

Hydropower and its future role
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Renewable energy and their integration in the region

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Centre for Renewable Energy Sources & Saving

Information on CRES

CRES is the National Energy Agency of Greece
Supporting the Greek Ministry of Energy with

- Studies and Projects
- Research mainly related to the penetration of RES and Energy Efficiency Technologies into the Energy System

Present work was implemented by the Division of Energy Policy
and Planning

Current composition of the Greek Power System

The Greek Power System is composed of

- The mainland system
- Autonomous grids of the non-connected islands

Hydro plants are large hydro currently totaling a capacity of 2,7 GW and they are positioned in the mainland system

An additional 700 MW of pumped storage plants exist today

They are all owned by the PPC

Installed Capacity of the Greek Power System (GW)

	2015
Lignite	3,9
Coal	0,0
Oil Products	1,9
Natural Gas	4,8
Fuel Cells NG	0,0
Biogas	0,1
Fuel Cells Biogas	0,0
Hydro	2,7
Pumped storage hydro	0,7
Wind	2,0
PV	2,7
CSP	0,0
Geothermal	0,0
Fuel Cells H2	0,0
Total	18,8
of which CHP	1,9

Emissions Targets

	2005	2010	2012	2020	2030 Ref	2030 40%min	2030 40%max
Total emissions	135,31	117,88	110,98	96,09 (-29%)	71,71 (-47%)	66,30 (-51%)	60,89 (-55%)
Energy sector emissions	104,89	99,69	87,29				
Non-ETS	64,06	57,64	49,54	61,50 (-4%)	43,56 (-32%)	39,08 (-39%)	37,79 (-41%)
ETS by subtraction	71,25	59,94	61,44		28,15	27,22	23,01

RES Targets

	2005	2010	2012	2020	2030 Refer.	2030 40%min	2030 40% max
Final energy consumption (ktoe)	21631	19704	17857	17954			
RES generation (ktoe)	1522 (7%)	1931 (10%)	2397 (13%)	18%	21%	25%	29%
Total electricity consumption (GWh)	63207	63073	62556				
RES electricity (GWh)	5191 (8%)	7762 (12%)	10236 (16%)				

Expansion of the Greek Power System

The expansion of the Greek Power System is designed to ensure compliance with the EU RES and emissions abatement targets

At present two scenarios are examined in detail

BaU

Targets Compliance

Business as Usual Scenario

BaU scenario is expressing the difficulty for investments due to the economic crisis

The BaU scenario includes 20% penetration of RES in 2020 and incorporates the emission targets for both ETS and non-ETS in 2020. RES in electricity is expected at the level of 30 %.

The BaU scenario includes less than 30 % penetration of RES in 2030 and incorporates the emissions targets foreseen in the reference scenario of the EC (impact assessment)

Compliance with EU targets of 2020, 2030

The compliance scenario includes 20% penetration of RES in 2020 and incorporates the emission targets for both ETS and non-ETS in 2020. RES in electricity is expected to exceed 35 %.

The compliance scenario includes 30 % penetration of RES in 2030 and incorporates the emissions targets foreseen in the GHG40 scenario of the EC (impact assessment)

Analysis with Stochastic Models

Calculations that follow are based on stochastic models developed by CRES in the context of research conducted over the last five years (2010-2015)

Stochastic Model for Expansion Planning under Large scale RES penetration

Stochastic Model for Hourly Reliability Analysis and assessment of hourly ancillary services requirements

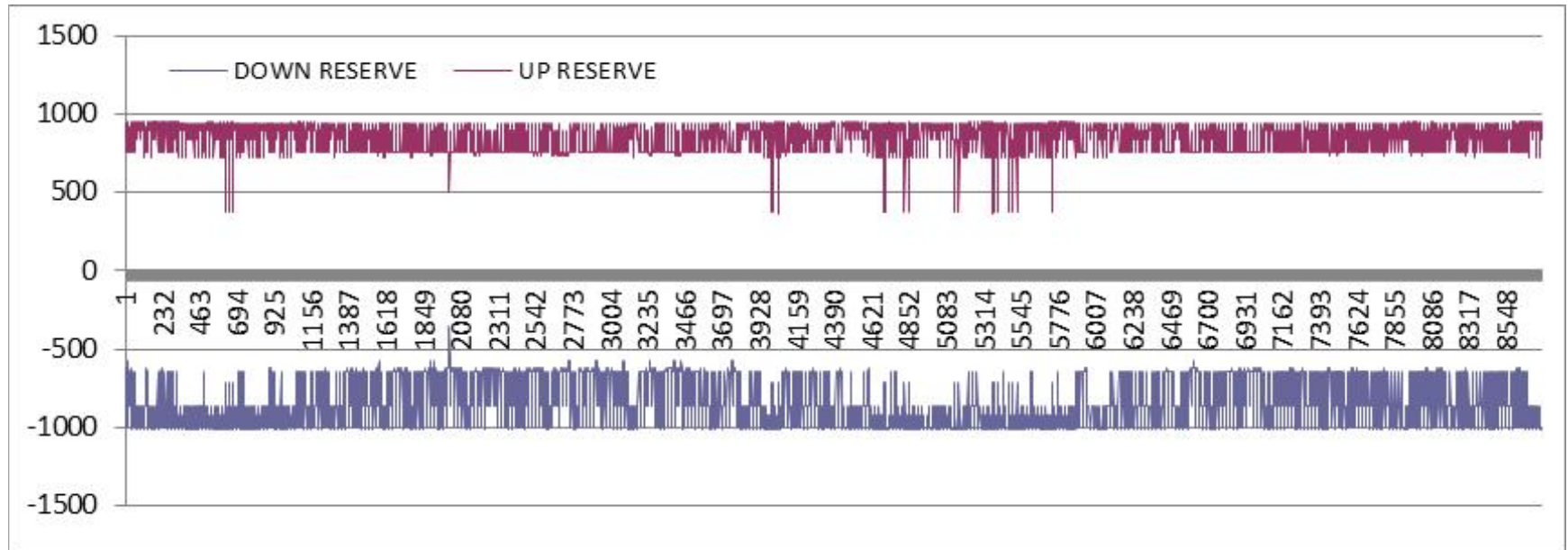
Generation Capacity Expansion

Capacity [GW]		2013	BaU		Compliance	
			2020	2030	2020	2030
	Lignite	4,5	3,4	2,6	3,4	2,0
	Oil	2,6	2,2	2,1	2,2	2,1
	Natural Gas	4,9	5,2	5,4	5,2	5,2
	Biomass & Biogas	0,0	0,1	0,0	0,1	0,1
	Hydro	2,5	2,9	2,9	2,9	3,2
	Pumped Storage	0,7	0,7	1,5	0,7	1,5
	Wind	1,9	3,9	9,2	3,9	8,4
	PV	2,7	3,1	3,9	4,7	5,8
	Geothermal	0,0	0,0	0,2	0,0	0,2
	Total	19,8	21,6	28,0	23,1	28,6

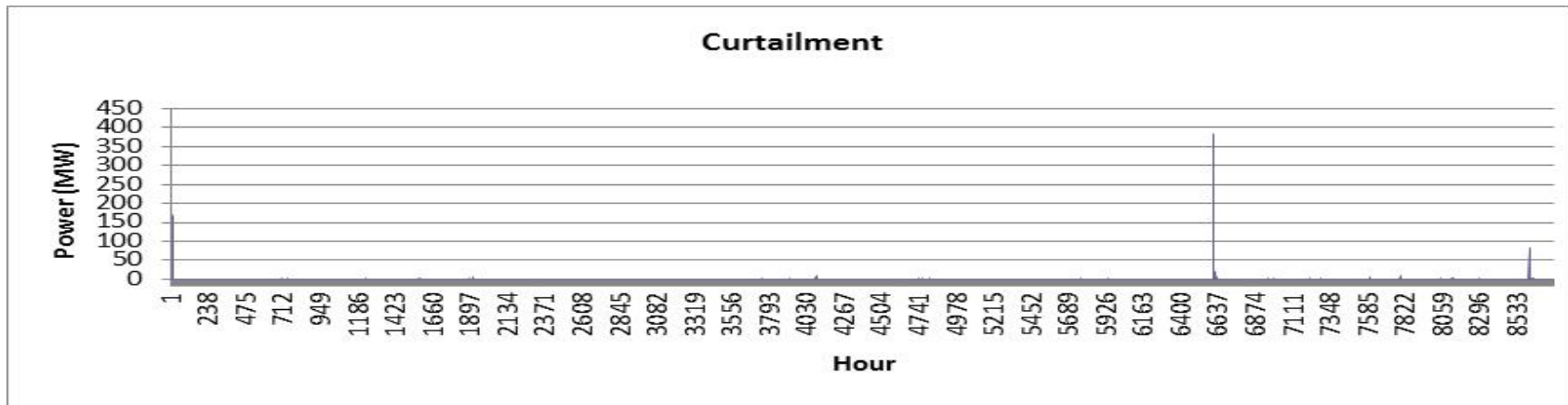
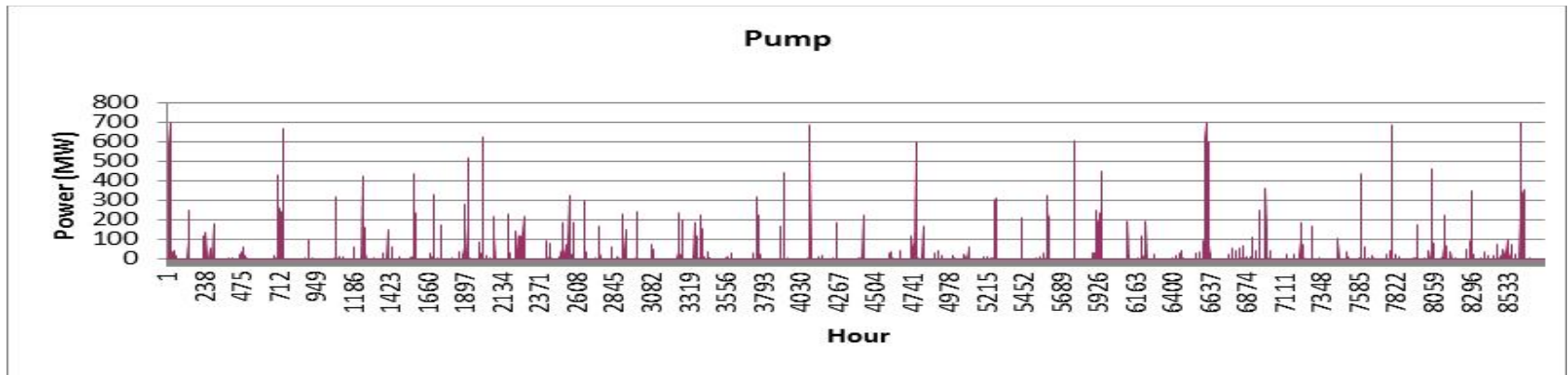
Generation 2013-2020-2030

Generation [GWh]		BaU			Compliance	
		2013	2020	2030	2020	2030
	Total	54417	53372	58567	53434	59152
	Lignite	23228	20944	12876	20944	12006
	Oil	4908	3504	2568	3536	2574
	Natural Gas	12150	9259	8353	7080	7713
	Biomass & Biogas	19	249	243	110	430
	Hydro	6341	5596	5596	5593	6495
	Wind	4211	8860	20741	8892	18750
	PV	3559	4616	5892	6937	8625
	Geothermal	0	342	1390	342	1390

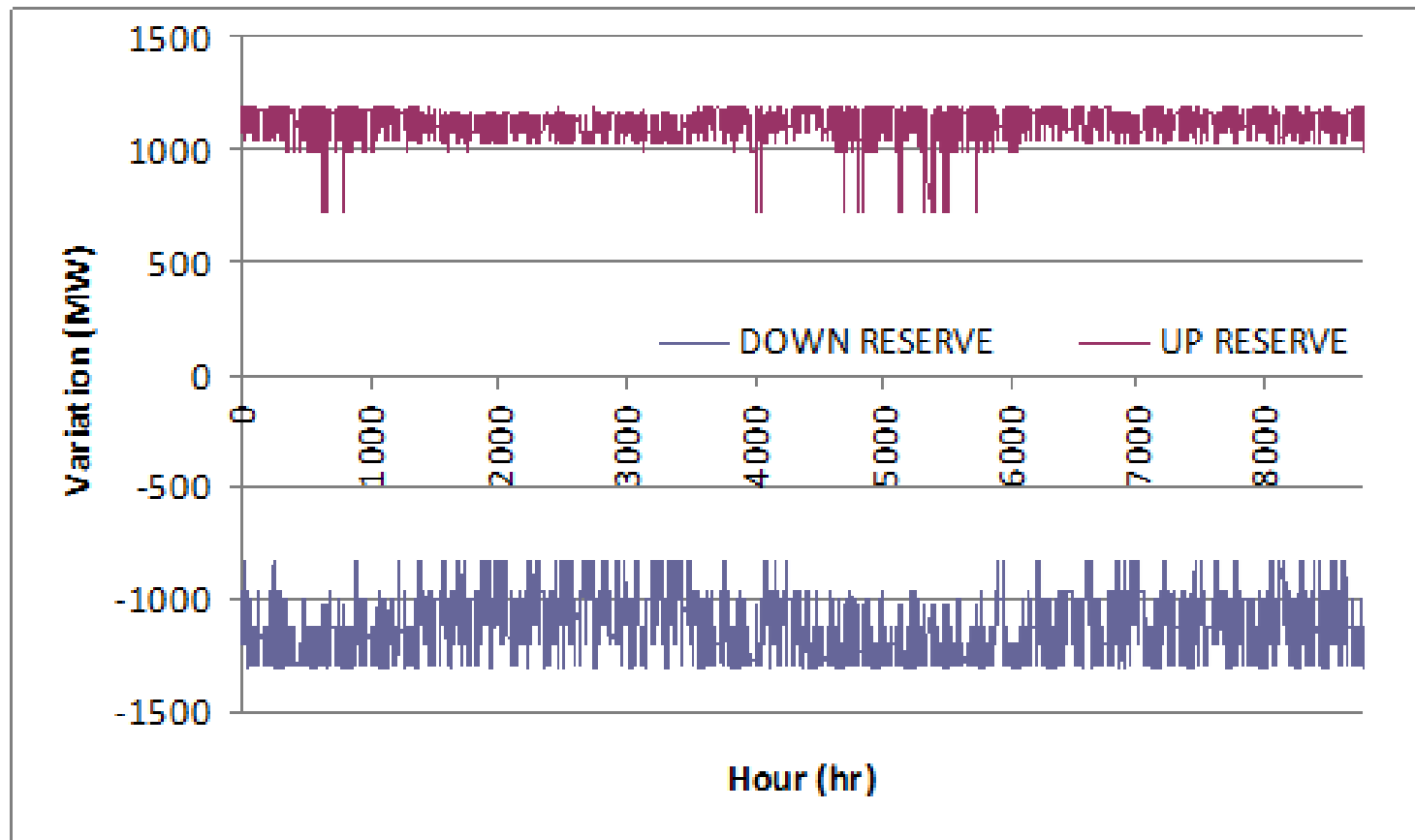
Hourly Flexibility Requirements 2020- BaU



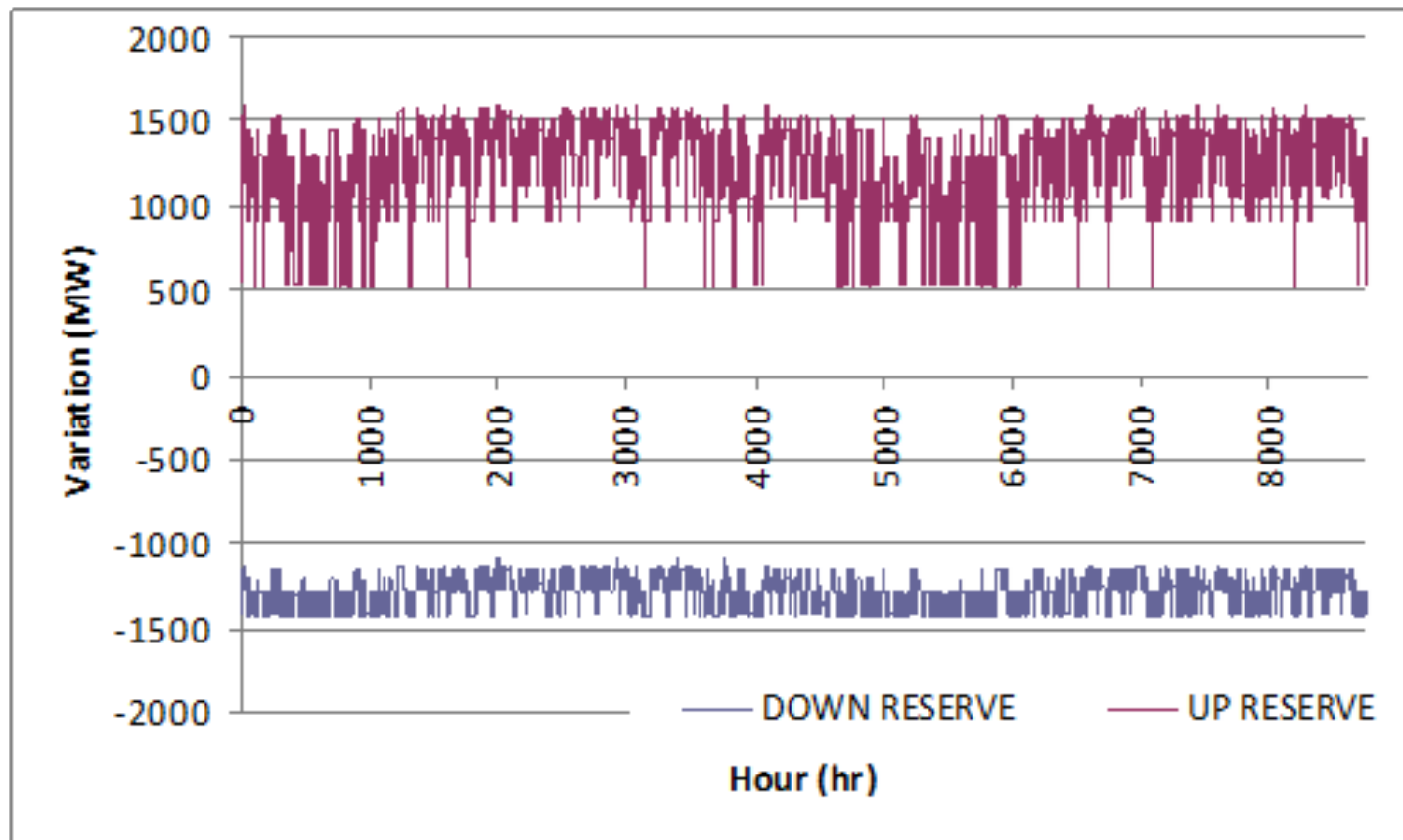
Hourly Pumping Requirements 2020- BaU



Hourly Flexibility Requirements 2030- BaU



Hourly Flexibility Requirements 2030- Compliance



Pumped Storage Requirements

Pumping Requirements	BaU		Compliance	
	Year (GWh)	Pumping	Curtailement	Pumping
2015	1,6	0,0	1,90	0,00
2016	1,7	0,0	1,25	0,03
2017	1,2	0,0	2,17	0,08
2018	1,7	0,1	8,37	0,44
2019	11,5	0,4	59,39	7,79
2020	15,9	1,1	64,19	13,16
2025	162,1	37,1	406,33	233,69
2030	858,8	77,5	920,49	127,16
2035	839,5	90,7	983,59	162,95
2040	1084,3	147,0	1257,43	250,40

Current Operation of Hydro (2015)

All owned by the PPC

Peak Load but also for Intermediate Load (2,6 MW)

Pumped storage (700 MW) used to operate as follows :

- Pumping at night using lignite generation
- Producing over day to avoid use of Gas Turbines
- Recently they started to operate as storage for wind

Future Operation of Hydro (2030)

Peak Load but also Ancillary Services for Load Balancing required due to residual load variations (2,9-3,2) GW)

Pumped storage (1,5 GW) :

- Pumping mainly at night to avoid minimize curtailment
- Producing over day to avoid use of Gas Turbines

A new pumped storage plant of 800 MW is expected to operate in the year 2030

Current situation of the Greek Electricity Market

Feed in Premium system is being established by Ministry of Energy supported by CRES, GIZ

Market operation under the EU Target model is being studied by Ministry of Energy supported by CRES, the Regulator and the TSO (ADMIE, LAGIE)