

# Supporting Mitigation of Climate Change

## The essential role of STE plants

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- ✓ Decarbonization of human activities is the main challenge for the next decades
- ✓ Electricity is the easiest energy vector to be decarbonized, as renewable technologies are currently cheaper than fossil fuel plants
- ✓ Electrification of final uses – particularly transport and climatization – along with increase of energy efficiency is a clear trend
- ✓ **The large majority of new capacity to be added** – as result of demand increase and decommissioning of conventional plants – **will be Renewable**
- ✓ **BUT**, non dispatchable renewables (PV / Wind) require fossil backup and their deployment is clearly limited by curtailments and market conditions

As transition is already happening,  
Is there any short term solution envisaged  
to avoid the need of fossil backup?

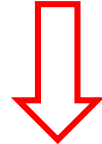


❑ Meeting the demand at any time is about programming the dispatch of generation units

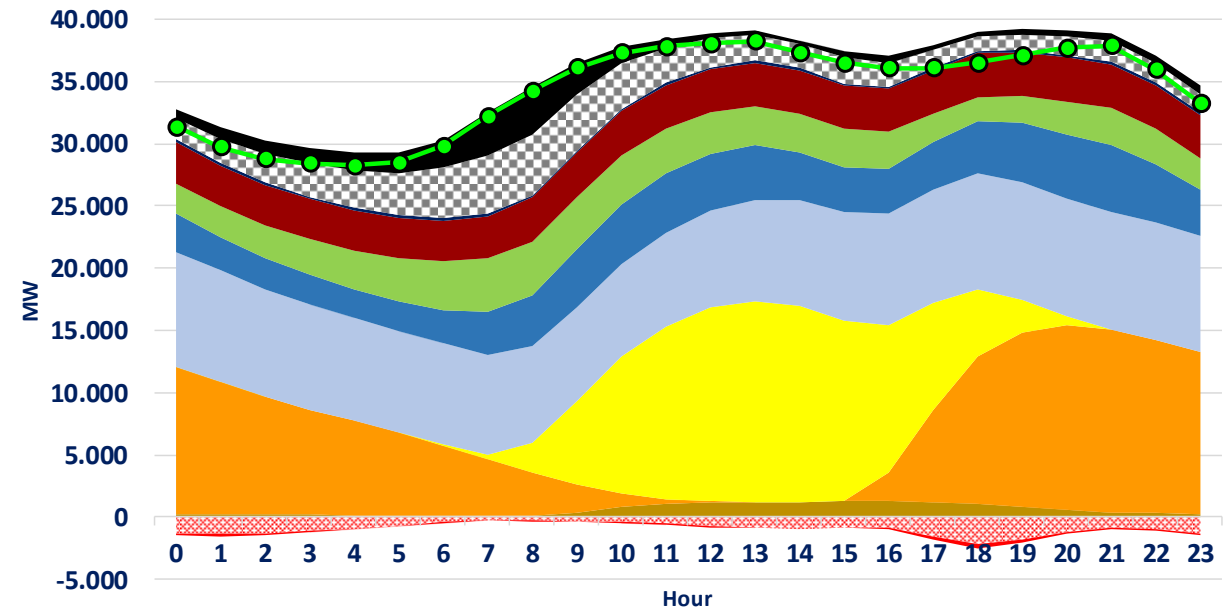
❑ The goal of planning is:

1. To achieve a carbon-free generation system
2. To ensure quality of supply and grid stability
3. At an affordable cost

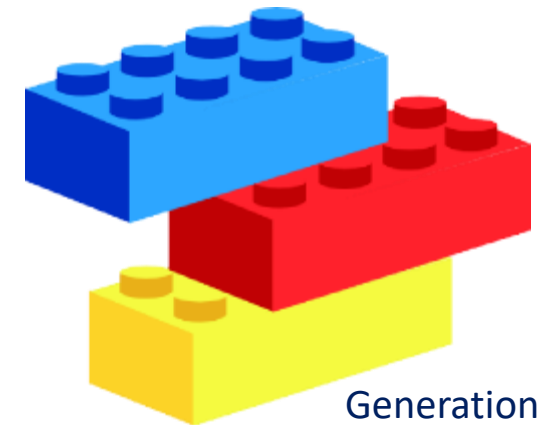
Right  
approach



**Least Cost Expansion models do the other way around**

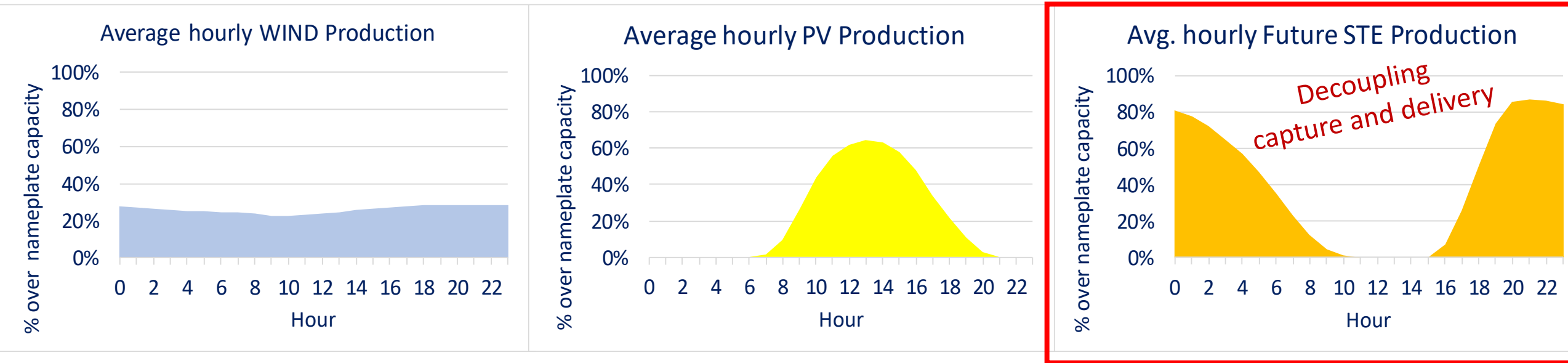


- ✓ Wind and sun will be the pillars of electricity generation in the future. Large hydro and biomass will also contribute with their dispatch flexibility
- ✓ But wind parks and PV plants generate only when the resource is available
- ✓ The appropriate generation pieces should be put together to meet the demand avoiding as much CO<sub>2</sub> emissions as possible



Generation units

# What is the missing piece? No possible transition without STE/CSP



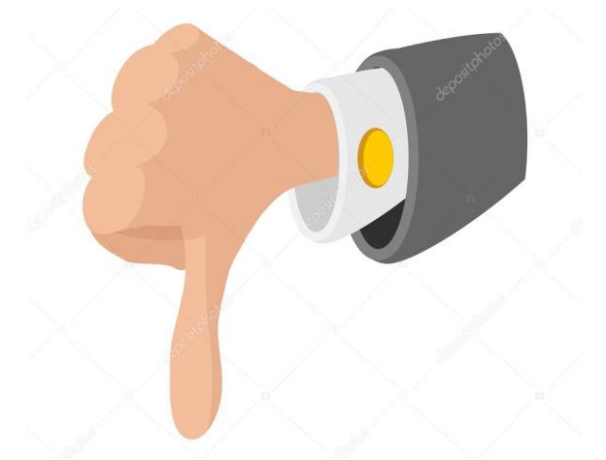
Renewable generation technologies are quite different from each other. Policy Makers must understand their differences to achieve an optimum generation structure with the minimum fossil backup, as markets and expansion models can not do it. Therefore:

- ❖ Neutral technology auctions are not the right way. They create additional technical and economic problems
- ✓ **Competitive specific auctions**, either by dispatch profile or technology - requesting what the system needs at specific times of day along with the decommissioning process of old plants – **are the right approach**

## ❑ The optimization criteria is cost but not decarbonization

This was the usual way until now but it shouldn't be the case any longer.

- ❑ The input data on the models regarding CAPEX and OPEX and capacity factors, which have used until now do not correspond usually to the current PPAs resulting from the competitive tendering and auction processes. The sensibility of this inputs on the results are very high and correspondently their conclusions very doubtful.
- ❑ In addition feed back between resulting capacity factors and costs as well as market power forces are usually not considered
- ❑ Their approach, which have been relatively correct for conventional generation technologies, lead them to unfeasible technical and economical results when incorporating renewables. Meeting the demand at any time – in real meteorological years – has constraints and requirements, which must be solved by somebody else, with additional costs and emissions.
- ❑ And, above all, **these models do not include the most essential aspect of renewables:** their intrinsic **differences** (geographical and operational) in particular, in terms of **dispatch profiles and operational strategies**.



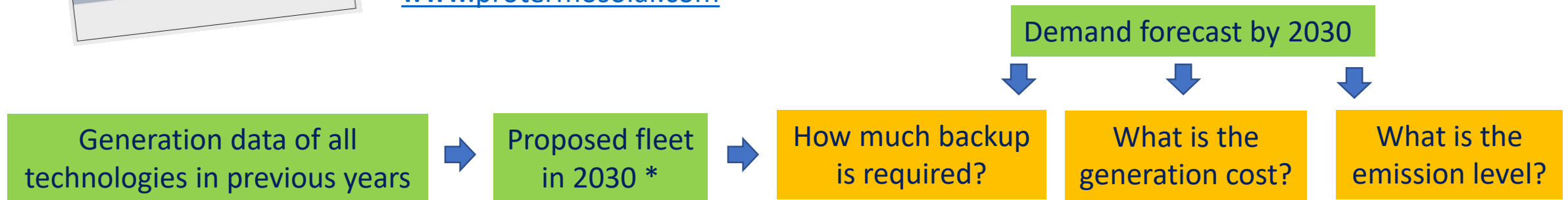


**On the contrary, Protermosolar's study is based on real data of hourly generation and demand.**

**We used an inductive instead of a deductive approach**

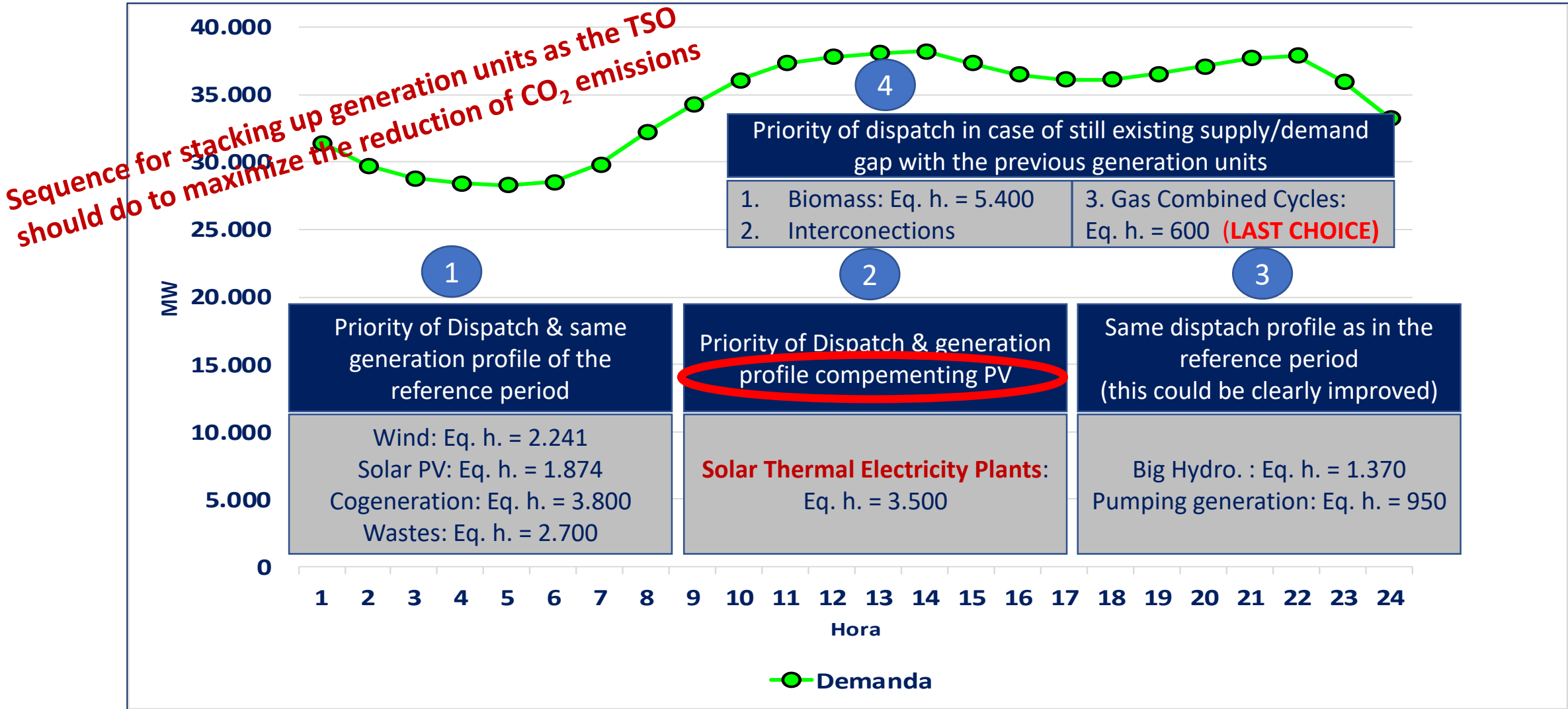
**It could answer to the following questions very precisely**

[www.protermosolar.com](http://www.protermosolar.com)



\* The **fleet breakdown in another variable** that can be modified to optimized the answer to each specific goal

Dispatch sequence in the Protermosolar Transition Report



**Hourly production projections with from real data in different years  
implementing the dispatch flexibility of STE and Biomass plants**

**Identification of the hourly required backup**

What if 2030 was like 2014 (2030'14), 2015 (2030'15), 2016(2030'16) o 2017(2030'17) regarding renewable resources, or an average of these 4 years (2030'M)?

## **Additional degrees of freedom**

- **Optimized Hydro management**
- **Proactive Demand management**
- **Interruption contracts**
- **Optimization of the renewable mix**

## **Reflections on market model**

- **All new capacity will have stable remuneration during its life span**
- **The increase of the renewable share will make the marginal market not viable**
- **The backup payments should be established on reasonable profitability basis**



*The report:*

**Another mix of electric generation is possible (and desirable)**

**Alternative proposal to the Expert Commission report**



The natural complementarity of renewables in Spain (Wind / Sun and Water) along with a smart dispatch profile of STE plants after sunset would allow a 2030 scenario\*:

- ✓ **Without coal plants**
- ✓ **Without nuclear power plants**
- ✓ **With less support of combined cycles than in the report of the Expert Committee (ExpCom)**
- ✓ **With 85.6% of renewable generation with very few curtailments (82% less than the discharges foreseen by the ExpCom)**
- ✓ **With very reduced emissions (half than those provided by the ExpCom)**
- ✓ **Achieving a 34% penetration of renewable energy in the final energy demand**
- ✓ **Fulfilling EU objectives**
- ✓ **And less than 5 c€/kWh generation cost**

That means realizing a **True Energy Transition** with enormous additional benefits for the economy of the country

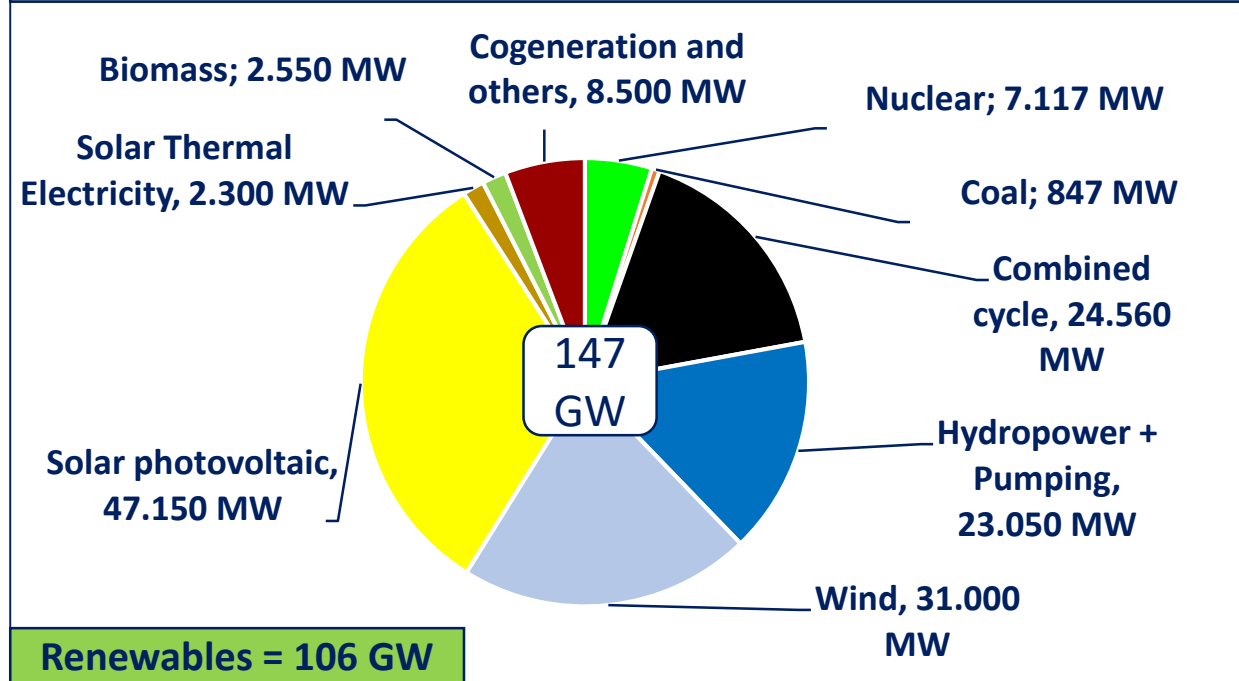
**\*Note:** The results of this report do not correspond to theoretical simulations, but to the projection made from generation data of the considered fleet in real years

## Comparison vs. the Expert Committee least cost expansion model

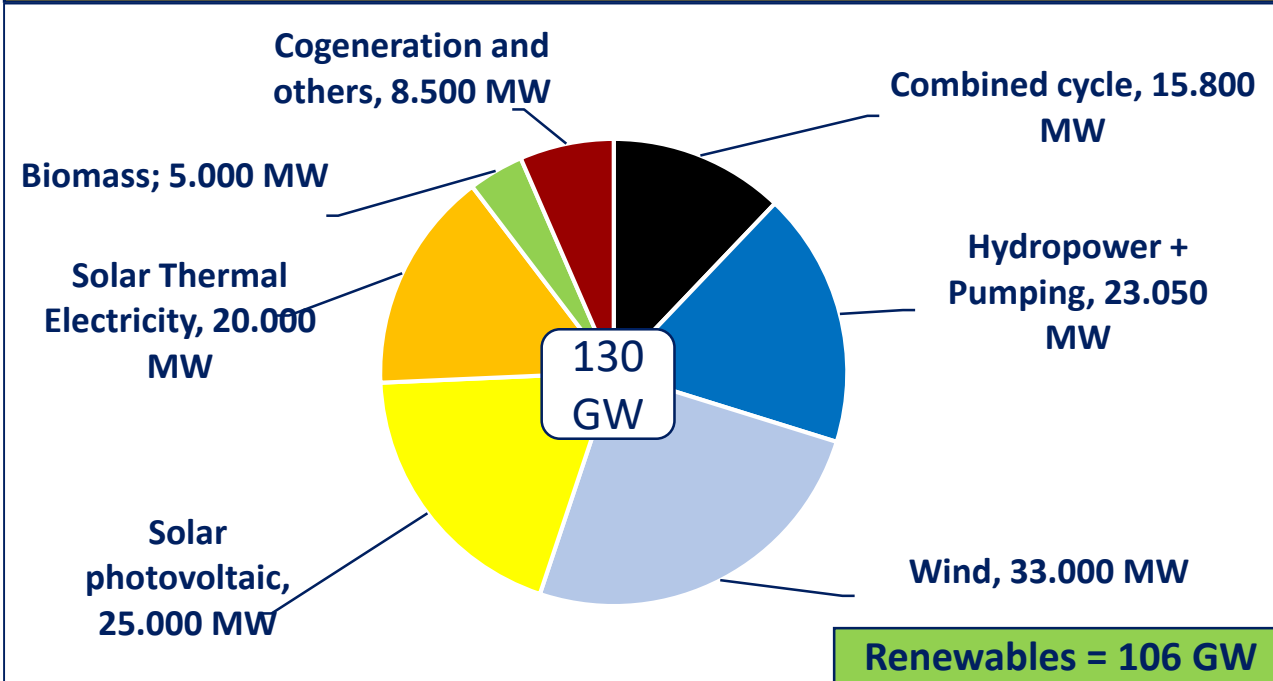
	2017 Mix	Expert Committee Mix	Protermosolar Mix	
Electric power demand	268,5 TWh	296 TWh	296 TWh	=
Total installed power of the Mix	104,5 GW	147 GW	130 GW	↓
Total Renewable Power	51 GW	106 GW	106 GW	=
Installed Power Wind	23 GW	31 GW	33 GW	↑
Installed Photovoltaic Power (PV)	4,7 GW	47,15 GW	25 GW	↓
Installed Power Solar Thermal Electricity (STE/CSP)	2,3 GW	2,3 GW	20 GW	↑
Installed Power Other Renewable	0,75 GW	2,55 GW	5 GW	↑
Curtailments		4.600 GWh	830 GWh	✓
Emissions	66.000 kton CO <sub>2</sub> *	12.593 kton CO <sub>2</sub>	4.991 kton CO <sub>2</sub>	✓
Additional comments	Data from the REE report "The Spanish Electric System - Progress 2017"	It maintains the nuclear and gas fleet and does not reach the EU's objectives.  <b>Can this be called transition?</b>	Without coal, without nuclear, with less gas support and fulfilling EU objectives  <b>This is an Energy Transition</b>	✓

\* REE takes into account emissions from Other Renewables and from Cogeneration. Both the CoE and Protermosolar do not take into account the emissions of these two sources

*MIX Commission of Experts*



*MIX PROTERMOSOLAR*

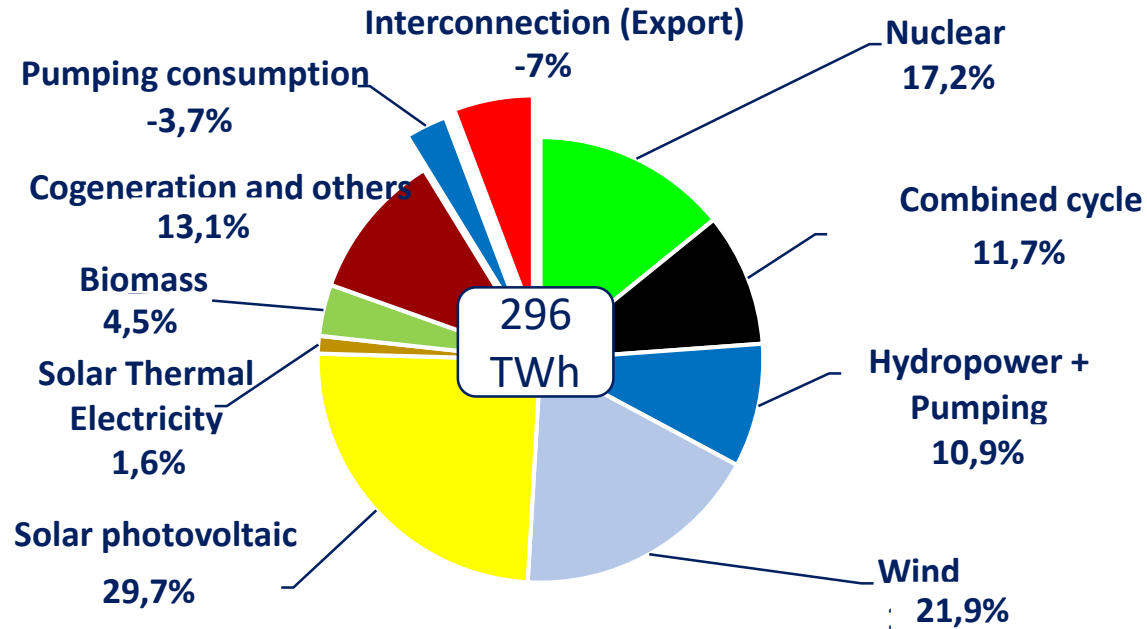


**Same amount of renewables but much more efficient**

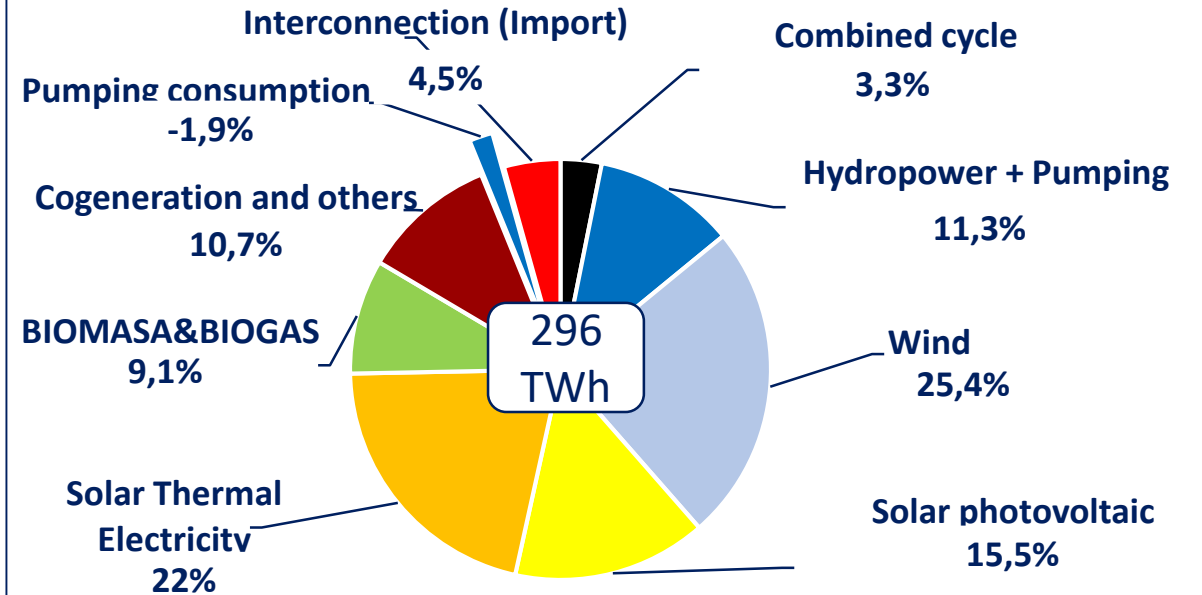


## Supply of the Demand Comparison Scenarios: Expert Committee vs Protermosolar

*MIX Commission of Experts*



*MIX PROTERMOSOLAR*



- In the mix proposed by Protermosolar, the demand coverage for renewable sources is 83%, compared to 69% of the ExpCom
- Both generation mix correspond to a demand of 296 TWh. (The hydraulicity of the mix of Protermosolar (hydropower + pumping) shown in this graph takes into account the average of the last 4 years = 33.5 TWh, a value very close to the 32 TWh of the scenario of average hydraulicity taken into account in the base case by the ExpCom)
- The saturation of interconnection considered for 2030 in the scenario proposed by Protermosolar is 7 GW, both import and export, which can be considered as more conservative compared to the sum of capacity with France, Portugal and Morocco taken by ExpCom

		Mix 2030 'xx = extrapolation to 2030 of the year XX				
	ExpCom values	2030'M	2030'17	2030'16	2030'15	2030'14
Backup Power Cycles (GW)	24,6	15,8	15,8	15,7	15,7	14,2
Number of equivalent hours in combined cycles	1.413	615	598	734	701	478
Generation of combined Cycles (GWh)	34.702	9.700	9.430	11.565	11.015	6.792
% Renewable/Generation	62%	85,6%	84,5%	85,0%	85,3%	87,6%
Generation cost(€/MWh)	52	48,8	49,97	48,67	49,16	47,45
Kton CO <sub>2</sub> Mix	12.593	4.990,9	4.890	5.639	5.513	3.921
Accumulated curtailments (GWh)	-4.616	-833,3	-289	-1.488	-723	-834

In the mix proposed by Protermosolar (2030'M):

- ✓ It takes 8.8 GW less than backup power
- ✓ The generation with combined cycles is 72% lower than that proposed by the ExpCom.
- ✓ The RES participation in demand coverage is 85.6%
- ✓ The cost of the generation mix would be less than the ExpCom.
- ✓ **CO<sub>2</sub> emissions would fall by 60% as compared with the least cost expansion approach**
- ✓ The curtailments would be 82% lower than those estimated by the ExpCom (which, in addition, we believe have been underestimated)

Reasons to increase the resulting backup power

Security reserve

Technical constraints

Temporary interconnections unavailability

Reasons to decrease the resulting backup power

Interruptible contracts

Demand management

Hydro power management

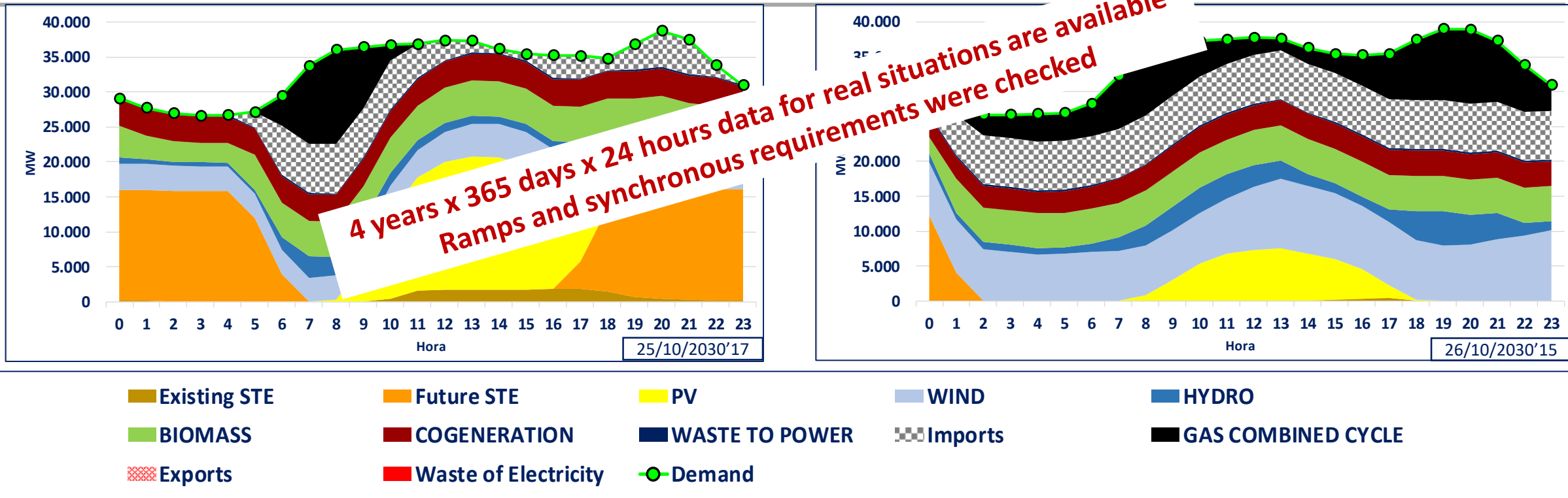
One of the conclusions of this report is that the maximum necessary gas combined cycle backup never went beyond 16 GW

It does not mean that we say that 16 GW is the necessary backup.

There are reasons to move the balance in either way but what is clear is that there are no reasons to maintain the whole current gas combined cycle fleet of 25 GW even in the case of decommissioning of the complete nuclear fleet.

Technical constraints – if these occur – would happen precisely when there were not many cycles in operation. Therefore it could happen that the amount of production from GCC could slightly increase over the year - but not much additional backup power would be required.

# Comparison of days with/without sun in autumn Examples of actual days projected at 2030

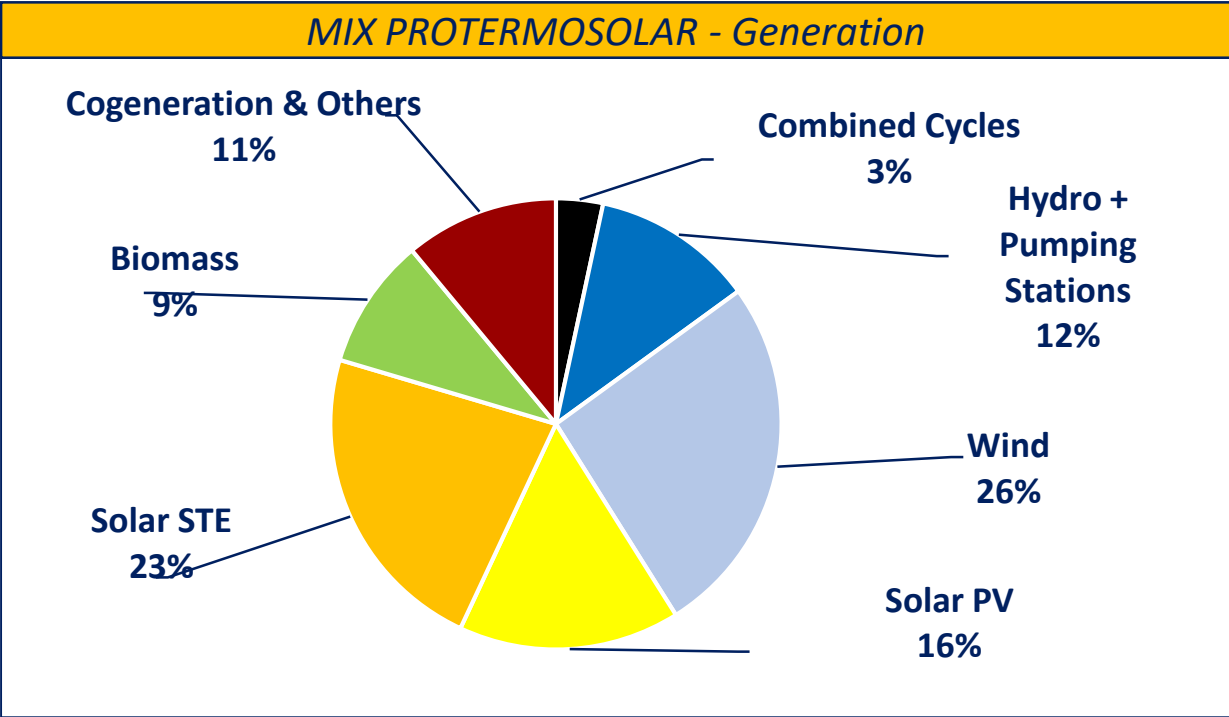


- On a sunny autumn day, the solar thermal works until late into the following night, although the decrease of solar thermal generation coincides with the absence of the photovoltaic, which implies that the combined cycles are required to cover the demand from 5:00 to 10:00 in the morning.
- On a autumn day with low solar resource, the biomass operates at nominal load all day, imports saturate throughout practically 24h and finally the combined cycles work to cover the demand; their contribution is higher when photovoltaic plants works at very low load does not contribute. Neither the wind nor the hydropower have been able to operate at high load due to the scarcity of resources.

# Cost stimations of renewables in the next decade

	STE		PV		Wind		Biomass	
	€/MWh	Added Power MW	€/MWh	Added Power MW	€/MWh	Added Power MW	€/MWh	Added Power MW
<b>2021</b>	75	500	40	2.700	45	514	95	200
<b>2022</b>	72	500	38	2.700	43	514	85	200
<b>2023</b>	70	500	37	2.700	42	514	75	200
<b>2024</b>	67	1.000	35	2.000	41	514	70	300
<b>2025</b>	63	1.500	32	1.500	40	514	65	400
<b>2026</b>	59	2.000	31	1.000	39	514	60	500
<b>2027</b>	54	2.925	30	701	39	514	55	536
<b>2028</b>	51	2.925	29	701	38	514	50	536
<b>2029</b>	48	2.925	28	701	37	514	50	536
<b>2030</b>	47	2.925	27	701	36	514	48	536
<b>Average cost by 2025</b>	<b>67</b>		<b>37</b>		<b>42</b>		<b>75</b>	
<b>Average cost by2030</b>	<b>55</b>		<b>35</b>		<b>40</b>		<b>60</b>	

The renewable park would be built over the next decade.  
 A reasonable estimate of the average cost resulting from the successive technology-specific auctions would be:



To the current renewable park would be endowed with remuneration stability and the incentives would continue to being paid independently to the generation

Energy Source	Generation Costs in 2030 (€/MWh)
Combined cycle(50€/ton CO <sub>2</sub> )	74
Hydropower	20
Pumping	25
Wind	40
Solar photovoltaic	35
Solar Thermal Electricity	55
Biomass & Biogas	60
Cogeneration	70
Waste to Power	80
Import	60
Export	40
Total Generation Costs	48.8

The left part of the table shows the allowable generation cost from STE plants to meet 50 or 60 €/MWh, keeping the other cost fixed

The right part of the table shows the effects of specific variations. The last column shows the combined effect of all of them

Precio Aritmético de España	€/MWh
2017	52,24
2016	39,67
2015	50,32
2014	42,13

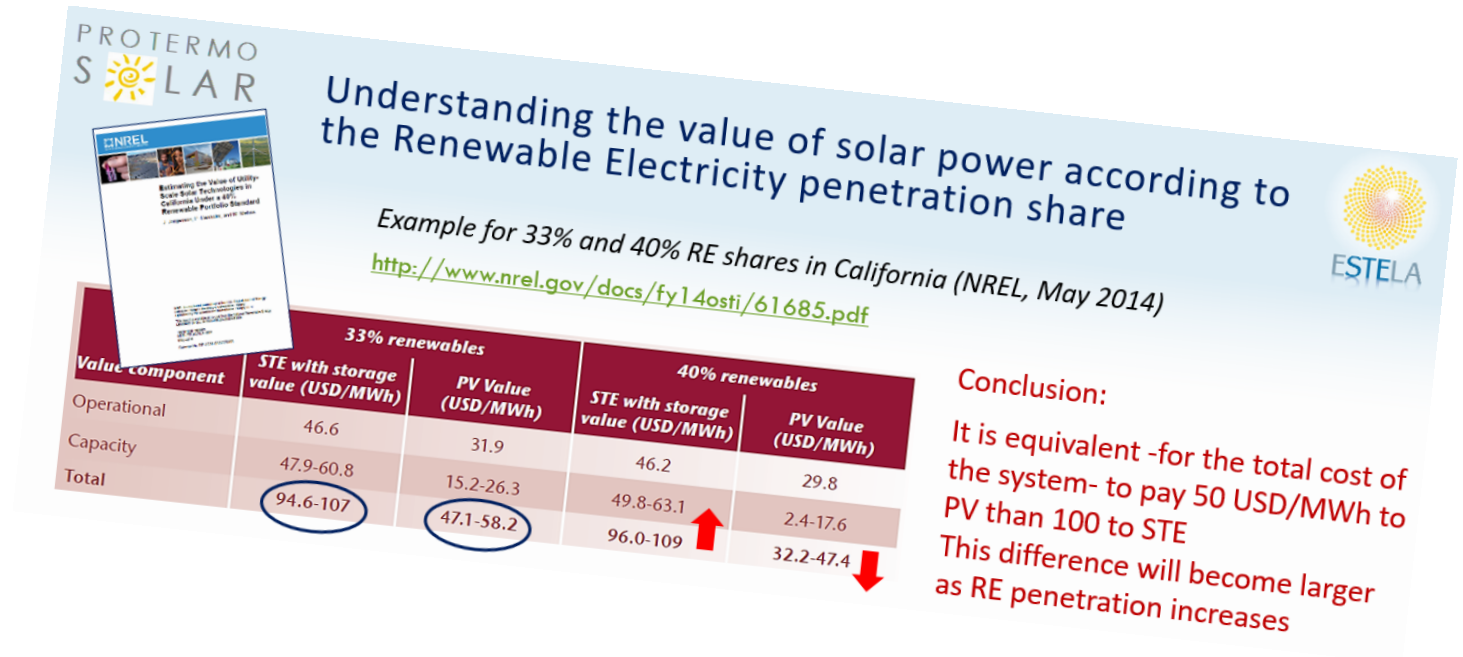
[http://m.omie.es/reports/index.php?m=yes&report\\_id=411](http://m.omie.es/reports/index.php?m=yes&report_id=411)

Fuente Energética	Costes de Generación en 2030 (€/MWh)	Análisis de sensibilidad para Costes Gen a 50€/MWh	Análisis de sensibilidad para Costes Gen a 60€/MWh	Análisis de sensibilidad 1	Análisis de sensibilidad 2	Análisis de sensibilidad 3	Análisis de sensibilidad 4	Análisis de sensibilidad 5
Ciclo Combinado (50€/ton CO <sub>2</sub> )	73,83	73,83	73,83	73,83	73,83	73,83	73,83	73,83
Hidráulica	20	20	20	20	20	20	20	20
Bombeo	25	25	25	25	25	25	25	25
Eólica	40	40	40	40	40	37	40	37
Solar Fotovoltaica	35	35	35	35	35	32	35	32
Solar Termoeléctrica	55	60,5	106	65	55	55	55	65
Biomasa & Biogas	60	60	60	60	80	60	60	80
Cogeneración	70	70	70	70	70	70	70	70
Residuos no renovables	80	80	80	80	80	80	80	80
Importación	60	60	60	60	60	60	65	65
Exportación	40	40	40	40	40	40	35	35
Total Costes de Generación	48,8	50	60	51	50,6	47,6	49,3	52,1
Variación (%)	0%	+2,48%	+23,02%	+4,51%	+3,75%	-2,51%	+1,06	+6,80

[http://m.omie.es/reports/index.php?m=yes&report\\_id=411](http://m.omie.es/reports/index.php?m=yes&report_id=411)



## Did we target it right?



This is true, BUT ...



## ... It doesn't sell



- ❑ Policy makers and planners are currently concerned not so much on decarbonization speed but on adding capacity at the lower cost. Electrical systems have still enough backup, thus they are not much worried about dispatchability. Planning of new capacity is being driven by the **tyranny of the “least cost expansion models”**
- ❑ PV plants will always offer lower costs while the sun is shining but they will always require backup after sunset. Thus the key issue is, which technology will be able to offer lower prices from sunset till sunrise next day?
- ❑ We have to compare apples to apples on how to fulfill the system needs. Not PV or Wind + 3 or 6 hour batteries versus STE plants, but **systems that first store and then dispatch from around 5 pm till 8 am**
- ❑ **This is the great opportunity for the deployment of STE plants at a large scale.** Responding to the “duck curve” and delivering firm and synchronous power at evening and night will be enough – in terms of capacity factor – to favorably compete against gas combined cycles and coal plants as well
- ❑ Planners will not have a better choice in Sunbelt countries. **A balance mix between PV & STE is the way to decarbonize the electrical system at an unbeatable price**





*Key of "sol"*

Sol is the key

Thank you for your attention