

**REFORM Meeting  
Salzburg  
3.10.2022**

**Cuban Energy Transformation  
Possibilities towards 100 %  
Renewable Energy System**

**Anaely Saunders  
Jyrki Luukkanen**





# CONTENTS OF THE PRESENTATION

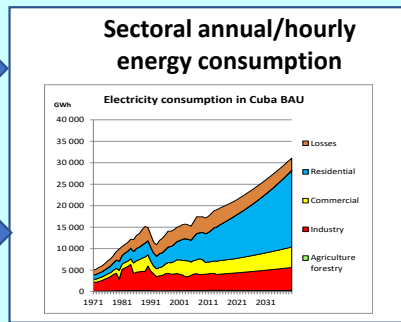
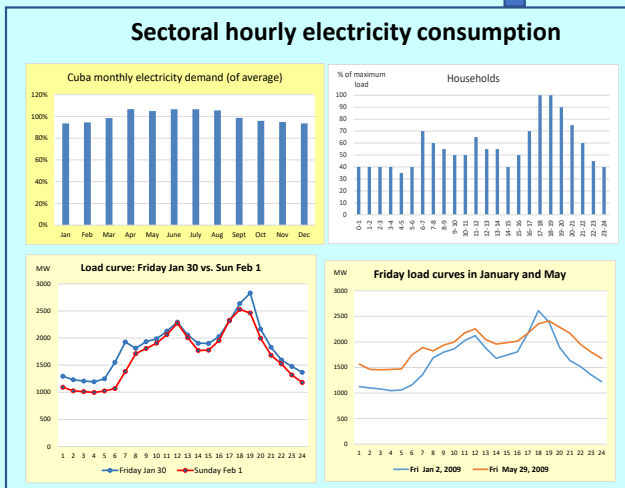
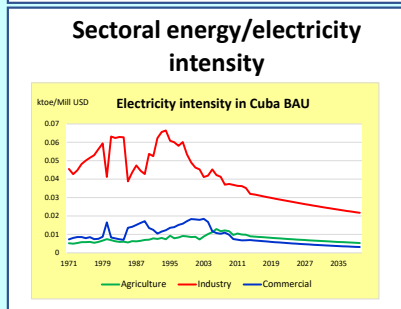
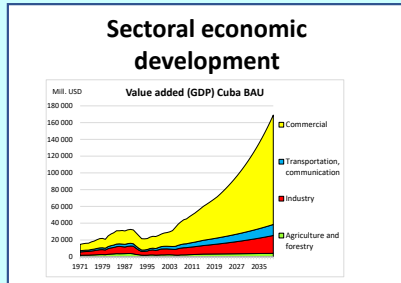
- CubaLinda model
- Construction of scenarios
- Challenges and opportunities





# CUBALINDA MODEL

## Energy demand



## CubaLinda model

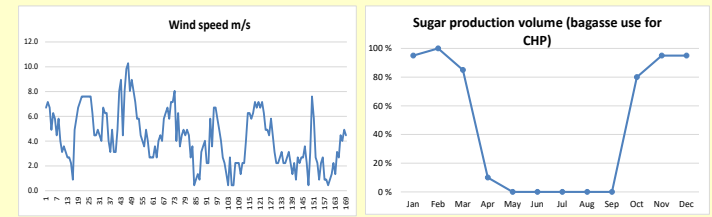
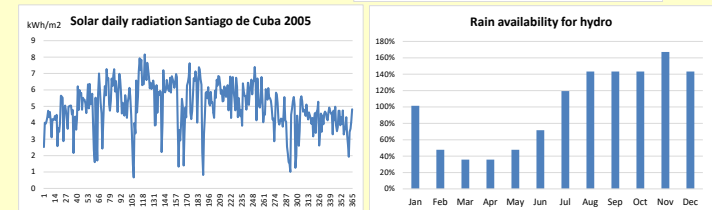
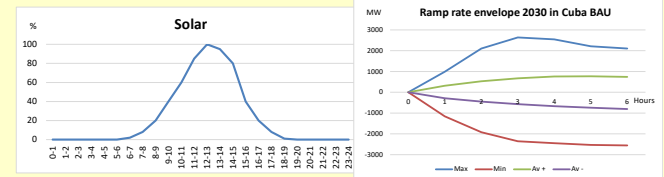
## Energy supply

Controllable power production (fossil)

Electricity storage?

Power plant technology and economics

## Variable electricity production

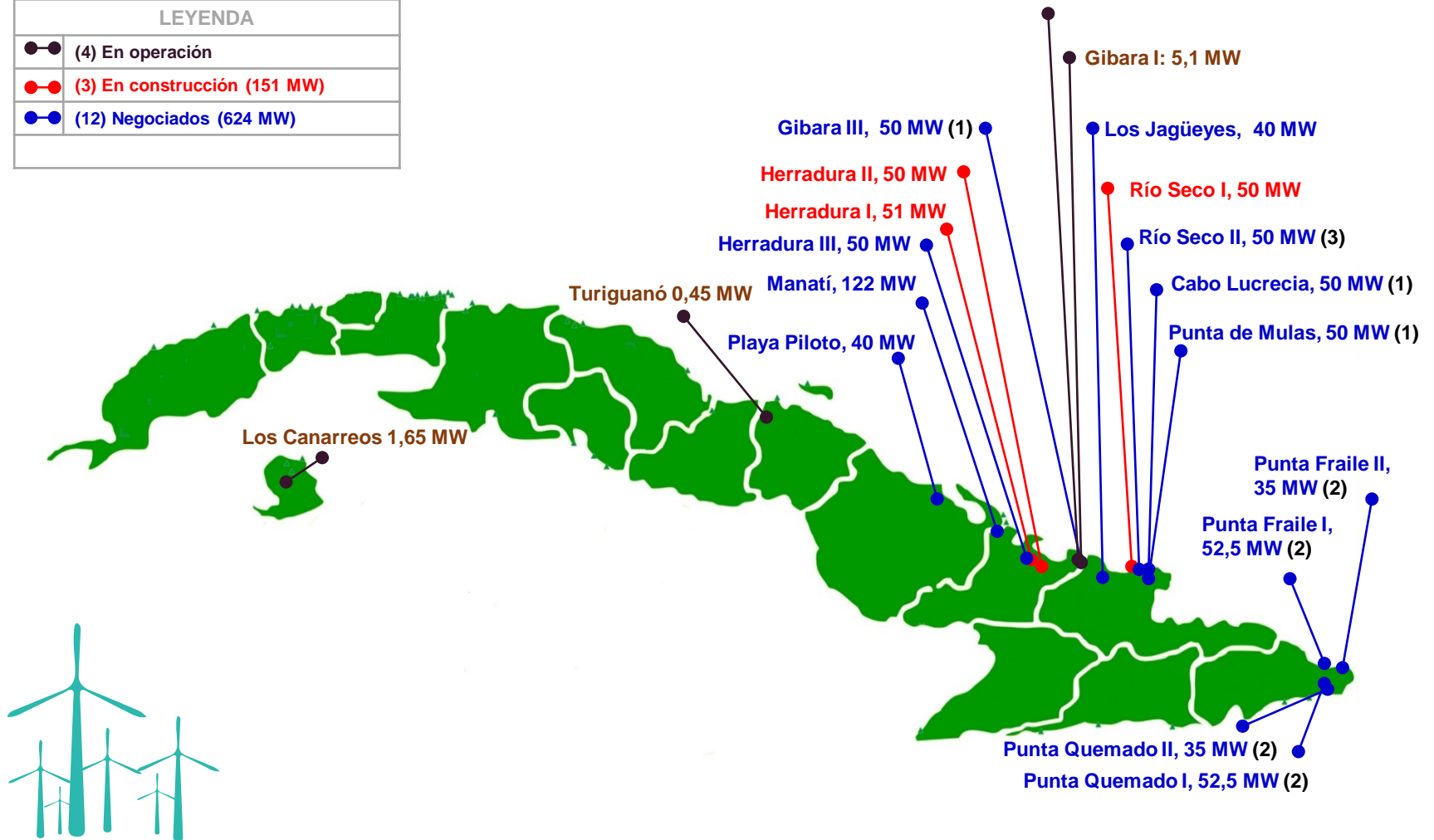




# CubaLinda model Wind power production

# Scenario till 2050

LEYENDA	
●●	(4) En operación
●●	(3) En construcción (151 MW)
●●	(12) Negociados (624 MW)





# Solar PV

- In model solar PV power plants are situated in different provinces
- Incoming radiation is obtained from the MERRA database using renewables.ninja website (Renewables.ninja 2021).
- Model uses hourly data from 2019 for different locations and combines the incoming radiation data with the installed PV capacity in different provinces defined in scenarios.





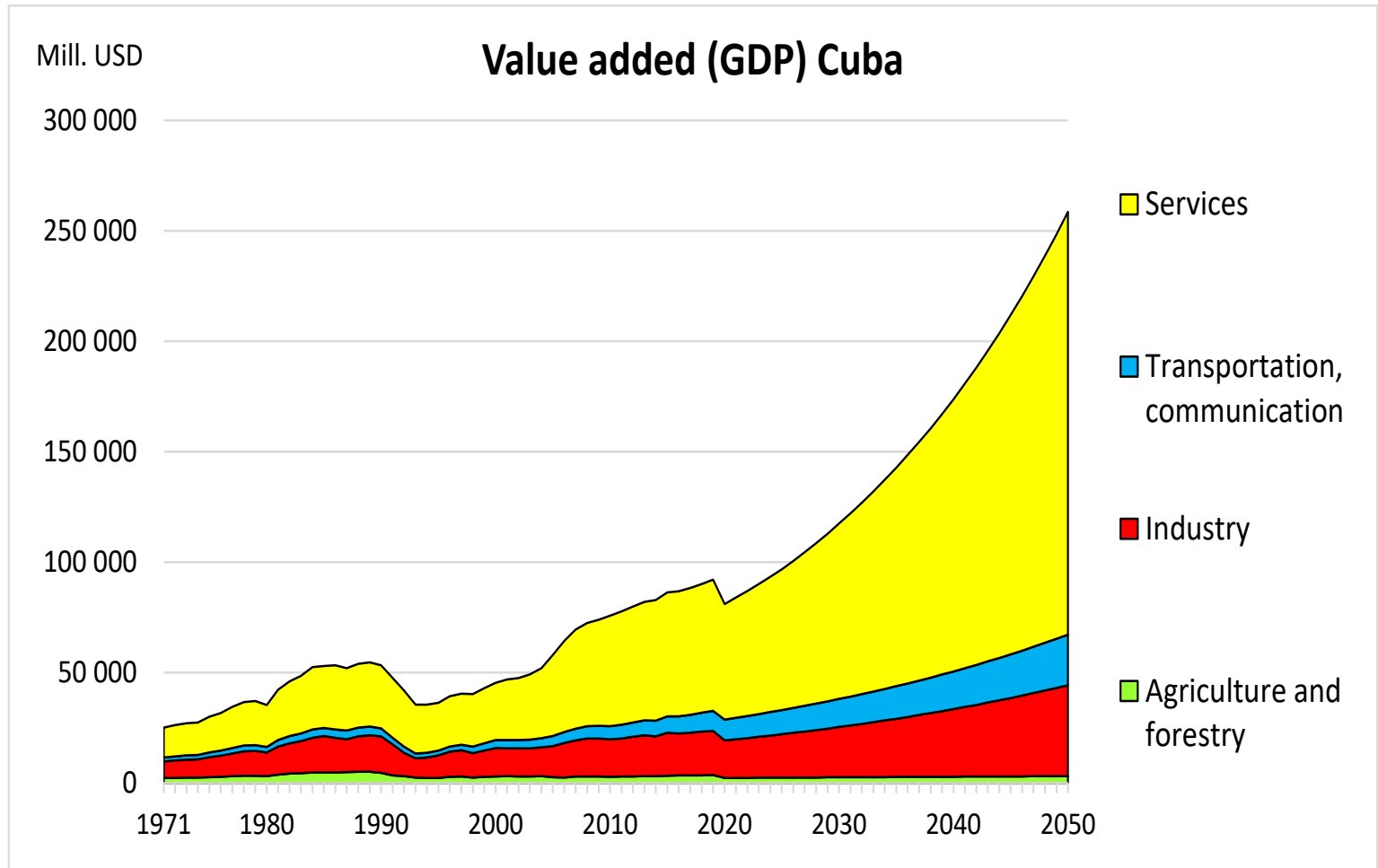
# Balancing of supply and demand

- **Balancing the supply and demand of electricity is done in the model using controllable power plants.**
- **The first option for balancing is electricity storage, in this case, pumped hydro storage. It will carry out balancing and if there is not enough capacity in the pumped hydro storage then fossil ICE and gas turbine power plants will be used.**
- **According to Montes (2019) there exist a potential pumped hydro storage capacity of almost 20 000 MW with 5 hours of operation as an average in generation (discharge) mode, which could result in a maximum generation of 100 GWh / Day**



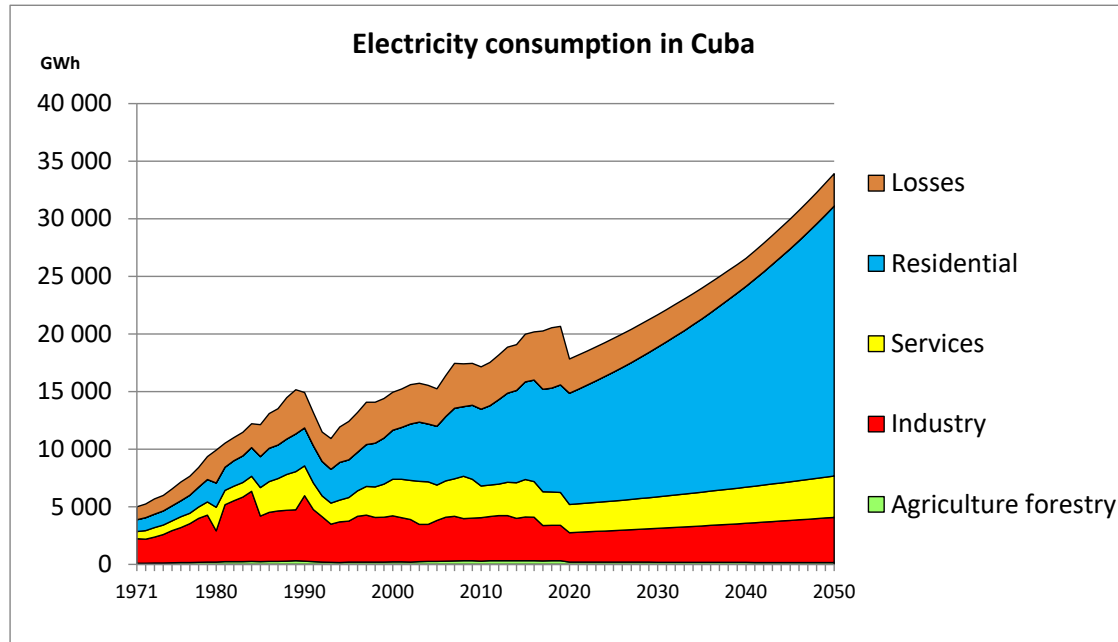


# Scenario 1





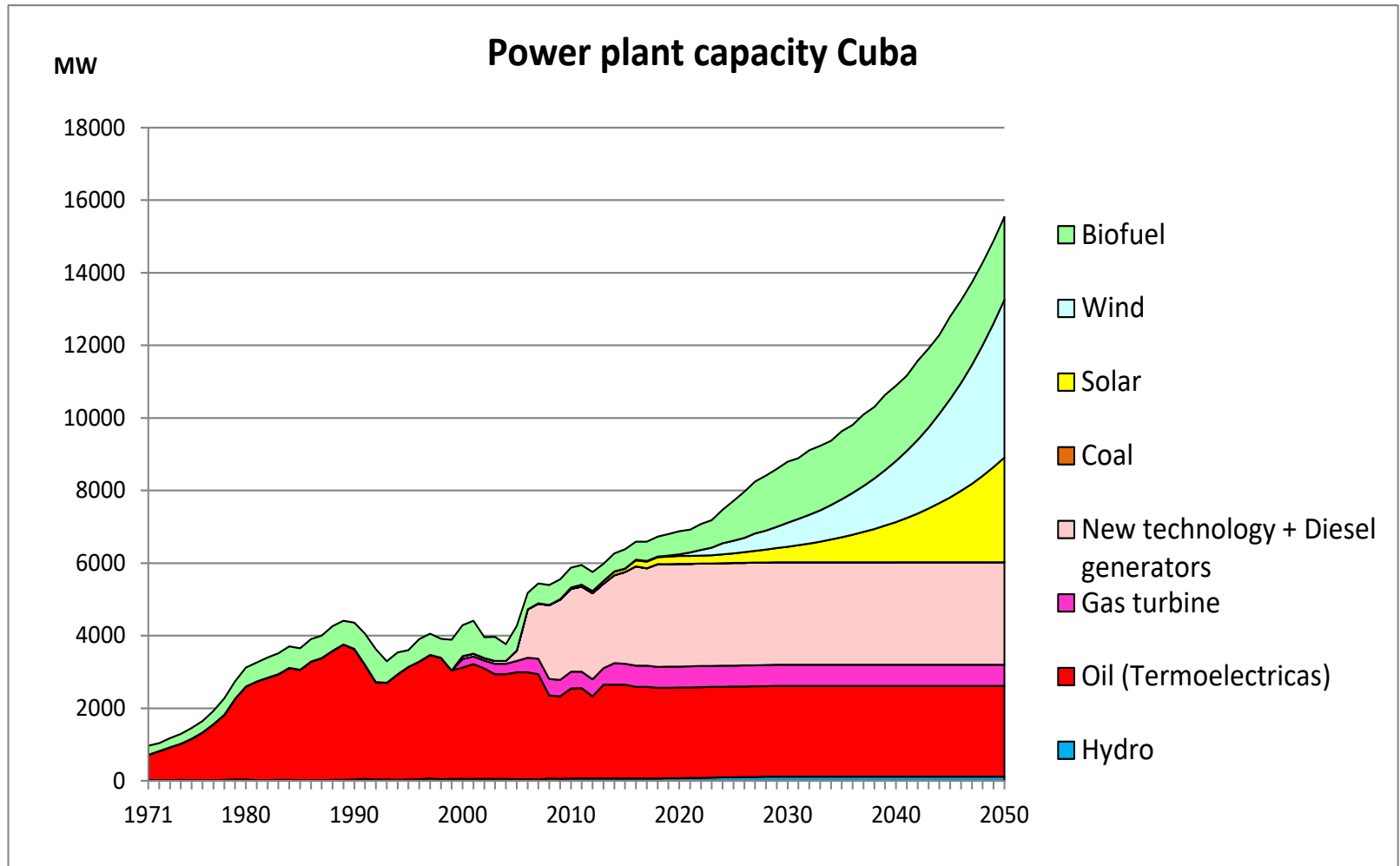
# Scenario 1





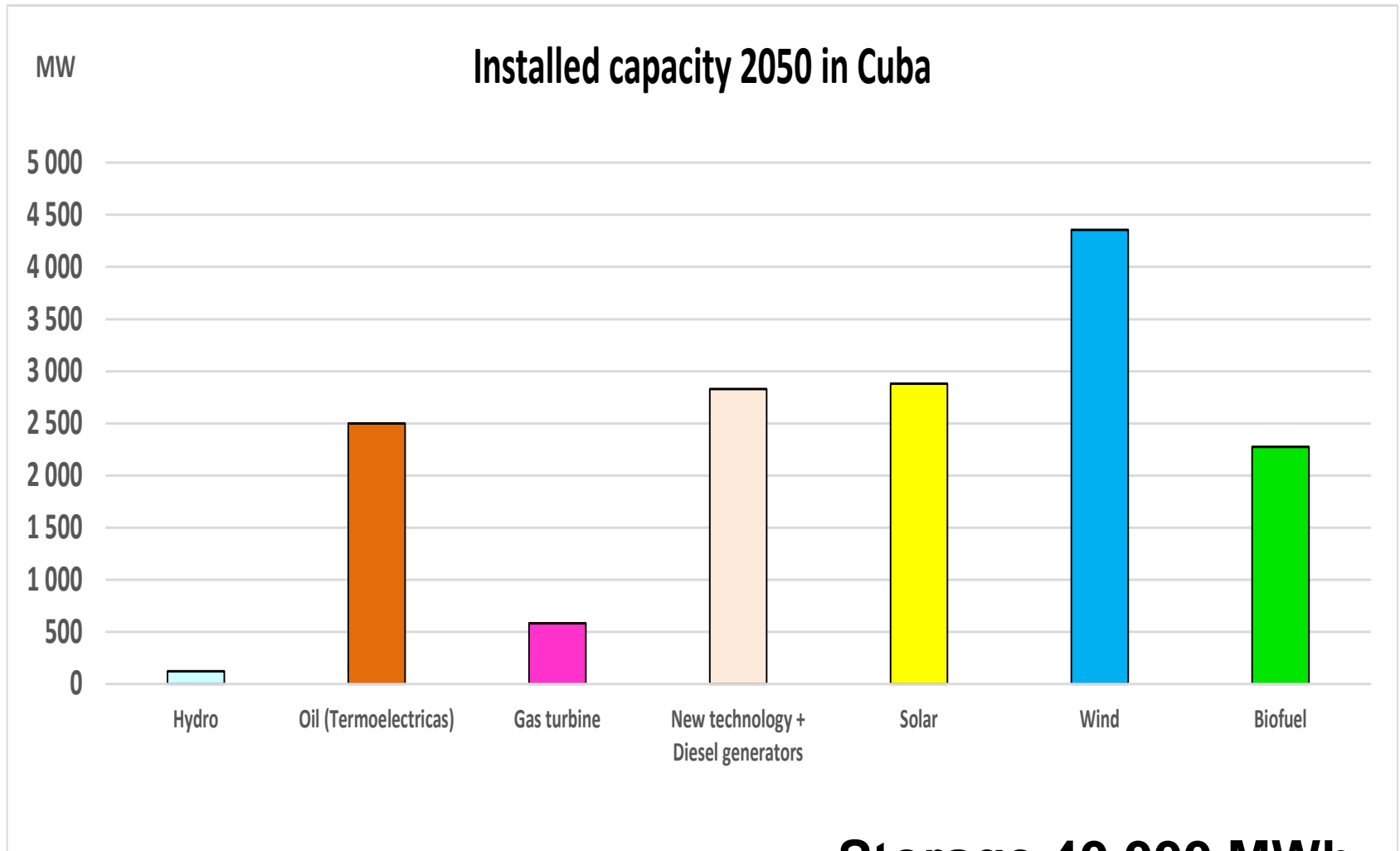


# Scenario 1





# Scenario 1

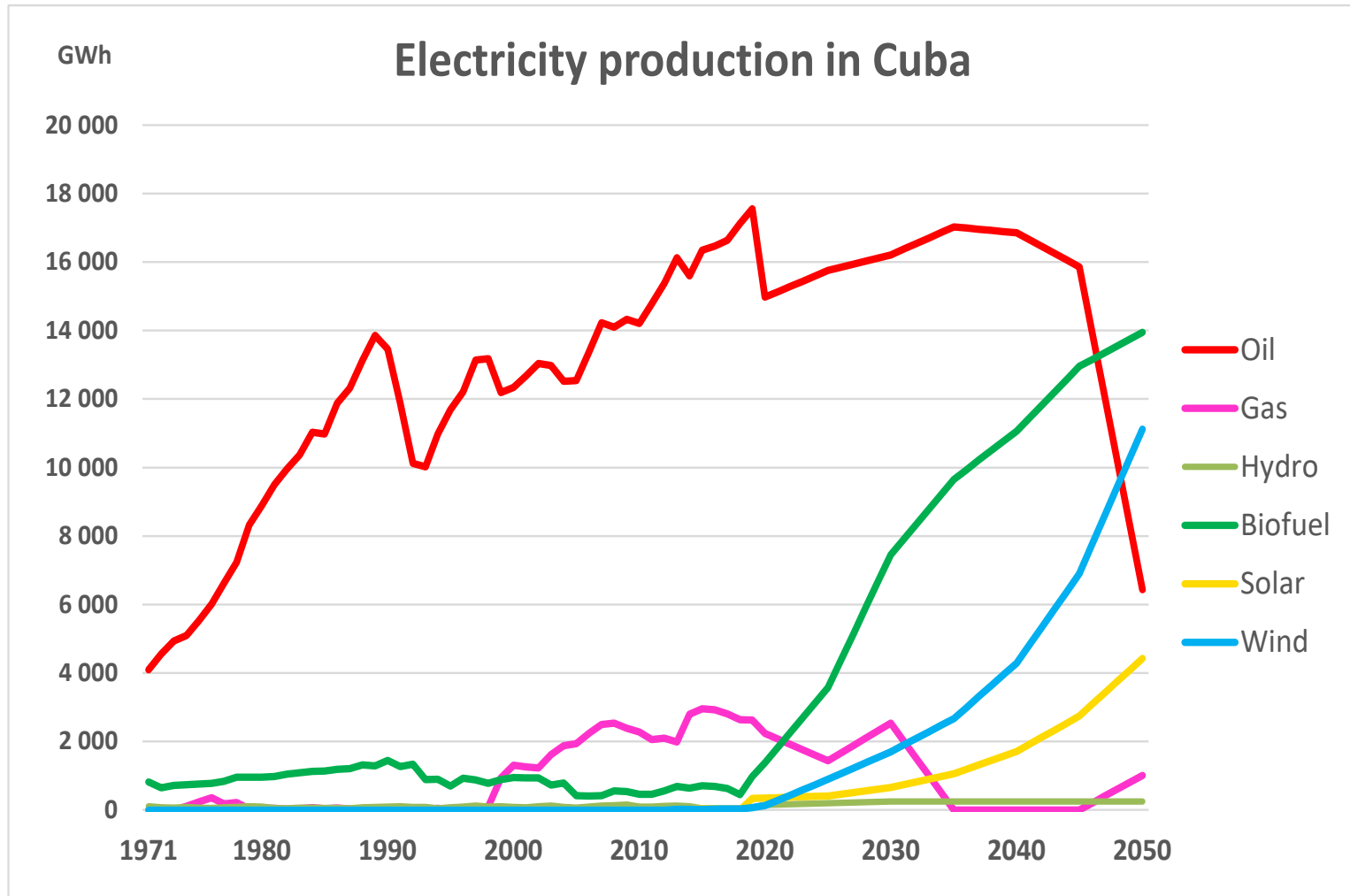


**Storage 40 000 MWh**



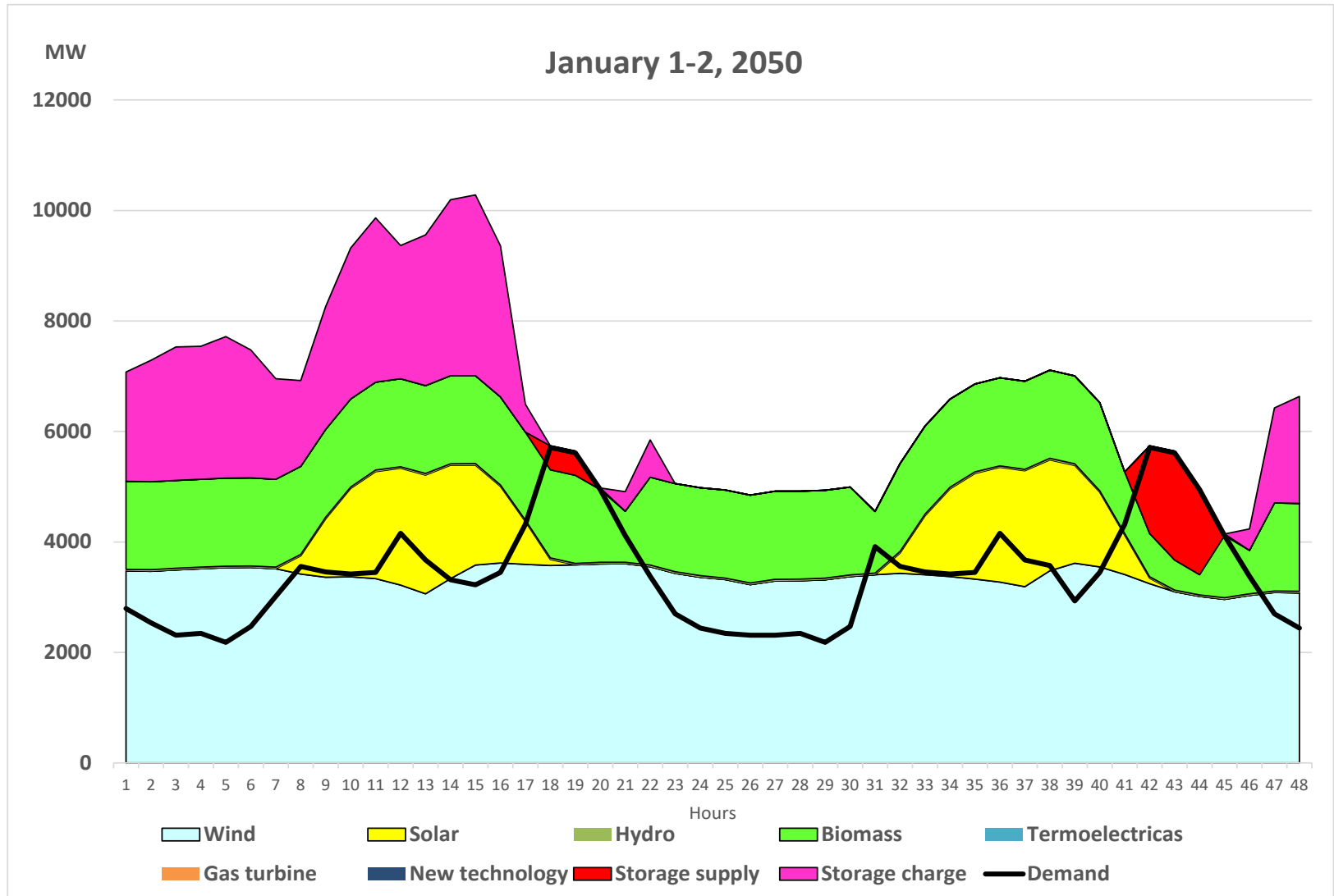


# Scenario 1



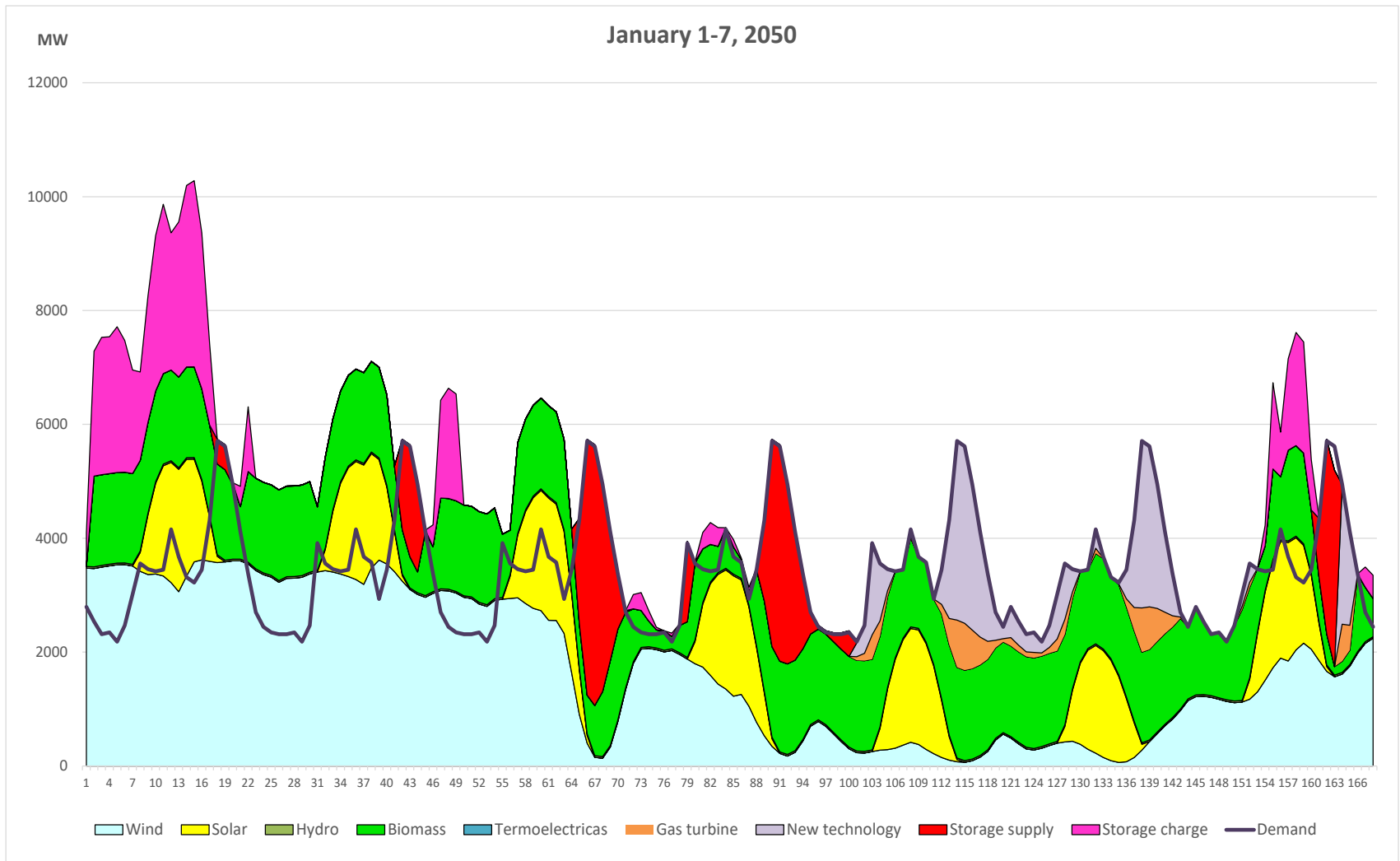


# Scenario 1



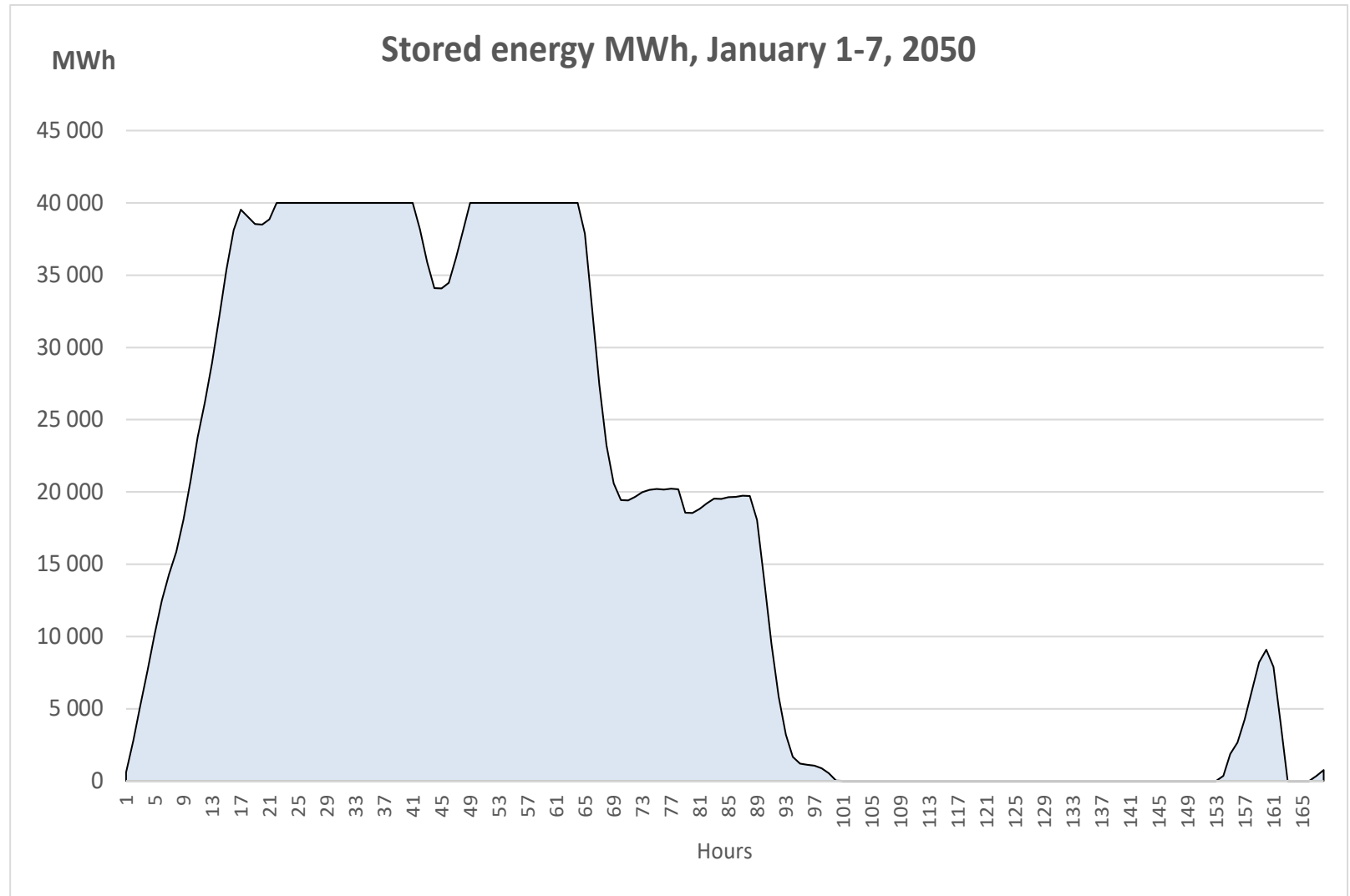


# Scenario 1



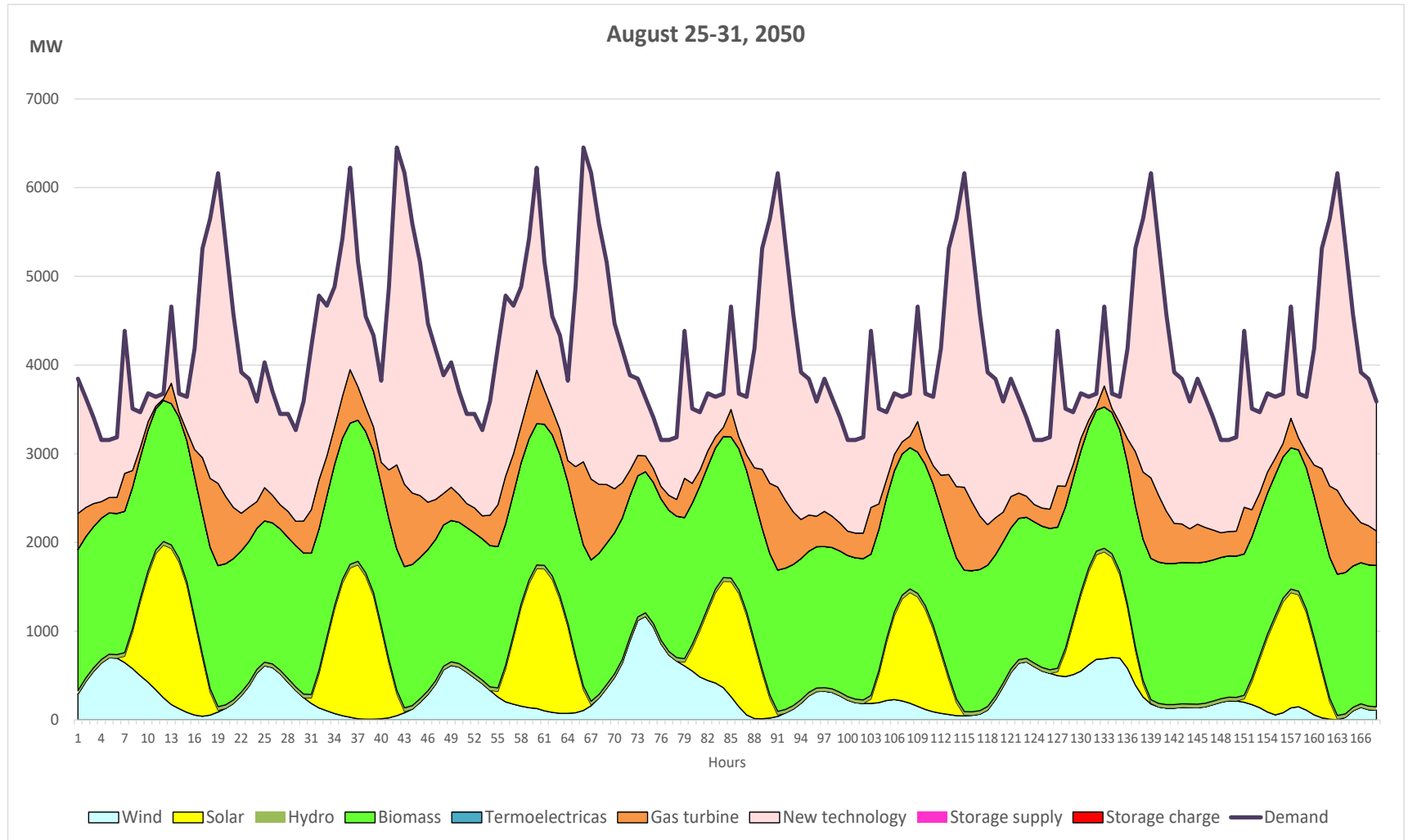


# Scenario 1



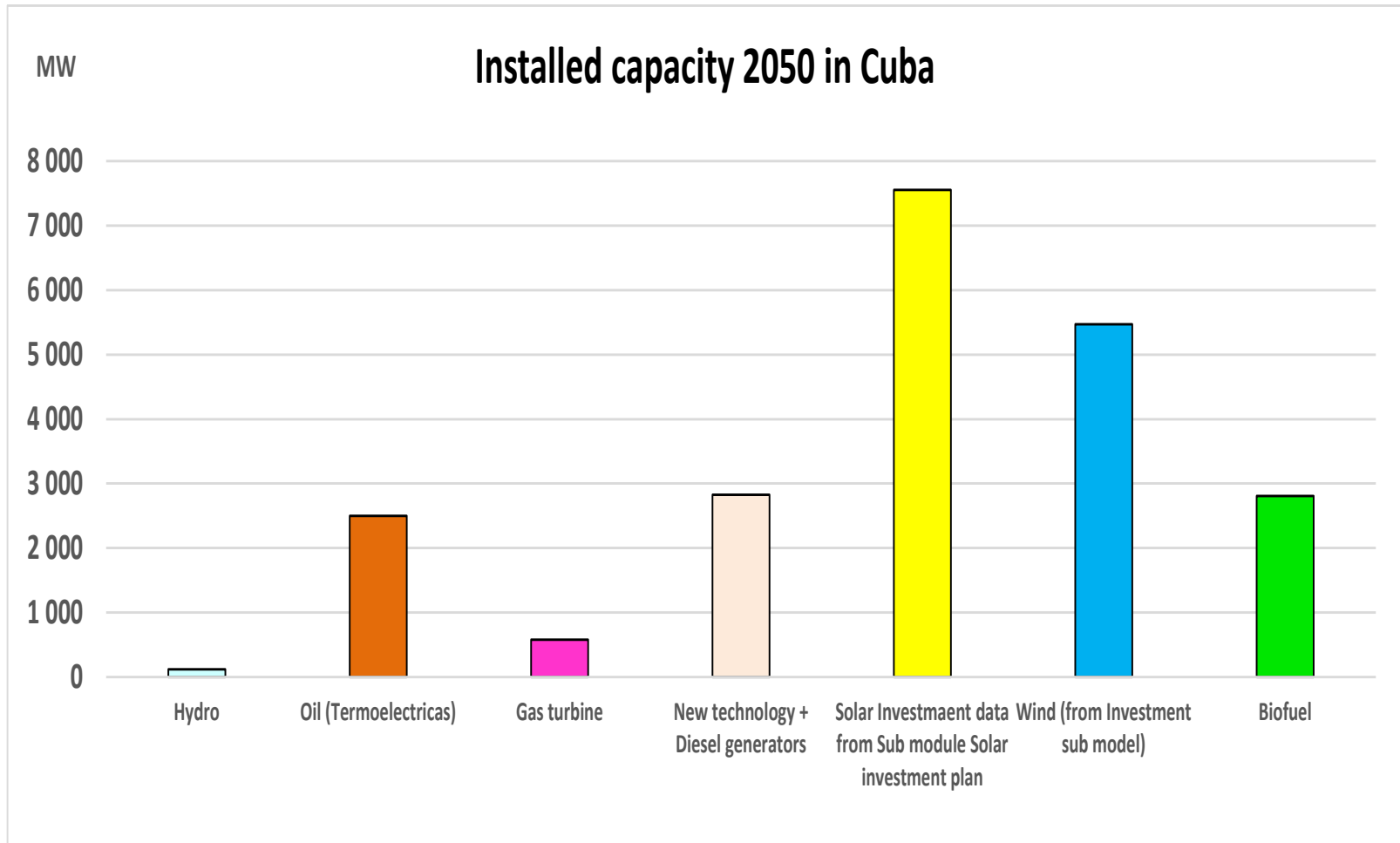


# Scenario 1





# Scenario 2



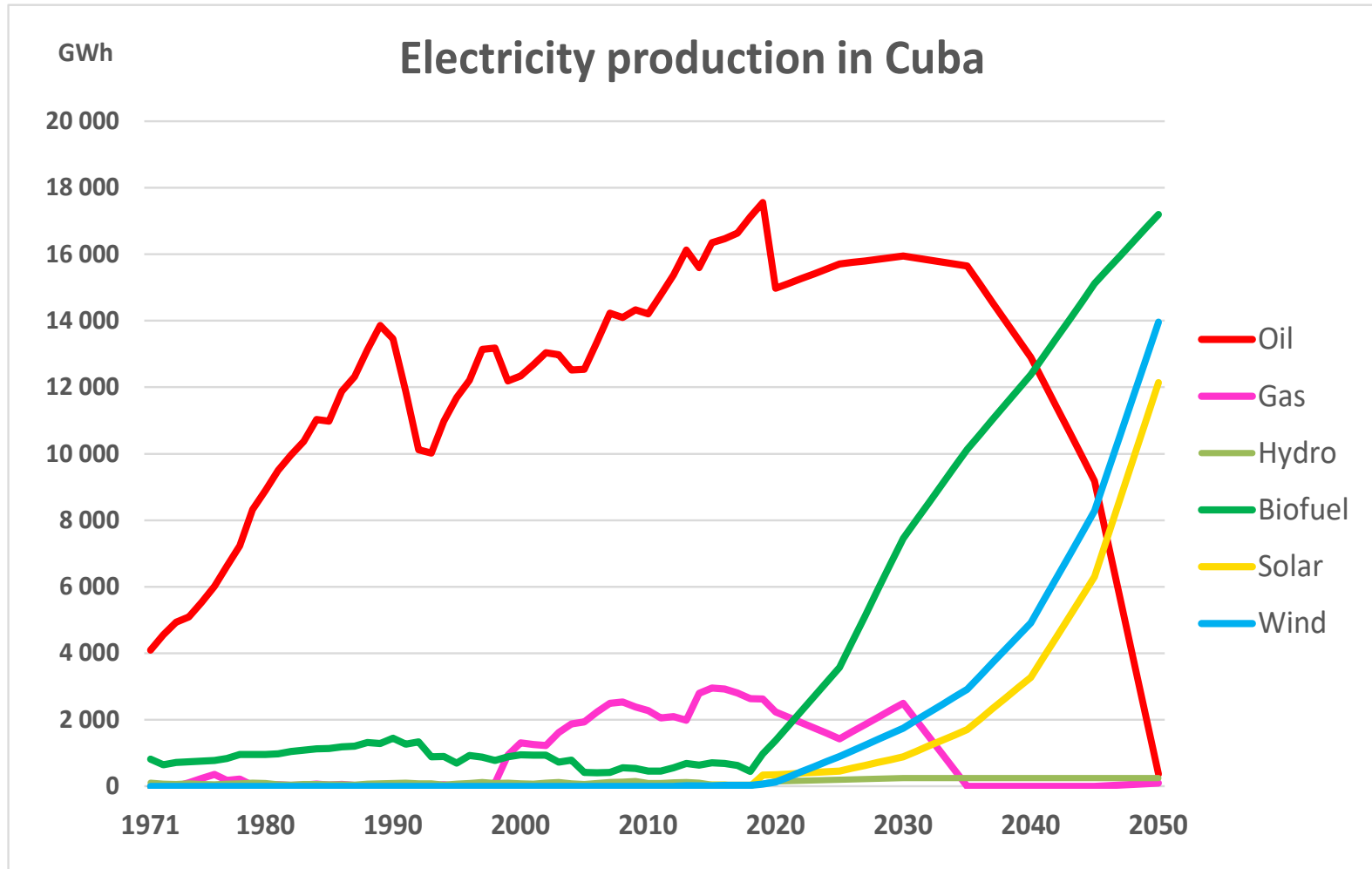
**Storage 100 000 MWh**





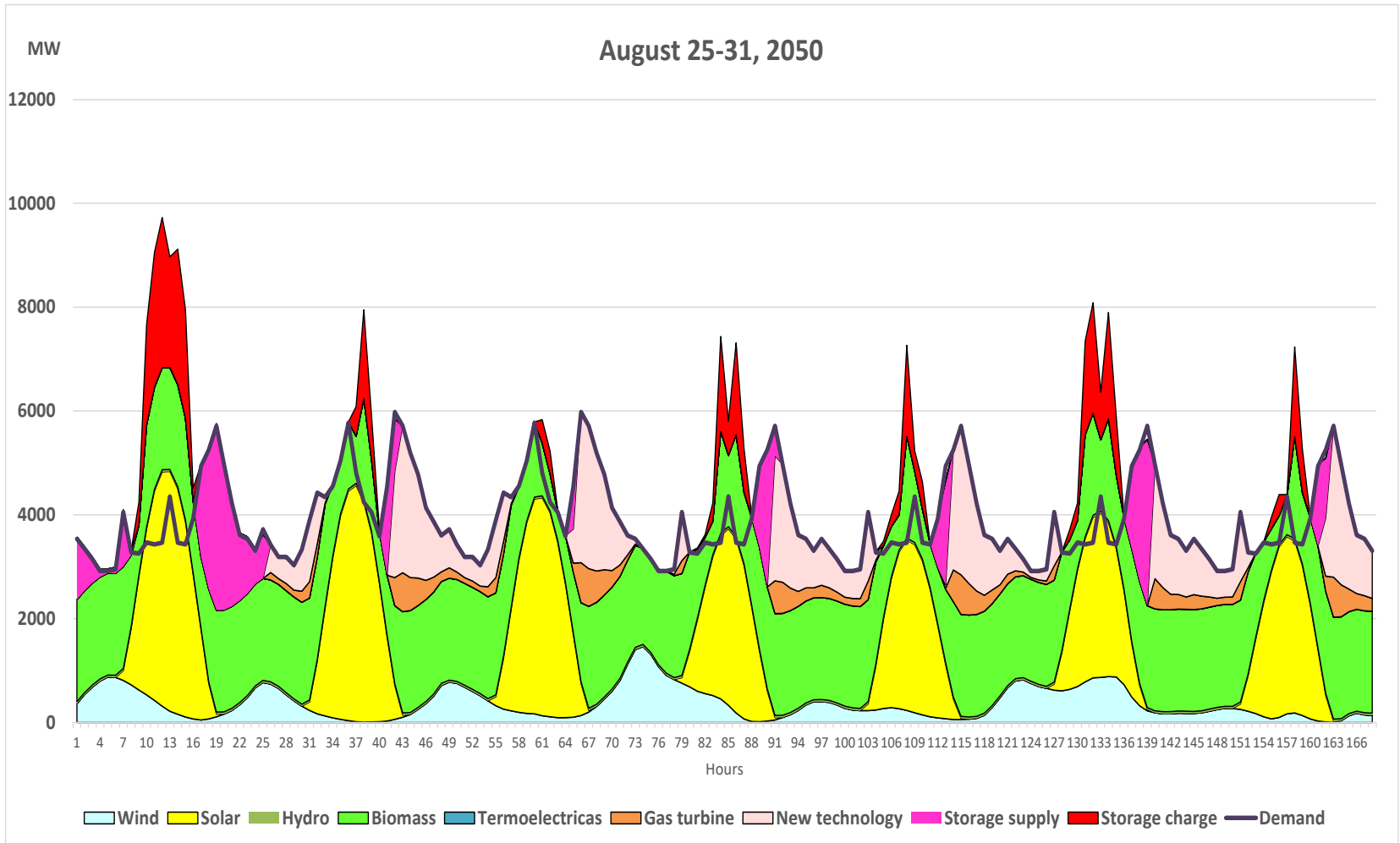


# Scenario 2



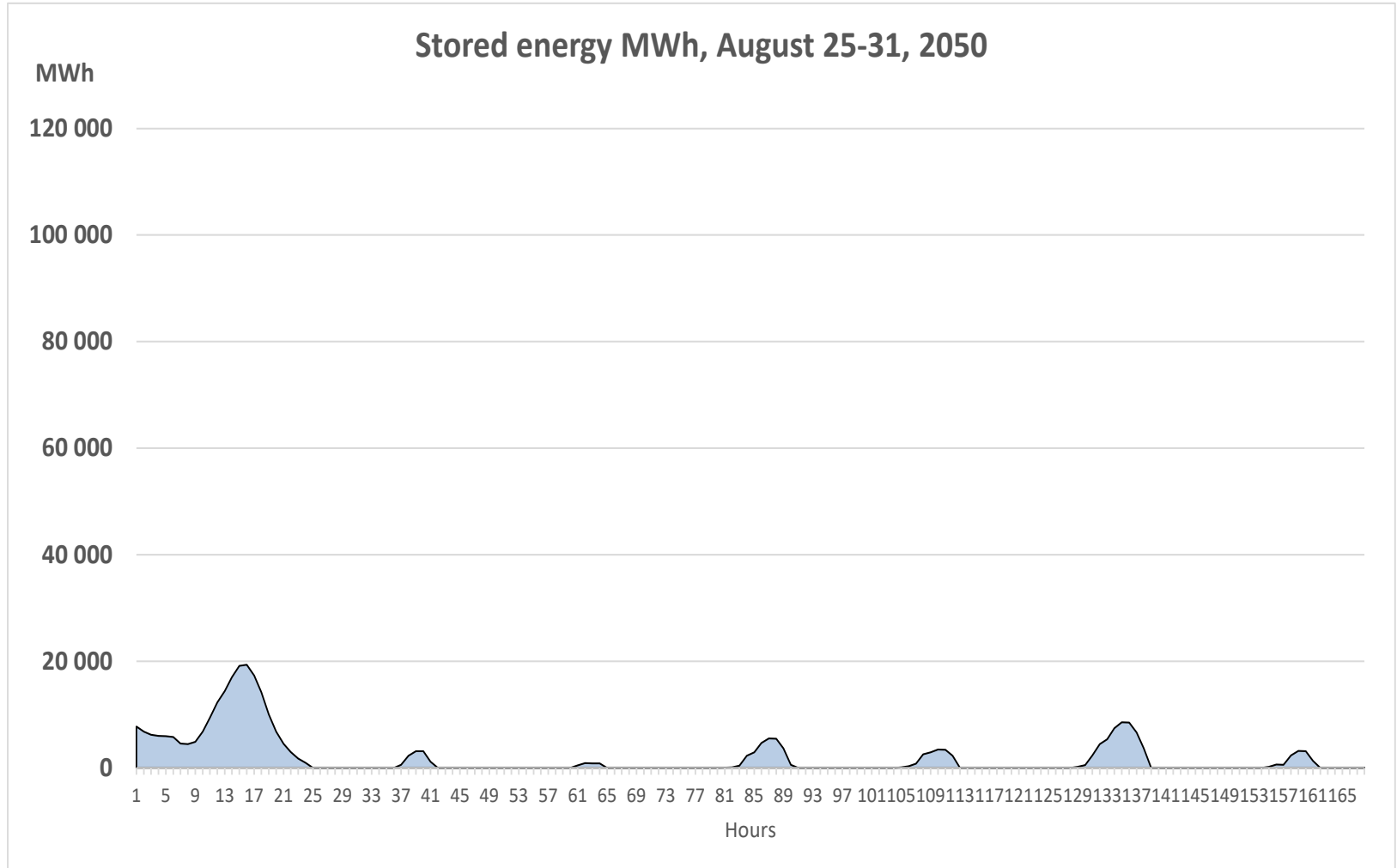


# Scenario 2



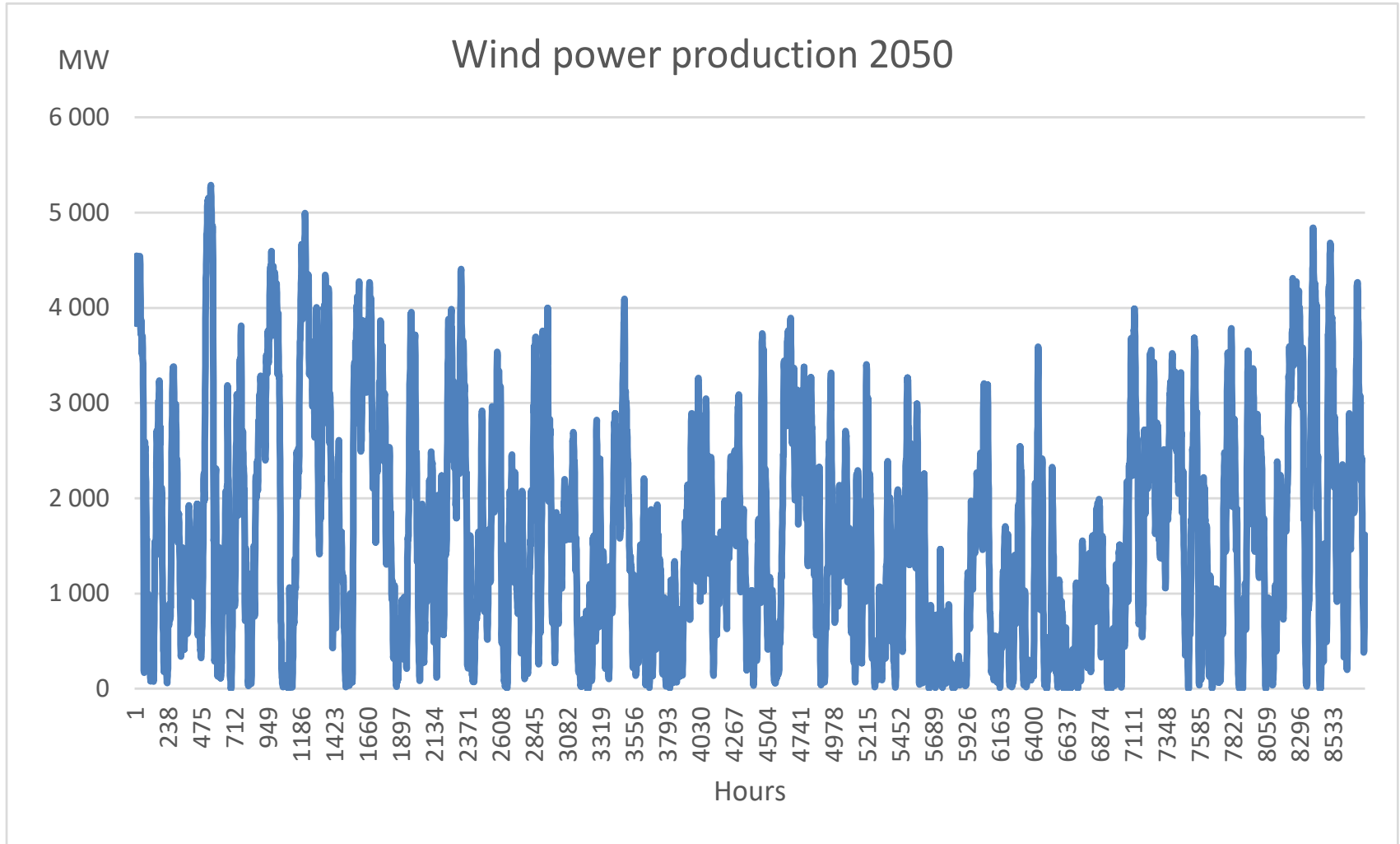


# Scenario 2



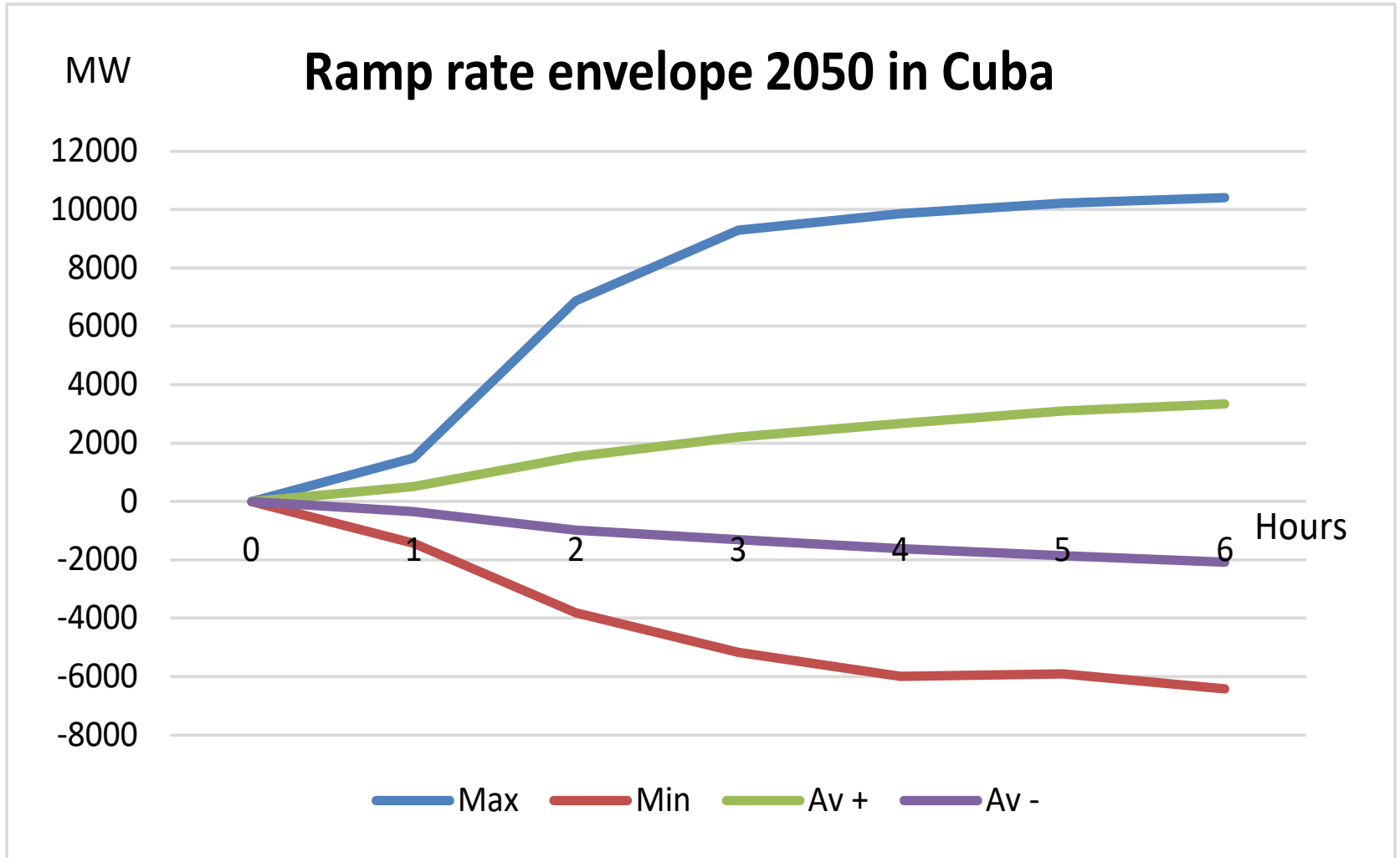


# Scenario 2



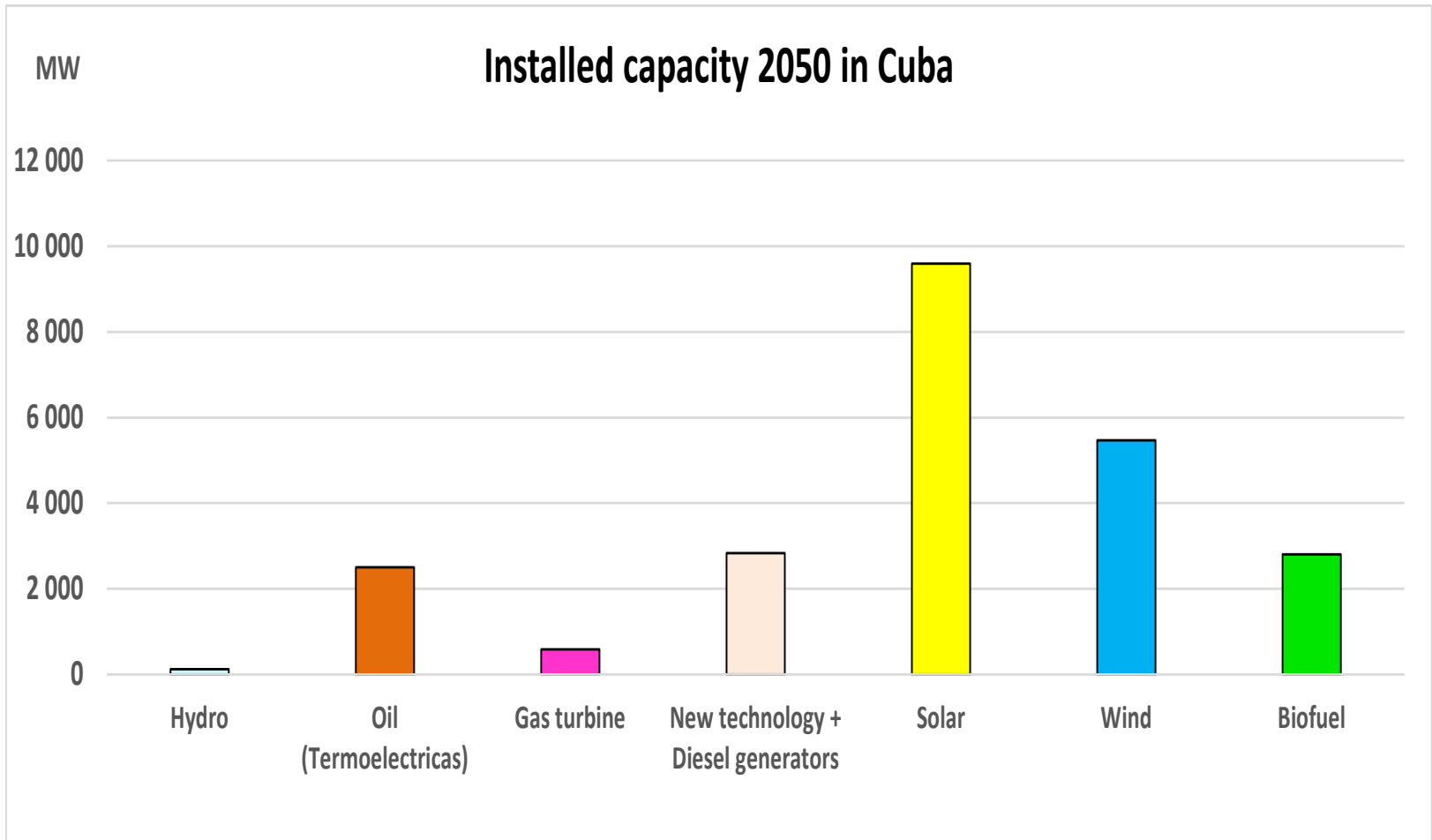


# Scenario 2





# Scenario 3

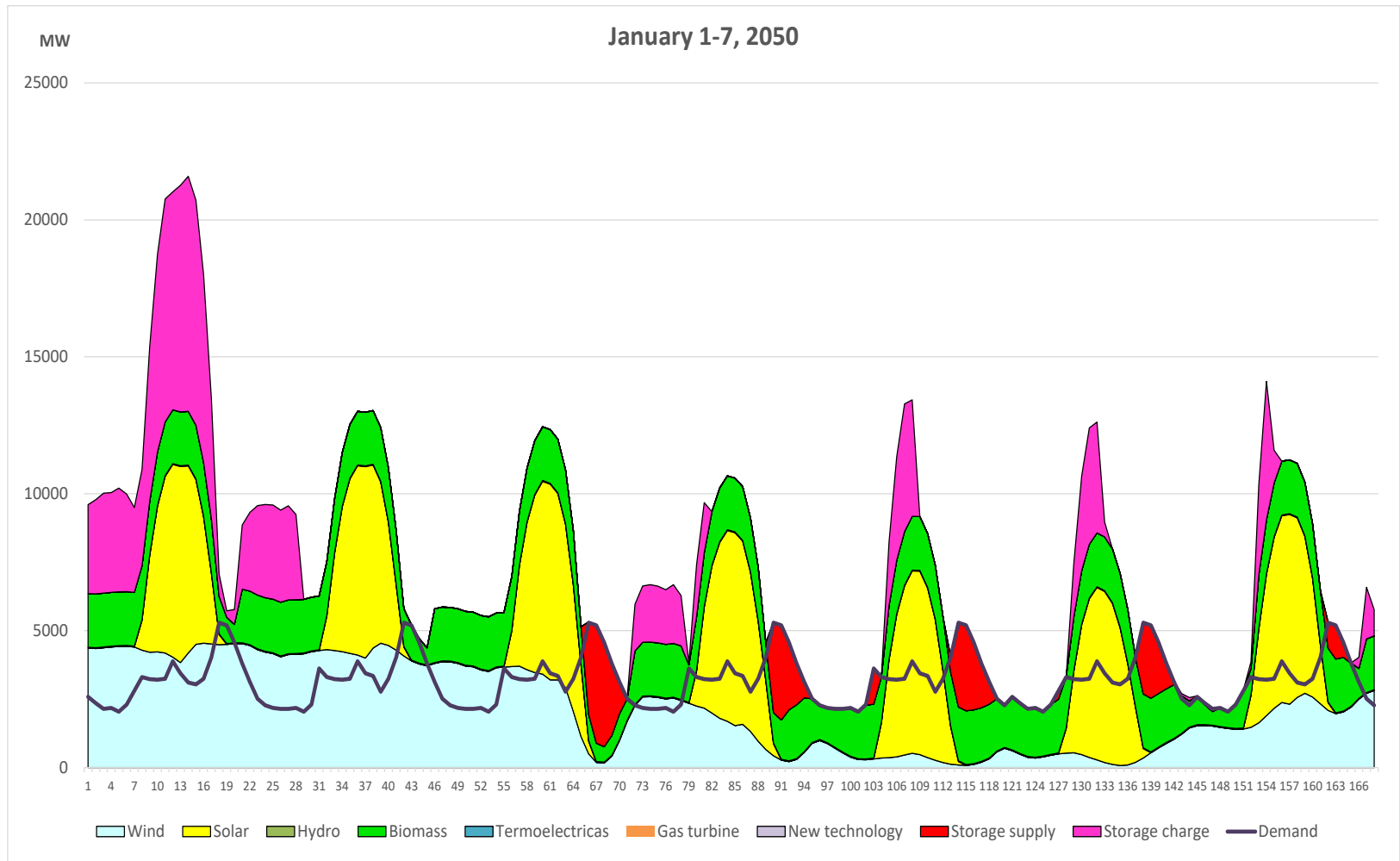


**Storage 120 000 MWh**



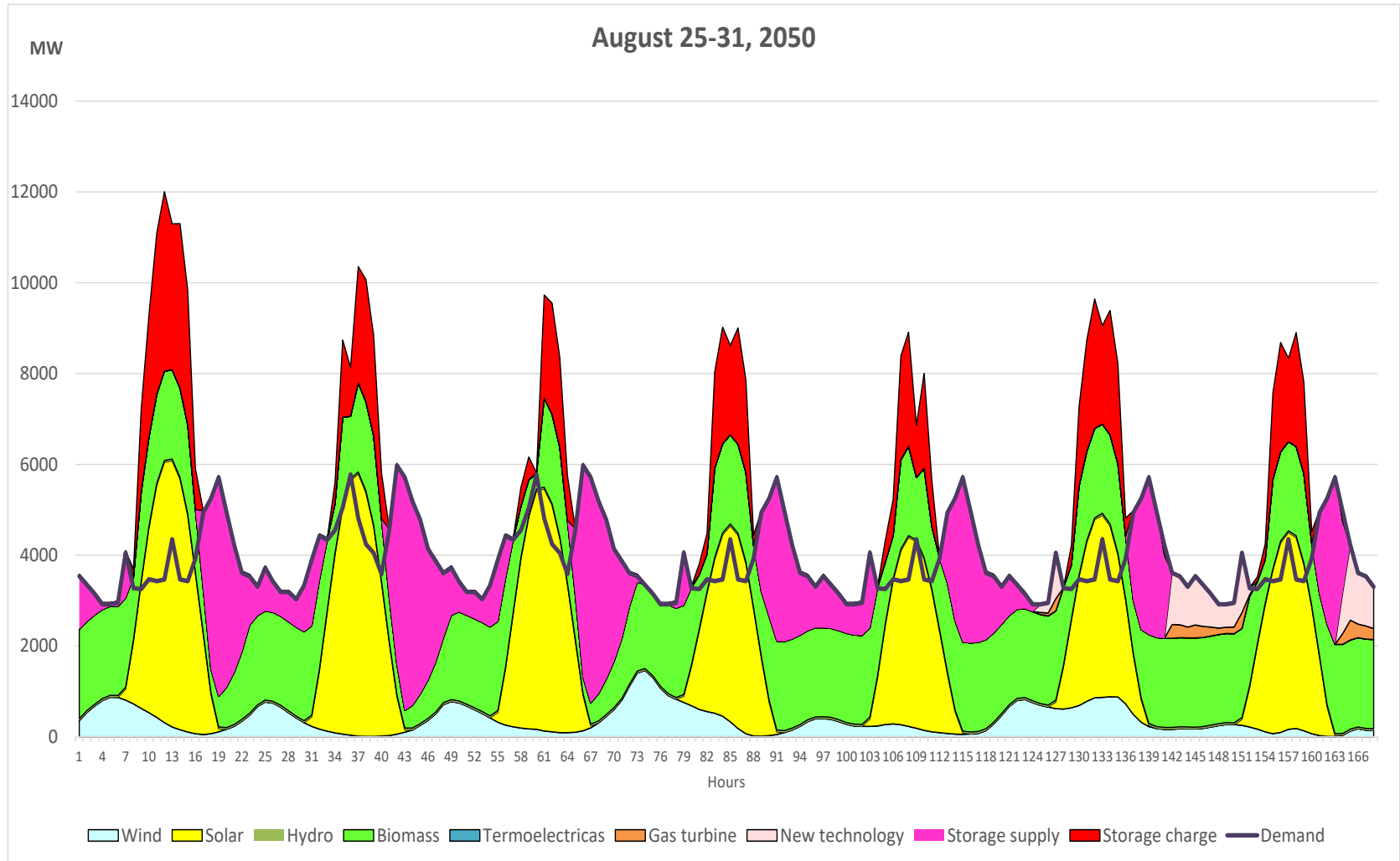


# Scenario 3





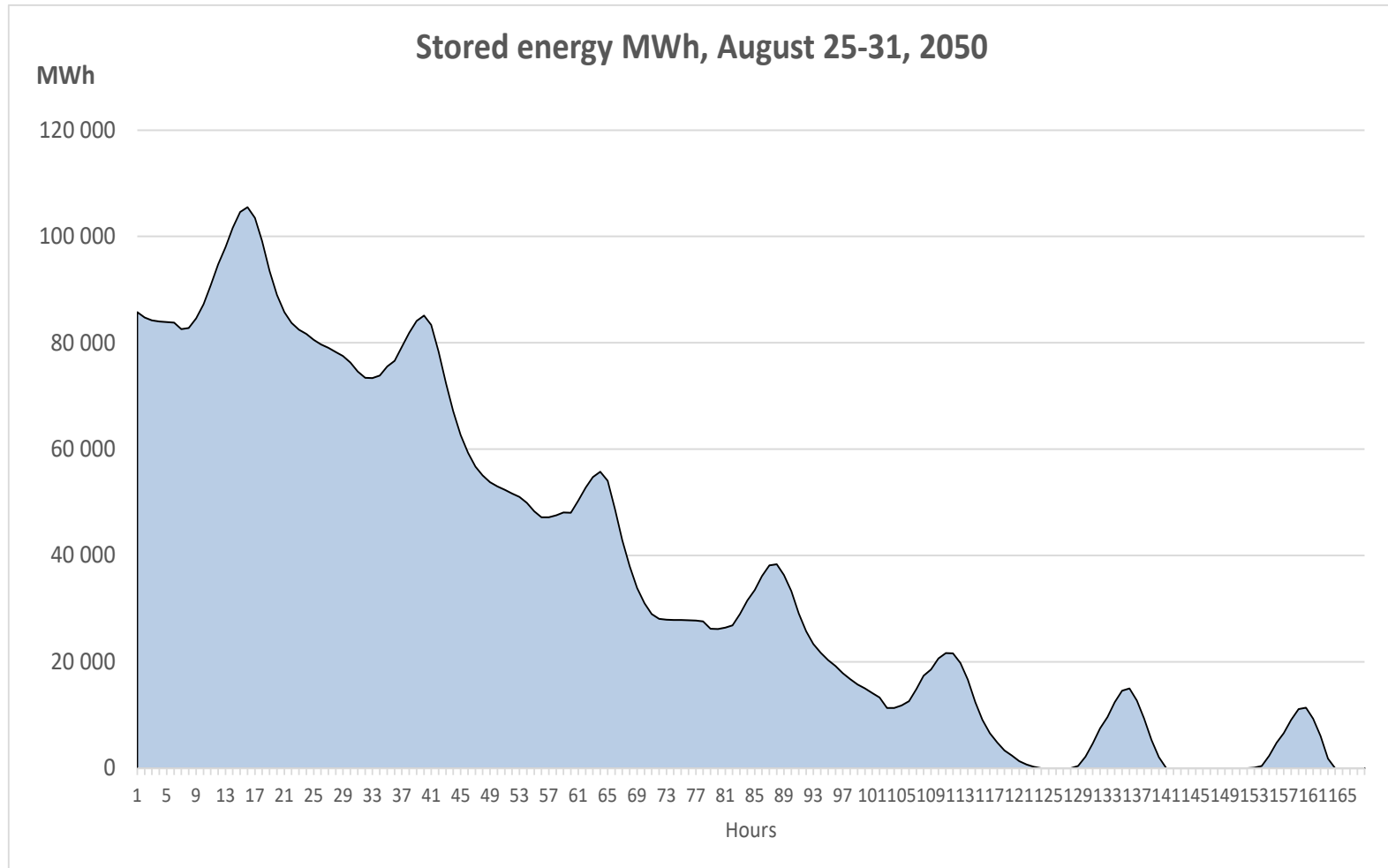
# Scenario 3





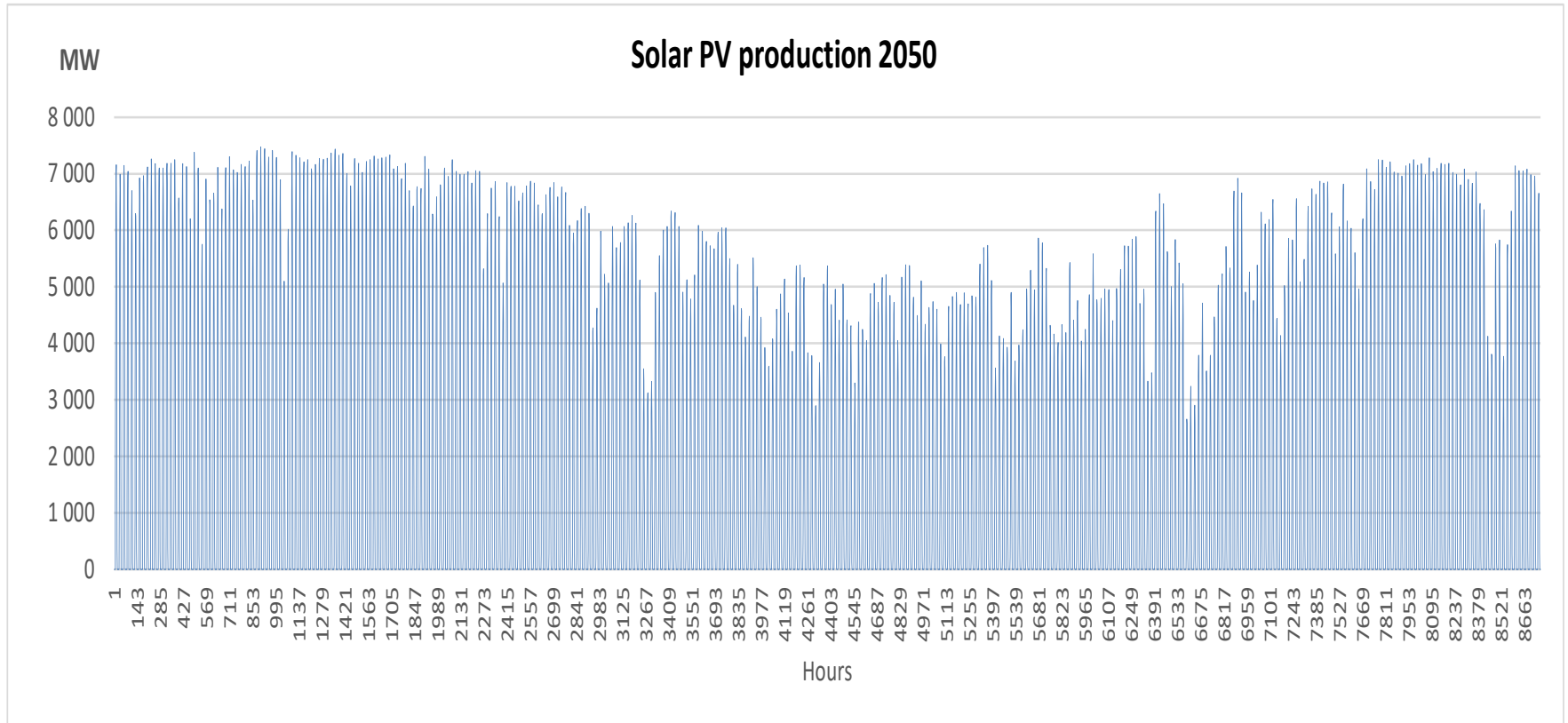


# Scenario 3



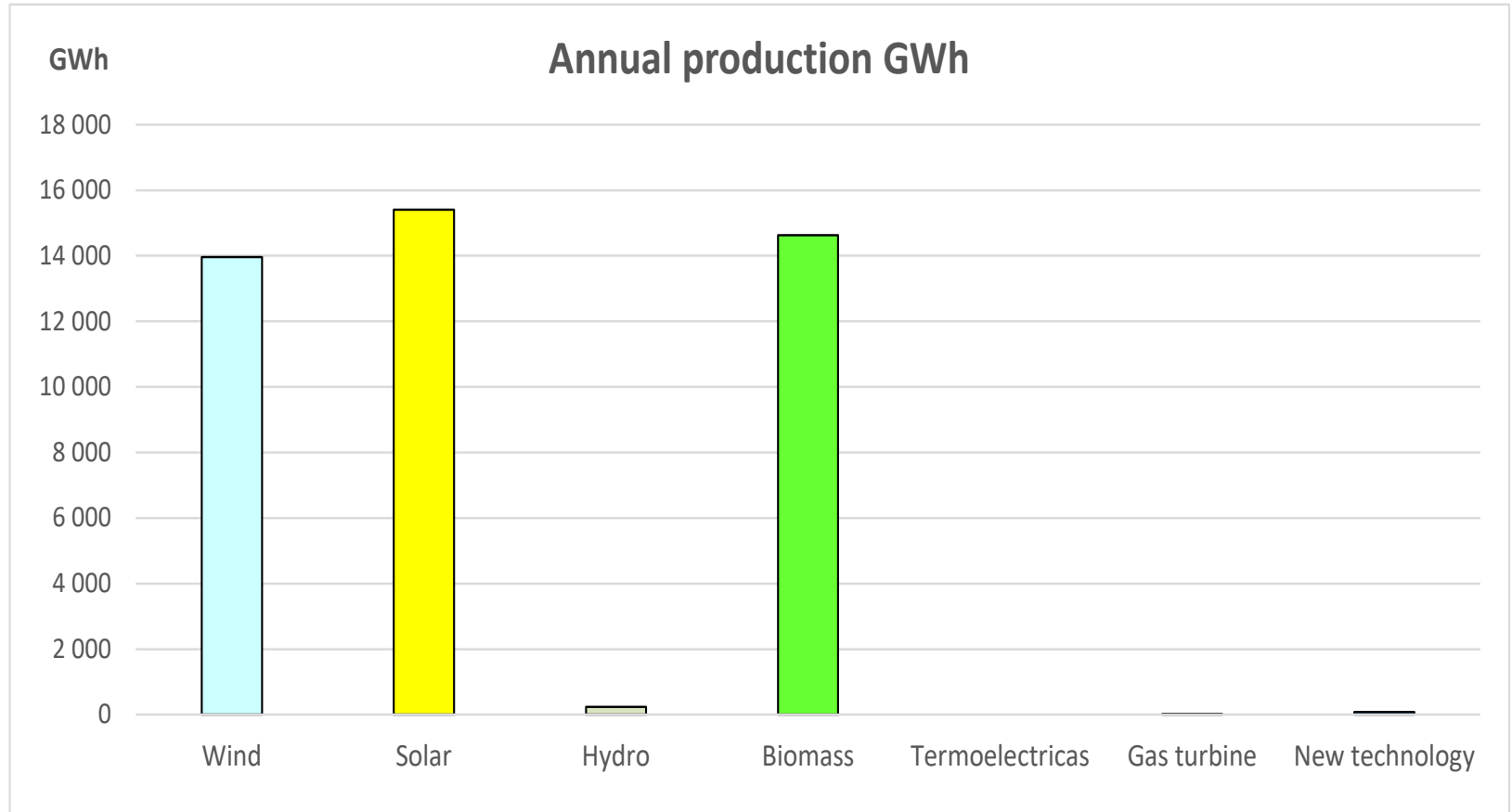


# Scenario 3





# Scenario 3



**0.2 % fossil energy**





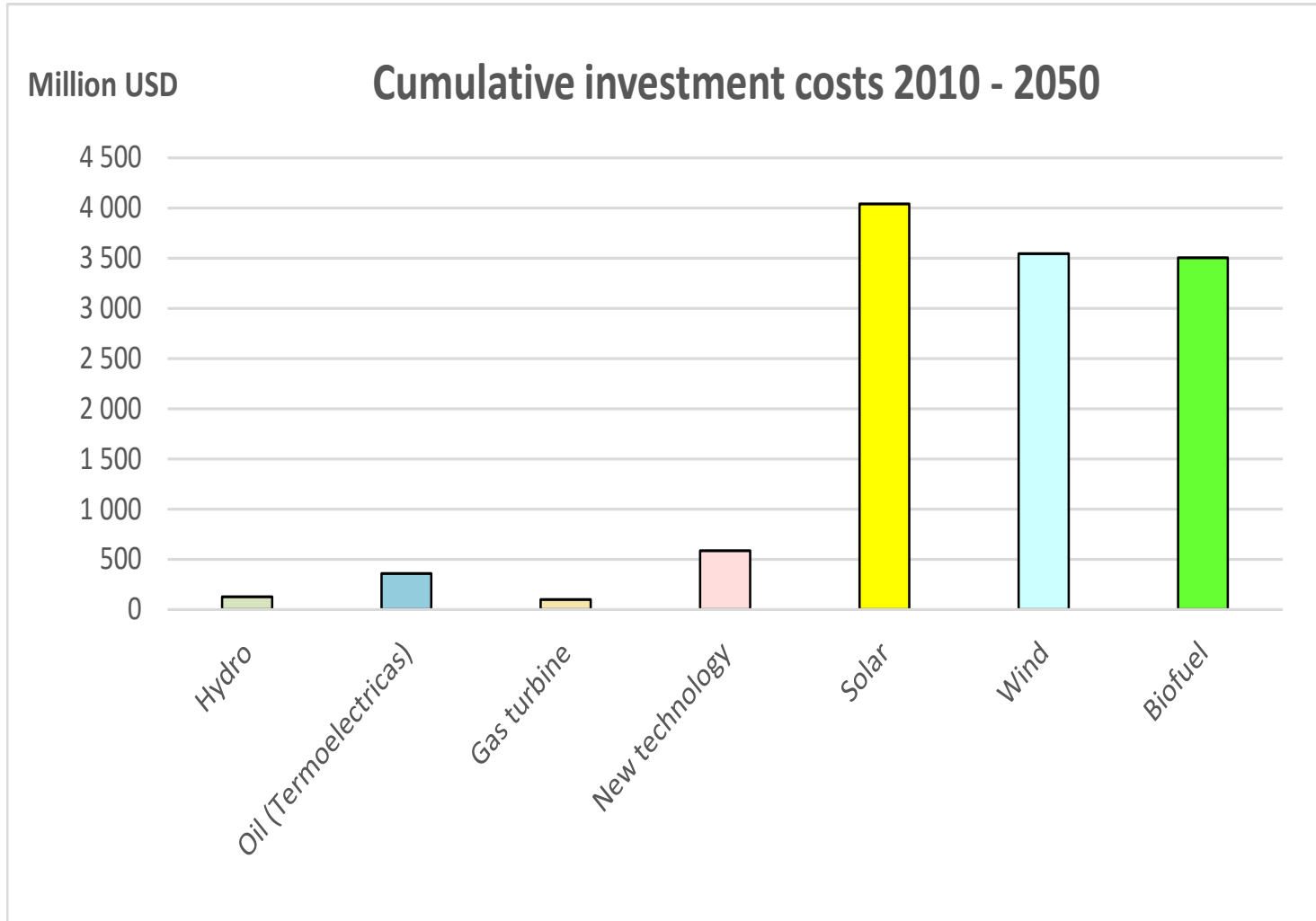
## Scenario 3

- **0.2 % fossil energy**
- **Can be replaced by bio-diesel and bio-fuel**
- **Fossil energy is about 100 GWh in 2050**
- **Fuel requirement is about 255 GWh in motor use - this is about 22 ktoe**
- **Price difference of standard diesel and bio-diesel would mean about 11 million USD additional cost**



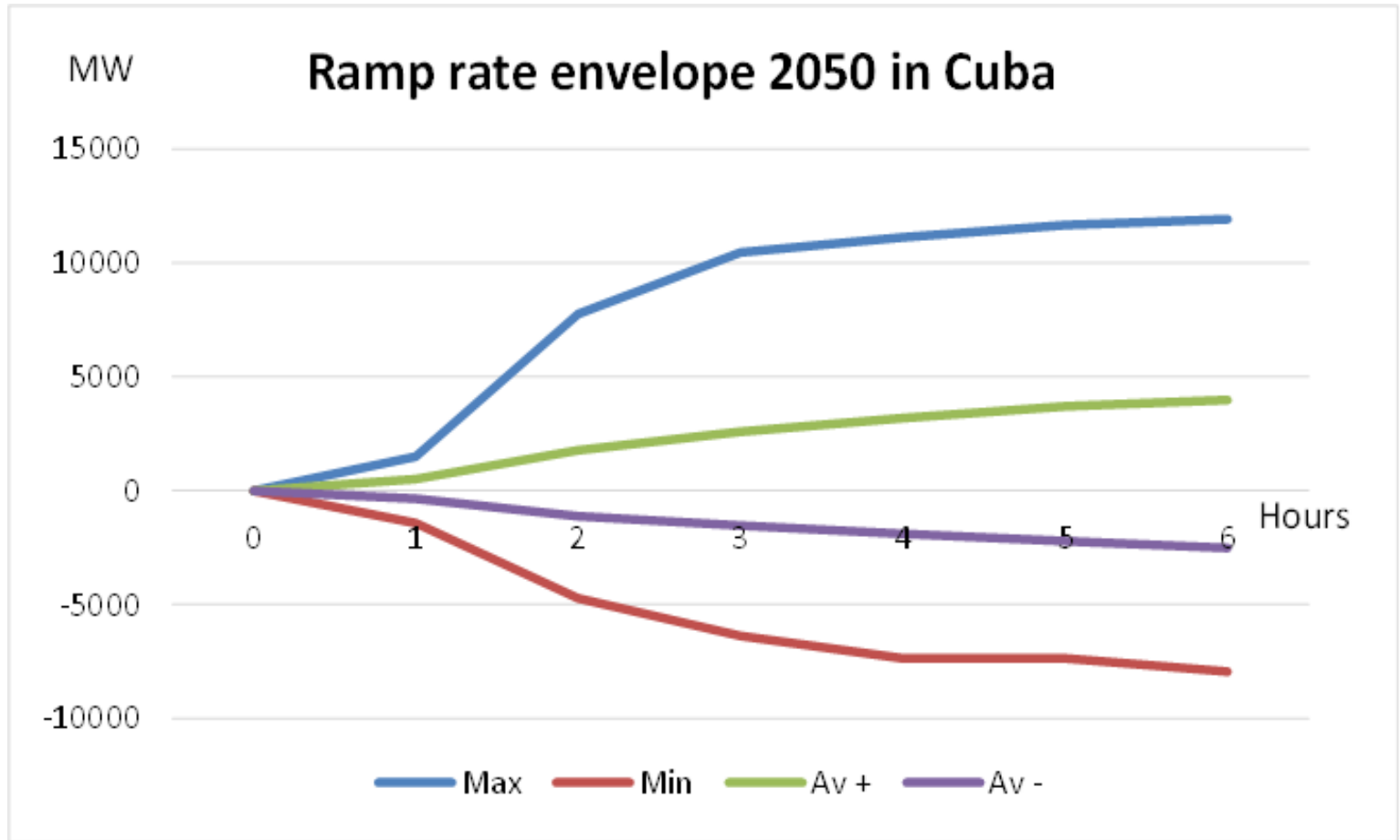


# Scenario 3





# Scenario 3





# Challenges and possibilities

- **The target of a 100% renewable electricity system is challenging for Cuba.**
- **Some of the challenges are related to the economics of the energy system.**
- **A switch to a 100 % renewable system requires large investments in wind and solar power plants.**
- **International climate change funds could provide one possibility for obtaining resources for the investments**
- **The use of renewable energy sources instead of fossil energy will naturally lead to a decrease in the fuel costs of electricity production**





# Challenges and possibilities

- **Need for investing in the electricity transmission and distribution grid.**
- **Part of the investments are carried out decentralised especially in the case of solar PV the need for increased transmission could even be reduced.**
- **Required ramp rates needed for balancing the power system with a high share of variable renewable generation requires a lot of controllable capacity both in the generation and on the consumption side.**







# Challenges and possibilities

- **Theoretical potential for large scale pumped hydro capacity exists in Cuba according to UNE estimations even up to 20 000 MW and 100 GWh capacity.**
- **Battery storages can provide some advantages for fast balancing and frequency control of the grid, but their role in large energy storage is implausible if their future prices will not decrease radically.**





# Challenges and possibilities

- **One possible technical solution to medium- and long-term energy storage is power-to-X-to-power technology (P2X2P), where hydrogen is produced by electrolysis and, together with carbon, converted to ammonia, methane or some other storable medium to be reconverted back to electricity when needed**
- **Hydrogen can also be used as raw material for different industrial processes (ammonium -> fertilizer production, methane -> transport fuel production, etc.**





# Challenges and possibilities

- **Demand-side management can provide possibilities for balancing especially if electric transport increases and the charging and discharging of vehicles is carried out using smart technology.**
- **One possibility for demand-side management is to use variable electricity prices which directs demand towards time periods when renewable production is high. This type of policy requires hourly based smart electricity metering and changes in the tariff structures.**





## Sesión del Consejo Nacional de Innovación: Vamos a trabajar con todas las energías

Por: René Tamayo

En este artículo: [Cuba](#), [Desarrollo](#), [Economía](#), [Energías Renovables](#), [Innovación](#), [Miguel Díaz-Canel Bermúdez](#), [Política](#)

16 octubre 2021 |  52 |  



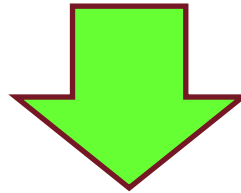
*“No solo se trata de generar a partir de estas fuentes renovables. Debe verse como un asunto integral que implica el incremento de la eficiencia energética, con la introducción de nuevas tecnologías, y también una gran conciencia de ahorro”, dijo Díaz-Canel. Foto: Estudios Revolución.*



# TRANSITION TOWARDS RENEWABLES



**For Cuba to achieve one hundred percent of electricity generation from FRE, integrating them all (although keeping fossil fuel generation capacities in reserve) is possible, Díaz-Canel emphasized.**



**PESTEC approach**

**Research question: What is needed to increase the share of renewables in the Cuban energy system and to reach 100 % renewable electricity production**





Turun yliopisto  
University of Turku

# Thank you



**Anaely Saunders Vázquez**



**Jyrki Luukkanen**

Contact information:

Anaely Saunders  
alelysava @gmail.com

Jyrki Luukkanen  
jyrki.luukkanen@utu.fi



Turun kauppakorkeakoulu • Turku School of Economics