CAETS 2021
ARGENTINA
Engineering a Better World
THE FUTURE OF ENERGY

Buenos Aires, September 17-24, 2021

How to handle intermittency (or better variability) in Renewable Energies
The case of Uruguay.

Acad. Ing. Oscar Ferreño

Characteristics of Uruguay

- Uruguay is a small country in Latin America with a low population density.
- Population: 3:500,000 inhabitants
- Surface: 180,000 km2
- Not have fossil energy resources.
- Simple and flat topography.
- Economy is totally agricultural.

Characteristics of Uruguay

All possible hydroelectric potential fully developed.
Annual hydrolectric production:
Maximal: 9,000 GWh
Medium: 7,000 GWh
Minimal : 3,500 GWh

- Annual electricity demand today: 11,000 GWh, with a Growth rate: close to 2%, and a maximum power demand peak of 2000 MW.

- Argentina International Connection: 2,000 MW

- Brazil International Connection: 570 MW

Brief History

- Argentina has abundant fossil resources.
- Uruguay fed the domestic electricity demand with the generation of hydroelectric plants, complementing and supporting them with thermal energy imported from Argentina.
- Uruguayan electricity system was very vulnerable to the economic and energy problems of Argentina.
- Different alternatives for electricity generation began to be analyzed:
  Nuclear power plant.
  Regasification plant.
  And renewables energy.

Although Wind Power and Photovoltaic was viewed as a possible alternative, they were seen as a marginal solution.

It is true that in the first decade of this century no electricity market showed shares of wind or solar energy greater than 10%.

They said: “Let's not pretend that the non-conventional renewable energies solve the energy problem, but we do want them to collaborate to do so.”

This distrust was based on the so-called intermittency of wind and solar photovoltaic.

Uruguay experience

The Uruguay experience showed that these fears were unfounded. In fact, its electrical system has functioned as a laboratory where the viability of these technologies could be verified.
To date, wind and photovoltaic have totally displaced fossil thermal generation, leaving this only for a backup that can be considered as emergency.
There are several reasons for this behavior:

1. Solar photovoltaic and wind power are not really intermittent, but are "persistent variables".

2. There is a natural complementarity between the wind resource and the solar resource.

3. There is also a natural complementarity between hydroelectric production from reservoir plants that allow some management of their production and wind and solar plants that are not manageable. The hydraulic phenomena are of low frequency, while the variations of wind and sun are of high frequency. Reservoir hydroelectric plant has reliability in short and medium term, but there have not in annual terms, while photovoltaic and wind power plants are predictable in annual terms.

4. The reservoirs act as true energy storage batteries, the variable renewable energies displaces the hydroelectric plants of the reservoir and these accumulate their natural flow.

5. Uruguay has a great interconnection capacity with Argentina, this increases the region where renewable energies have influence and causes an attenuation of variations.

Is it possible to keep this in the future?

- The reservoirs have contributed to the integration of variable energies.
  This composition of the current generating park will only be enough to supply the vegetative growth of demand for the next 8 or 10 years.

- If we want to continue supplying electricity demand with non-conventional renewable energies, we must resort to a complementary storage to that provided by hydroelectric plants.

- It is necessary to determine what characteristics this storage should have in terms of reserve capacity over time.

- Photovoltaic plants have a clear frequency of daily variation, but it also has a seasonal variation, a photovoltaic park with trackers has a capacity factor of 24% in Uruguay, but this varies between 13% for the June-July two-month period, to a 35% for the December-January two-month period.

- It is more difficult to identify variations in wind capacity factors.

The following graphs show the capacity factors of the best wind farms in Uruguay, (totaling 1,190 MW) for one day, for 10, for 30 and for 60 days.

Capacity factor one day, May to May.

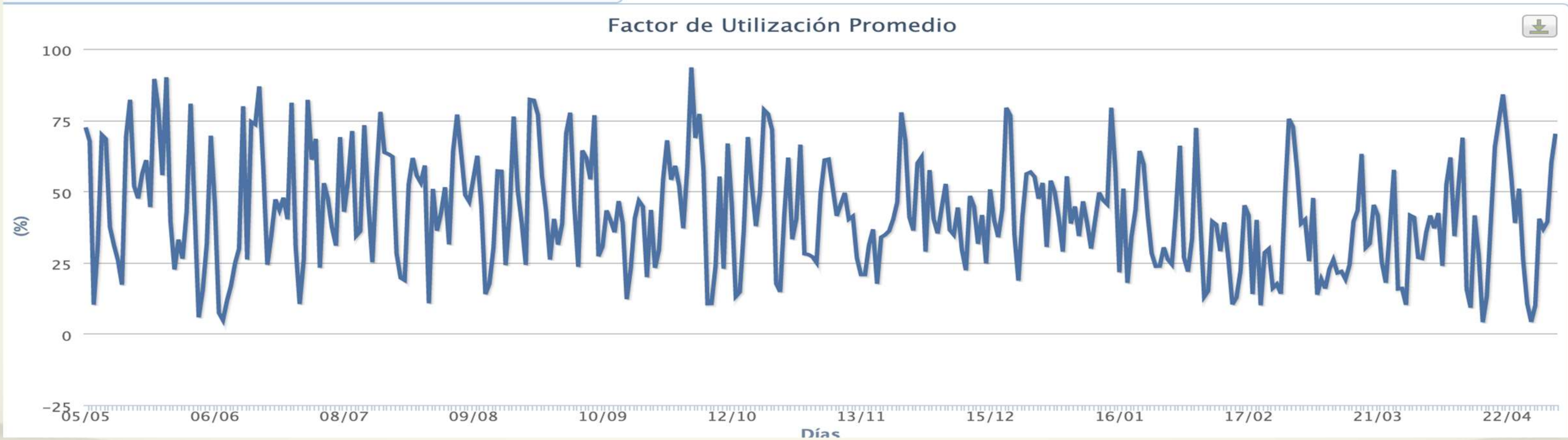
Factor de Utilización en el período (%): 42,49

Energía media en el período (MWh/Día): 12.130

Potencia Instalada (MW): 1.190

Potencia Autorizada (MW): 1.185

Factor de capacidad diario



Capacity factor ten days, May to May.

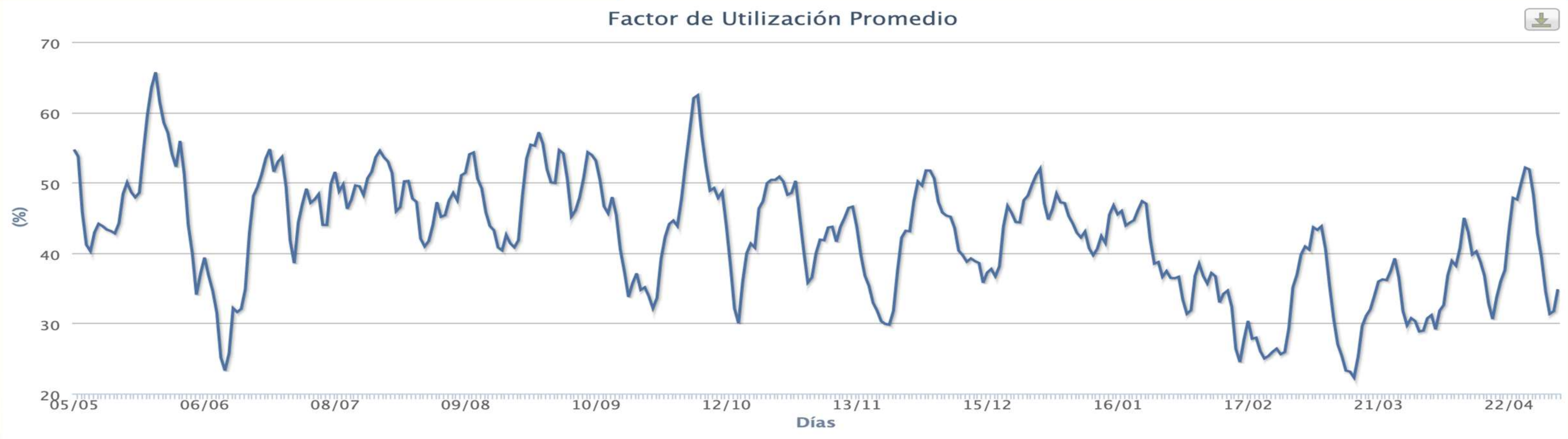
Factor de Utilización en el período (%):
42,44

Energía media en el período (MWh/Día):
12.128

Potencia Instalada (MW):
1.191

Potencia Autorizada (MW):
1.186

FACTOR DE
CAPACIDAD 10 DIAS



Capacity factor thirty days, May to May.

Factor de Utilización en el período (%):
42,44

Energía media en el período (MWh/Día):
12.128

Potencia Instalada (MW):
1.191

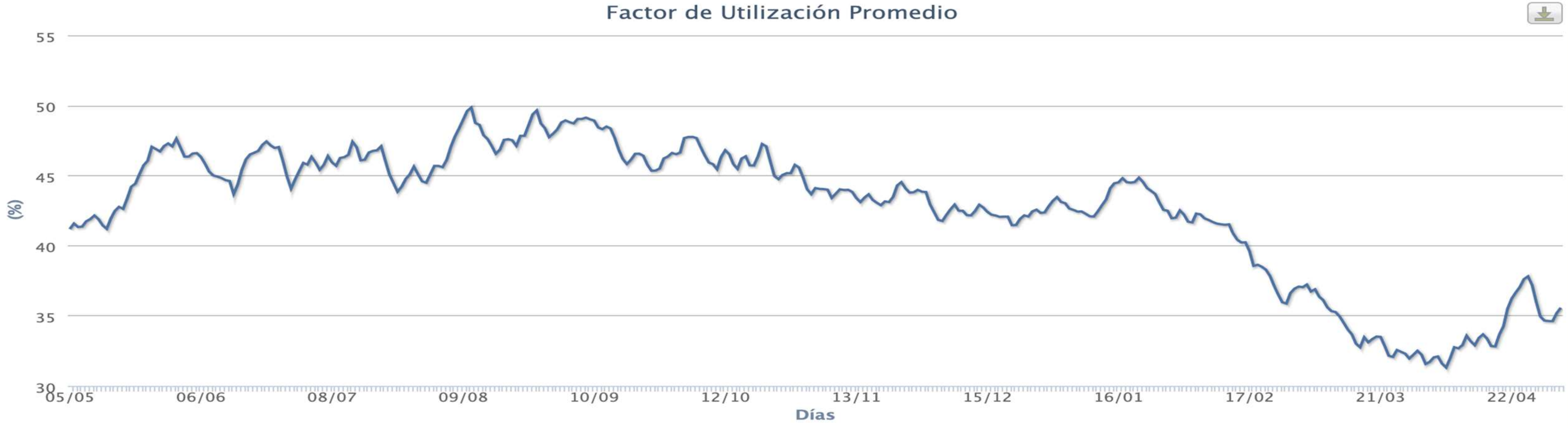
Potencia Autorizada (MW):
1.186

FACTOR DE
CAPACIDAD 30 DÍAS

Capacity factor sixty days, May to May.

Factor de Utilización en el período (%):
42,44
Energía media en el período (MWh/Día):
12.128
Potencia Instalada (MW):
1.191
Potencia Autorizada (MW):
1.186

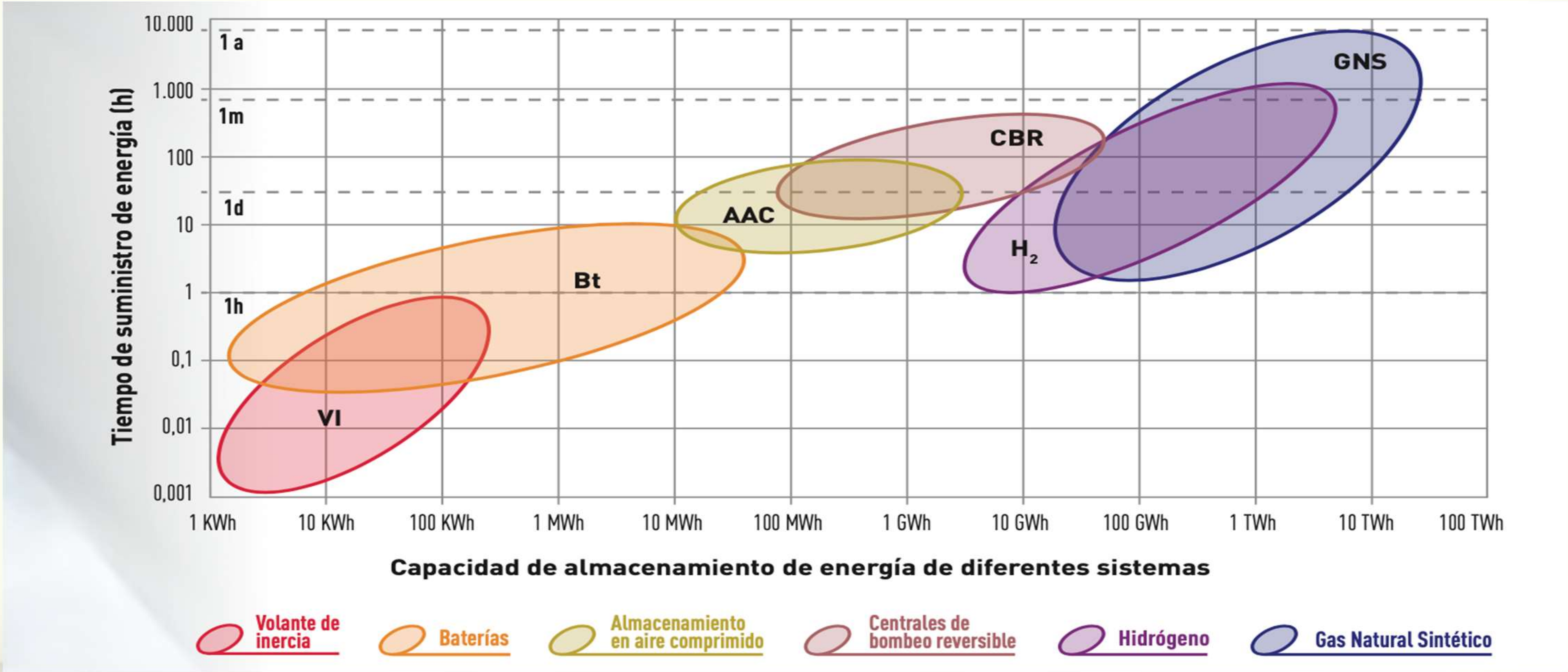
FACTOR DE CAPACIDAD 60 DÍAS



- In the graph of 30 and 60 days, the difference in the capacity factor of the wind power between winter and summer can be clearly seen, partly due to the higher density of the air in winter and partly to the higher wind speed, that is complementary to solar photovoltaic production.
- On the other hand, the variations in the wind power capacity factor in 10 days are of the order of 45% in winter and 20% in summer, while for 30 and 60 days these differences are less than 10% in both winter and summer.
- This leads to suppose that the ideal is to combine the solar source with the wind source and with a storage capacity of the order of thirty to sixty days.

Let us now see in the following figure which are the storage technologies that best adapt to these characteristics. This figure is taken from: Specht, M.; Baumgart, F.; Feigl, B.; Frick, V., ;Stürmer, B.;Zuberbühler, U.;Sterner, M. and Waldstein, G.; (2009). Storing renewable energy. Available at https://bit.ly/2ZhQtvD.

Different storage technologies.



For the characteristics of Uruguay, with an annual Electricity Market of 11 TWh and a need for storage of around a month, the only technologies that are adapted are storage using pure H2 or using synthetic natural gas, which is obtained through H2.

This is very interesting since the only way to "decarbonize" the energy matrix is to gradually replace the energy from fossil fuels with hydrogen produced by non-conventional renewable energies.

The Uruguayan fossil fuel market is between 4 and 5 times the Electricity Market, if that Market begins to be replaced by "green" H2 obtained from non-conventional renewable energies, the problem of non-conventional renewable energies variability will be gradually resolved, since this H2 it will also serve as storage.

Two questions may arise: is there enough potential in Uruguay? Is it economically competitive?
For Windpower in Uruguay there is at a rate of 1 MW each 30 hectares, if we consider that there are 14,000,000 hectares dedicated to agricultural tasks, we see that the potential is several times than necessary.
Regarding economic viability, today the production of “green” H2 with dedicated wind and solar energy should be around 6 U $ S / kg, the calorific value of H2 is three times higher than that of fossil fuels and the efficiency of the use of Hydrogen in electromechanical activities can be up to twice the use of fossil fuels.

This brings the cost of green H2 closer to the cost of fossils, although it is not yet competitive, however, the expected technological development will bring it closer and at some point, we will have to monetize the environmental impact of continuing to emit greenhouse gases.

CAETS 2021
ARGENTINA
Engineering a Better World
THE FUTURE OF ENERGY

Buenos Aires, 17 - 24 September 2021

THANK YOU

Author