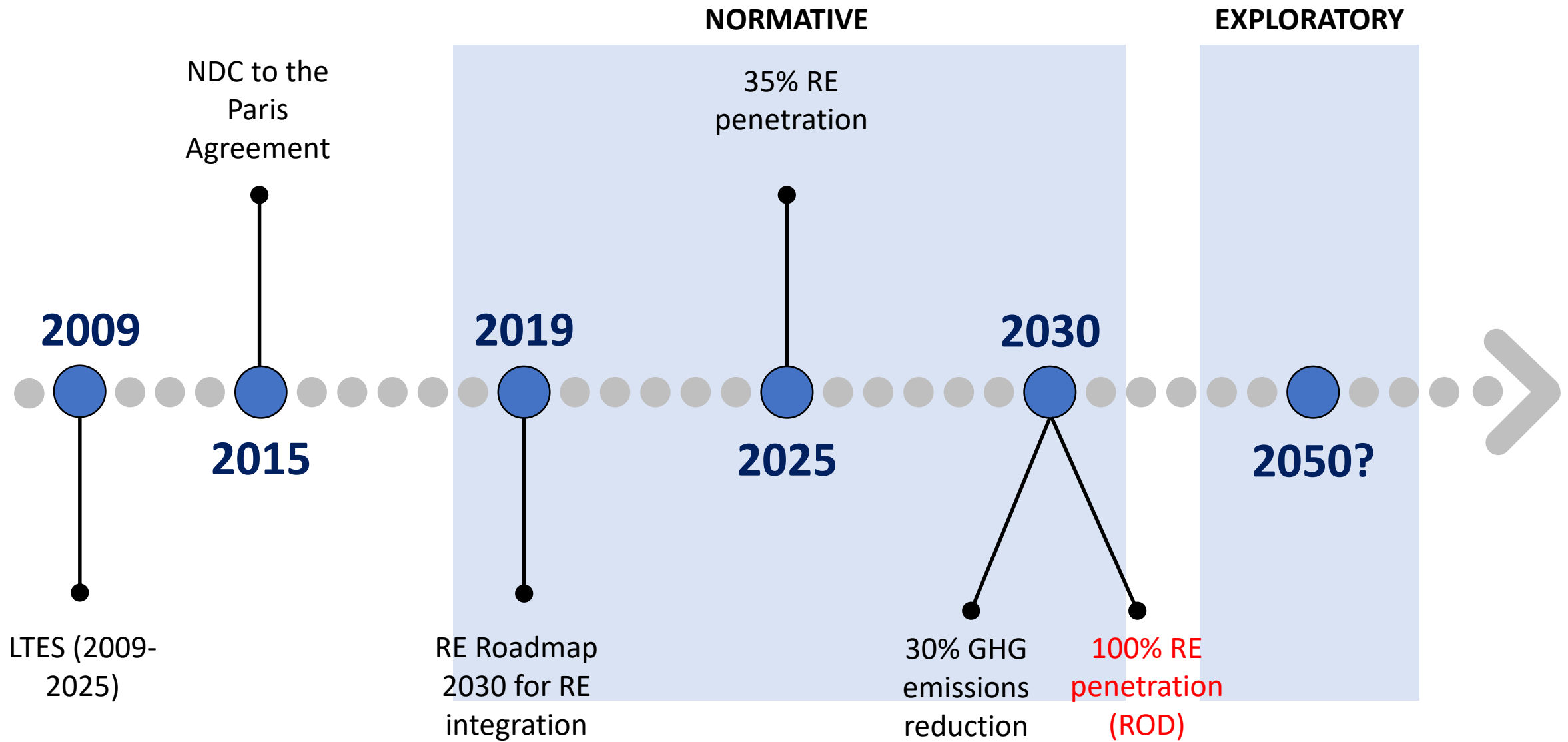
# Evolution of power generation by source - Mauritius



# Evolution of power generation by source - Rodrigues



# 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 <i>et al.</i> (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

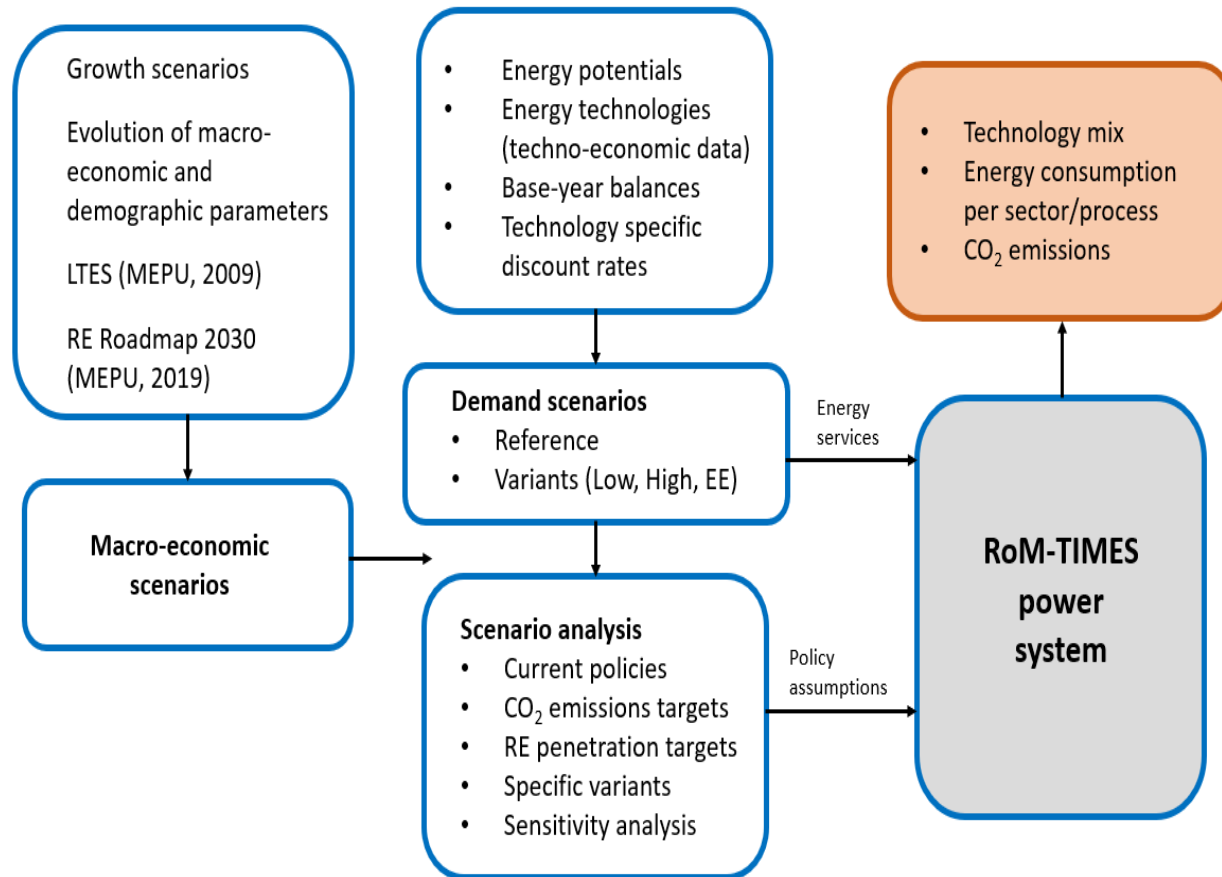


# Contributions

- 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<sub>2</sub> 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

- NDC targets not reached
- No policy intervention to correct current trends

## 35RE

- Development of renewables as per RE target

Normative

Exploratory

- Additional 15% points RE penetration by 2050

## 30GHG

- 2030 NDC target achieved
- CO<sub>2</sub> emissions growth slow-down

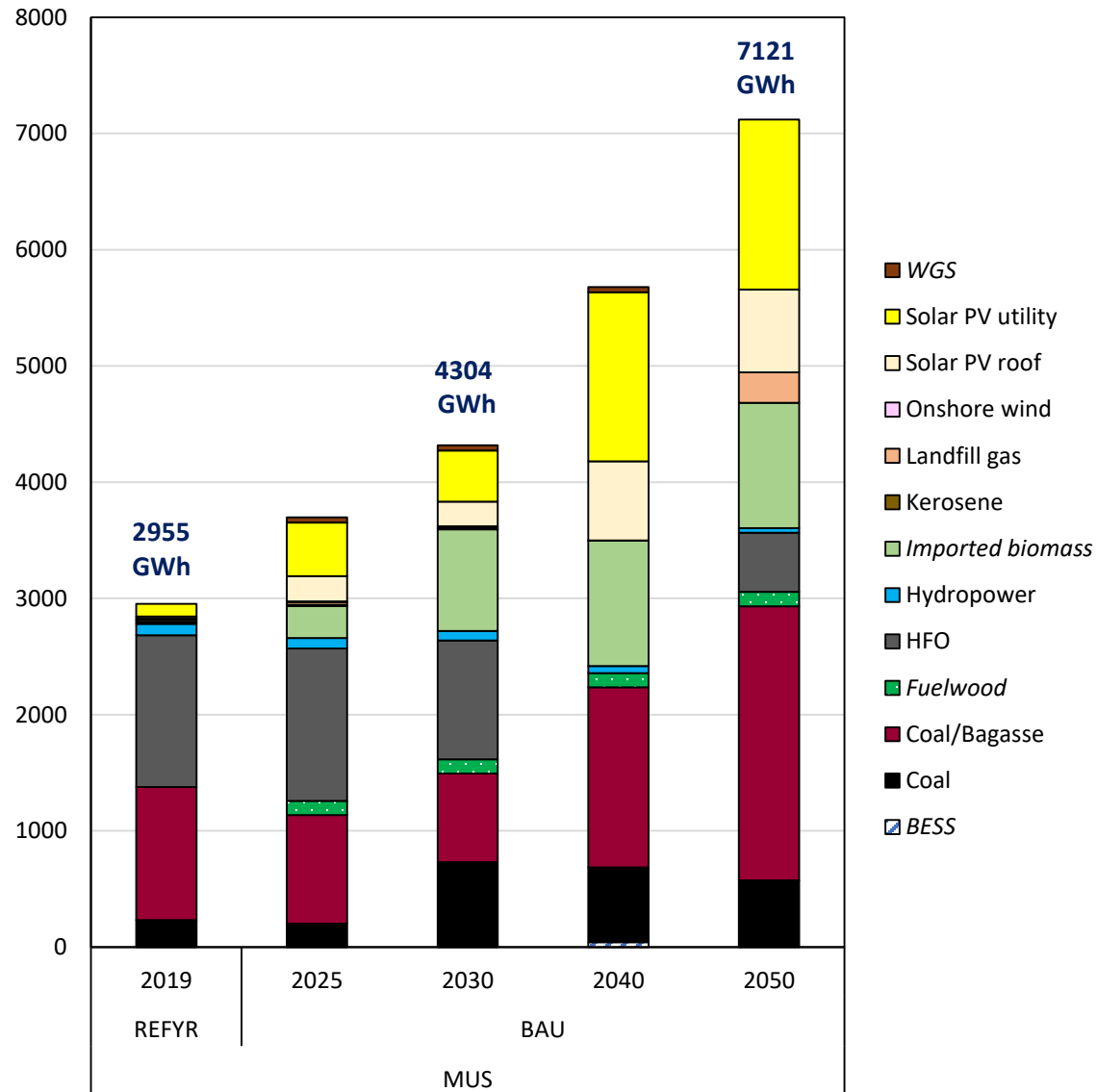
Normative

Exploratory

- Additional 20% points reduction in CO<sub>2</sub> emissions by 2050

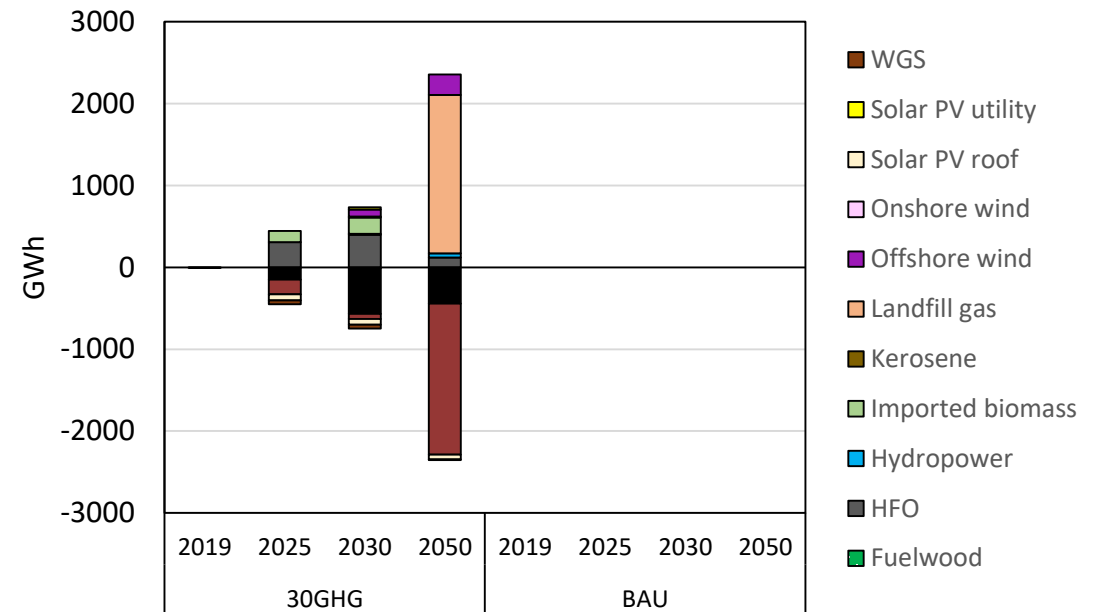
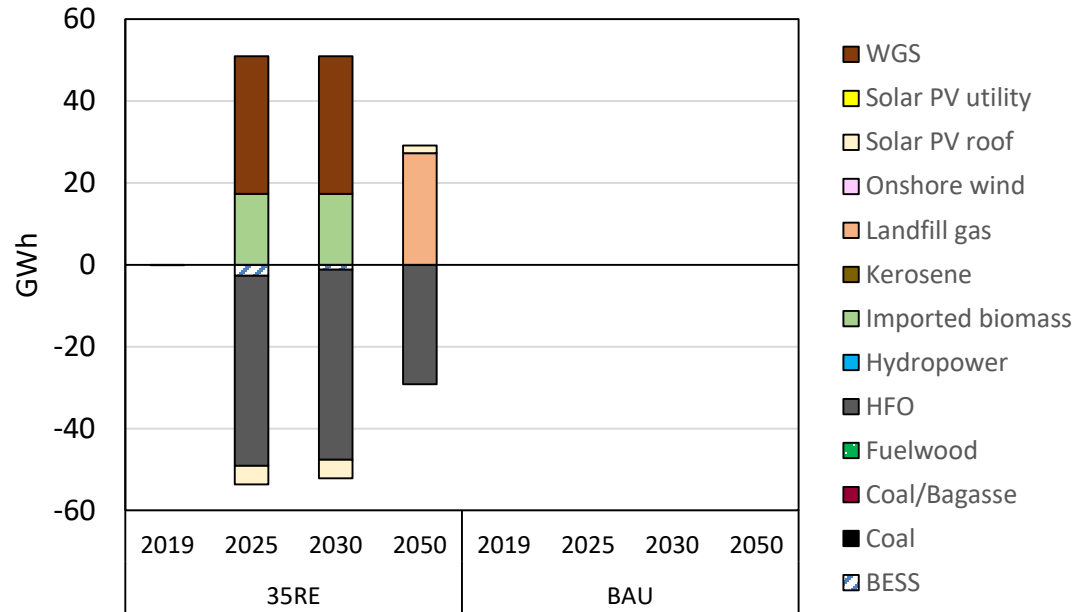
# 3. Results

# 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



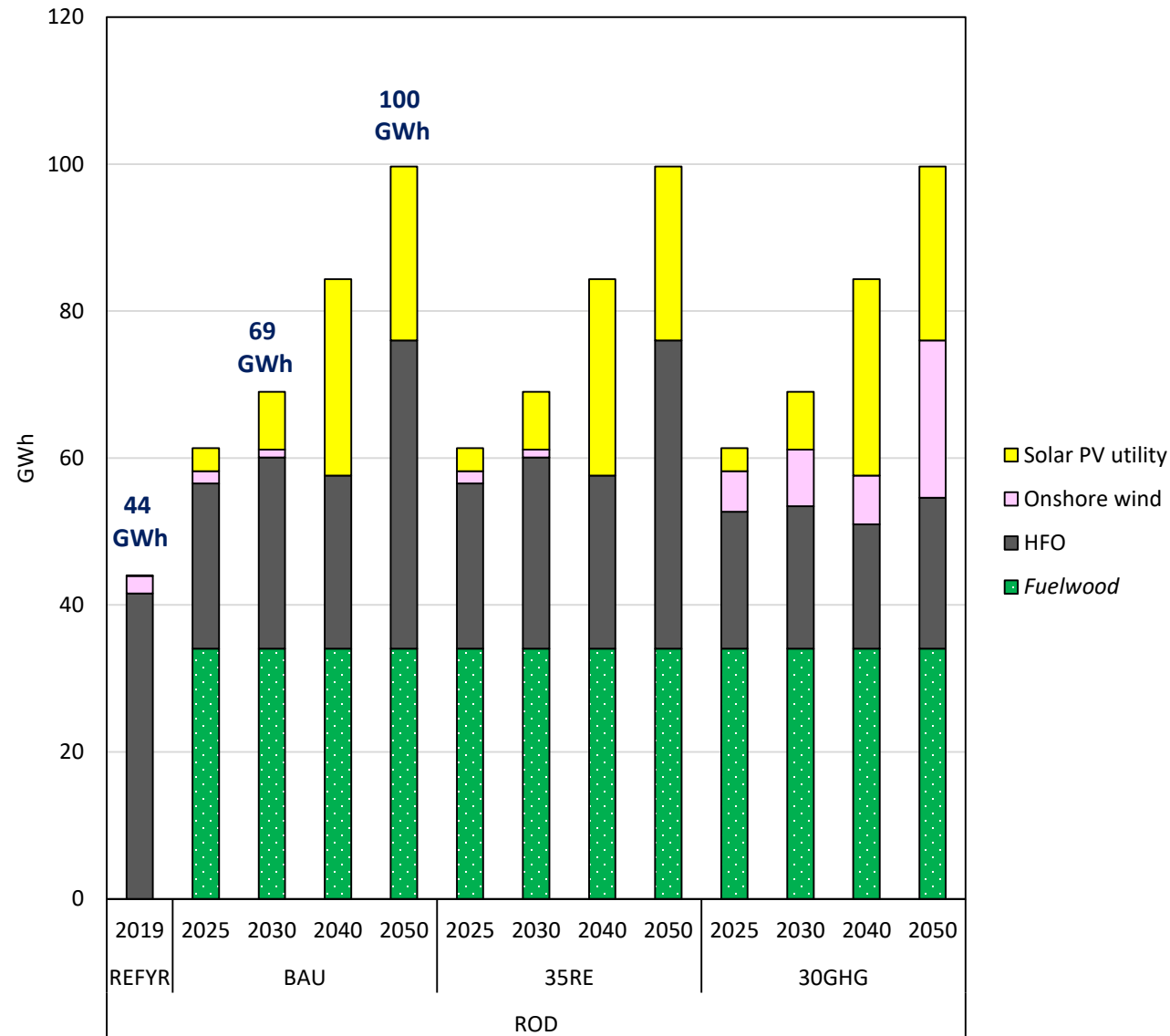
## 35 RE VS BAU

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

## 30GHG VS BAU

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

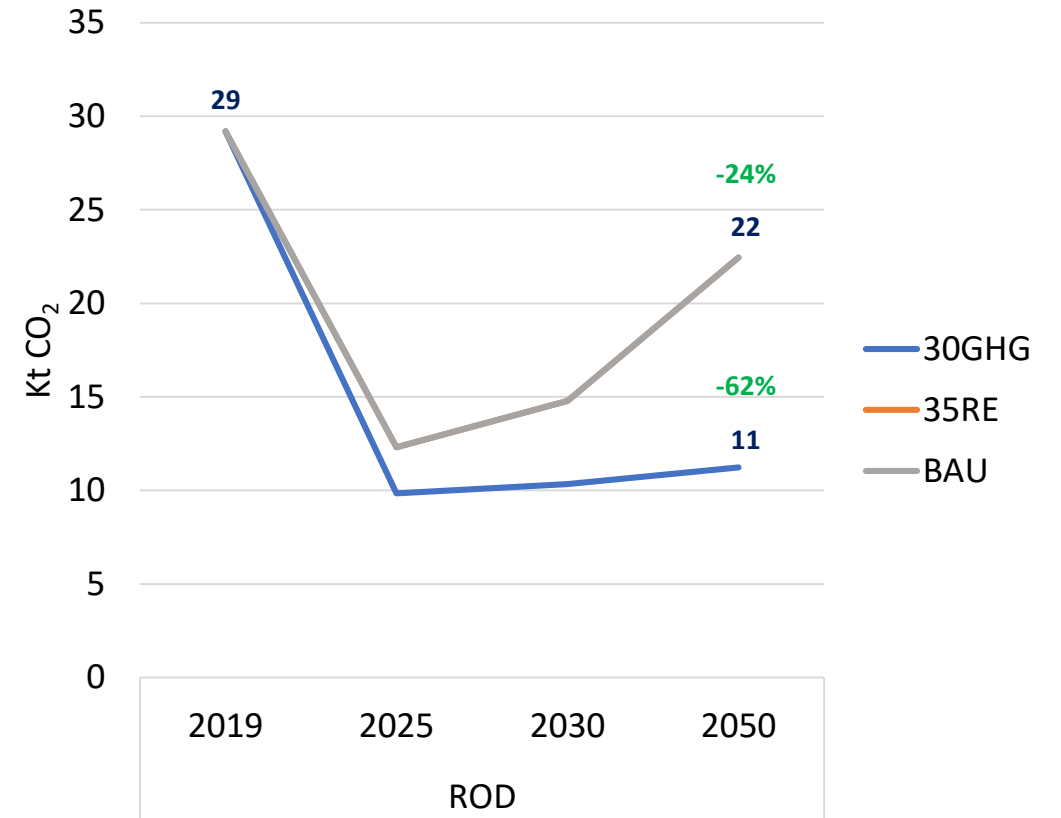
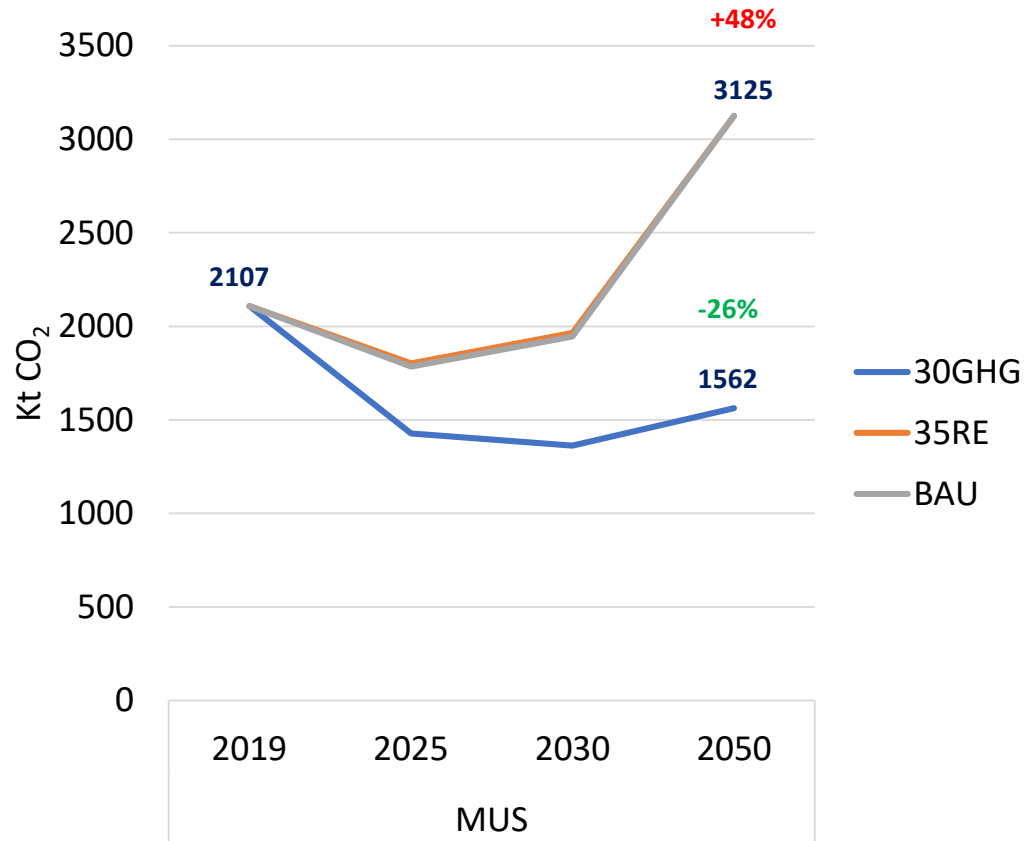
# Power generation mix evolution - Rodrigues



- 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



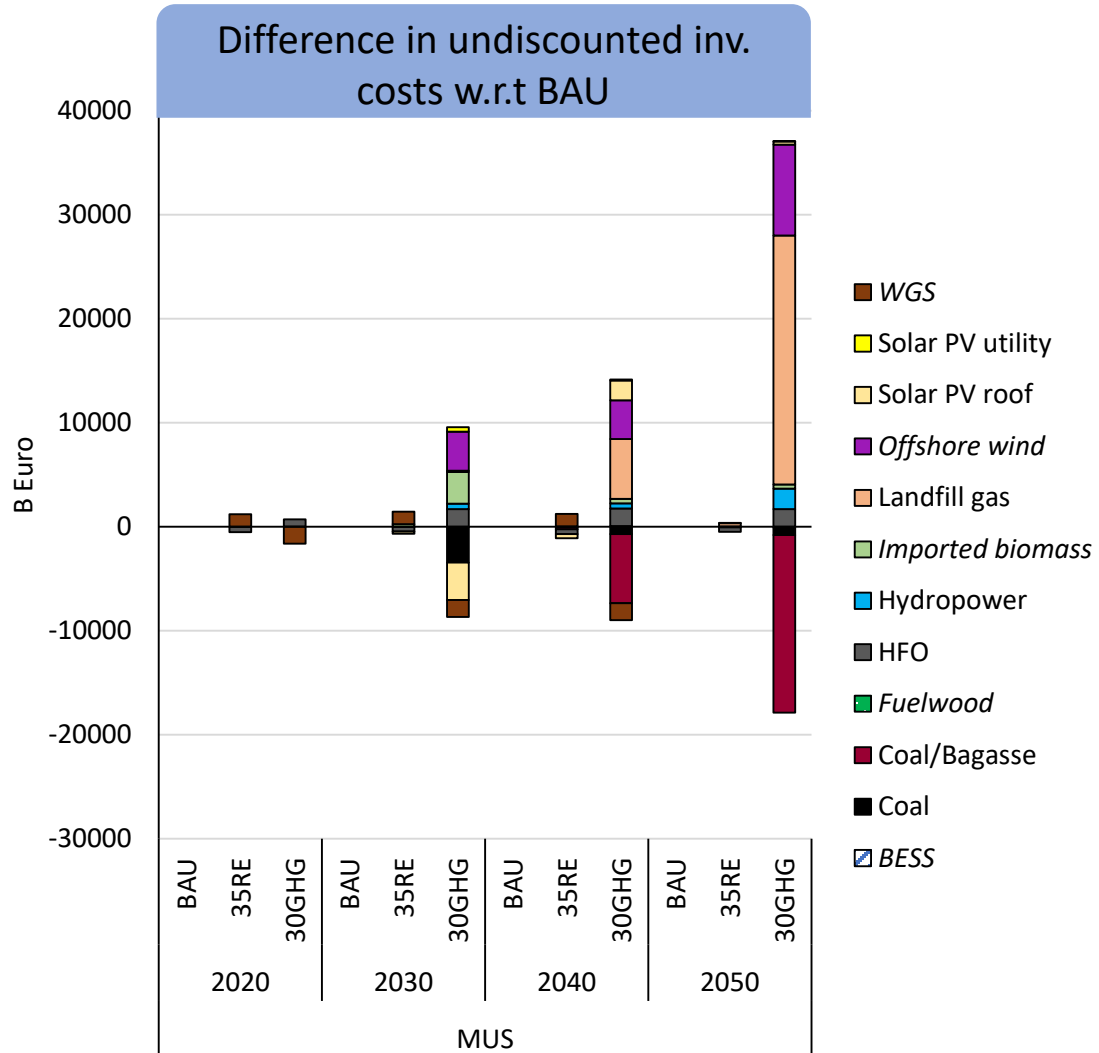
# CO<sub>2</sub> emissions trajectories



RE targets not compatible with NDC pledges of the RoM

30GHG results in more stringent emissions reduction

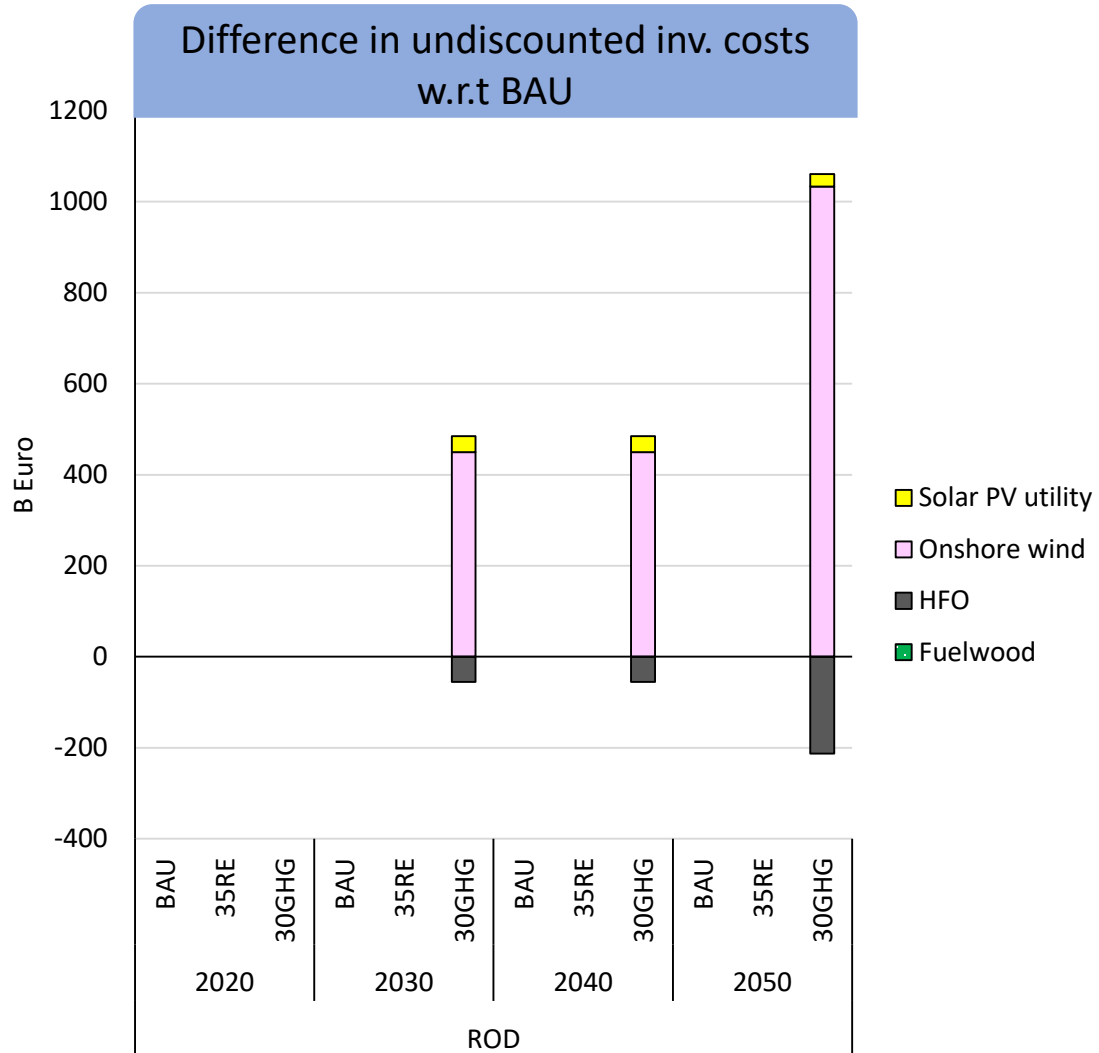
# Economic impacts - Mauritius



Region	NPV (B Euro)		
	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



Region	NPV (B Euro)		
	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<sub>2</sub> emissions reduction efforts and design adequate policy packages for climate mitigation

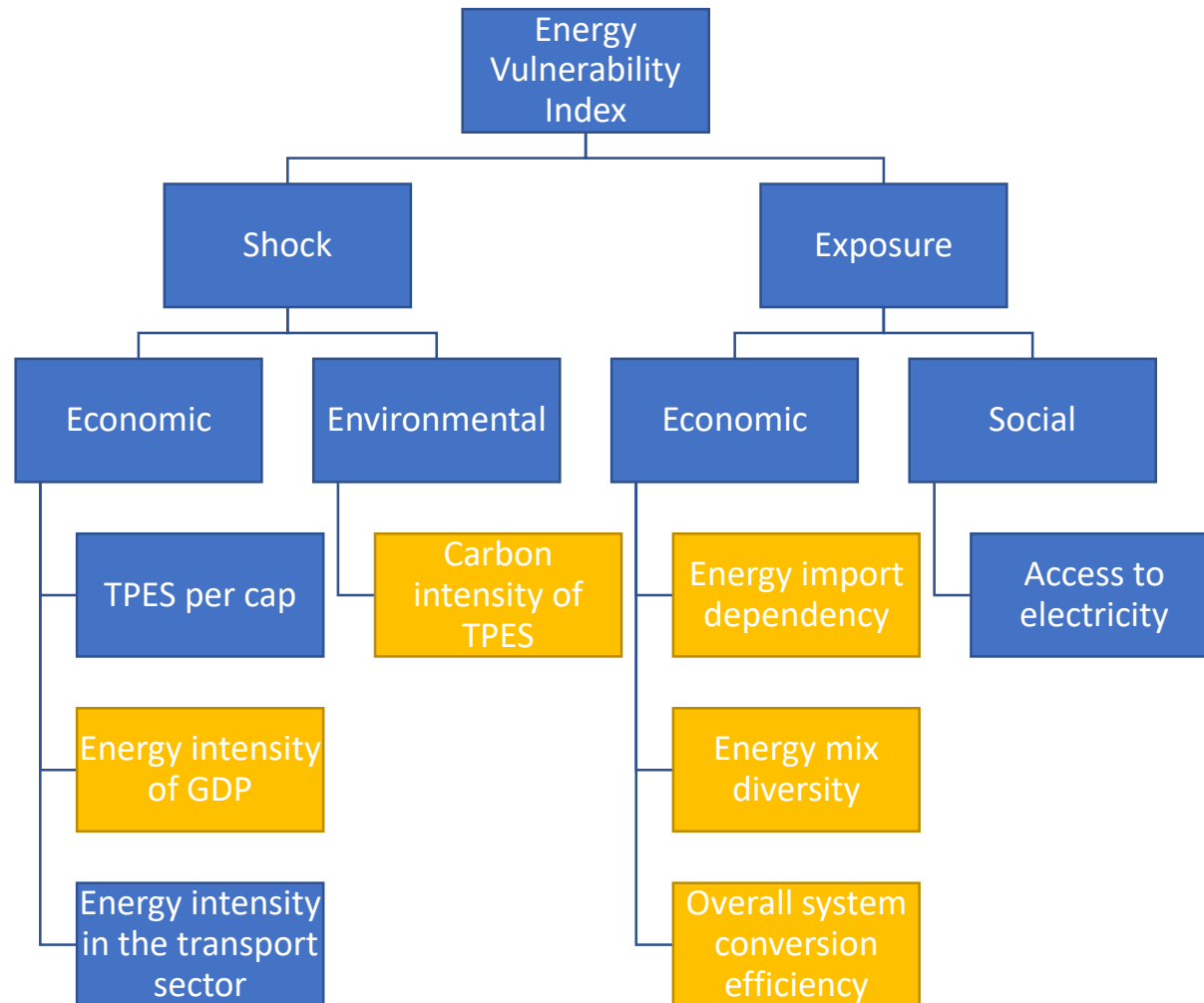
# What's next? (1)

Comprehensive sensitivity analysis on key parameters to deal with uncertainty

- Price of fossil fuels
- **Biomass potential** → land usage, non-CO<sub>2</sub> 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<sub>2</sub> emissions
- ↓ fossil imports
- More diversified mix
- More efficient system

# Thank you for your attention!



## Any questions?



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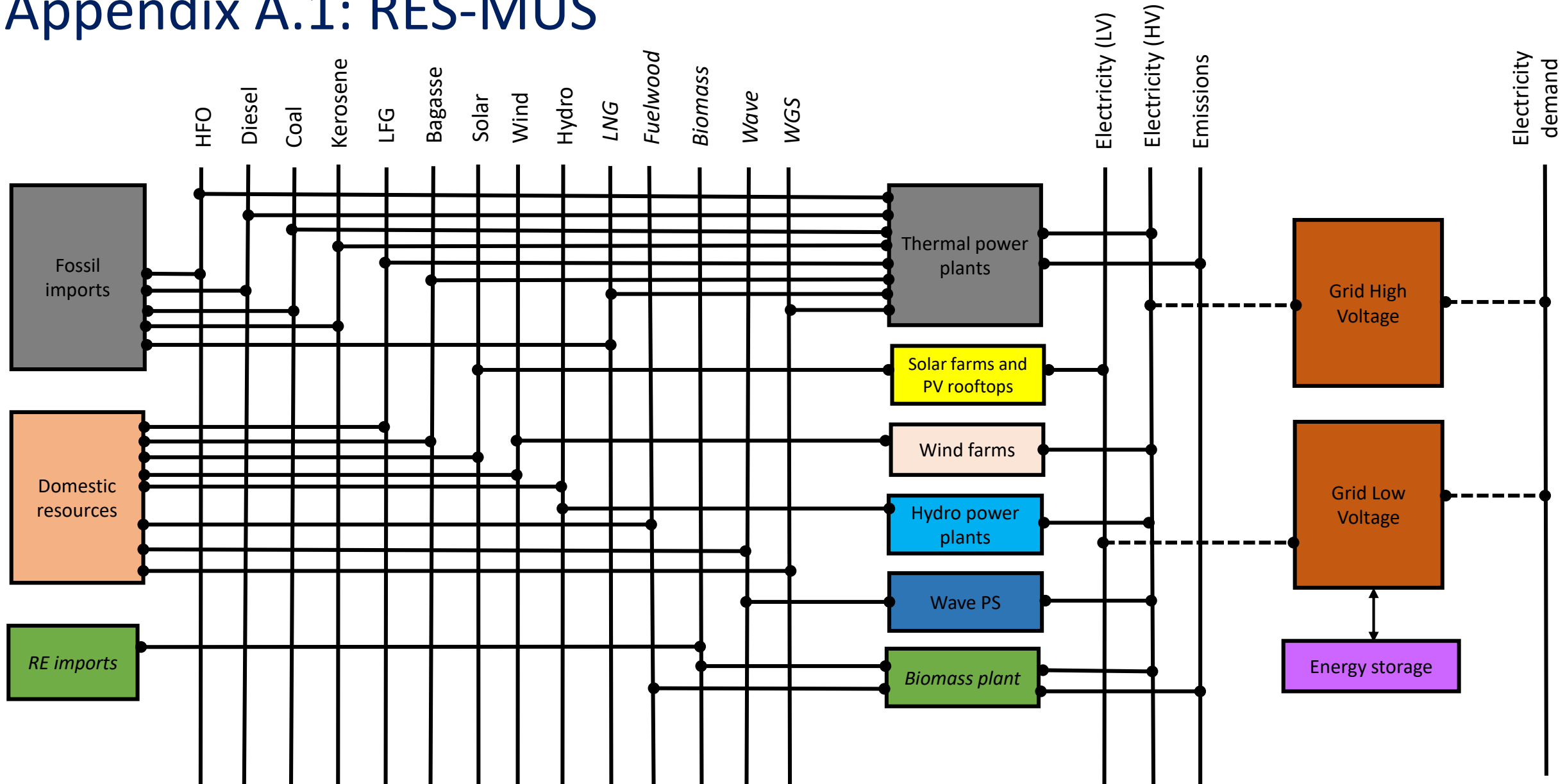


# References

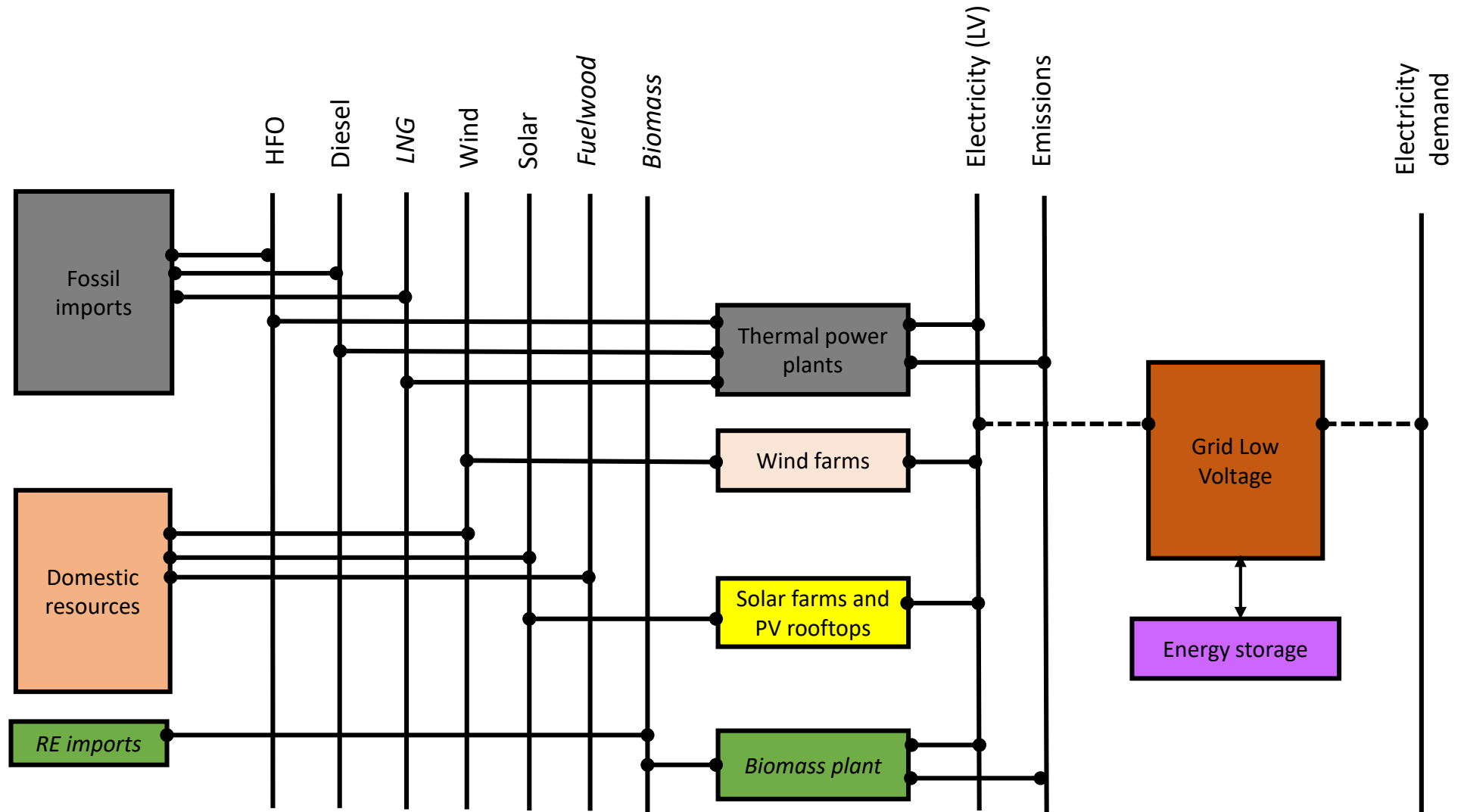
- Edo, M. N., & King, R. T. A. (2020). New insights into the technical challenges of the Mauritius long term energy strategy. *Energy*, 195, 116975.
- Genave, A., Blancard, S., & Garabedian, S. (2020). An assessment of energy vulnerability in Small Island Developing States. *Ecological Economics*, 171, 106595.
- IPCC (2006). Chapter 2: Stationary combustion in 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. Available at [https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2\\_Volume2/V2\\_2\\_Ch2\\_Stationary\\_Combustion.pdf](https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf)
- MEPU (2009). Long term energy strategy 2009–2025. Ministry of Energy and Public Utilities (October 2009). The Republic of Mauritius. Available at <https://sustainabledevelopment.un.org/content/documents/1245mauritiusEnergy%20Strategy.pdf>
- MEPU (2015). Intended Nationally Determined Contribution for The Republic of Mauritius. Ministry of Energy and Public Utilities (September 2015). Republic of Mauritius. Available at <https://www4.unfccc.int/sites/submissions/INDC/Published%20Documents/Mauritius/1/Final%20INDC%20for%20Mauritius%2028%20Sept%202015.pdf>
- MEPU (2019). Renewable Energy Roadmap 2030 for the electricity sector. Ministry of Energy and Public Utilities (August 2019). Republic of Mauritius. Available at <http://publicutilities.govmu.org/English/publications/Pages/default.aspx>
- MESD (2017). National Greenhouse Gas Inventory Report – UNFCCC. Ministry of Social Security, and Environment and Sustainable Development – Environment and Sustainable Development Division (August 2017). Republic of Mauritius. Available at [https://www4.unfccc.int/sites/SubmissionsStaging/NationalReports/Documents/3251748\\_Mauritius-NC3-1-NIR%20%20NC3.pdf](https://www4.unfccc.int/sites/SubmissionsStaging/NationalReports/Documents/3251748_Mauritius-NC3-1-NIR%20%20NC3.pdf)
- Shea, R. P., & Ramgolam, Y. K. (2019). Applied levelized cost of electricity for energy technologies in a small island developing state: A case study in Mauritius. *Renewable energy*, 132, 1415-1424.
- Timmons, D., Dhunny, A. Z., Elahee, K., Havumaki, B., Howells, M., Khoodaruth, A., ... & Surroop, D. (2019). Cost minimisation for fully renewable electricity systems: A Mauritius case study. *Energy Policy*, 133, 110895.
- Weisser, D. (2004). Costing electricity supply scenarios: A case study of promoting renewable energy technologies on Rodriguez, Mauritius. *Renewable energy*, 29(8), 1319-1347

# Appendices

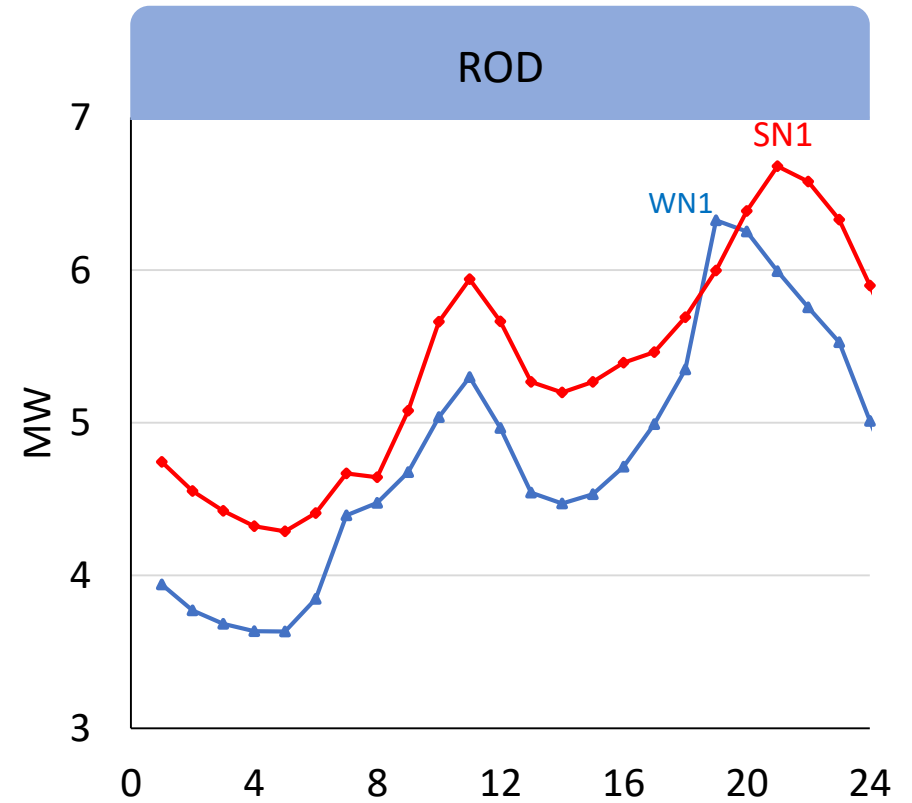
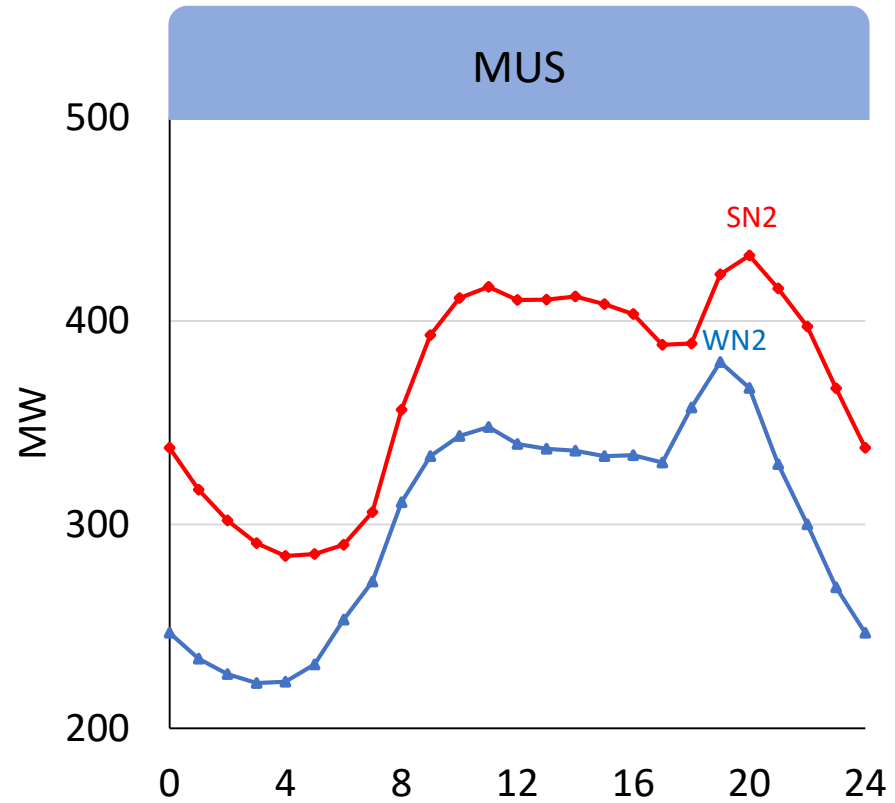
# Appendix A.1: RES-MUS



# 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