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MINISTRY OF ENVIRONMENT & ENERGY

Subject: Public Consultation of the proposal of the Ministry of Energy and Environment for the submission of the final notification to DG Competition for the establishment of a Long-Term Capacity Remuneration Mechanism in the Greek Electricity

Following the public consultation, the Ministry of Environment and Energy would like to thank all the interested parties for their beneficial contribution. At this point, it is considered appropriate to clarify the following:

Concerning some general comments on the purposefulness of the Capacity Remuneration Mechanism (CRM), it is highlighted that the commodity of *electric power system reliability* is materially different from the commodity of *electric energy* and is a typical *public good*.

Reliability is the overall objective in power system design and operation and can be addressed by considering two basic functional aspects of the power systems, the *adequacy* (which is the ability of the power system to supply the aggregate electric power and energy requirements of the customer at all times) and the *security*, i.e. the ability of the power system to withstand sudden disturbances such as electric short circuits.

The proposed CRM concerns the part of adequacy provided by electric power generation sources (or equivalent, e.g. demand response providers), i.e. the *generation capacity adequacy*, and is technology-neutral or pro-RES in some aspects.

A certain approach for guaranteeing the generation capacity adequacy is based only on energy-only market design. However, the ability of energy markets to send relevant economic signals to trigger the investments required to maintain capacity adequacy is being questioned European-wise. It is further argued that guaranteeing the generation capacity adequacy based on energy-only markets is not the most economically efficient design comparing to other forms of market organization, based on a combination of energy markets and capacity mechanisms. To help meet their security of supply requirements, many European countries have opted to introduce capacity mechanisms.

In addition, energy-only markets are unable to promote a coordinated development of generation and transmission capacity also due to the information asymmetry among the various players of the electricity sector (i.e. Transmission System Operator and generation capacity providers) and important variations in time frames for implementation of power plant and transmission projects.

The proposed CRM is a measure that has been designed to support and complement the ongoing reform of the Greek Electricity Market and support the energy transition towards a low-carbon electricity production. Furthermore, Greek Authorities have developed a CRM that complies with the requirements of the State Aid Guidelines. The proposed design has the advantage of being similar to what has already been approved in Italy which is an important neighbor for Greece given the Interconnector Capacity between both countries. The basic product is a physically-backed capacity Contract for Differences 'CfD' settled against the Reference market price. It is a CfD with a strike price based on the running costs of the most expensive thermal plant operating in the Greek Power Market. This ensures that prices can rise above the strike price, but consumers are not exposed to them if the options cover the whole demand.

The CRM defines a market for capacity, however it is not the installed or the nominal capacity that matters. In order for different technologies to participate in a single capacity market, the concept of *firm capacity* or *capacity credit* is used internationally. There are specific scientifically sound methods to calculate for the firm capacity of different technologies and a fair and functional CRM should be based on these.

According to the provisions of Law 4618 (ΦΕΚ 89 Α’) and the 15th article, the Greek Authorities will issue a Ministerial Decision and a CRM Rulebook. The MD will specify the basic principles of the mechanism design such as the duration, the price/bid caps of the auction, the way of remuneration, the duration of the contracts between the TSO and the selected capacity provider, and any other issue.

The CRM Rulebook will specify issues relating to the basic parameters of the design and operation of the mechanism with **transparent and non-discriminatory rules** such as, inter alia:

- The participation of capacity providers and their relevant obligations,
- The penalties of not being compliant with the obligations,
- The methodologies regarding the derating capacity of each capacity category, taking into account the historical data and contribution to the adequacy
- The cost allocation to the suppliers
- The formulation of the strike price
- The qualification process and testing
- etc.

Finally, the summary of the HTSO “Generation Adequacy Study for the period 2019-2030” (compiled on Oct. 2018) submitted by the HR to DG COMP for the purpose of the notification is published for the information of the participants.

***Summary of the Generation adequacy assessment for the period 2019-2030* - Produced on October 2018**

The justification of the requirement is based on the adequacy analysis by the Greek TSO, and the current market conditions in the Hellenic Interconnected System.

Basic assumptions of national adequacy analysis

The Greek TSO performed an adequacy analysis for the period 2019 – 2030. The adequacy of the Greek power system was estimated through probabilistic methods, by calculating the LOLE (Loss of Load Expectation) and EUE (Expected Unserved Energy) reliability indices, considering many decommissioning scenarios of thermal capacity, power demand inrease, renewable and cross-border transmission capacities and hydraulic conditions. The basic methodology and assumptions used by the TSO in the national adequacy study have been aligned with the methodology used in ENTSOE' s European Midterm Adequacy Forecast (MAF), issued in 2018. In this light, the assessment of the effect of climate factors (air, sunshine and temperatures) on the adequacy of the power system was considered. Specifically, for each demand evolution scenario and year, different time series of loads and RES generation were developed using the available historical data of the PECD 2.0 database maintained by ENTSO-E. These time series correspond to different climatic conditions, covering a wide range of potential, both "normal" and "extreme".

The TSO will revise the adequacy assessment every year and publish the results of the assessment.

Basic scenario for evolution of Greek generation electricity system

Total installed capacity is 17.1 GW (May of 2018). Table 3 summarizes the existing power generation capacity by technology. Most of the power generation system (51% of the total installed capacity) consists of thermal units, including lignite units and gas units. These plants also cover the bulk of electricity demand (61.1% for 2017).

Table 3: Total installed capacity by technology (May 2018)

	Installed Capacity (MW)	(%)
Conventional power plants	8.819,3	51,4
Hydroelectric with reservoir	3.170,7	18,5
RES and CHP	5.165,3	30,1
Total	17.155,3	100,0

The main bulk of thermal units is quite old since nearly half of the units have completed more than twenty years of operation. For the purposes of the Adequacy Study, a baseline scenario for the evolution of the power generation system for the period 2019-2030 is set. This scenario includes the new entries and withdrawals of thermal plants as presented in Table 4.

It should also be noted that all the scenarios considered in the adequacy study take account of the contribution of inflows of cross-border interconnections, based on historical data from recent years.

Table 4: Basic Scenario of evolution of Greek electricity generation system

New Entries				Withdrawals			
Plant	Net Power (MW)	Fuel	Year of entry	Plant	Net Power (MW)	Fuel	Year of withdrawal
Megalopoli V				Amydaio I	273	Lignite	end 2018
- reduced power	500	NG	2018	Amydaio II	273		end 2018
- full power	811	NG	mid-2019	Kardia I	271		end 2018
Ptolemaida V	620	Lignite	mid-2021	Kardia II	271		end 2018
				Kardia III	280		end 2018
				Kardia IV	280		end 2019
				Megalopoli III	255		end 2025
				Ag. Dimitrios I	274		end 2029
				Ag. Dimitrios II	274		end 2029

The adequacy study covers three scenarios for the evolution of demand (Low, Reference and High). Each scenario is built by different assumptions regarding the evolution of national GDP, as described in the following Table.

Table 5: National GDP evolution scenarios

	2018	2019	2020	2021	2022-2030
Scenario	(%)				
Low growth	1,6	0,9	0,9	0,8	0,5
Reference	2,5	2,5	1,9	1,3	0,9
High growth	2,5	2,5	1,9	1,8	1,3

Assumptions for the years 2018-2019 were taken from ECFIN Winter forecast 2018[1], while for the years 2020-2022, information published by the IMF was considered[2,3].

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[1] *'Winter 2018 Economic Forecast'*, (https://ec.europa.eu/info/sites/info/files/economy-finance/ecfin_forecast_winter_0718_el_en.pdf), European Commission, February 2018.

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The demand scenarios include the foreseen demand of the islands that are planned to be interconnected to the mainland in the next decade (exports to Crete through the AC interconnection from mid-2020, total demand of Crete from mid-2022, the demand of the western Cyclades islands from 2025 and the demand of the Dodekanisa islands from 2028).

Need for new Capacity

Reference Scenario

Tables 5 and 6 from the adequacy analysis present the reliability indices for the period 2019 – 2030, considering the assumptions for the basic scenario for the evolution of the generation system and the basic scenario for load forecast (Reference Scenario), for three hydraulic scenarios (dry, normal, wet). Furthermore, all these assumptions were combined with two RES penetration scenarios (mild and high penetration).

The reliability criterion in terms of LOLE has been chosen as 1,25 days in ten years or 3 hours per year.

In Tables 6 and 7, cases where the reliability criterion is not met are marked with orange. The calculations show that under a business as usual scenario and for the average expected conditions (average year in terms of rainfall), the reliability criterion will not be met during most years throughout the 2019-2030 period, even in case of the scenario of high RES penetration. The high LOLE values in two years 2019 - 2020, are mainly due to the almost simultaneous withdrawal of the plants of Kardia and Amydaio (end 2018, early 2019).

Tables 8 and 9 present the average value of the necessary additional net thermal capacity required to meet the reliability criterion. For the baseline Reference Scenario and for average hydraulic, additional power needs through the years 2019-2030 are estimated between 135 MW and 250 MW or 150 MW and 300 MW, depending on RES penetration.

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[2] *'World Economic Outlook Database'*, (http://www.imf.org/external/pubs/ft/weo/2016/02/weodata/weorept.aspx?pr.x=67&pr.y=12&sy=2014&ey=2021&scsm=1&ssd=1&sort=country&ds=.&br=1&c=174&s=NGDP_RPCH&grp=0&a=), IMF, October 2016.

[3] *'Greece: Preliminary Debt Sustainability Analysis – Updated Estimates and Further Considerations, Country Report No 16/130'*,(http://www.imf.org/external/pubs/ft/scr/2016/cr16130.pdf), IMF, May 2016

Table 6: Reliability indices for the Reference Scenario (Basic Scenario for the evolution of the generation system with the Basic Scenario for Demand) considering the scenario of mild RES penetration

	Dry Year		Average Year		Wet Year	
	LOLE (hours/year)	EUE (GWh)	LOLE (hours/year)	EUE (GWh)	LOLE (hours/year)	EUE (GWh)
	Basic Scenario for Demand					
2019	36,499	9,853	11,074	3,374	7,207	2,324
2020	21,645	5,856	7,252	2,185	4,692	1,480
2021	20,967	6,069	6,513	2,229	4,561	1,620
2022	11,133	3,161	4,862	1,569	3,365	1,121
2023	11,114	3,241	4,775	1,627	3,464	1,207
2024	5,097	1,509	2,454	0,841	1,852	0,641
2025	6,241	1,896	3,099	1,084	2,329	0,825
2026	11,439	3,543	5,365	1,933	4,028	1,470
2027	12,880	4,068	6,108	2,236	4,651	1,731
2028	24,002	8,037	11,617	4,472	8,688	3,410
2029	26,433	9,125	13,067	5,104	9,912	3,958
2030	90,618	34,747	38,110	16,194	27,104	11,758

Table 7: Reliability indices for the Reference Scenario (Basic Scenario for the evolution of the generation system with the Basic Scenario for Demand) considering the scenario of high RES penetration

	Dry Year		Average Year		Wet Year	
	LOLE (hours/year)	EUE (GWh)	LOLE (hours/year)	EUE (GWh)	EUE (GWh)	EUE (GWh)
	Basic Scenario for Demand					
2019	35,275	9,534	10,725	3,295	7,111	2,319
2020	19,515	5,293	6,614	2,023	4,417	1,409
2021	17,577	5,103	5,821	2,038	4,256	1,540
2022	8,758	2,540	3,964	1,312	2,855	0,962
2023	8,064	2,440	3,814	1,341	2,855	1,017
2024	3,522	1,097	1,915	0,679	1,474	0,521
2025	4,090	1,318	2,315	0,839	1,781	0,646
2026	6,901	2,267	3,771	1,414	2,945	1,108
2027	7,431	2,498	4,145	1,584	3,249	1,242
2028	13,132	4,633	7,460	2,976	5,890	2,351
2029	13,910	5,041	8,161	3,307	6,478	2,627
2030	40,091	15,152	21,032	9,015	16,693	7,175

Table 8: New Capacity required for period 2019 – 2030 for the satisfaction of the reliability criterion, considering the scenario of mild RES penetration

	Basic Scenario for Demand		
	Dry Year	Average Year	Wet Year
	(MW)		
2019	230	150	105
2020	190	105	55
2021	190	95	60
2022	135	60	40
2023	140	70	45
2024	75	20	10
2025	90	40	20
2026	145	85	50
2027	170	95	80
2028	230	160	145
2029	235	190	150
2030	370	300	280

Table 9: New Capacity required for period 2019 – 2030 for the satisfaction of the reliability criterion, considering the scenario of high RES penetration

	Basic Scenario Demand		
	Dry Year	Average Year	Wet Year
	(MW)		
2019	225	135	105
2020	180	85	60
2021	180	90	60
2022	125	55	30
2023	120	50	35
2024	35	10	5
2025	55	20	10
2026	105	55	35
2027	120	60	40
2028	175	130	100
2029	185	135	100
2030	315	250	230

Scenario of decommissioning of natural gas combined cycle power plants

Table 10 presents the reliability indices for the period 2019 – 2030, considering the decommissioning of 1 to 2 natural gas combined cycle power plants of 400 MW, for the basic scenario for load forecast, the average hydraulic scenario and mild RES penetration scenario. Furthermore, Figure 10 compares the values of the LOLE index with those of the Reference Scenario (basic scenario for generation system and load forecast).

From the results presented in Table 9, it is obvious that the eventual withdrawal of Combined Cycle plants over the analysis horizon significantly exacerbates LOLE index values. Moreover, it seems that in the event of a possible withdrawal of two units the operation of the system becomes completely inadequate throughout the period, regardless of the circumstances.

Table 10: Decommissioning of 1 to 2 CC plants (Basic Demand Scenario, Average Hydraulicity Scenario, mild RES penetration Scenario)

	1 CC besides		2 CC besides	
	LOLE (hours/year)	EUE (GWh)	LOLE (hours/year)	EUE (GWh)
	Basic Scenario for Demand			
2019	31,056	9,683	123,104	44,411
2020	20,045	6,213	68,648	23,716
2021	17,108	5,826	53,680	19,691
2022	12,397	4,093	38,202	13,615
2023	11,871	4,102	33,503	12,073
2024	6,081	2,115	16,618	5,892
2025	7,489	2,672	19,994	7,307
2026	12,727	4,665	33,864	12,961
2027	14,296	5,332	37,537	14,702
2028	26,600	10,722	70,449	30,202
2029	29,687	12,181	77,619	33,963
2030	88,205	39,653	225,620	109,850

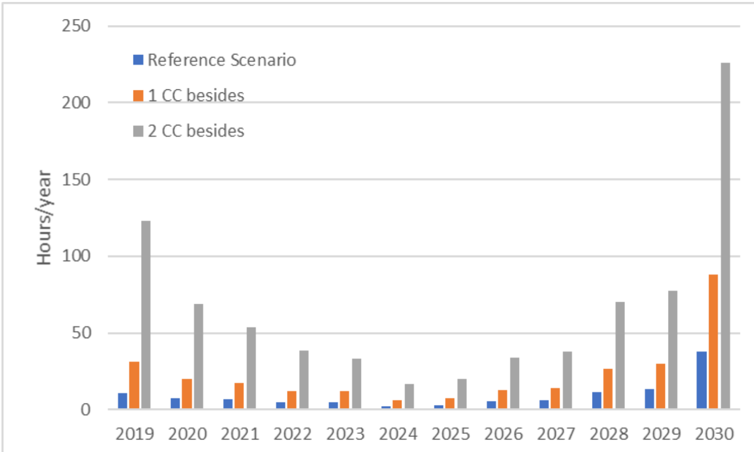

Figure10: Impact on LOLE index from any withdrawal of 1-2 CCWTs for the Reference Scenario

Scenario of decommissioning of lignite power plants

Table 11 presents the reliability indices for the period 2019 – 2030, considering the decommissioning of 1 to 2 lignite power plants of 300MW (beyond the planned), for the basic scenario for load forecast, the average hydraulicity scenario and mild RES penetration scenario. Furthermore, Figure 11 compares the values of the LOLE index with those of the Reference Scenario (basic scenario for generation system and load forecast).

As it was expected, a possible withdrawal of lignite plants, beyond the planned ones, significantly exacerbates the adequacy of the electricity system.

Table 11: Decommissioning of 1 to 2 lignite plants (Basic Demand Scenario, Average Hydraulicity Scenario, mild RES penetration Scenario)

	1 lignite besides		2 lignite besides	
	LOLE (hours/year)	EUE (GWh)	LOLE (hours/year)	EUE (GWh)
	Basic Scenario for Demand			
2019	11,565	3,486	21,549	6,541
2020	12,696	3,855	24,405	7,628
2021	11,194	3,794	20,046	6,821
2022	8,390	2,740	15,226	5,083
2023	8,077	2,775	14,115	4,893
2024	4,141	1,432	7,204	2,513
2025	5,157	1,827	8,864	3,173
2026	8,877	3,221	15,072	5,542

2027	10,033	3,701	16,929	6,343
2028	18,838	7,405	32,054	13,117
2029	21,160	8,457	35,938	14,947
2030	63,149	27,695	107,594	48,879

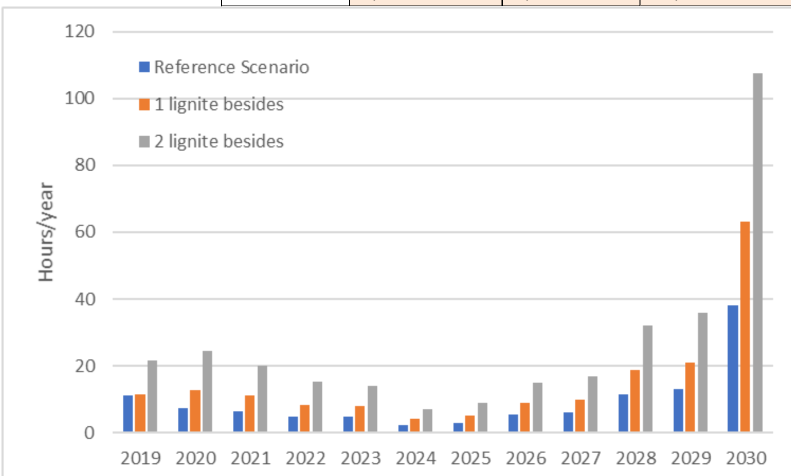

Figure11: Impact on LOLE index from any withdrawal of 1-2 lignite plants for the Reference Scenario

Summary - Conclusions

The adequacy analysis of the Transmission System Operator, assuming a LOLE reliability criterion of 1.25 days to ten years, justifies the following conclusions:

1. Considering the Reference Scenario, for mild RES penetration, the LOLE average values for most of the cases, over the 2019-2030 period, do not satisfy the reliability criterion, except of some specific, favorable, conditions (especially of high hydraulicity) only for the two years 2024-2025. Scenarios that are based on higher RES penetration lead to improved reliability indices (compared to the mild RES scenario), but in most cases the reliability criterion is still not met, except of the particularly favorable case of high hydraulicity for the years 2022-2026. Considering the EUE indices, it seems that in most of cases the power system is expected to have a high risk of inadequate peak coverage. Furthermore, at the end of the period under consideration, EUE indices reveal an increased risk of inadequate coverage also for the non-peak loads.
2. The Reference Scenario of the adequacy analysis presumes no premature retirement of thermal power plants takes place. However, current market conditions appear to place considerable challenges on CCGTS and lignite plants – i.e. increased CO_2 prices, high RES penetration etc., - which are much needed for achieving the above adequacy standards.

3. It should not be ignored that the contribution from the interconnections may be quite uncertain during scarcity periods (coincident peaks, cold spells, gas supply crises etc), therefore the adequacy of the power system could be even worse.