Power Market Design with Conventional and Renewable Energy Coexistence.

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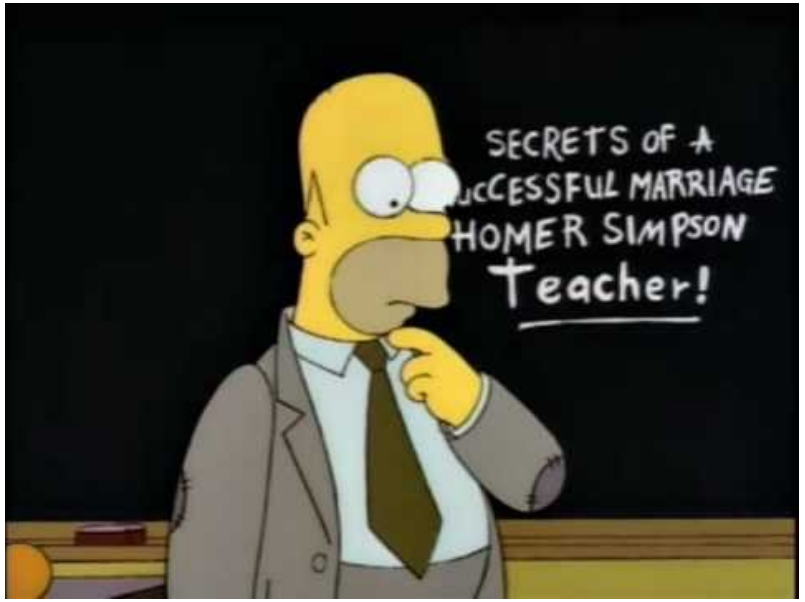
SimSEE

Do not forget that the goal is ***to provide reliable electricity at least cost to consumers***.



Minimize the **Future Cost** of operation at the same time that energy is supplied with **quality** and **safety**.

Future_Cost =

Expected_Present_Value_Of(Expenses - Income)

Power system complexity.

Instant Energy Balance.

The balance between supply and demand must be verified for any time interval, from less than a second to year

Long Term (Years)

Ensuring that investments are made, both in generation plants and in the capacity to transport energy to the final consumer.

Short Term (Month, Week, Day, hour)

Integrate the information of the real state of the system with the information of forecasts and optimize the supply.

Optimal dispatch minimizing variable costs, guaranteeing the instantaneous balance between generation and demand..

Temporal linking of the decision process..

If you use a resource (money, water, fuel, etc.) today you may need it in the future.

The optimal decisions are those that achieve the balance between the benefit of the present use with the benefit of future use.

UNCERTAINTY OF THE FUTURE.

STOCKING MODELS

FORECASTS

The Market as a tool for efficiency.

Some keys.

Number of players.

For competition between agents to be an efficiency tool, it must be verified that there is a large number of them..

Access to information.

All agents must be on an equal footing and for that they must have access to the same information in a fluid way.

Implementing access to information in an electricity market is technically simple..

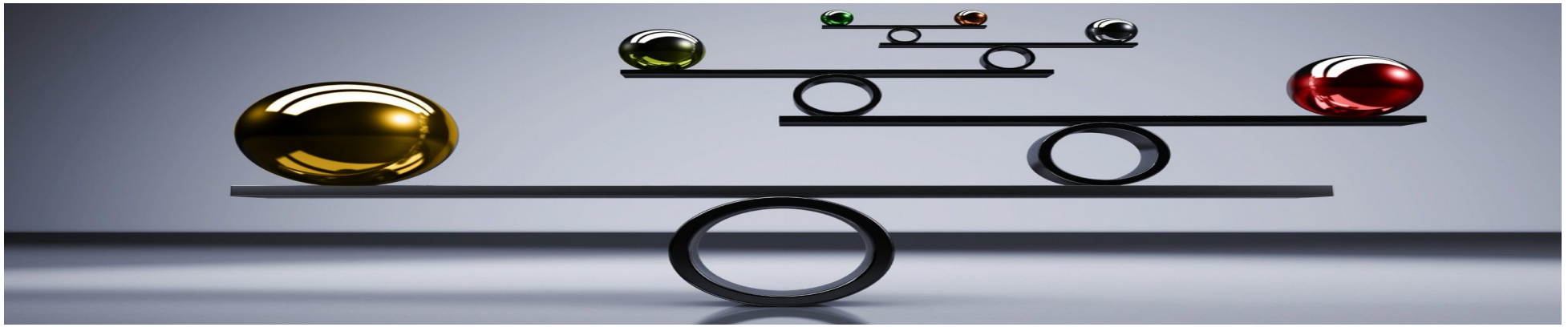
Risk allocation.

The Risk must be assigned in an appropriate manner. This point is fundamental, and is what most of the implementations of the last decades have failed and is where the incorporation of the VREs are impacting traditionally thermal markets.

The risk of poor market design.

Do not forget the goal is: ***to provide reliable electricity at least cost to consumers***..therefore, if things go wrong, they will pay for the mistakes.

Pure energy markets with remuneration at the marginal cost.



Marginal Cost of Generation. (CMG).

Many of the market implementations are based on generating a price signal for energy based on the Marginal Generation Cost (Variable cost of the most expensive resource needed in each hour, including the value of energy not suplied or rationing cost).

Optimal investments.

In theory, the remuneration of energy to the CMG, if the market were perfect, would lead to optimal investments.

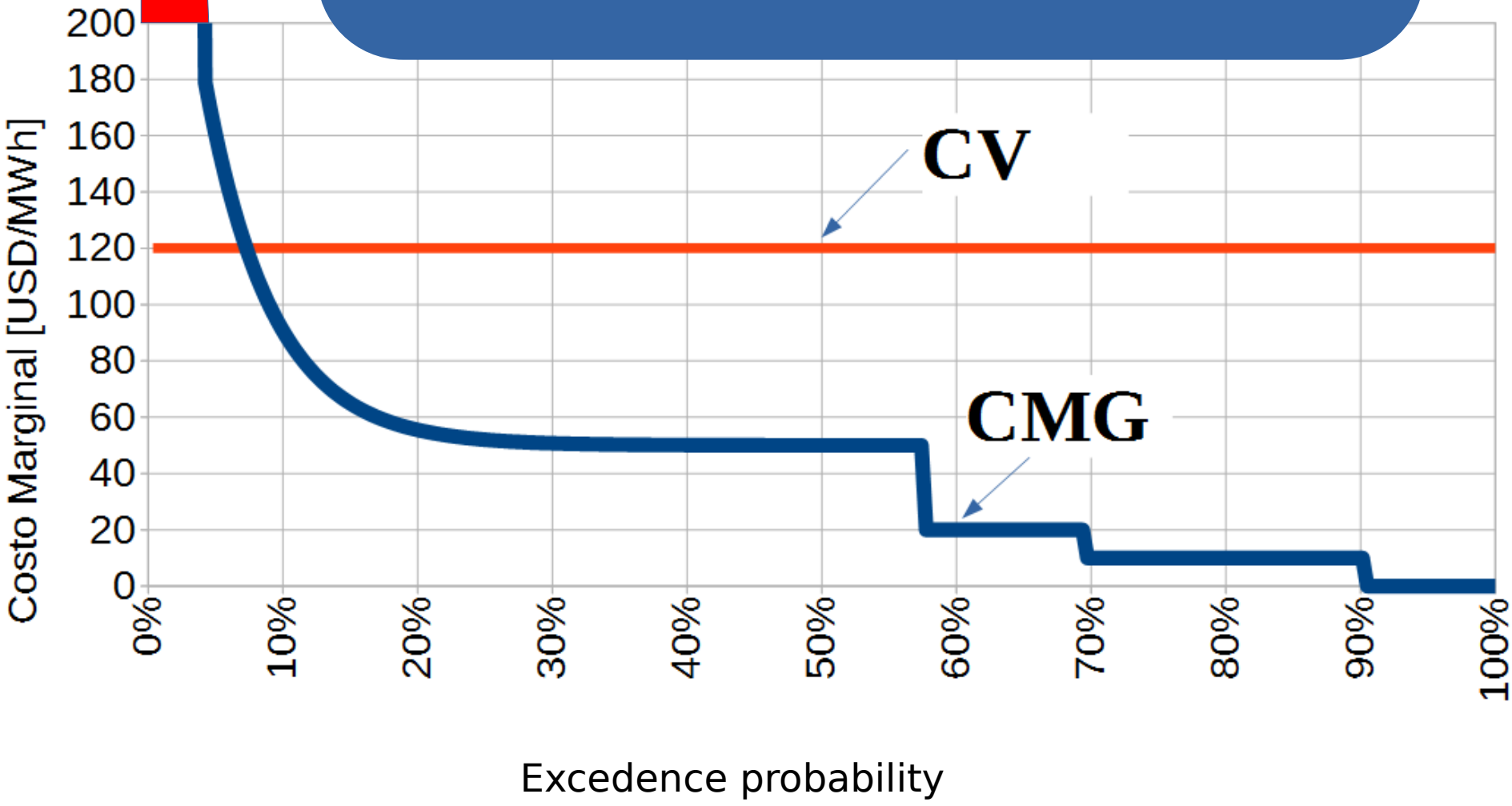
This concept is applicable also to the Capacity markets.

Risk management

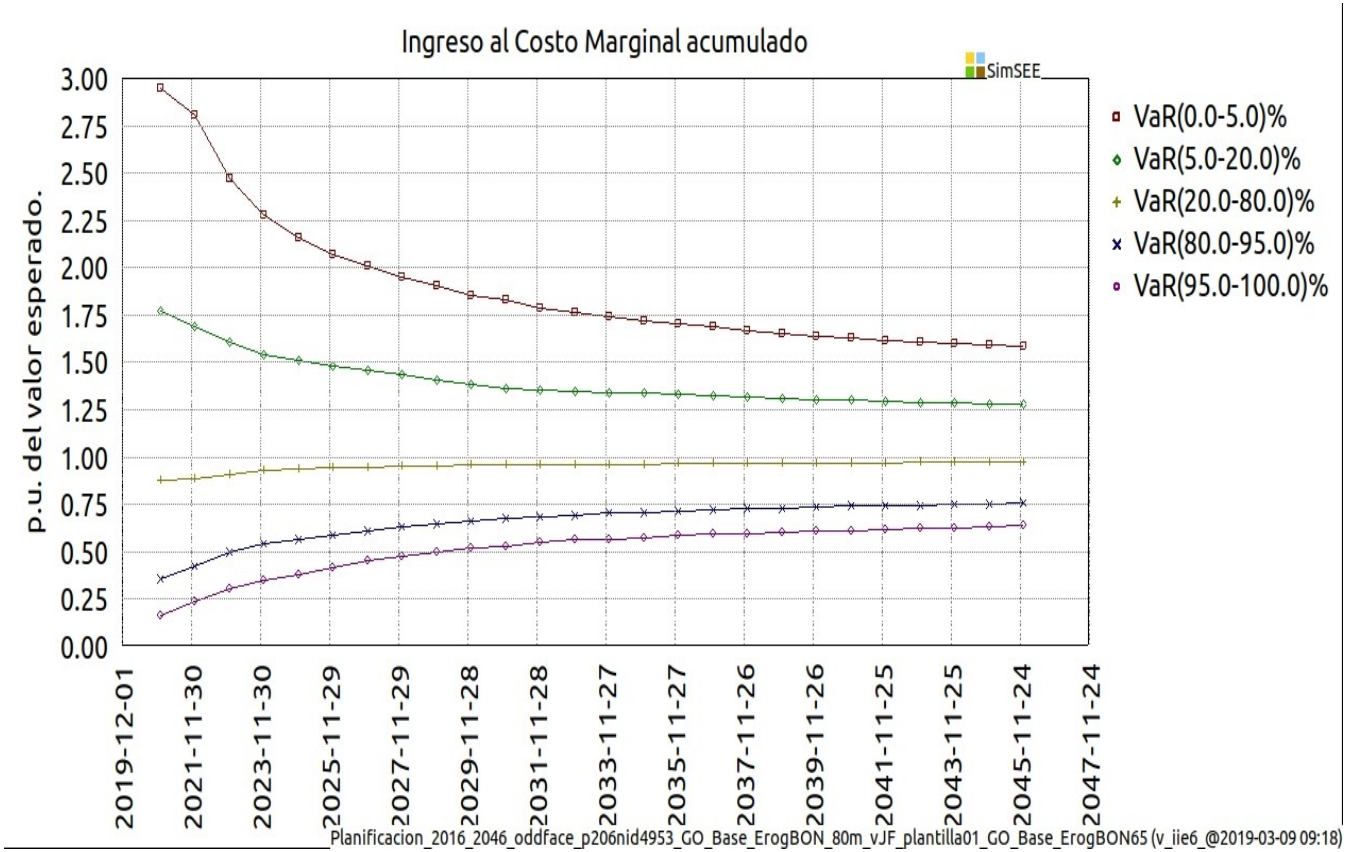
The main difficulty that the pure energy markets have had is in terms of risk mitigation instruments that allow the participation of many agents so that there is competition.

THE OPTIMAL EQUILIBRIUM

benefit by replacing 1MWh of generator power that marginalizes = Capital Costo + O&M.



Volatility of Marginalist Remuneration in a system with a strong hydro-electric component such as Uruguay.



Traditional products of Market implementations.

ENERGY (variable costs)

Thermal, Hydraulic, Wind, Biomass, Solar, etc.

Generally with a centralized dispatch that organizes the dispatch in order of increasing variable cost to supply the required instantaneous power.

CAPACITY. (fixed costs)

Transport capacity

Generation capacity

Regulation services.

SPOT Market and Contracts.

SPOT Market.

In the "pure energy" spot market, generators sell at the CMG price and consumers buy at the CMG price.

The level of risk is a barrier to direct investment in this market.

As a way to mitigate the risk, the Payment for Capacity arises ensuring a payment and as a counterpart the Spot price is formed as the CMG with "Ceiling".

The SPOT Market, with the capacity payment if it exists, can be thought of as: "the default contract offered by the system".

Contracts (PPAs).

The parties, Supply and Demand, have complementary risks in the Spot Market, therefore, they have the right incentives to sign contracts reducing the risk of the whole.

System of Guarantees.

The Guarantees required to PLAY in the SPOT must faithfully reflect the commitments assumed. If they are sub-valued there is no incentive to sign contracts between parties and the actual risk is not properly assigned.

Regional integration, other source of Market Risk to manage.

Investment planning and sovereignty..

Given the political variability (in time and space) of Latin America it is difficult to think of a full Regional Energy Integration in the short term. This leads each country to plan its investments to ensure supply regardless of the possibilities of exchange with its neighbors. No doubt this "distorts" the economic optimum.

In the case of Uruguay, we recently carried out the optimal expansion plan in three Integration scenarios: Closed (neither exported nor exported), Open Exp. (It is exported but not imported) and Open ExpImp (It is allowed to export and import) .

The result shows that opening the export implies a cost reduction for Uruguay of 7.7% and opening the Import an additional reduction of 5.7%.

Closed planning but Open Operation.

Claramente, la necesidad de asegurar el abastecimiento lleva a un diseño “Cerrado” mientras que en la operación real se intenta por todos los medios realizar intercambios entre los países de mutuo beneficios. Estos intercambios cambian sin duda la remuneración marginalista.

The best is the enemy of the good.

Lo Mejor es enemigo de lo BUENO.

O melhor é inimigo do bom.

Should we abandon the marginalist idea?

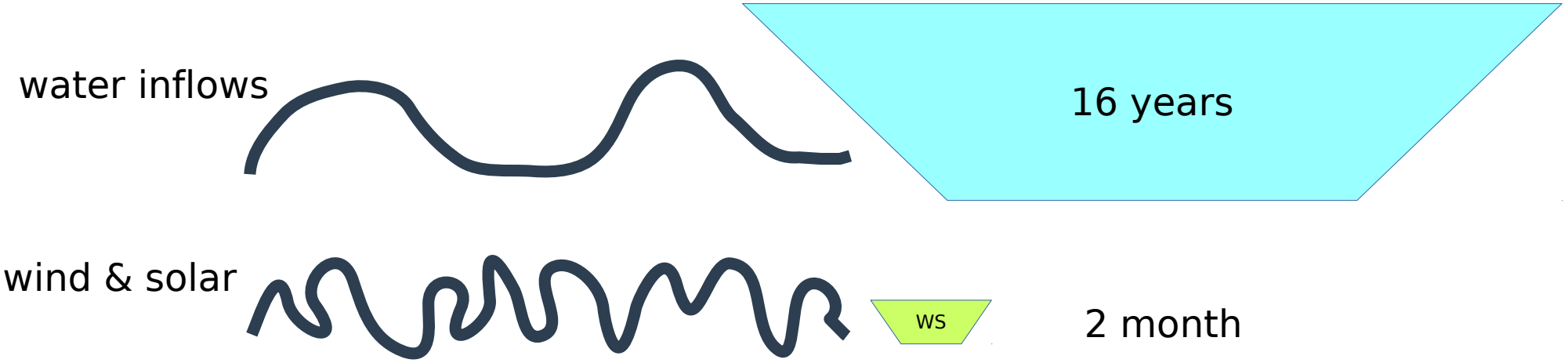
In my opinion NO, NO !. It's a good tool.

In my opinion, the concept of marginal remuneration is a tool that allows "efficient thinking". As such, we must maintain it as the "basis of the designs", but we must certainly add "layers" that maintain the optimal equilibria.

For example: a tariff of exports and imports to allow the coupling of regional markets.

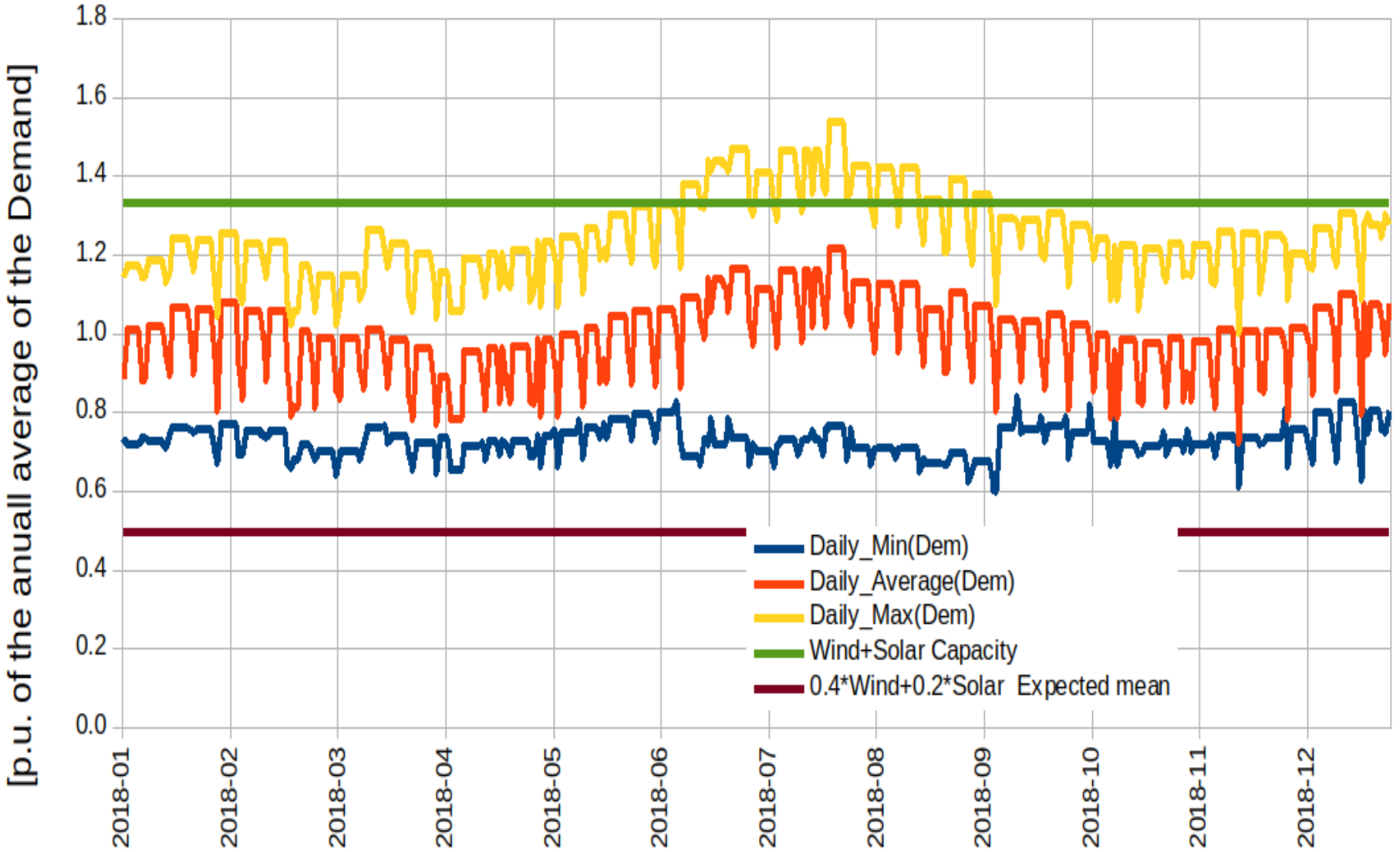
In the case of the need for more or less closed planning vs. integration, a possible tool is the definition (by each country) of a tariff to be charged for exports and / or imports of energy. The design must be such that the amount collected by this means reconstructs the remuneration of the supply / demand balance of the desired planning.

Characterization of the variability in Uruguay.

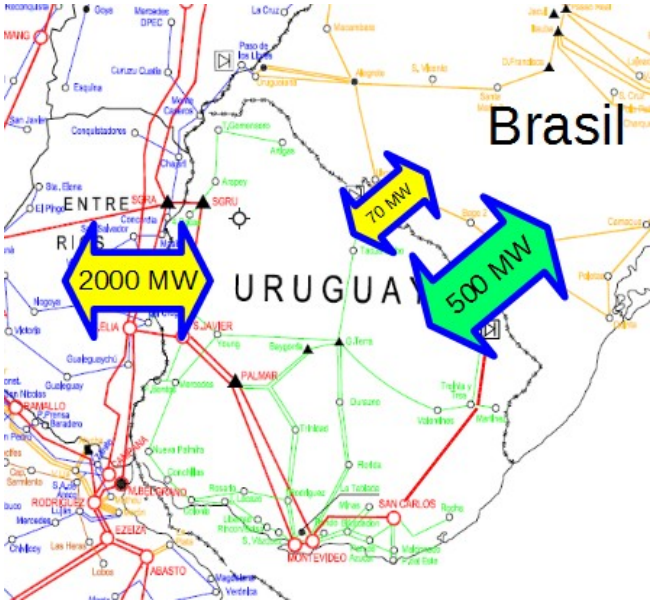


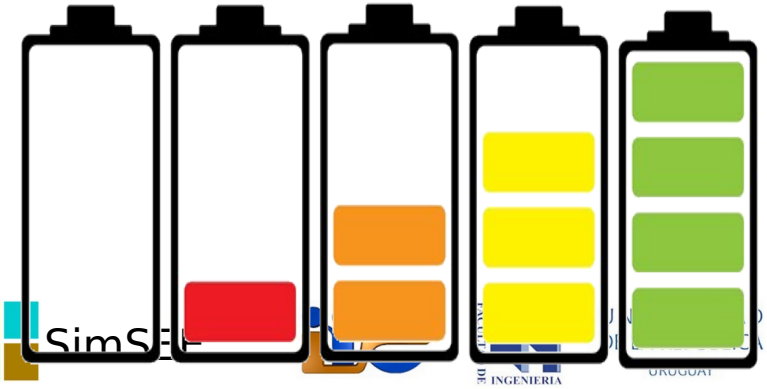
averaging time to we get the expected value width a tolerance of 10% and 90% confidence as a measure of filtering effort.

Uruguay 2018.
Wind and Solar installed capacity compared with daily Demand.



In the future, when the filtering capacity of the hydroelectric subsystem is exhausted, regional integration, Responsive Demands and Battery-storage will be the key to filter the variations of energy availability within the week.





Regulation for Responsive Demand

We have resolved the first step (compute and publish the forecast of the Spot Price).

Now we need a good regulation to enable Responsive Demands to appear.

There are details to consider. For example, if all the automatic controllers of the Responsive Demands are informed at the same time and all take the same action (moving the consumption to the time of lower marginal cost) the system is unstable.

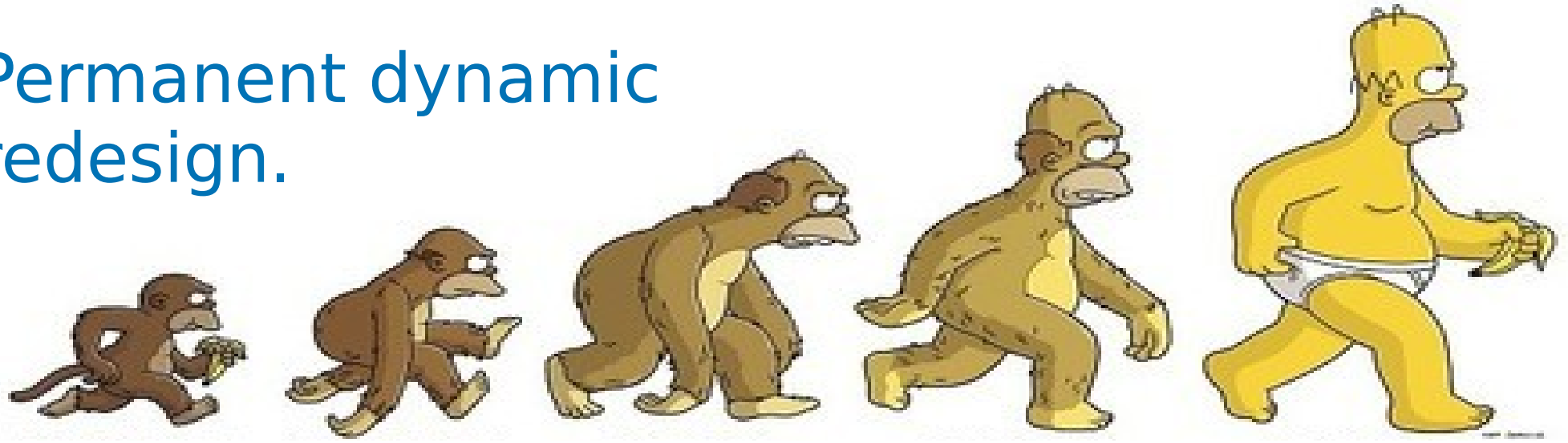
Firm Capacity. Is new regulation needed?

It is necessary to recognize the contribution to the Firm Capacity of the resources in their synergy with the other elements of the systems.

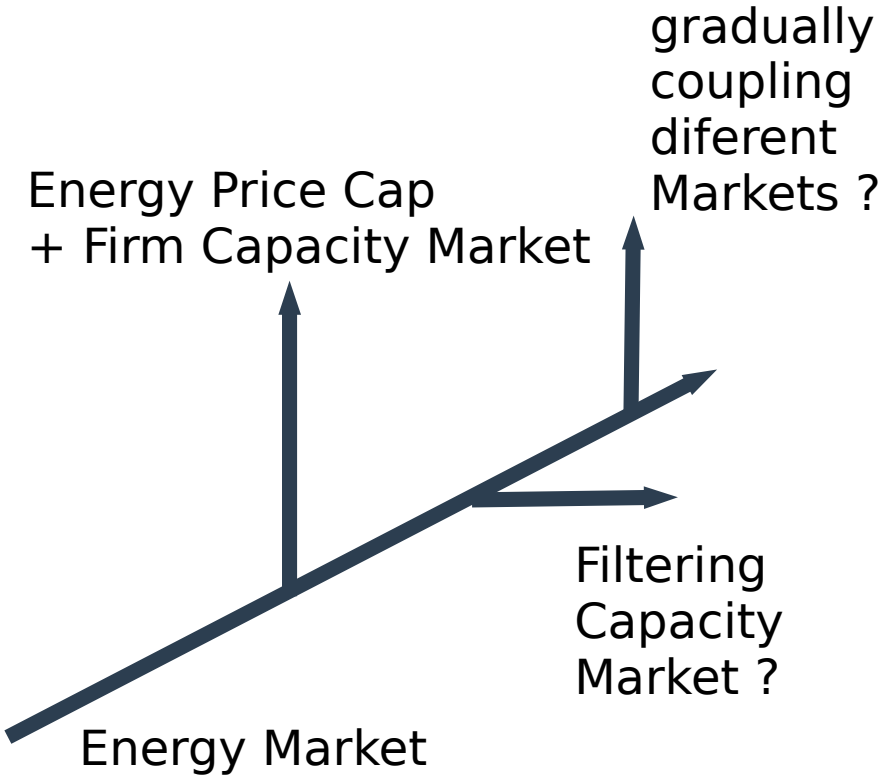
A silly example: A village in the desert that must be powered by solar panels and a battery bank. Neither of the two elements alone has a Firm Capacity, but the set does.

Filtering Capacity, a new Product?

Permanent dynamic redesign.



The important thing is to maintain the coherence and rationality of the modifications with respect to the theoretical optimum so that the Participants can trust that the interventions of the regulators "are always for the good".



Thank you very much for your attention!

Be quick enough not to miss the train and slow enough not to get on the wrong one.