

MINISTRY OF ENERGY, COMMERCE AND INDUSTRY

Technical Support on Long-Term Energy Modelling: Assumptions and Scenario Results

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JRC

The OSeMOSYS modelling framework

- Open-Source Energy Modelling System (OSeMOSYS)
 - Long-term cost-optimization energy system model
 - Technology-rich, bottom-up technoeconomic model that is demand-driven: the **defined demand has to be met**, no matter the cost
 - The choice of technologies and energy mix is based on technoeconomic data inserted in the model (e.g. fuel costs, technology costs, resource availability, emission limits etc.)
- Objective function
 - **Minimize total discounted system cost** over the entire modelling horizon

SYSTEM COST

Optimisation of the whole system

ENERGY INPUT

Transport



ELECTRICITY COST

Electricity Supply



Heating and Cooling

ENERGY SERVICES

- Modelling choices from the side of consumers
 - Technology-specific discount rates
 - Taxation included in the analysis
- Two scenarios were developed:
 - Existing Policies and Measures (PaMs): considers legislation and actions that are already in place (FSRU for gas imports)
 - No storage nor electrified transport
 - *No pumped hydro storage*
 - *Cap on PV – 750 MW in 2030 based on TSO-Cy study*
 - Planned PaMs: considers implementation of additional legislation and actions (EuroAsia Interconnector and EastMed pipeline)
 - Reduced Net Transfer Capacity of Interconnector (500 MW instead of 1000 MW)

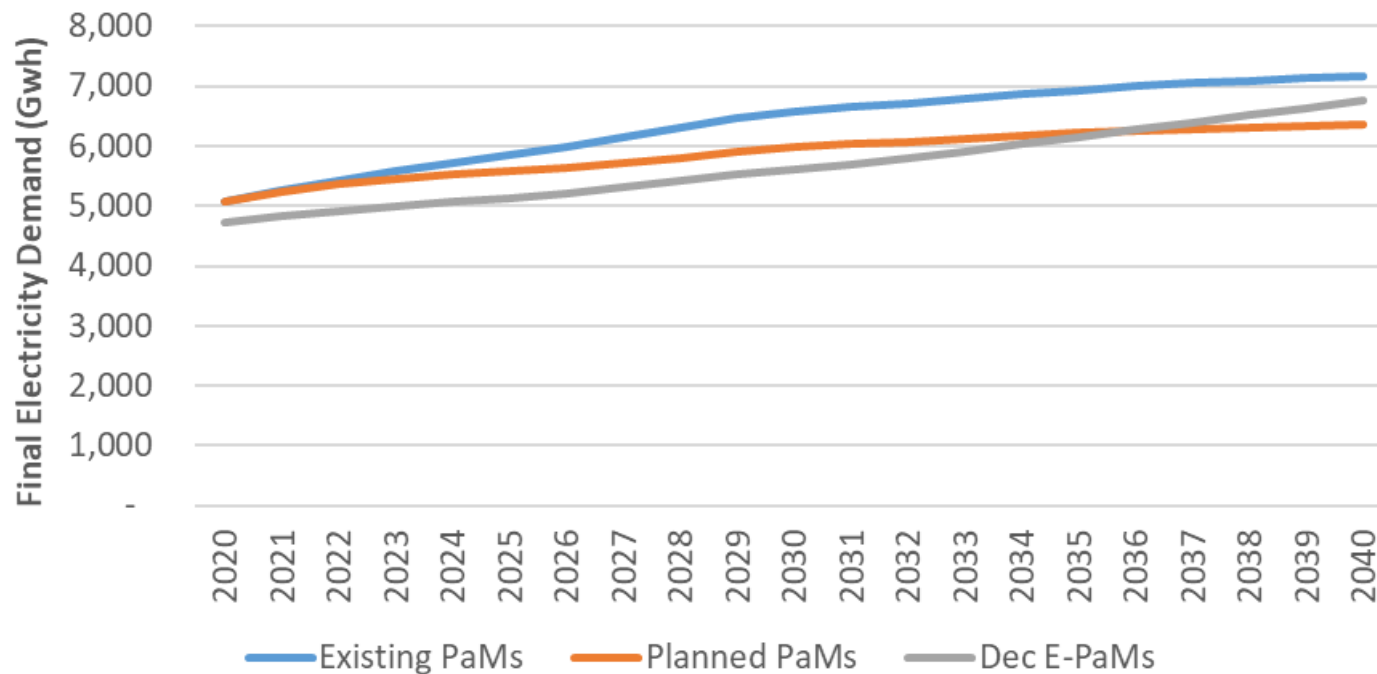
Fossil Fuel Prices and ETS Price Projections

- A low fossil fuel price projection was adopted according to MECL recommendations
 - 2030 values in EC recommendations were
 - Oil at 15.02 EUR2016/GJ
 - Gas at 9.09 EUR2016/GJ
- ETS price projections follow EC recommendations

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2040
Oil	EUR2016/GJ	5.12	5.40	5.69	5.99	6.30	6.64	6.71	6.79	6.86	6.93	7.00	8.51	9.61
Gas	EUR2016/GJ	5.16	5.43	5.73	6.03	6.34	6.68	6.76	6.84	6.91	6.98	7.06	8.57	9.68
Carbon price ETS sectors	EUR2016/ton CO2	15.5	17.6	18.6	20.7	21.7	23.3	25.9	27.9	30.0	32.1	34.7	43.5	51.7

Final Electricity Demand Projections

- Projections by Dr. Zachariadis in line with latest TSO-Cy forecast – *17% increase from December's Existing PaMs*
- Electricity demand in transport sector is additional



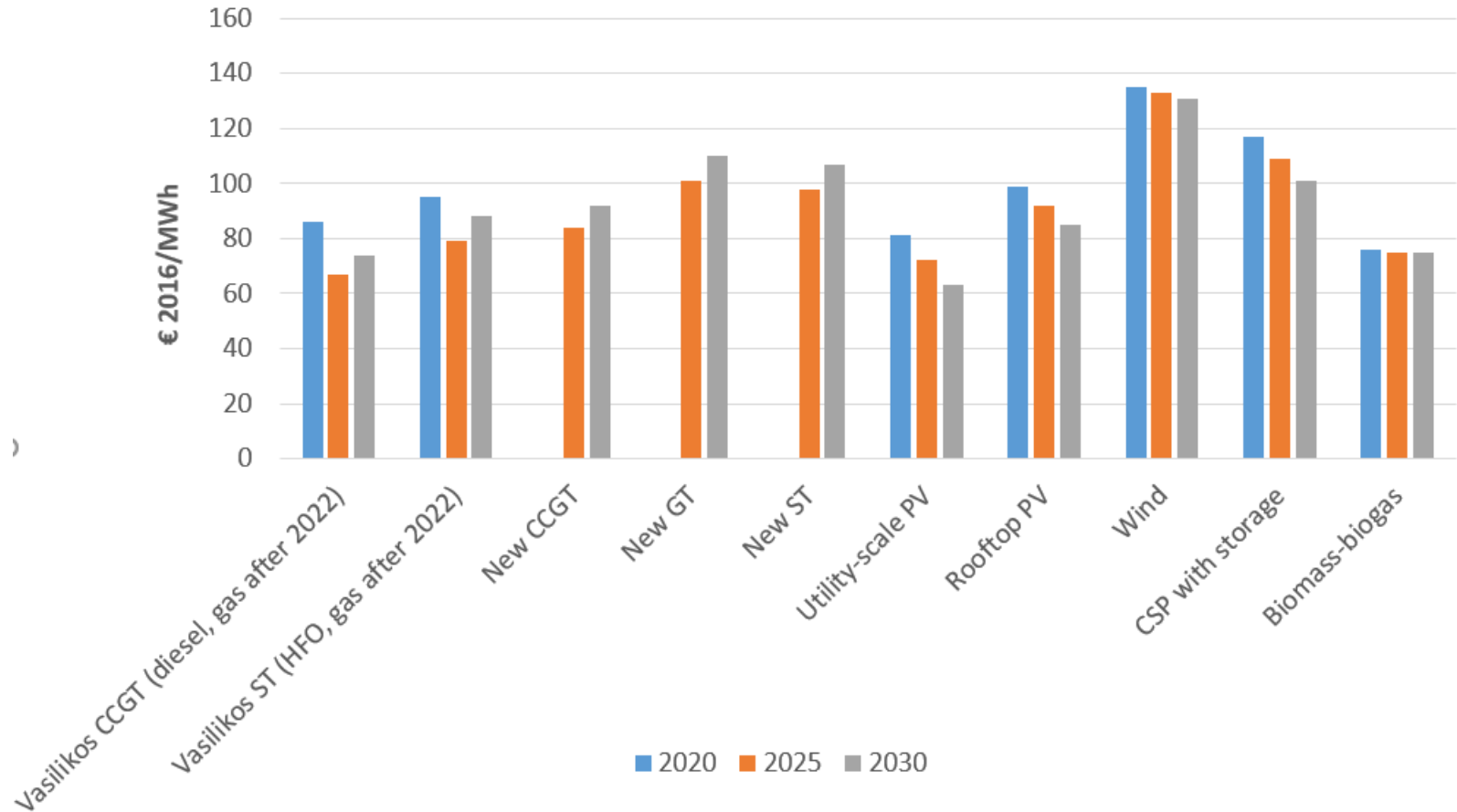
Electricity - Renewable Energy Technology assumptions

- As compared to EC recommendations, more moderate RET learning rates assumed to reflect local conditions
 - Exception for CSP for which more optimistic assumptions were adopted

	Investment Cost (EUR2016/kW)			Variable O&M cost (EUR2016/MWh)	Fixed Cost O&M cost (EUR2016/kW)	Capacity Factor	Lifetime (years)
	2020	2030	2040				
Utility-scale PV	1,161	886	611		9	18.5%	20
Wind	1,394	1,330	1,266		53	16%	25
Biomass-biogas	2,461	2,438	2,415		62	48.5%	30
Rooftop PV	1,467	1,241	1,016		12	18.5%	20
EOS 50 MW CSP with 8 hours storage	3,535				106	39.3%	30
CSP with 6 hours storage	4,410	3,724	3,430	3.1	58.2	50.8%	25

Electricity – LCOE in generation technologies

Increasing fossil-fired generation cost vs decreasing RES cost



Electricity - Storage assumptions

- **Pumped Hydro storage**

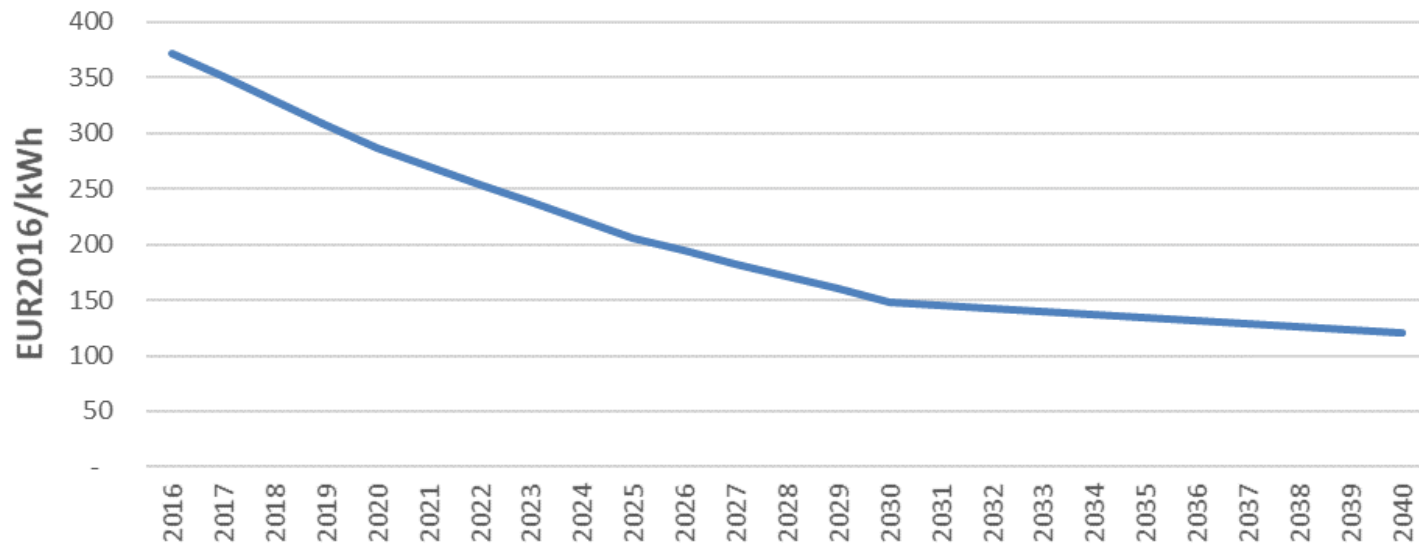
Power Capacity (MW)	Storage Capacity (MWh)	Capital Cost (EUR2016/kW)	Fixed O&M Cost (EUR2016/kW)	First possible year	Efficiency
130	1,040	1,155	11	2027	77%

- **Lithium ion Batteries**

- A centralized option deployed at the transmission or distribution level – this option was forced to have a minimum ratio of kWh/kWp of 4 hours
- A decentralized (behind-the-meter) option deployed at the consumer level – this option was forced to have a minimum ratio of kWh/kWp of 2 hours.

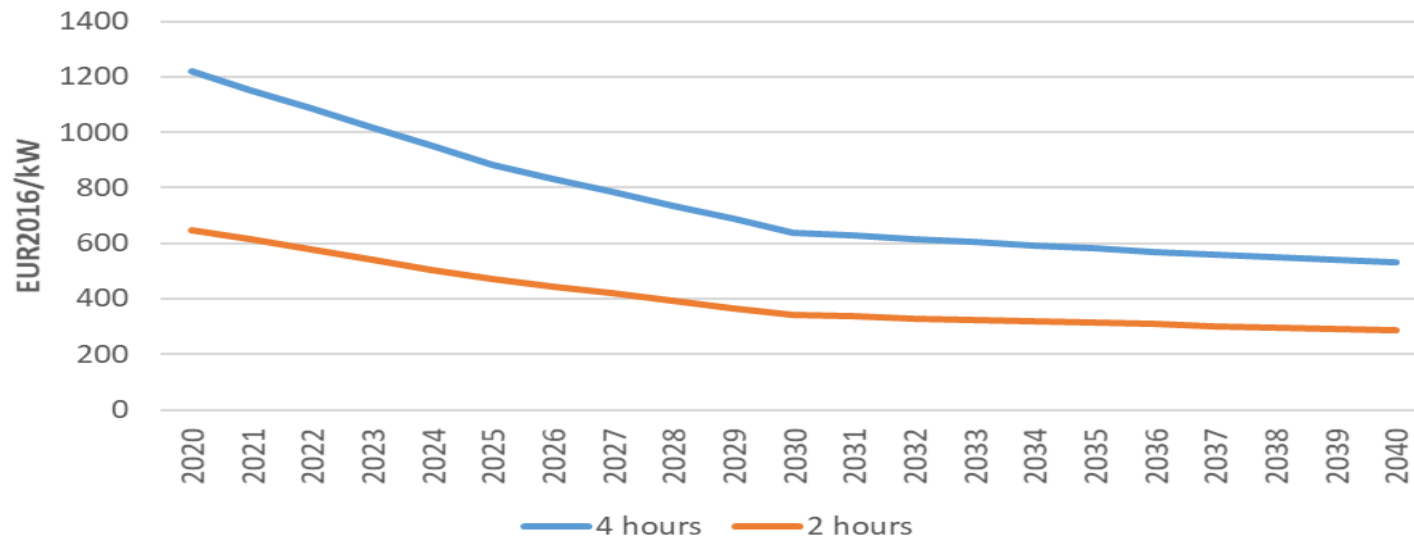
Storage assumptions – Battery storage

- Lithium ion Batteries - techno-economic assumptions from IRENA's 2017 report on *Electricity Storage and Renewables: Costs and Markets to 2030*
 - Lifetime extended to 15 years
 - Efficiency improved to 95%



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- Lithium ion Batteries - techno-economic assumptions from IRENA's 2017 report on *Electricity Storage and Renewables: Costs and Markets to 2030*
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EuroAsia Interconnector – Planned PaMs measures

- Net Transfer Capacity of 1,000 MW for 1st phase
 - Crete-Attica by end of 2022
 - Cyprus-Crete by end of 2023
 - Cyprus-Israel by end of 2023
- Total cost 3.5 billion EUR2016 - interconnector will become part of each local grid leading to an increase on each country's network tariffs. For Cyprus this is 2.9 EUR/MWh
- Interconnector does not contribute to operational reserves
- Interconnector contributes to the capacity reserve at 50%
- Electricity prices (EUR/MWh) taken from ENTSOE's TYNDP 2018

	2020	2025	2030	2035	2040
Greece	72.8	73.5	74.2	74.9	75.6
Israel	50.1	63.0	75.9	88.8	101.7

Transport Sector – Demand

Forecast till 2030 provided by Public Works Department

- *Existing PaMs*

Billion veh-km	2020	2025	2030	2035	2040
Busses	0.0683	0.0732	0.0782	0.0842	0.0908
Light commercial vehicles	1.9174	2.0570	2.1966	2.3664	2.5493
Motorcycles	0.2079	0.2230	0.2381	0.2565	0.2764
Passenger cars	6.7533	7.2450	7.7367	8.3347	8.9788
Heavy duty vehicles	0.3173	0.3404	0.3636	0.3917	0.4219

- *Planned PaMs*

Billion veh-km	2020	2025	2030	2035	2040
Busses	0.0683	0.1022	0.1362	0.1467	0.158
<i>Change from Existing PaMs scenario</i>	0%	40%	74%	74%	74%
Light commercial vehicles	1.9174	2.0305	2.1436	2.3093	2.4877
<i>Change from Existing PaMs scenario</i>	0%	-1%	-2%	-2%	-2%
Motorcycles	0.2079	0.1919	0.176	0.1896	0.2042
<i>Change from Existing PaMs scenario</i>	0%	-14%	-26%	-26%	-26%
Passenger cars	6.7533	6.1724	5.5915	6.0237	6.4892
<i>Change from Existing PaMs scenario</i>	0%	-15%	-28%	-28%	-28%
Heavy duty vehicles	0.3173	0.3459	0.3744	0.4033	0.4345
<i>Change from Existing PaMs scenario</i>	0%	2%	3%	3%	3%

Transport Sector – Fuel Efficiency

Fuel efficiency based on figures from transport study by ifeu

		2020	2025	2030
Busses	Diesel	11.92	11.56	11.27
	BEV	4.33	4.06	3.91
	Natural gas	10.44	10.12	9.86
Light commercial vehicles	Diesel plug-in hybrid	2.76	2.69	2.60
	BEV	1.22	1.20	1.16
	Diesel	3.19	2.94	2.75
Motorcycles	Gasoline	1.20	1.20	1.21
Passenger cars	Diesel plug-in hybrid	2.76	2.69	2.60
	BEV	0.94	0.89	0.89
	Gasoline plug-in hybrid	2.20	2.15	2.17
	Diesel	3.06	2.87	2.71
	Gasoline hybrid	2.15	2.15	2.11
	Gasoline	2.99	2.87	2.74
	LPG	2.52	2.48	2.44
	Natural gas	2.54	2.49	2.50
Trucks	BEV	3.40	3.27	3.14
	Diesel	9.37	9.30	9.05
	Natural gas	8.20	8.14	7.92

Transport Sector – Biofuels

- Cost for 1st generation biofuels retrieved from UNCTAD, 2015 report on *Second Generation Biofuel Markets: State of Play, Trade and Developing Country Perspectives*
 - Biodiesel cost inclusive of taxes at approximately 1.8 EUR/litre
- Cost for 2nd generation biofuels retrieved from IRENA, 2016 report on *Innovation Outlook: Advanced Liquid Biofuels*
 - Biodiesel cost inclusive of taxes exceeds 2 EUR/litre
- Target for 2030 (14% with first generation of biofuels or 7% with second generation of biofuels) – target **unachievable** unless:
 - Fleet becomes reliant entirely on diesel
 - Bioethanol mixing is introduced
 - B100 vehicles are introduced

Transport Sector – Planned PaMs measures

- Modal shift away from passenger cars to public transport
- Clean Vehicles Directive:
 - *45% of new busses for period 2022-2025 should be BEV or CNG*
 - *65% of new busses for period 2026 onwards should be BEV or CNG*
- Nicosia Tram – in operation by 2028 and serving 17.9 million passengers in 2030

	Unit	Value
Line length	km	14.2
Tram Services	services/day	108
Daily Service	km/day	2,706
Capital Cost	million EUR2016	225
Operation and Maintenance Cost	million EUR2016/yr	11.8
Energy Consumption	MJ/km	35.92

Heating and Cooling Sector – Demand in Existing PaMs

Values taken from previous JRC work and forecast by Dr. Zachariadis

- Useful Energy Demand (PJ)*

Service	Sector	2020	2025	2030	2035	2040
Cooling	Residential	7.58	8.46	9.37	10.28	11.14
	Others	6.10	6.41	6.75	7.08	7.39
Heating	Residential	7.63	7.80	7.95	8.06	8.12
	Others	8.22	8.37	8.77	9.15	9.65

- Final Energy Demand (PJ)*

	2020	2025	2030	2035	2040
Oil Products	9.01	8.90	8.53	7.63	6.71
LPG	3.38	3.38	3.49	3.36	3.20
Pet coke	4.33	4.12	3.82	3.57	3.33
Biofuels/biomass	1.42	1.56	1.80	1.89	1.93
Solar Thermal & Geothermal	4.21	4.37	5.23	6.56	7.93
Electricity	7.56	8.69	9.78	10.31	10.67

Heating and Cooling Sector – Demand in Planned PaMs

Additional efficiency measures lead to lower demand projections

- *Final Energy Demand (PJ)*

	2020	2025	2030	2035	2040
Oil Products	8.9	8.6	8.19	7.21	6.21
<i>Change from Existing PaMs scenario</i>	-1%	-3%	-4%	-6%	-7%
LPG	3.32	3.21	3.27	3.05	2.77
<i>Change from Existing PaMs scenario</i>	-2%	-5%	-6%	-9%	-13%
Pet coke	4.32	4.07	3.81	3.54	3.3
<i>Change from Existing PaMs scenario</i>	0%	-1%	0%	-1%	-1%
Biofuels/biomass	1.39	1.48	1.7	1.72	1.69
<i>Change from Existing PaMs scenario</i>	-2%	-5%	-6%	-9%	-12%
Solar Thermal & Geothermal	4.1	4.1	4.83	5.66	6.23
<i>Change from Existing PaMs scenario</i>	-3%	-6%	-8%	-14%	-21%
Electricity	7.56	8.29	8.89	9.17	9.29
<i>Change from Existing PaMs scenario</i>	0%	-5%	-9%	-11%	-13%

Existing Policies and Measures Scenario Results

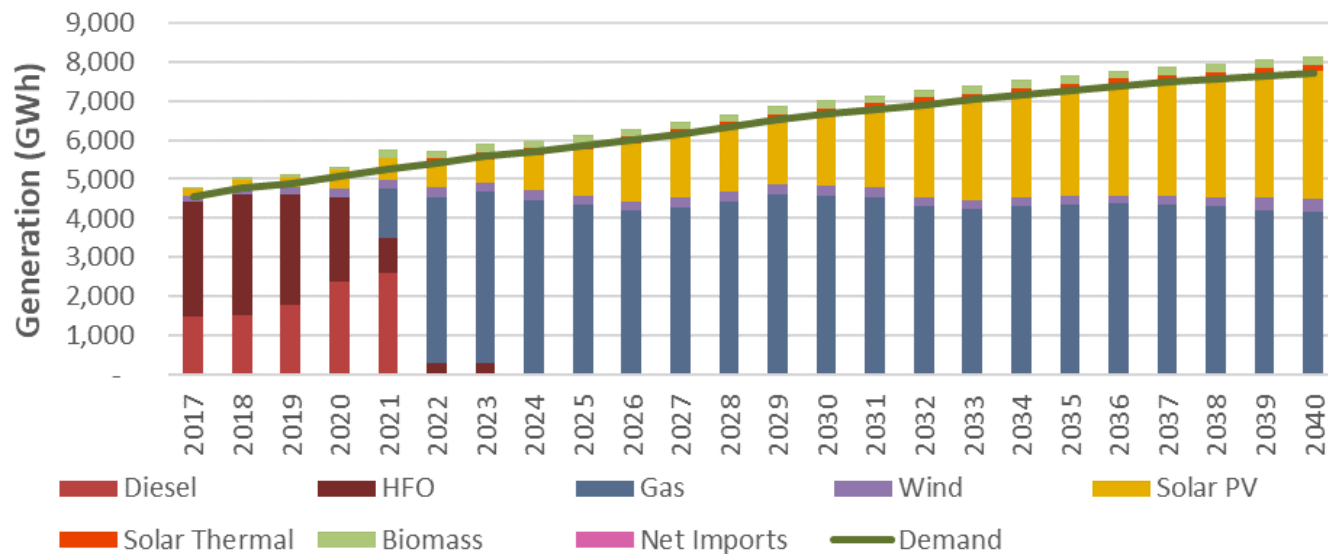
Electricity Supply - Capacity

- Early increase in solar PV coincides with new gas turbine of 62 MW
- Continued penetration of PV – enabled by storage deployment

	2020	2025	2030	2035	2040
Vasilikos	868	868	868	608	0
Dhekelia	460	102	102	0	0
Moni	150	150	150	0	0
New CCGT	0	432	432	648	864
New ICE	0	0	0	0	0
New ST	0	0	0	0	228
New GT	0	62	62	62	62
Light fuel oil CHP	0	0	0	0	21
Solar PV	312	726	1132	1742	2243
Solar Thermal	0	50	50	50	50
Wind	174	174	174	174	296
Biomass	17	50	50	50	59
Pumped Hydro	0	0	130	130	130
Li-Ion Batteries	0	16	16	168	396

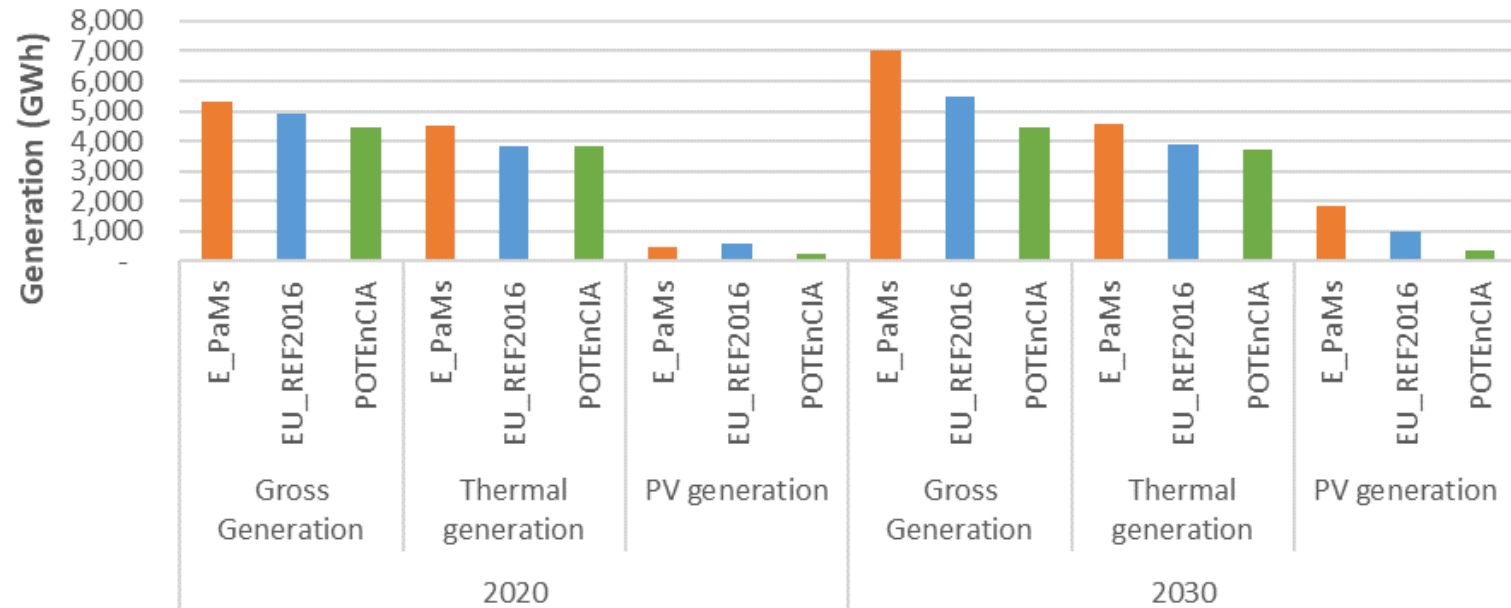
Electricity Supply - Generation

- Conventional thermal generation remains stable
- Electricity demand increase covered primarily by PV
- RES-E share in 2030 at 34.7%
- Curtailment in 2030: 0.7% for Solar PV and 3.1% for wind



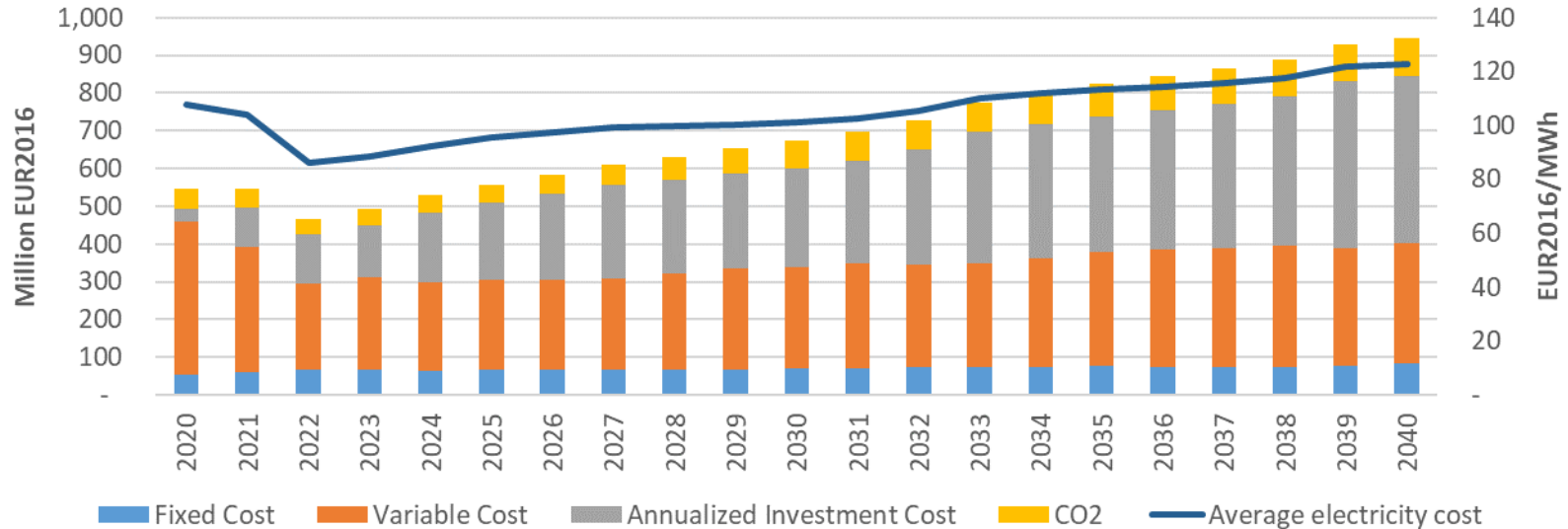
Electricity Supply – Comparison with other models

- Discrepancy in terms of projected electricity demand
 - Moderate increase in EU Reference Scenario 2016
 - Stable electricity demand in POTEnCIA
- Thermal generation remains stable in all models, while increased demand is covered primarily by solar PV



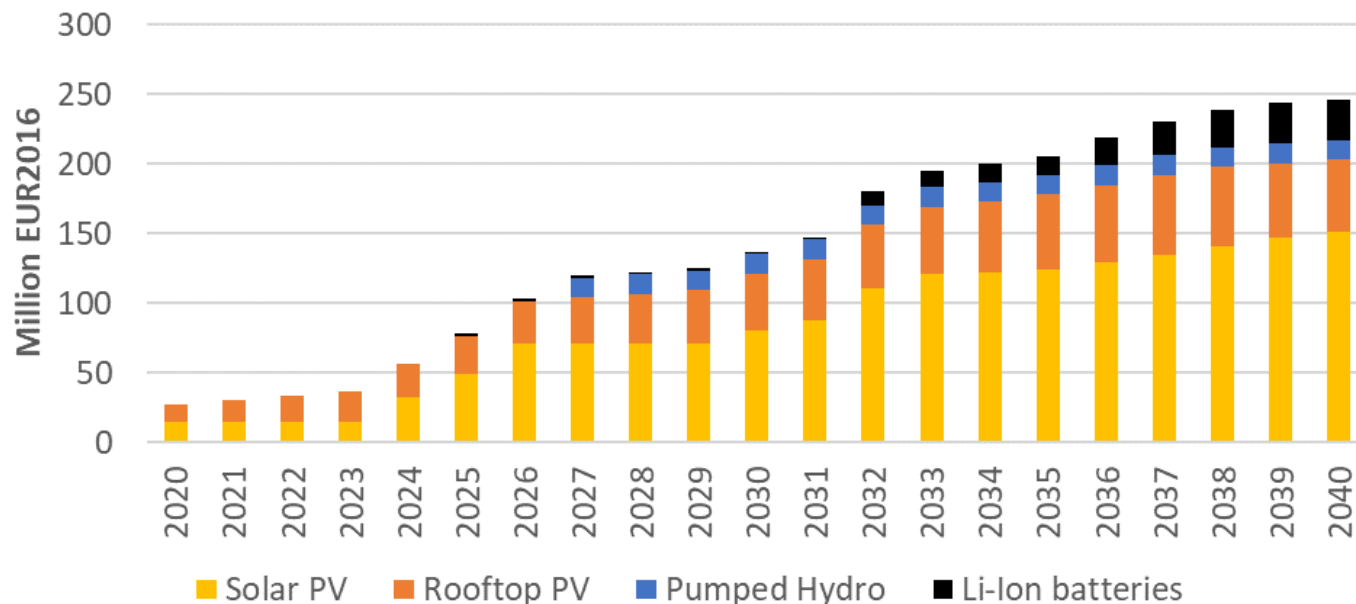
Electricity Supply - Cost

- Noticeable decrease in cost in 2022 when gas is fully available
- Increasing fuel prices, ETS cost and substantial investments lead to a mild gradual increase in electricity cost.
- 2020 cost is 108 EUR/MWh, while in 2030 it is 101 EUR/MWh



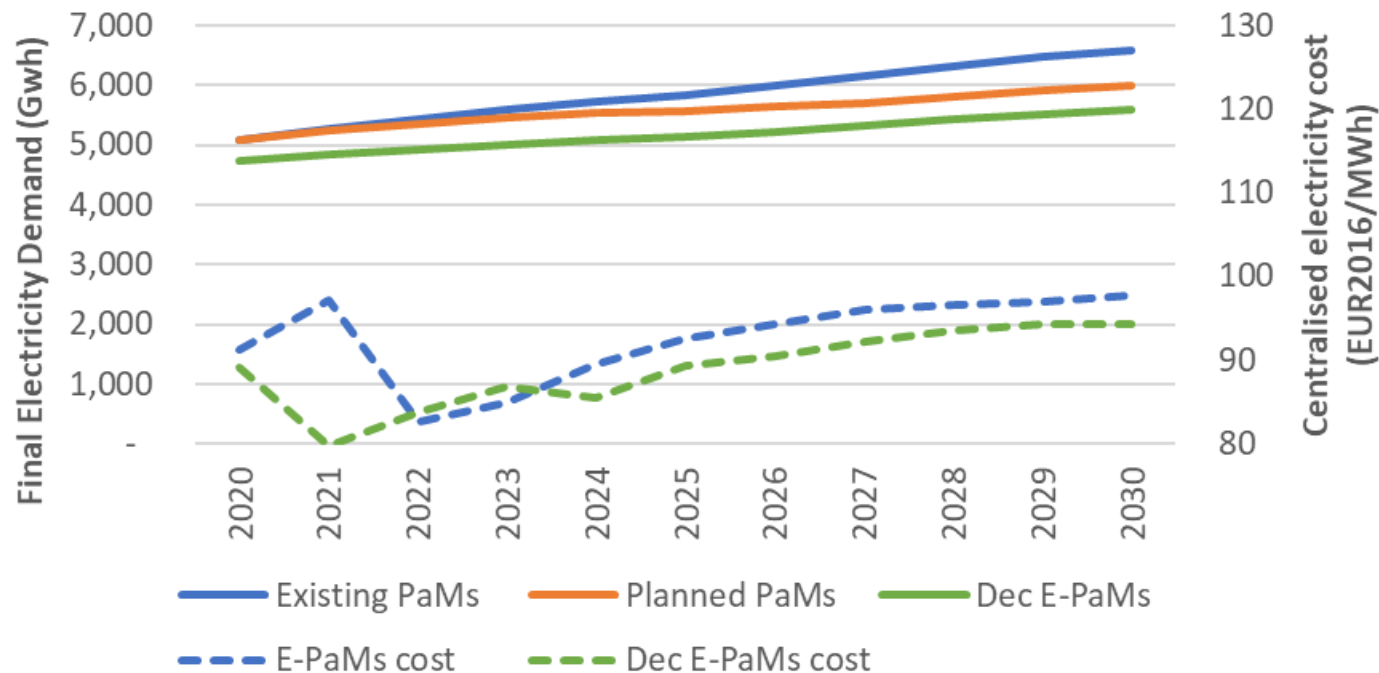
Electricity Supply – Selected Annualized Investments

- Considerable investments in solar PV coupled with investments in storage technologies



Final Electricity Demand vs Electricity Cost

- Electricity cost increases with higher electricity demand
- 2020-2021 difference due to different gas availability dates



Transport Sector – Vehicle fleet

		2020	2025	2030	2035	2040
Passenger cars	Diesel	69,175	40,372	11,570	-	-
	Diesel hybrid	-	-	-	-	-
	Diesel PHEV	-	-	-	-	-
	Gasoline	471,730	539,054	548,877	472,227	375,138
	Gasoline Hybrid	5,170	5,170	32,710	98,633	173,422
	Gasoline PHEV	-	-	-	-	-
	BEV	100	100	31,545	102,537	177,327
	LPG	210	736	1,173	963	437
	Natural gas	-	-	-	-	-
	Hydrogen	-	-	-	-	-
		2020	2025	2030	2035	2040
Busses	Diesel	3,014	3,230	3,450	3,715	4,006
	Diesel hybrid	-	-	-	-	-
	BEV	-	-	-	-	-
	CNG	-	-	-	-	-
		2020	2025	2030	2035	2040
MCs	Gasoline	50,925	54,667	58,383	62,806	68,087
	BEV	-	-	-	-	-
		2020	2025	2030	2035	2040
Trucks	Diesel	12,978	13,648	14,502	14,646	16,158
	BEV	-	274	366	1,371	1,096
	Natural gas	-	-	-	-	-
		2020	2025	2030	2035	2040
Light Trucks	Diesel	119,614	128,323	137,032	147,625	159,035
	BEV	-	-	-	-	-
	PHEV Diesel	-	-	-	-	-
	Hybrid diesel	-	-	-	-	-
	Grand Total	732,920	785,578	839,609	904,521	974,707

Transport Sector – Fuel Consumption

- Diesel consumption undergoes a moderate reduction by 2030
- Gasoline consumption increases by 2030
- Electricity demand increases to 104 GWh by 2030
- RES-T share in 2030 at 4.1%

		2020	2025	2030	2035	2040
Biodiesel 1st gen	Litres	19,363,037	17,663,248	16,243,884	15,670,404	16,083,264
Biodiesel 2nd gen	Litres	-	-	-	-	-
Bioethanol 1st gen	Litres	-	-	-	-	-
Bioethanol 2nd gen	Litres	-	-	-	-	-
Diesel	Litres	330,278,984	301,285,377	277,075,012	267,293,043	274,335,275
Gasoline	Litres	521,143,308	572,266,164	577,668,281	527,708,637	470,108,837
LPG	Litres	286,789	971,297	1,616,118	-	153,750
Natural gas (STP)	m3	-	-	-	-	-
Electricity (road)	MWh	322	6,402	104,122	336,310	545,486
Electricity (rail)	MWh	-	-	-	-	-

Heating and Cooling Sector – Final Energy Demand

- Over time the use of fossil fuels reduces
- Considerable increase in solar thermal
- Increased electrification of the sector & heat-pump deployment
- RES-H&C share in 2030 at 34.1%

PJ	2020	2025	2030	2035	2040
Electricity	7.56	8.69	9.78	10.31	10.67
Heating oil/light fuel oil/Gas	9.01	8.01	7.68	6.87	6.51
Oil					
Pet Coke	4.33	3.71	3.44	3.21	3.00
LPG	4.32	3.99	4.14	4.08	4.01
Biomass	1.42	1.41	1.62	1.70	1.84
Solar & Geothermal	4.21	3.94	4.70	5.90	7.14
RES share	24.4%	28.3%	34.1%	41.1%	46.7%

Primary Energy Supply (ktoe)

- Moderate decrease in total primary energy supply
- A shift away from oil products to natural gas and increased RES

	2020	2025	2030	2035	2040
Diesel	850	259	238	230	236
Gasoline	398	437	442	403	359
Heavy Fuel Oil	460	0	-	-	-
LPG	103	96	100	97	96
Heating Oil/light fuel oil/Gas oil	215	191	183	164	156
Pet coke	103	89	82	77	72
Natural gas	-	784	832	781	745
Hydrogen	-	-	-	-	-
Electricity	-	-	-	-	-
Biomass (includes biofuels)	69	104	108	110	113
Solar thermal (H&C sector)	101	94	112	141	171
Solar thermal (Electricity sector)	0	15	15	15	15
Solar PV	43	101	157	231	280
Wind	19	20	20	19	29
Total	2,363	2,191	2,289	2,268	2,271

Final Energy Demand (ktoe)

- Moderate increase in Final Energy Demand
- The main driver is increased electricity demand, generated by more efficient gas-fired plants and renewable energy technologies

	2020	2025	2030	2035	2040
Diesel	284	259	238	230	236
Gasoline	398	437	442	403	359
LPG	103	96	100	97	96
Heating Oil/light fuel oil/Gas oil	215	191	183	164	156
Natural gas	-	-	-	-	-
Pet Coke	103	89	82	77	72
Hydrogen	-	-	-	-	-
Electricity	437	502	574	625	664
Biomass (includes biofuels)	49	48	52	53	57
Solar thermal	101	94	112	141	171
Total	1,691	1,716	1,783	1,790	1,809

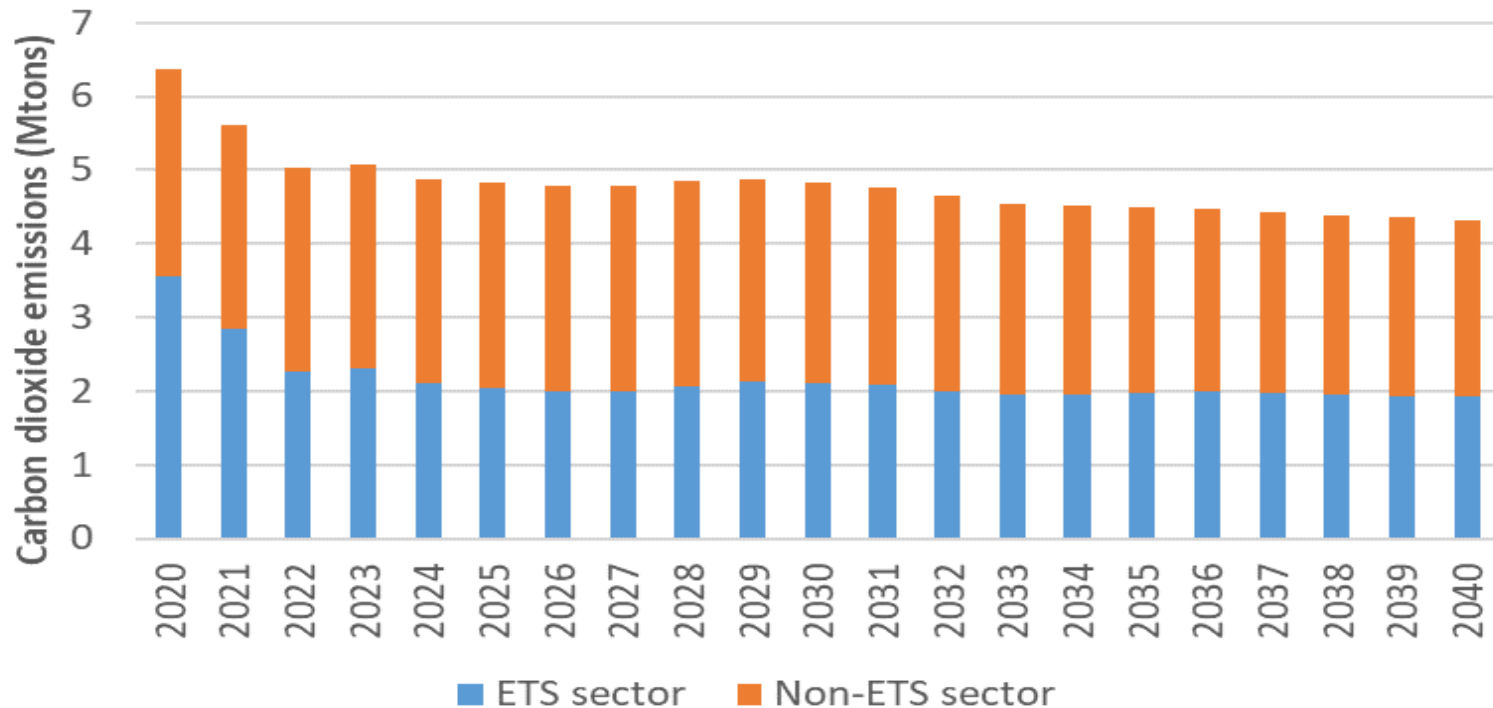
RES shares projections

- Comparison with POTEnCIA and EU Reference Scenario 2016

	2020	2025	2030	2035	2040
All sectors	12.8%	17.8%	22.0%	28.1%	33.1%
<i>POTEnCIA</i>	14.8%	16.5%	21.2%	27.1%	34.0%
<i>EU Reference Scenario 2016</i>	14.8%	15.7%	18.4%	18.9%	20.3%
Electricity	15.0%	29.3%	34.7%	43.1%	49.0%
<i>POTEnCIA</i>	15.4%	16.1%	27.2%	35.7%	51.1%
<i>EU Reference Scenario 2016</i>	21.5%	22.6%	29.4%	27.2%	28.0%
Heating and cooling	24.4%	28.3%	34.1%	41.1%	46.7%
<i>POTEnCIA</i>	27.4%	30.3%	33.6%	41.4%	45.6%
<i>EU Reference Scenario 2016</i>	24.1%	26.4%	29.6%	33.5%	37.6%
Transport (Directive 2009/28/EC methodology)	2.2%				
Transport (RED Recast methodology)		2.0%	4.1%	11.5%	19.1%
<i>POTEnCIA</i>	5.0%	5.2%	5.5%	6.1%	7.1%
<i>EU Reference Scenario 2016</i>	10.2%	10.2%	9.9%	10.9%	11.4%

Carbon dioxide emissions

- Early decrease in CO₂ emissions attributed to shift towards gas-fired generation



Sensitivity run without storage nor electrified transport

- PV capacity reduced to 933 MW by 2030
- GT units substitute flexibility offered by storage and BEVs
- RES-E share in 2030 reduced to 30.5%
- Overall RES share in 2030 reduced to 20.3%
- CO2 emissions increase to 5 Mt instead of 4.8 Mt in 2030
- Curtailment at 2.1% for PV and 4.6% for wind

MW	2020	2025	2030	2035	2040
Vasilikos	0	0	0	0	0
Dhekelia	0	0	0	0	0
Moni	0	0	0	0	0
New CCGT	0	0	0	216	432
New ICE	0	0	0	0	0
New ST	0	0	0	0	-171
New GT	0	62	186	186	372
Light fuel oil CHP	0	0	0	0	-21
Solar PV	0	-156	-198	-519	-510
Solar Thermal	0	0	0	0	0
Wind	0	0	0	0	-122
Biogas	0	0	0	0	-9
Pumped Hydro	0	0	-130	-130	-130
Li-Ion Batteries	0	-16	-16	-168	-396

Sensitivity run without pumped-hydro storage

- Minor reduction in PV capacity by 2030
- Battery storage substitutes pumped-hydro in 2030
- Slight reduction of RES-E share in 2030 to 34.5%
- Curtailment in 2030 increases to 1.2% for PV and 4% for wind

MW	2020	2025	2030	2035	2040
Vasilikos	0	0	0	0	0
Dhekelia	0	0	0	0	0
Moni	0	0	0	0	0
New CCGT	0	0	0	0	0
New ICE	0	0	0	0	0
New ST	0	0	0	0	-57
New GT	0	0	0	0	0
Light fuel oil CHP	0	0	0	9	10
Solar PV	0	-80	-6	-130	-137
Solar Thermal	0	0	0	0	0
Wind	0	0	0	0	188
Biogas	0	0	0	0	12
Pumped Hydro	0	0	-130	-130	-130
Li-Ion Batteries	0	16	131	156	254

Sensitivity run with a cap on PV capacity

- Decrease in PV capacity for 2030 compensated by an additional GT unit
- Pumped-hydro delayed till 2033
- Additional batteries are deployed by 2030 – energy arbitrage for CCGTs
- 2030 RES-E share at 26.6%
- Overall 2030 RES share at 19.4%
- CO2 emissions at 5.1 Mt in 2030
- Curtailment at 0.05% for PV and 0.5% for wind

MW	2020	2025	2030	2035	2040
Vasilikos	0	0	0	0	0
Dhekelia	0	0	0	0	0
Moni	0	0	0	0	0
New CCGT	0	0	0	-216	0
New ICE	0	0	0	0	0
New ST	0	0	0	0	-57
New GT	0	62	62	62	62
Light fuel oil CHP	0	0	0	3	3
Solar PV	0	-228	-382	36	-4
Solar Thermal	0	0	0	0	0
Wind	0	0	0	0	-60
Biogas	0	0	0	0	-3
Pumped Hydro	0	0	-130	0	0
Li-Ion Batteries	0	-16	144	147	44

- 2030 average cost of electricity rises slightly to 102 EUR/MWh instead of 101 EUR/MWh in main Existing PaMs scenario

Planned Policies and Measures Scenario Results

Electricity Supply - Capacity

- As compared to Existing PaMs scenario, one CCGT unit less by 2030 and no new GT, ST, CHP
- Lower storage investments
- Pumped hydro remains – due to no sharing of reserves
- Substantial increase in PV deployment

	2020	2025	2030	2035	2040
Vasilikos	868	868	868	608	0
Dhekelia	460	102	102	0	0
Moni	150	150	150	0	0
New CCGT	0	216	216	216	432
New ICE	0	0	0	0	0
New ST	0	0	0	0	0
New GT	0	0	0	0	0
Light fuel oil CHP	0	0	0	0	0
Solar PV	312	412	1632	2744	3684
Solar Thermal	0	50	50	50	50
Wind	174	174	174	174	174
Biomass	17	50	50	50	50
Pumped Hydro	0	0	130	130	130
Li-Ion Batteries	0	0	0	0	200

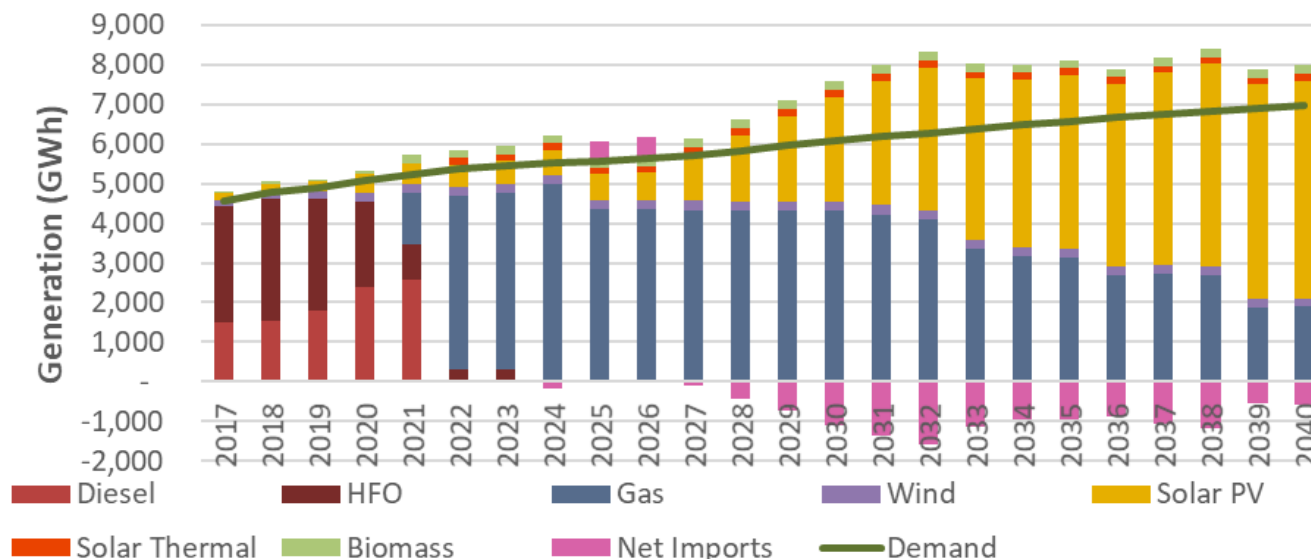
Electricity Supply - Capacity

- As compared to Existing PaMs scenario, one CCGT unit less by 2030 and no new GT, ST, CHP
- Lower storage investments
- Pumped hydro remains – due to no sharing of reserves
- Substantial increase in PV deployment

	2020	2025	2030	2035	2040
Vasilikos	0	0	0	0	0
Dhekelia	0	0	0	0	0
Moni	0	0	0	0	0
New CCGT	0	-216	-216	-432	-432
New ICE	0	0	0	0	0
New ST	0	0	0	0	-228
New GT	0	-62	-62	-62	-62
Light fuel oil CHP	0	0	0	0	-21
Solar PV	0	-314	500	1002	1441
Solar Thermal	0	0	0	0	0
Wind	0	0	0	0	-122
Biogas	0	0	0	0	-9
Pumped Hydro	0	0	0	0	0
Li-Ion Batteries	0	-16	-16	-168	-196

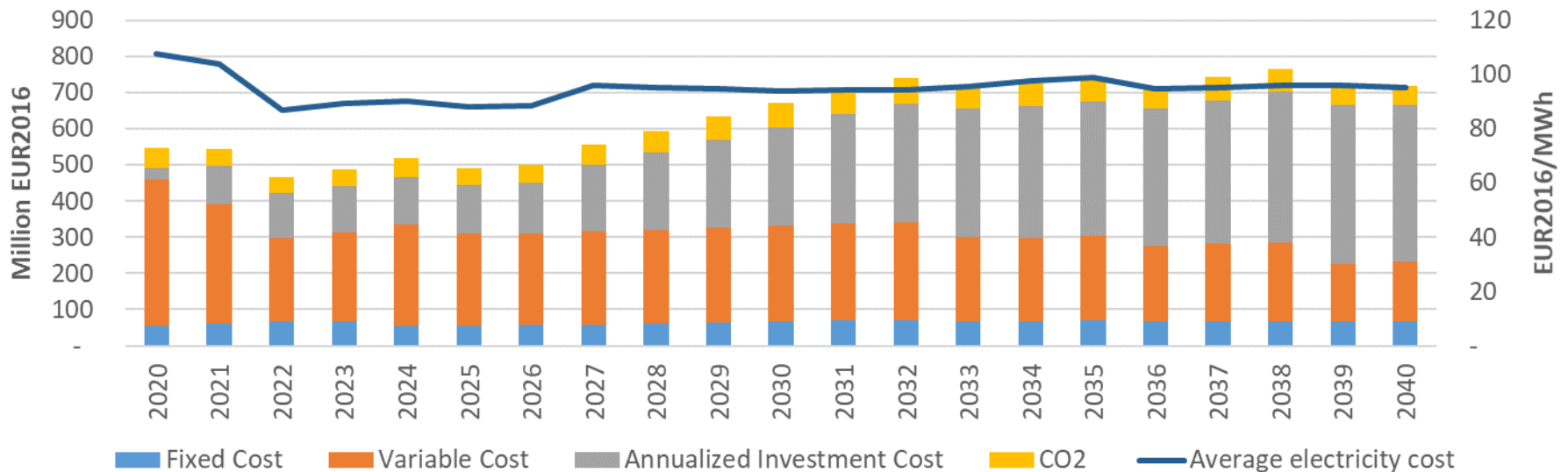
Electricity Supply - Generation

- Conventional thermal generation in 2030 decreases from 4,585 GWh in E-PaMs to 4,300 GWh
- RES generation for export purposes – 41% of PV generation in 2030
- RES-E share in 2030 increases to 50.4% (*absolute figure is 43%*)
- Curtailment in 2030: 0.05% for Solar PV and 0.5% for wind



Electricity Supply - Cost

- Stable electricity cost is maintained throughout horizon
- 2030 electricity cost decreases to 94 EUR/MWh instead of 101 EUR/MWh in Existing PaMs scenario



Transport Sector – Vehicle fleet

		2020	2025	2030	2035	2040
Passenger cars	Diesel	69,175	40,372	11,570	-	-
	Diesel hybrid	-	-	-	-	-
	Diesel PHEV	-	252	799	1,474	1,923
	Gasoline	471,512	453,009	384,167	294,002	182,611
	Gasoline Hybrid	5,170	5,170	27,840	93,762	168,552
	Gasoline PHEV	-	-	-	-	-
	BEV	100	100	27,641	98,633	173,422
	LPG	214	739	1,174	963	437
	Natural gas	-	-	-	-	-
	Hydrogen	-	-	-	-	-
Busses		2020	2025	2030	2035	2040
	Diesel	3,012	4,372	5,574	5,669	5,923
	Diesel hybrid	-	-	-	-	-
	BEV	-	138	436	804	1,049
	CNG	-	-	-	-	-
MCs		2020	2025	2030	2035	2040
	Gasoline	50,945	47,066	43,182	46,502	50,132
	BEV	-	-	-	-	-
Trucks		2020	2025	2030	2035	2040
	Diesel	12,978	14,143	15,310	14,817	14,351
	BEV	-	-	-	1,675	3,416
	Natural gas	-	-	-	-	-
Light Trucks		2020	2025	2030	2035	2040
	Diesel	119,614	126,670	133,726	144,063	155,192
	BEV	-	-	-	-	-
	PHEV Diesel	-	-	-	-	-
	Hybrid diesel	-	-	-	-	-
Grand Total		732,720	692,031	651,417	702,363	757,007

Transport Sector – Fuel Consumption

- Gasoline consumption decreases considerably – 408 million litres instead of 578 million litres in Existing PaMs scenario
- Electricity demand in 2030 is at comparable levels as in Existing PaMs scenario
- RES-T share in 2030 at 5.2%

		2020	2025	2030	2035	2040
Biodiesel 1st gen	Litres	19,362,299	18,179,402	17,133,250	16,227,088	15,979,739
Biodiesel 2nd gen	Litres	-	-	-	-	-
Bioethanol 1st gen	Litres	-	-	-	-	-
Bioethanol 2nd gen	Litres	-	-	-	-	-
Diesel	Litres	330,266,412	310,089,514	292,245,097	276,788,517	272,569,430
Gasoline	Litres	521,142,631	481,085,283	408,440,633	354,114,526	292,748,628
LPG	Litres	286,789	971,297	1,516,809	-	-
Natural gas (STP)	m3	-	-	-	-	-
Electricity (road)	MWh	322	3,829	95,125	350,202	605,190
Electricity (rail)	MWh	-	-	9,126	9,126	9,126

Transport Sector – Investment requirements

As compared to Existing PaMs scenario:

- Additional cumulative public investments until 2030 reach 1 billion EUR (more busses and Nicosia tram)
- Cumulative private investments for the same period are reduced by 3.2 billion EUR (fewer passenger cars)

Public acceptance of public transport modes is necessary to make such investments successful.

Heating and Cooling Sector – Final Energy Demand

- Efficiency measures result in lower final energy demand in the sector
- RES-H&C share in 2030 at 33.5%

PJ	2020	2025	2030	2035	2040
Electricity	7.56	8.29	8.89	9.17	9.29
Heating oil/light fuel oil/Gas Oil	8.90	7.74	7.37	6.49	5.59
Pet Coke	4.32	3.67	3.43	3.19	2.97
LPG	4.25	3.83	3.95	3.80	3.62
Biomass	1.39	1.33	1.53	1.55	1.52
Solar & Geothermal	4.10	3.69	4.34	5.09	5.61
RES share	24.1%	27.8%	33.5%	39.8%	45.0%

Primary Energy Supply (ktoe)

- Substantial decrease in total primary energy supply
- Lower by approximately 225 ktoe in 2030 and 490 ktoe in 2040

	2020	2025	2030	2035	2040
Diesel	850	267	251	238	234
Gasoline	398	368	312	271	224
Heavy Fuel Oil	460	-	-	-	-
LPG	102	92	95	91	87
Heating Oil/light fuel oil/Gas oil	212	185	176	155	134
Pet coke	103	88	82	76	71
Natural gas	-	775	768	559	338
Hydrogen	-	-	-	-	-
Electricity	-	39	-93	-81	-50
Biomass (includes biofuels)	68	103	107	107	106
Solar thermal (H&C sector)	98	88	104	122	134
Solar thermal (Electricity sector)	0	15	15	15	15
Solar PV	43	57	227	376	472
Wind	19	19	21	20	18
Total	2,354	2,095	2,065	1,947	1,782

Final Energy Demand (ktoe)

- Moderate decrease in Final Energy Demand
- Lower by 190 ktoe in 2030 and 278 ktoe in 2040 as compared to Existing PaMs scenario

	2020	2025	2030	2035	2040
Diesel	284	267	251	238	234
Gasoline	398	368	312	271	224
LPG	102	92	95	91	87
Heating Oil/light fuel oil/Gas oil	212	185	176	155	134
Natural gas	-	-	-	-	-
Pet Coke	103	88	82	76	71
Hydrogen	-	-	-	-	-
Electricity	437	479	523	566	599
Biomass (includes biofuels)	48	46	50	50	49
Solar thermal	98	88	104	122	134
Total	1,683	1,612	1,593	1,568	1,531

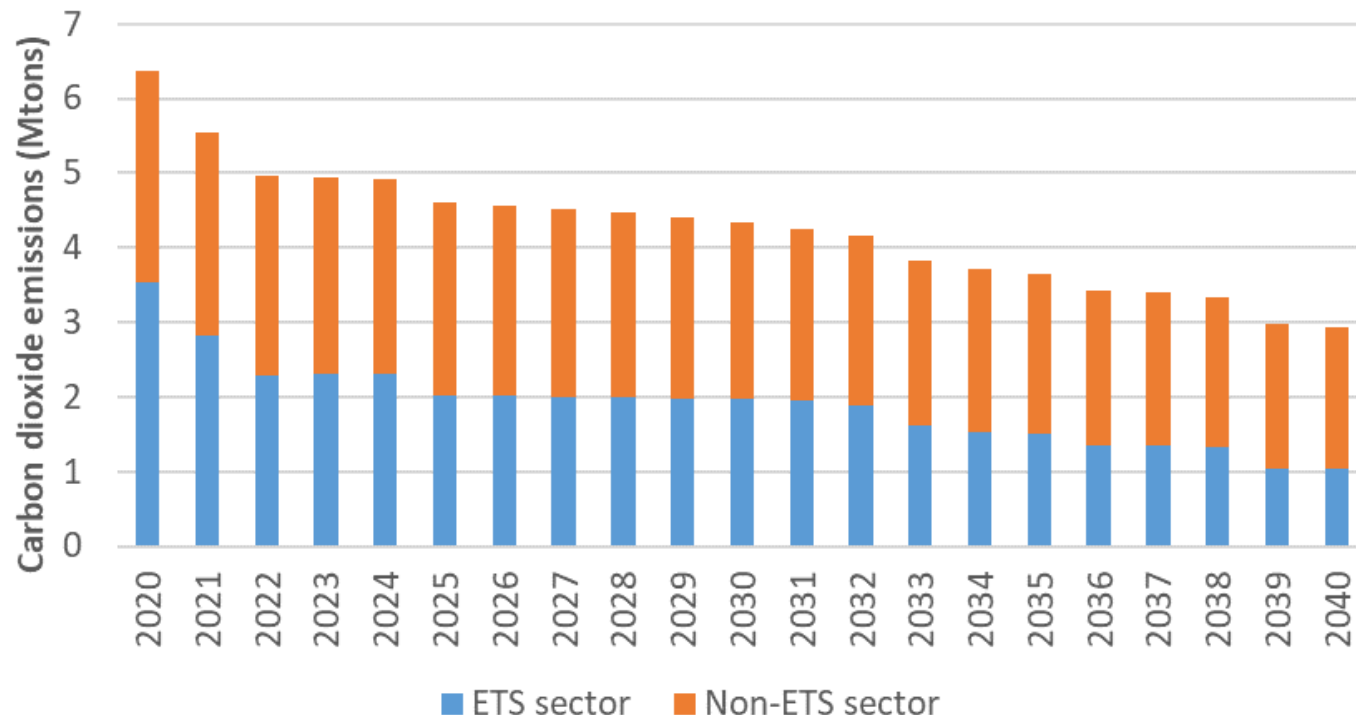
RES shares projections

- Overall RES share in 2030 increases from 22% in Existing PaMs scenario to 27.9% in the Planned PaMs scenario
 - Mainly driven by a higher RES-E
 - Assisted by lower fuel consumption in the transport and heating & cooling sectors

	2020	2025	2030	2035	2040
All sectors	12.7%	15.6%	27.9%	38.1%	46.5%
Electricity	15.0%	21.0%	50.4%	69.5%	82.2%
Heating and cooling	24.1%	27.8%	33.5%	39.8%	45.0%
Transport (Directive 2009/28/EC methodology)	2.2%				
Transport (RED Recast methodology)		2.3%	5.2%	22.5%	44.3%

Carbon dioxide emissions

- Overall decrease to 4.3 Mt instead of 4.8 Mt in the Existing PaMs scenario for 2030
 - 140 ktons lower in ETS sector
 - 355 ktons lower in non-ETS sector



Sensitivity run with 500 MW NTC

- Decrease in PV capacity in 2030
- 2030 RES-E share reduced to 47.2% instead of 50.4%
- In the long-term battery storage partially substitutes portion of the interconnector capacity

MW	2020	2025	2030	2035	2040
Vasilikos	0	0	0	0	0
Dhekelia	0	0	0	0	0
Moni	0	0	0	0	0
New CCGT	0	0	0	0	0
New ICE	0	0	0	0	0
New ST	0	0	0	0	0
New GT	0	0	0	0	62
Light fuel oil CHP	0	0	0	0	0
Solar PV	0	0	-127	-361	-647
Solar Thermal	0	0	0	0	0
Wind	0	0	0	0	0
Biogas	0	0	0	0	0
Pumped Hydro	0	0	0	0	0
Li-Ion Batteries	0	0	0	156	305

Conclusions

Summarized Scenario Comparison

		Existing PaMs scenario			Planned PaMs scenario		
		2020	2025	2030	2020	2025	2030
Primary Energy Supply	ktoe	2,363	2,191	2,289	2,354	2,095	2,065
Final Energy Demand	ktoe	1,691	1,716	1,783	1,683	1,612	1,593
Overall RES share	%	12.8%	17.8%	22.0%	12.7%	15.6%	27.9%
RES-E share	%	15.0%	29.3%	34.7%	15.0%	21.0%	50.4%
RES-H&C share	%	24.4%	28.3%	34.1%	24.1%	27.8%	33.5%
RES-T share	%	2.2%	2.0%	4.1%	2.2%	2.3%	5.2%
Total CO₂ emissions	Mt	6.4	4.8	4.8	6.4	4.6	4.3
ETS sector	Mt	3.5	2.0	2.1	3.5	2.0	2.0
non-ETS	Mt	2.8	2.8	2.7	2.8	2.6	2.4

Achievement of EU's 2030 energy and climate targets necessitates a noticeable transition of the current energy system

- Despite substantial investments in RES technologies in the Existing PaMs scenario, CO₂ emission reduction from 6.4 Mt in 2020 to 4.8 Mt in 2030 is attributed mainly to natural gas introduction
- Substantial measures are needed in the non-ETS sector - transport sector emissions do not reduce in the Existing PaMs scenario
- Heavy investments in transport sector are reliant on public acceptance
- Energy efficiency measures to curb final energy demand
- Strong indication that storage can assist RES and thermal generation
- Highly sensitive results to external electricity prices in Planned PaMs scenario

Potential model enhancements

- Representation of EuroAsia Interconnector with substantial detail of Greek and Israeli systems is needed to correctly estimated impact of the project and potential for electricity trade – data-intensive and data-dependent
- Additional detail in Heating & Cooling sector to capture all energy services – data-intensive and data-dependent
- Inclusion of demand-side management measures
- Model has been set up and can be used for additional sensitivity runs

Thank you

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Supporting slides