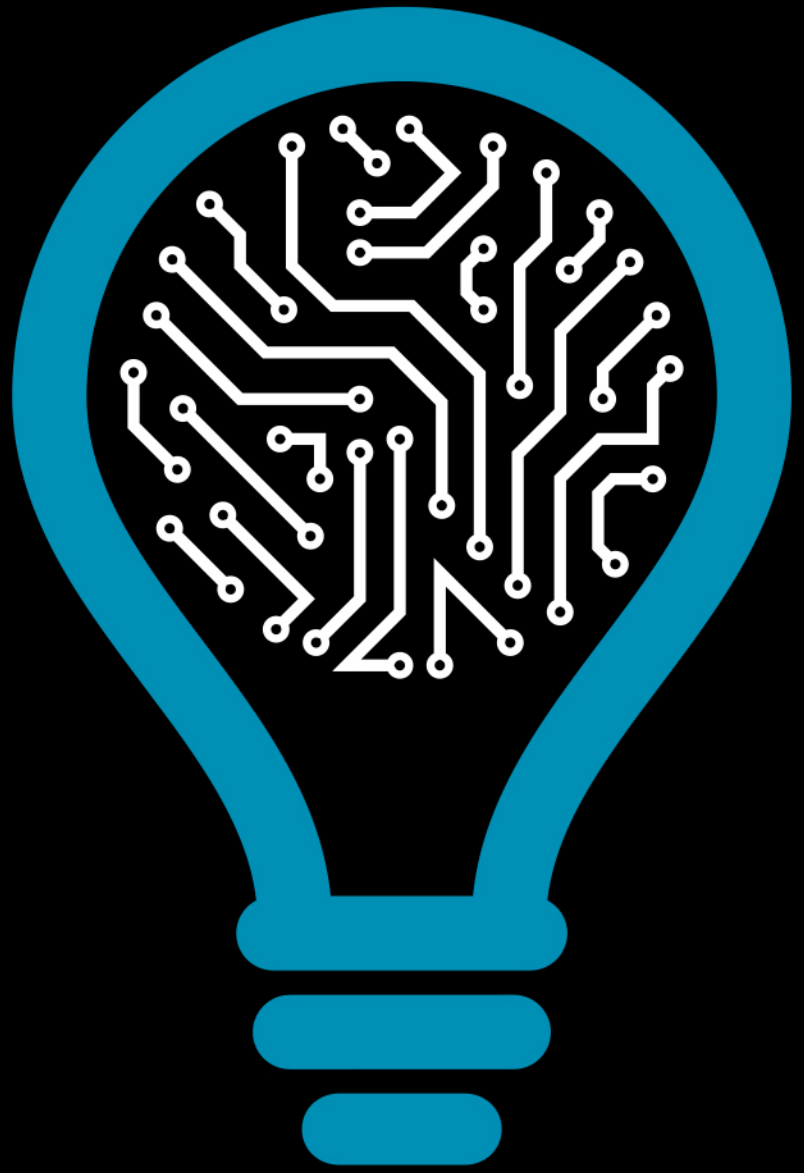
Força Açoreana

Final Simulation Results



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INSTITUTO DE ENGENHARIA
DE SISTEMAS E COMPUTADORES,
TECNOLOGIA E CIÊNCIA

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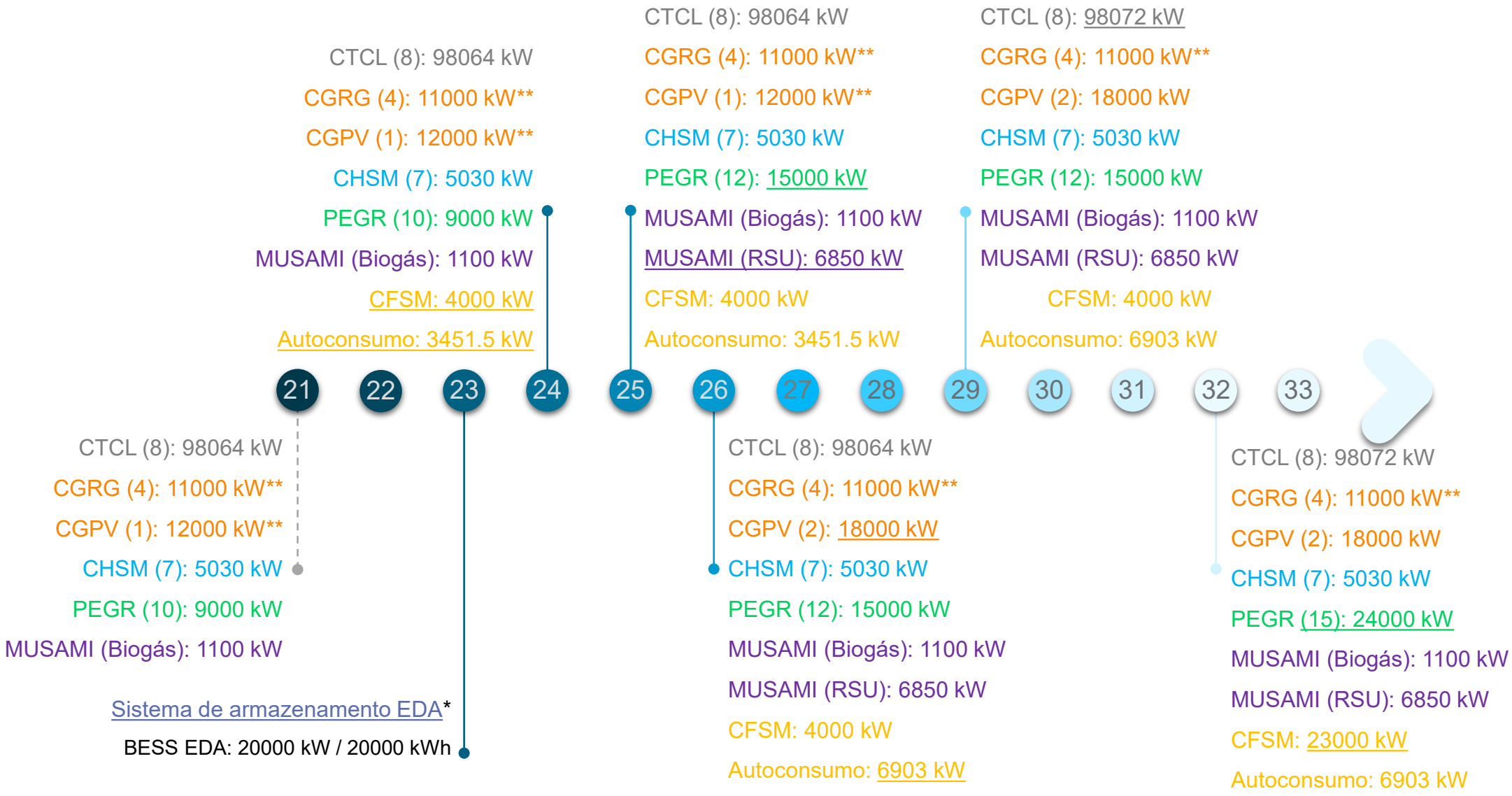
São Miguel

Description of the base case

Cenários de Oferta - EDA



* Permitirá substituir a reserva girante dos grupos geradores térmicos e colaborar na regulação da tensão e frequência da rede. permitindo reduzir o número de unidades térmicas em serviço.

Para efeitos de simulação considerou-se a sua entrada em operação em **janeiro de 2024**.

Parâmetros dos Geradores

* Potências consideradas. de acordo com informação fornecida pela EDA (ao invés de 16600 kW e 13000 kW. respetivamente)

Nome	Sigla	Fonte primária	Grupo / Nº unidades	Pot. inst. (kW)	Pot. min. (kW)	Pot. max. (kW)	TPP (min)	TDP (min)	Ordem de mérito					
									2023	2024	2025	2026	2029	2032
Caldeirão	CTCL	Fuel	I	7696	3078	7200	60	120	4				-	
			II						3				-	
			III						2				4	
			IV						1				3	
			V	16820	6728	15500	120		4					
			VI						2					
			VII						3					
			VIII						1					
			IX	7700	3080	7700	60		-				1	
			X						-				2	
Ribeira Grande	CGRG	Geotérmica	4	11000*	-	10000	-	-	1					
Pico Vermelho	CGPV	Geotérmica	1	12000*	-	11700	-	-	1			-		
			2	18000		16700			-			1		
Centrais Hídricas (agregadas)	CHSM	Hídrica	7	5030	-	5030	-	-	1					
Graminhais	PEGR	Eólica	10	9000	-	9000	-	-	3		-			
			12	15000		15000			-		3		-	
			15	24000		24000			-				3	
MUSAMI	MUSAMI	Biogás	1	1100	-	1000	-	-	2					
		RSU	1	6850	2260	3950	-	-	-		2			
S. Miguel	CFSM	Fotovoltaica	-	4000	-	4000	-	-	-	3			-	
				23000		23000			-				3	

Nome e sigla adotados no estudo

[1] 2. SMG_info_centrais.xlsx

[5] 2_SMG_Procedimentos Exploração do Sistema Eletroprodutor.pdf

[21] Combinacoes_Minimas_Centrais_Termicas_v2.xlsx

Regras de Operação

- Número mínimo de grupos térmicos em serviço na CTCL [5.21]:
  - Sem sistema BESS: **2 grupos** → 1 grupo de 16.82 MW (mínimo: 6.73 MW) + 1 grupo de 7.70 MW (mínimo: 3.08 MW)
  - Com sistema BESS: **1 grupo** de 7.70 MW (mínimo: 3.08 MW)
    - A partir de 2032: **0 grupos**
- Regras para cálculo da reserva girante [5]:
  - $15 \leq v_{vento}$ (m/s) ≤ 24: $Reserva_{CTCL} \geq max(0.5*P_{PEGR}. 0.2*P_{CTCL})$ [MW]
  - v_{vento} (m/s) > 24 ou v_{vento} (m/s) < 15: $Reserva_{CTCL} \geq P_{PEGR}$ [MW]

P_{CTCL}: produção da CTCL

- Considerações:
  - Incerteza da procura a curto-prazo (%): 1.5
  - Método de persistência para a previsão da potência eólica e solar nos próximos 30 min
- Ordem de mérito:
  - Mínimo técnico térmica > Hídrica > Geotérmica > Biogás > Resíduos > Solar > Eólica > Térmica (restante)
  - O Autoconsumo é subtraído à carga.

Description of the simulation scenarios and results

BESS – 30MWh

Simulation scenario updates

São Miguel

- ***Autoconsumo:*** 16.8 GWh/year
- **Solar:** 52 GWh/year – 36 GWh/year (FA) + 16 GWh/year
- **Wind:** 43 GWh/year
- **Load:** 552GWh/year, peak 87MW
- **BESS FA**:
  - Power: 12MW (inj./abs.)
  - Capacity: 30MWh
  - Range: 20% - 95%

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Share of annual average production

Technology	Without FA	Without FA's BESS	BESS GFL configuration	BESS GFM configuration
Thermal	28.39%	23.54%	22.41%	21.61%
BESS	--	--	0.82%	0.60%
Renewables + Waste to Energy	71.61%	76.46%	76.77%	77.79%

Renewable energy curtailment

Technology	Without FA	Without FA's BESS	BESS GFL configuration	BESS GFM configuration
Solar	1.09%	9.41%	4.67%	1.97%
Wind	11.83%	21.87%	15.00%	7.92%
Total	8.93%	15.09%	9.38%	4.68%

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Solar Production

	Without FA	Without FA's BESS	BESS GFL configuration	BESS GFM configuration
Production [MWh/year]	15 961.88	47 104.54	49 569.13	50 973.17
Curtailment [MWh/year]	175.68	4 894.27	2 429.68	1 025.64
Curtailment (% of Production Capacity)	1.09%	9.41%	4.67%	1.97%

Wind Production

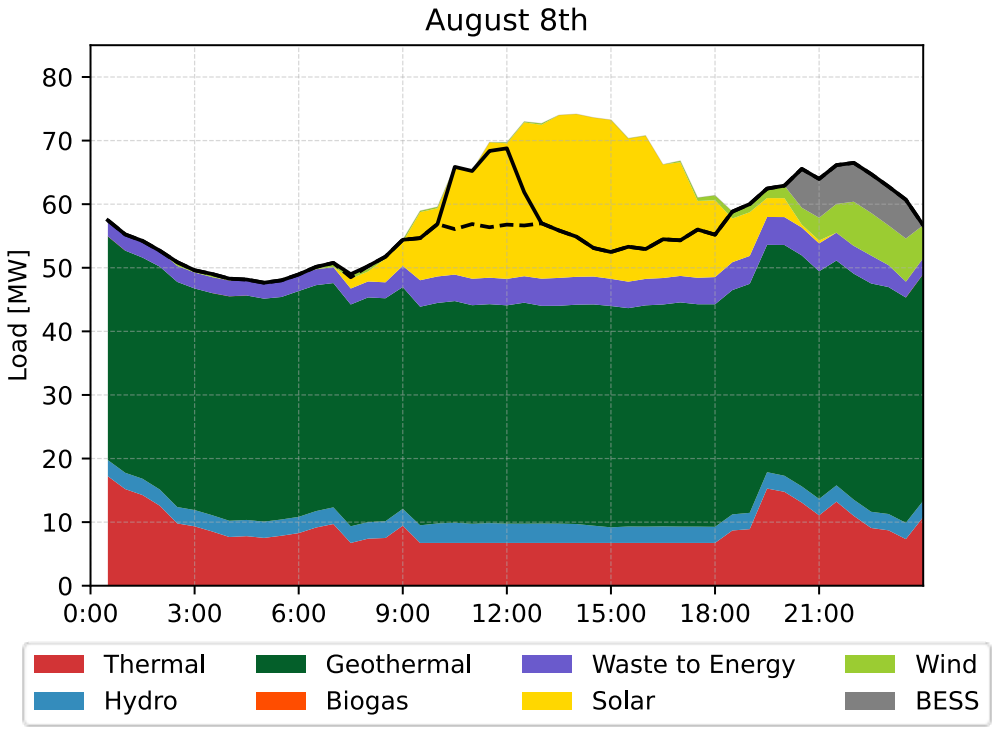
	Without FA	Without FA's BESS	BESS GFL configuration	BESS GFM configuration
Production [MWh/year]	38 392.18	34 020.36	37 013.5	40 096.72
Curtailment [MWh/year]	5 152.13	9 523.95	6 530.81	3 447.58
Curtailment (% of Production Capacity)	11.83%	21.87%	15.00%	7.92%

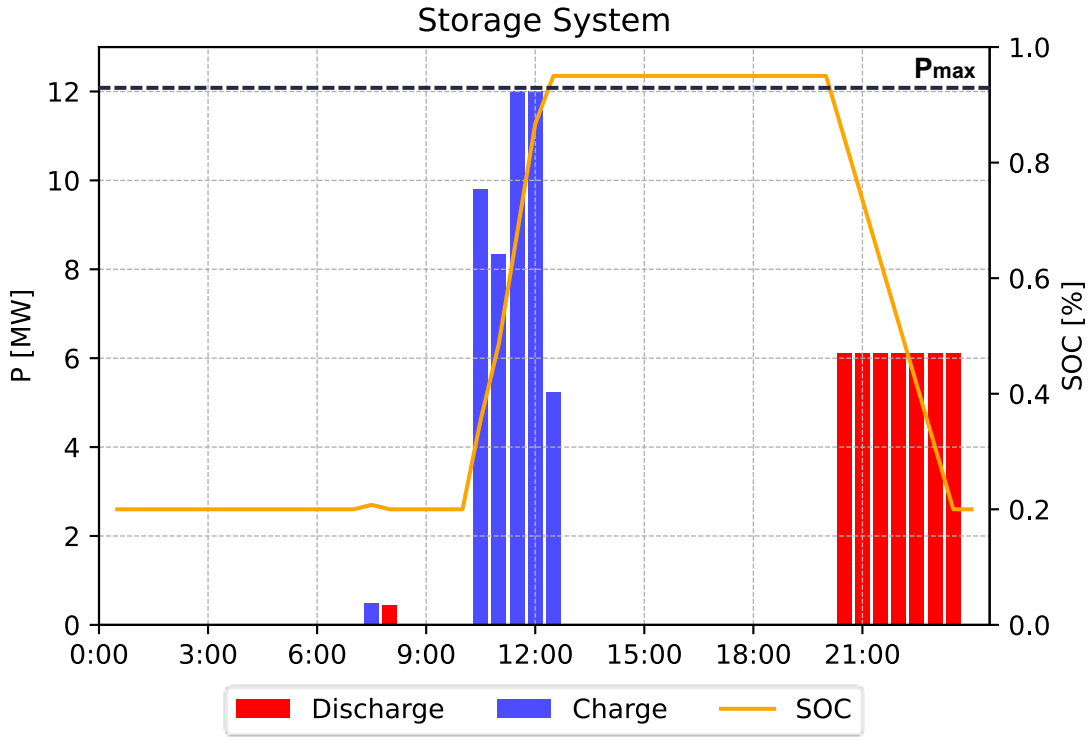
INESCTEC

Average annual production per technology (MWh/year)

Technology	Without FA	Without FA's BESS	BESS GFL configuration	BESS GFM configuration
Autoconsumo	16 765.13	16 765.13	16 765.13	16 765.13
Solar	15 961.88	47 104.54	49 569.13	50 973.17
Wind	38 392.18	34 020.36	37 013.5	40 096.72
Thermal	156 692.32	129 924.	124 831.67	120 069.89
Geothermal	270 723.35	270 723.44	270 742.15	270 776.51
Waste to Energy	28 673.4	28 675.12	28 786.11	28 891.48
Biogas	649.52	649.52	649.75	649.78
Hydro	24 121.78	24 121.78	24 121.78	24 121.78
BESS discharge	--	--	4 580.19	3 334.11
Total Production	**551 979.57**	**551 983.89**	**557 059.41**	**555 678.57**
Total Load	**552 000.**	**552 000.**	**557 075.**	**555 694.31**
BESS charge	--	--	5 075.	3 694.31
BESS losses	--	--	494.8	360.2

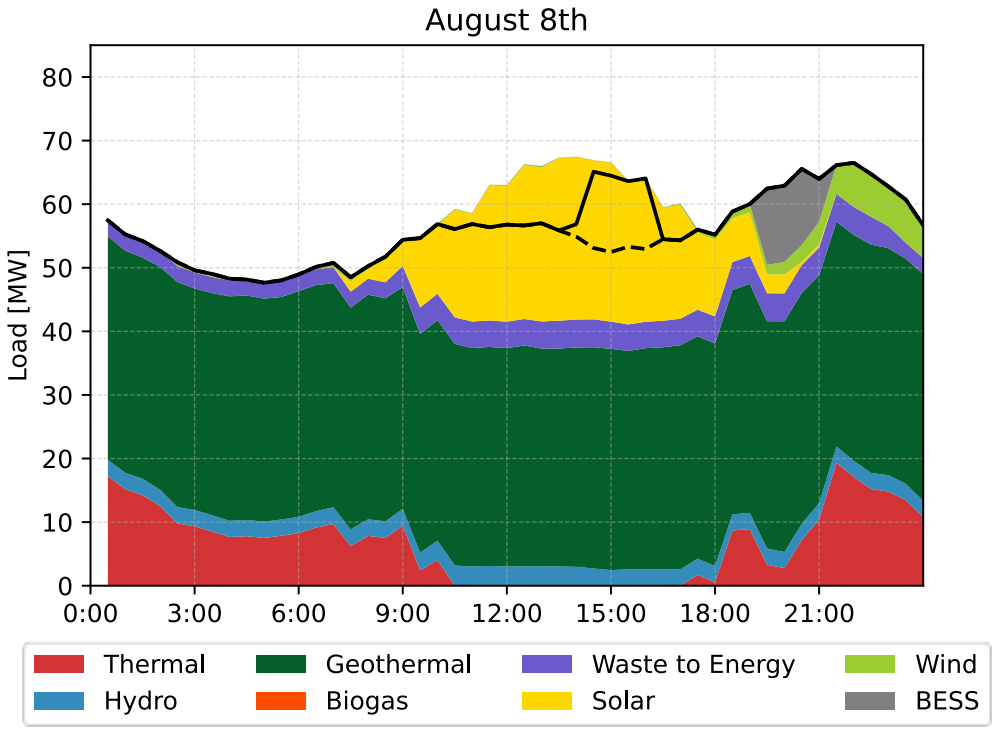
BESS GFL configuration
August

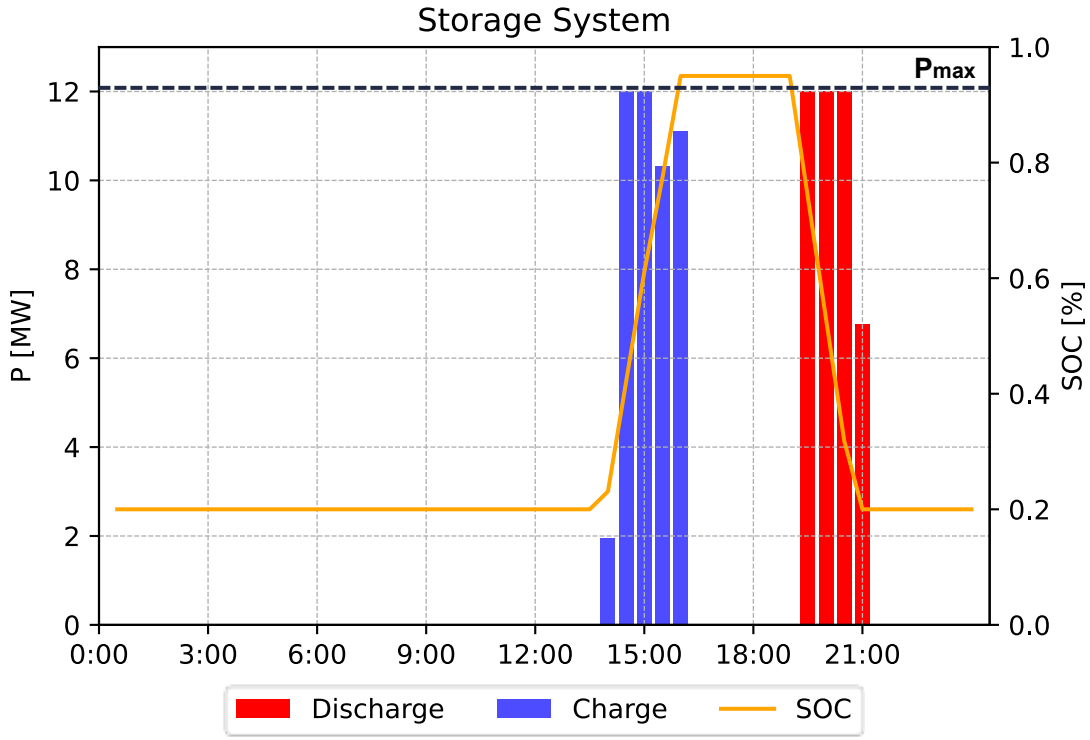




Test Case	Load [MWh]	Thermal [MWh]	Hydro [MWh]	Geothermal [MWh]	Biogas [MWh]	Waste to Energy [MWh]	Solar [MWh]	Wind [MWh]	BESS [MWh]
GFL config.	1 354.5	214.5	63.9	842.5	--	84.9	100.5	26.7	21.6

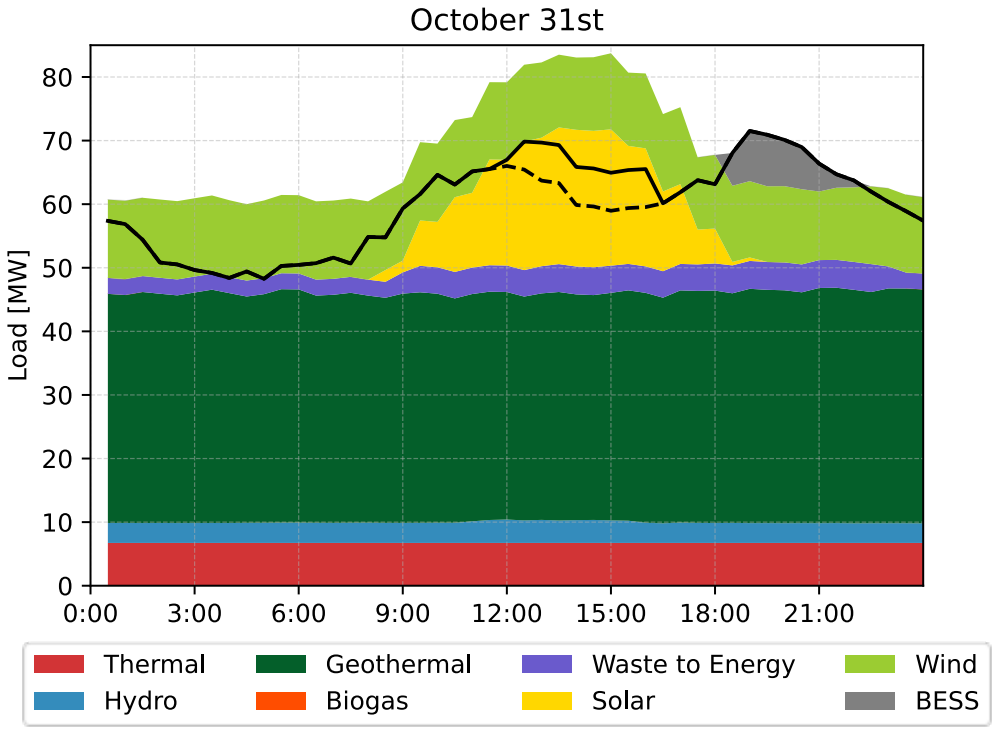
BESS GFM configuration
August

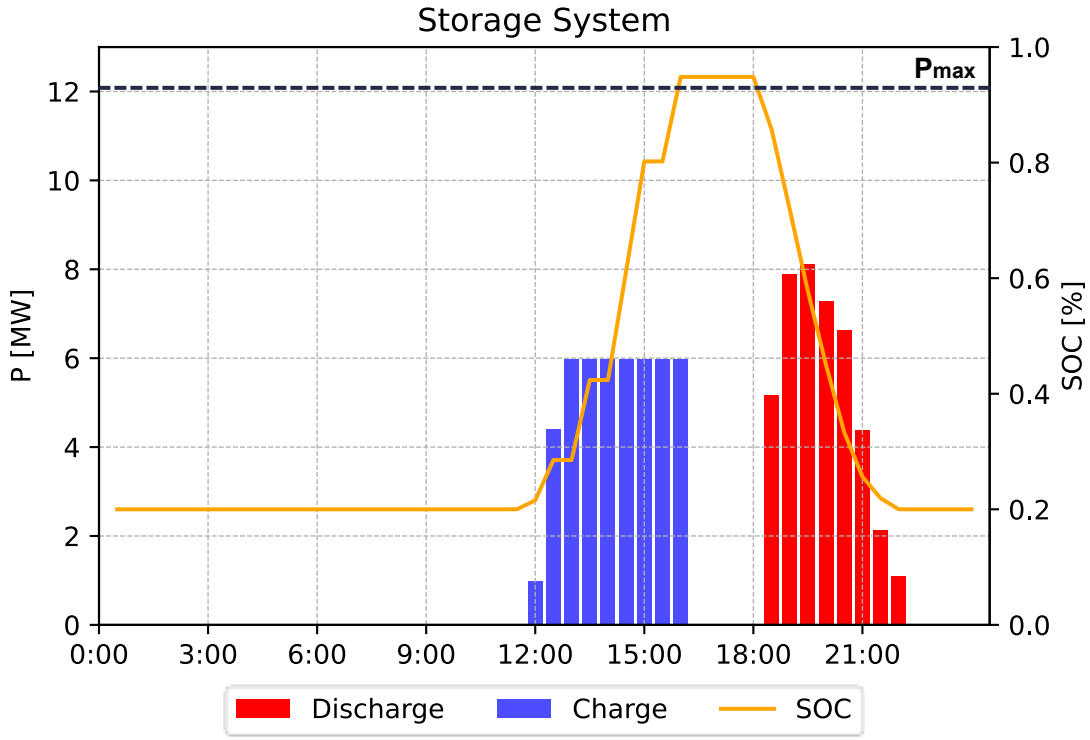




Test Case	Load [MWh]	Thermal [MWh]	Hydro [MWh]	Geothermal [MWh]	Biogas [MWh]	Waste to Energy [MWh]	Solar [MWh]	Wind [MWh]	BESS [MWh]
GFL config.	1 354.5	214.5	63.9	842.5	--	84.9	100.5	26.7	21.6
GFM config.	1 354.3	158.3	63.9	842.5	--	84.9	155.8	27.5	21.4

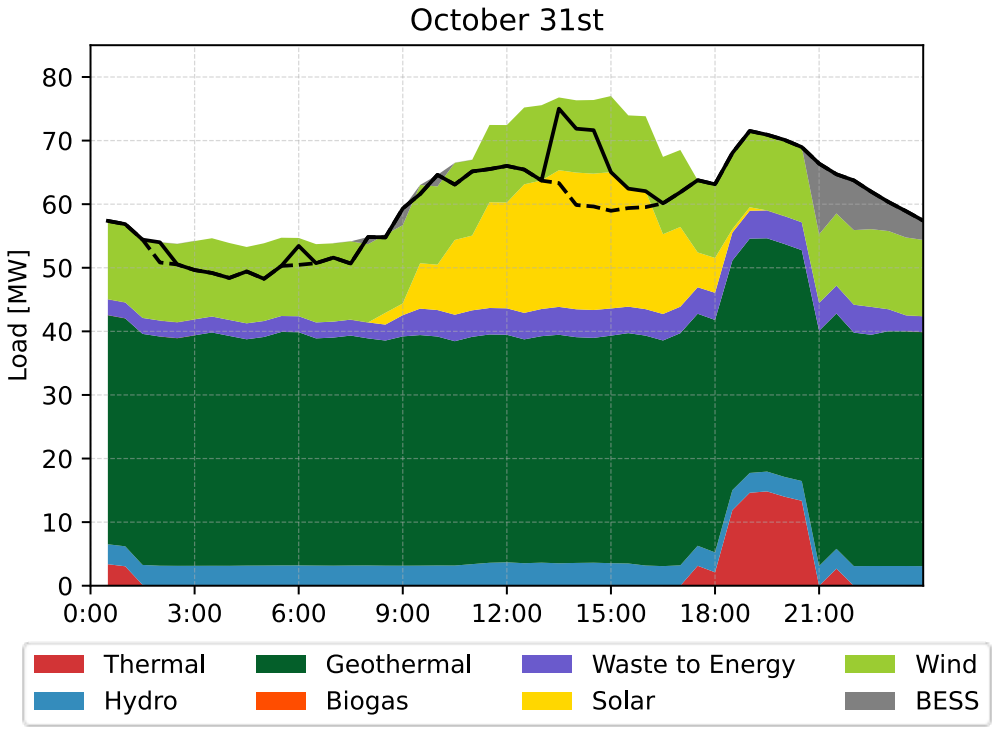
BESS GFL configuration
October

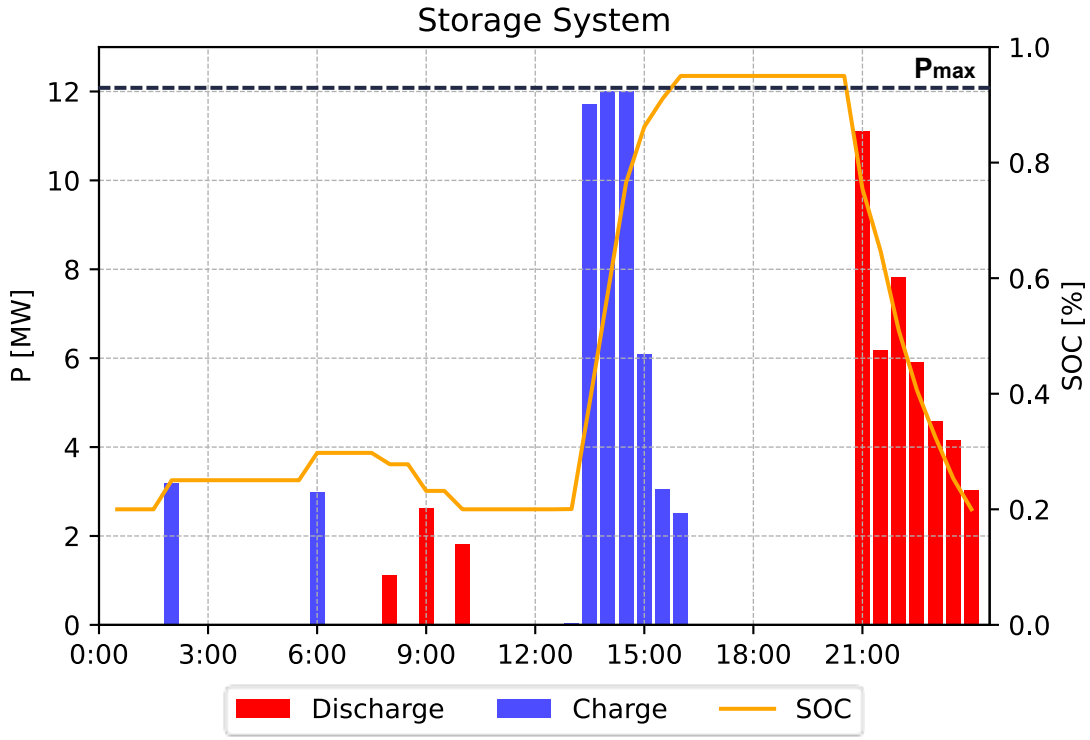




Test Case	Load [MWh]	Thermal [MWh]	Hydro [MWh]	Geothermal [MWh]	Biogas [MWh]	Waste to Energy [MWh]	Solar [MWh]	Wind [MWh]	BESS [MWh]
GFL config.	1 446.3	161.5	77.4	867.6	--	84.8	120.7	113.0	21.3

BESS GFM configuration
October





Test Case	Load [MWh]	Thermal [MWh]	Hydro [MWh]	Geothermal [MWh]	Biogas [MWh]	Waste to Energy [MWh]	Solar [MWh]	Wind [MWh]	BESS [MWh]
GFL config.	1 446.3	161.5	77.4	867.6	--	84.8	120.7	113.0	21.3
GFM config.	1 449.4	41.6	77.4	867.6	--	84.9	137.6	216.1	24.2

Description of the simulation scenarios and results

BESS – 24MWh

Simulation scenario updates

São Miguel

- ***Autoconsumo:*** 16.8 GWh/year
- **Solar:** 52 GWh/year – 36 GWh/year (FA) + 16 GWh/year
- **Wind:** 43 GWh/year
- **Load:** 552GWh/year, peak 87MW
- **BESS FA**:
  - Power: 12,22MW (inj./abs.)
  - Capacity: 24,44MWh
  - Range: 25,8% - 95%

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Share of annual average production

Technology	Without FA	Without FA's BESS	BESS GFL configuration	BESS GFM configuration
Thermal	49.05%	23.54%	22.59%	21.73%
BESS	--	--	0.68%	0.50%
Renewables + Waste to Energy	50.95%	76.46%	76.73%	77.77%

Renewable energy curtailment

Technology	Without FA	Without FA's BESS	BESS GFL configuration	BESS GFM configuration
Solar	1.09%	9.41%	5.51%	2.47%
Wind	11.83%	21.87%	16.09%	8.77%
Total	8.93%	15.09%	10.33%	5.34%

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Solar Production

	Without FA	Without FA's BESS	BESS GFL configuration	BESS GFM configuration
Production [MWh/year]	15 961.88	47 104.54	49 133.49	50 715.07
Curtailment [MWh/year]	175.68	4 894.27	2 865.32	1 283.74
Curtailment (% of Production Capacity)	1.09%	9.41%	5.51%	2.47%

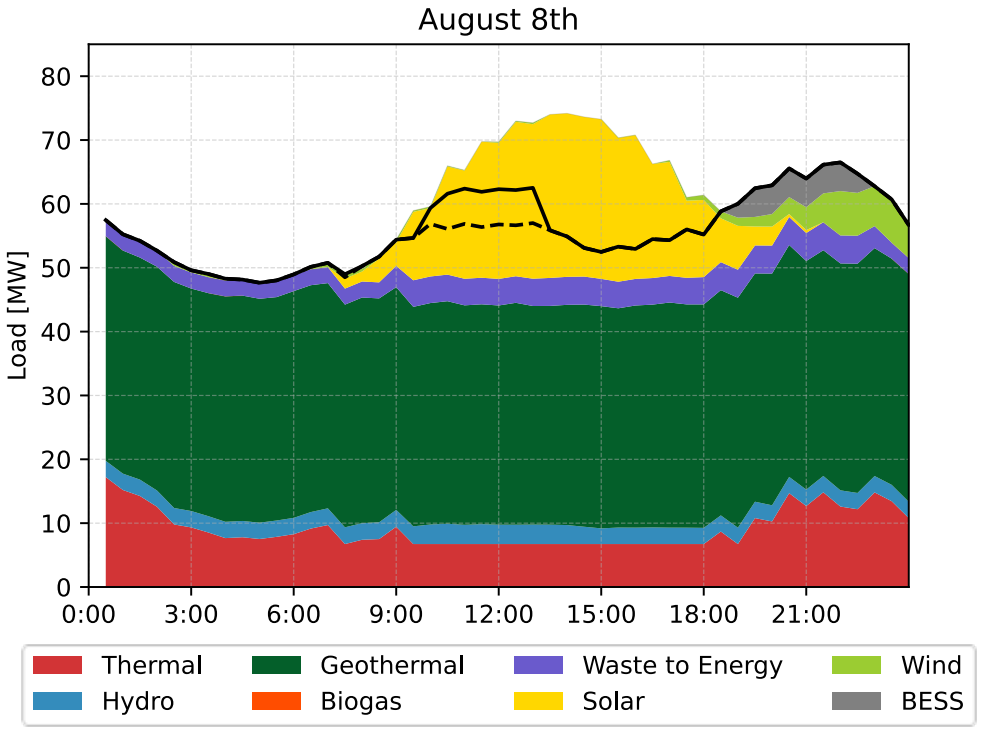
Wind Production

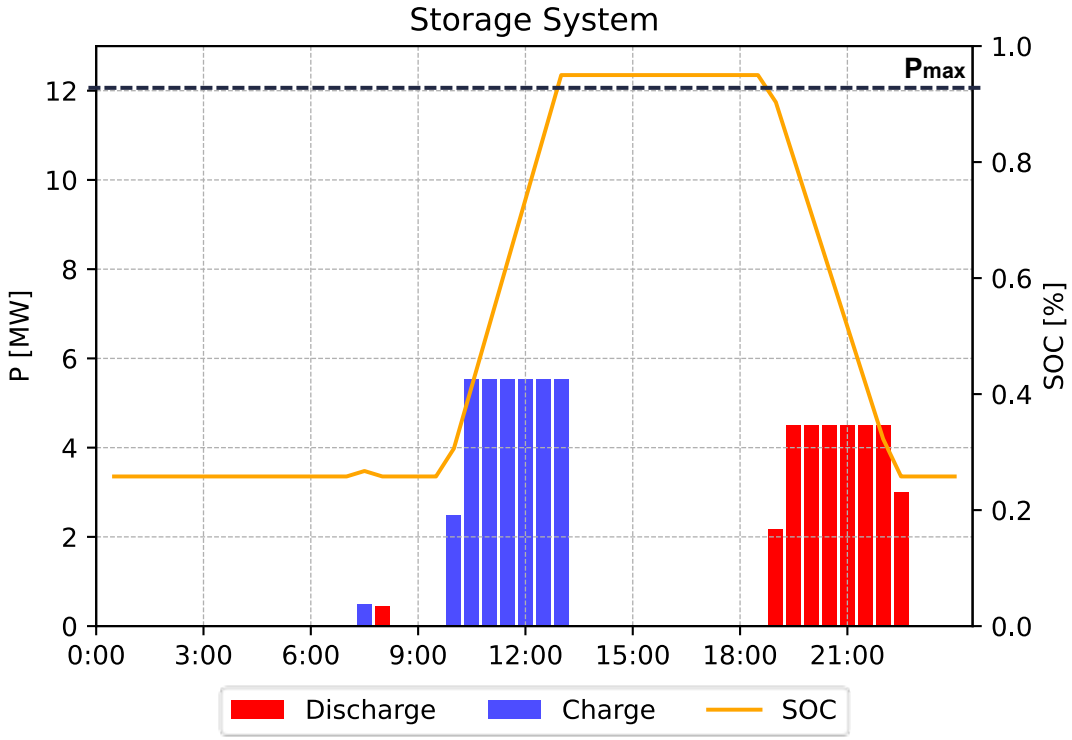
	Without FA	Without FA's BESS	BESS GFL configuration	BESS GFM configuration
Production [MWh/year]	38 392.18	34 020.36	36 537.99	39 725.77
Curtailment [MWh/year]	5 152.13	9 523.95	7 006.32	3 818.53
Curtailment (% of Production Capacity)	11.83%	21.87%	16.09%	8.77%

Average annual production per technology (MWh/year)

Technology	Without FA	Without FA's BESS	BESS GFL configuration	BESS GFM configuration
Autoconsumo	16 765.13	16 765.13	16 765.13	16 765.13
Solar	15 961.88	47 104.54	49 133.49	50 715.07
Wind	38 392.18	34 020.36	36 537.99	39 725.77
Thermal	156 692.32	129 924.	125 655.87	120 637.62
Geothermal	270 723.35	270 723.44	270 742.02	270 776.51
Waste to Energy	28 673.4	28 675.12	28 784.16	28 891.47
Biogas	649.52	649.52	649.75	649.78
Hydro	24 121.78	24 121.78	24 121.78	24 121.78
BESS discharge	--	--	3 756.	2 766.38
Total Production	**551 979.57**	**551 983.89**	**556 146.19**	**555 049.51**
Total Load	**552 000.**	**552 000.**	**556 161.77**	**555 065.24**
BESS charge	--	--	4 161.77	3 065.24
BESS losses	--	--	405.77	298.86

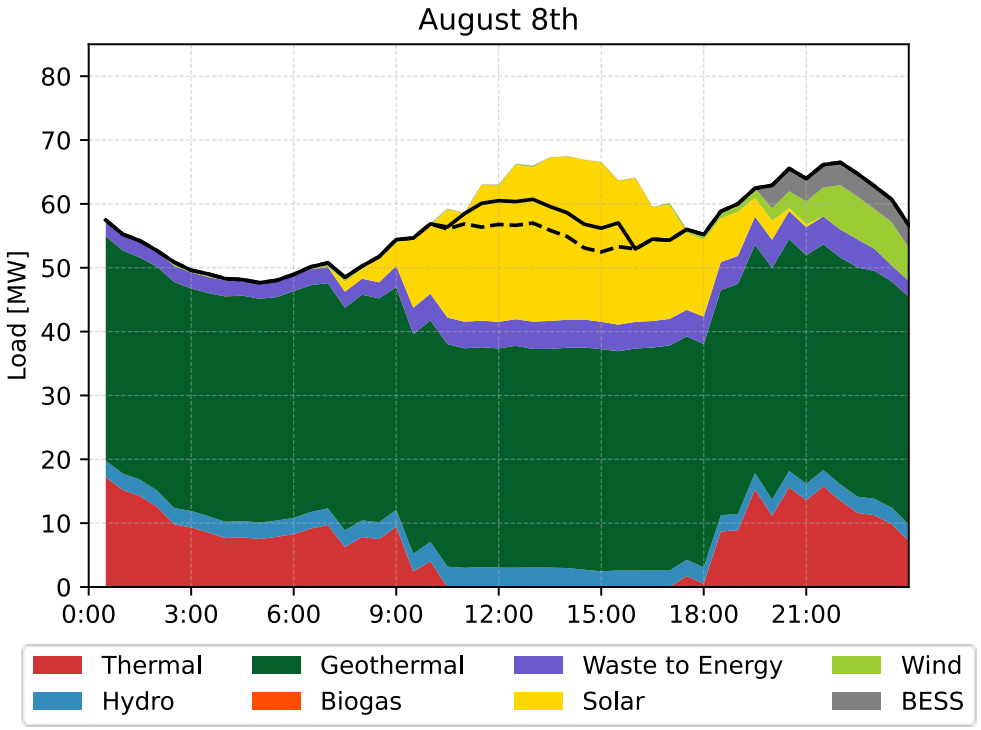
BESS GFL configuration
August

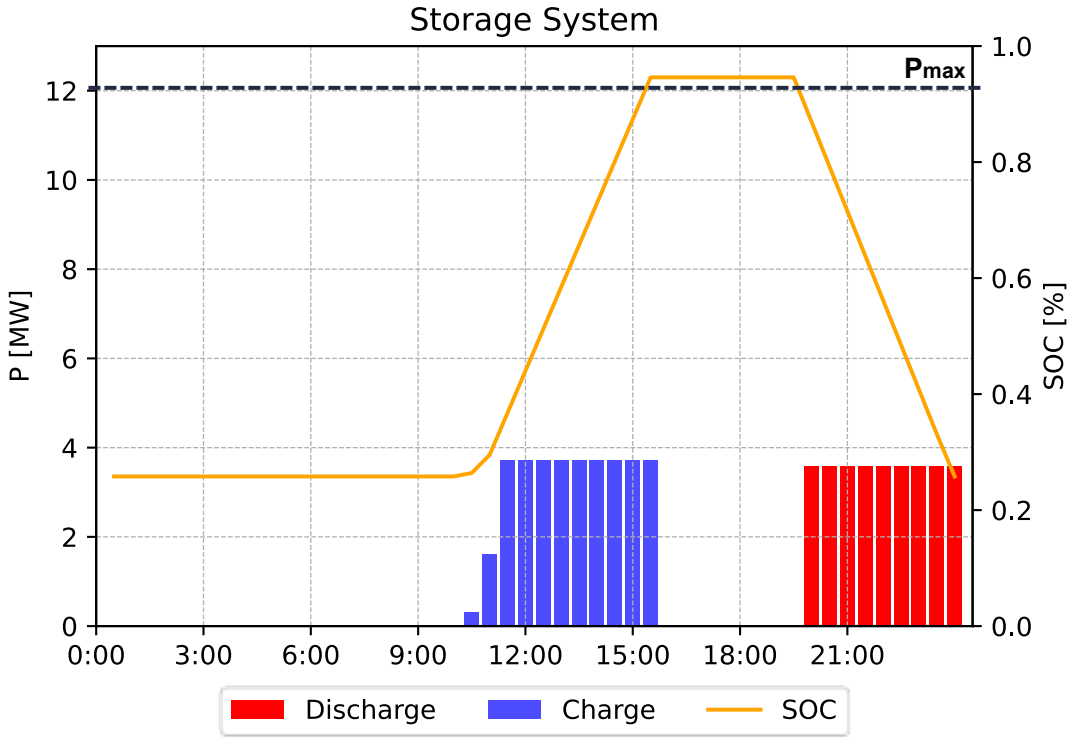




Test Case	Load [MWh]	Thermal [MWh]	Hydro [MWh]	Geothermal [MWh]	Biogas [MWh]	Waste to Energy [MWh]	Solar [MWh]	Wind [MWh]	BESS [MWh]
GFL config.	1 348.6	219.8	63.9	842.5	--	84.9	94.6	26.7	16.3

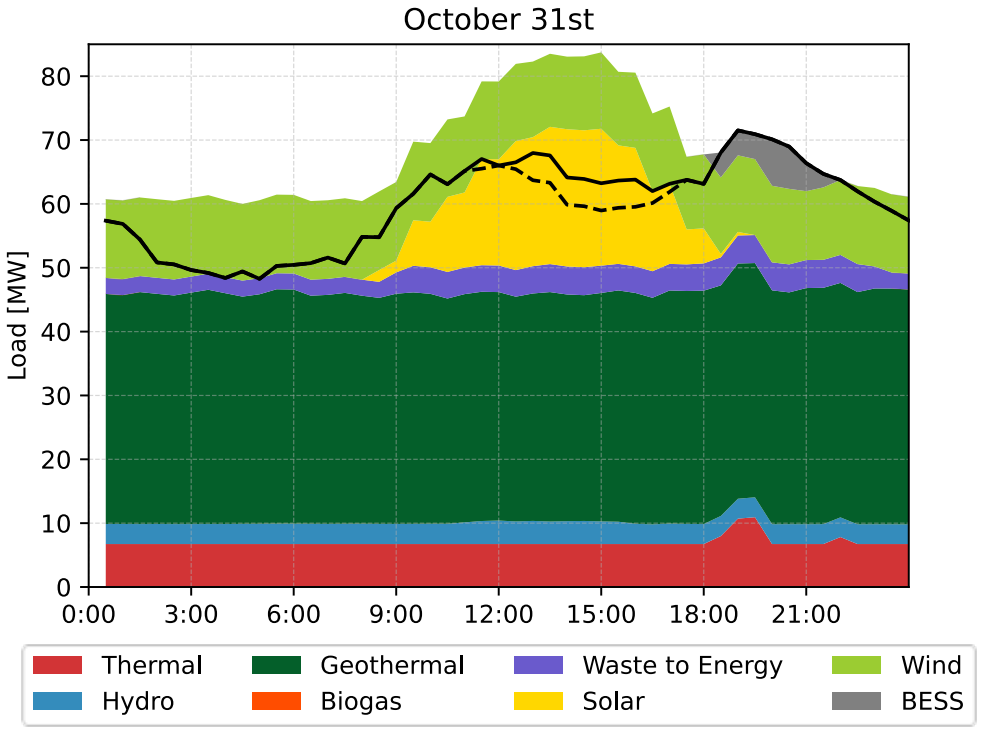
BESS GFM configuration
August

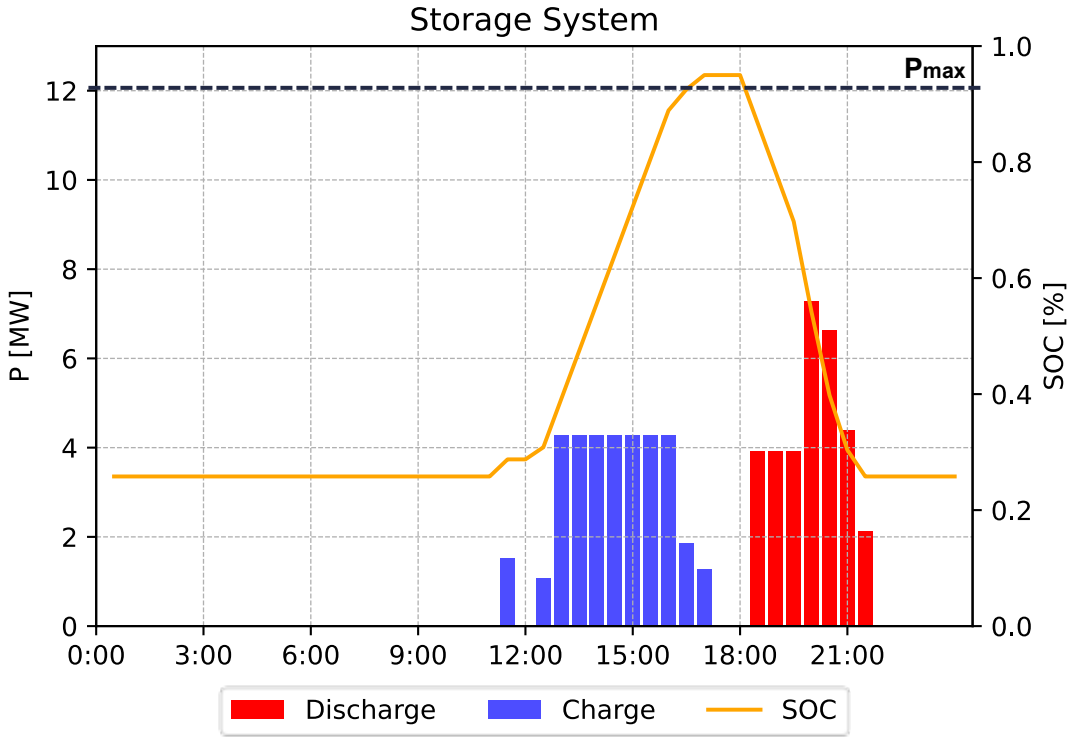




Test Case	Load [MWh]	Thermal [MWh]	Hydro [MWh]	Geothermal [MWh]	Biogas [MWh]	Waste to Energy [MWh]	Solar [MWh]	Wind [MWh]	BESS [MWh]
GFL config.	1 348.6	219.8	63.9	842.5	--	84.9	94.6	26.7	16.3
GFM config.	1 348.3	163.5	63.9	842.5	0.	84.9	149.9	27.5	16.1

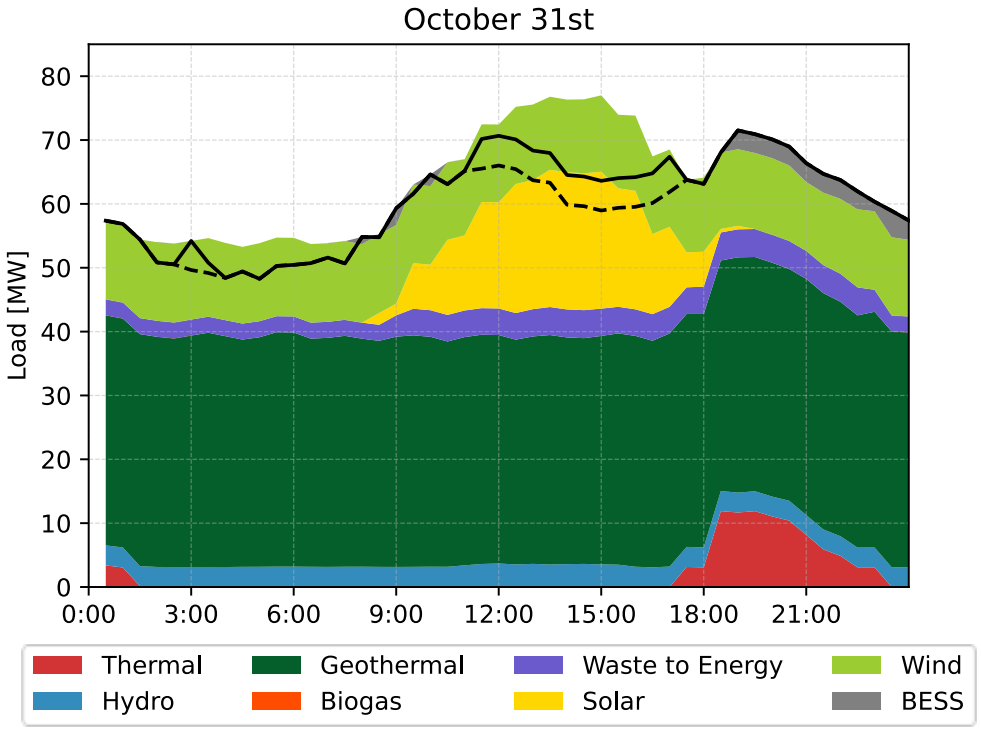
BESS GFL configuration
October

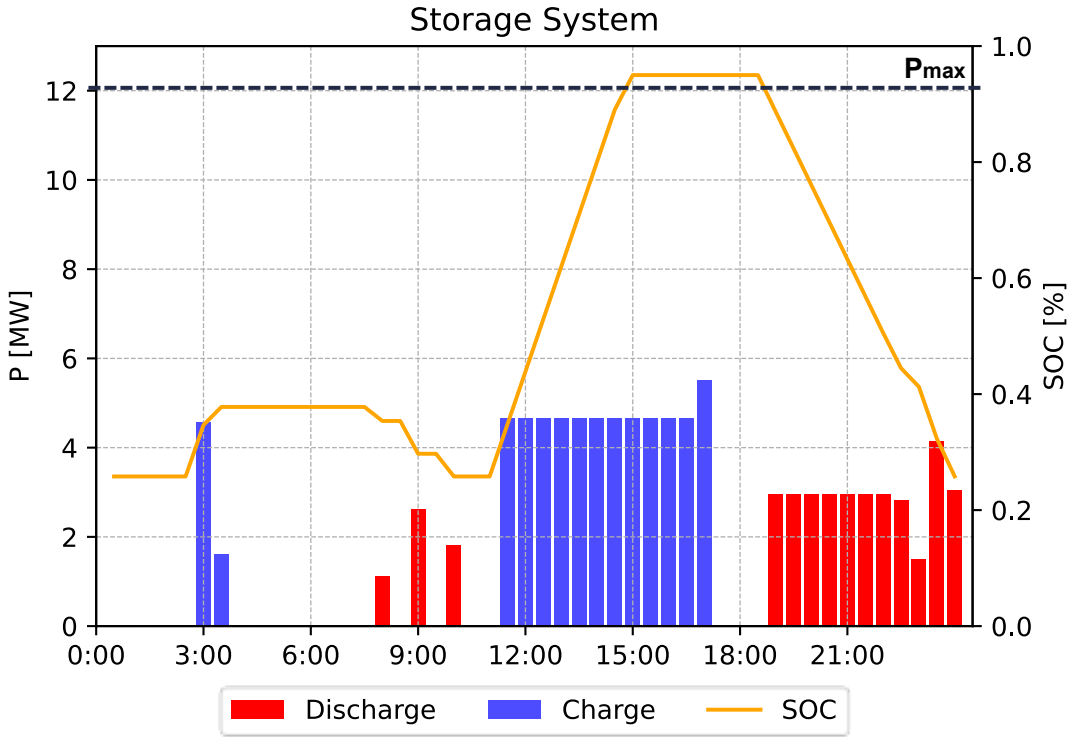




Test Case	Load [MWh]	Thermal [MWh]	Hydro [MWh]	Geothermal [MWh]	Biogas [MWh]	Waste to Energy [MWh]	Solar [MWh]	Wind [MWh]	BESS [MWh]
GFL config.	1 440.5	166.7	77.4	867.6	--	84.8	114.9	113.	16.1

BESS GFM configuration
October





Test Case	Load [MWh]	Thermal [MWh]	Hydro [MWh]	Geothermal [MWh]	Biogas [MWh]	Waste to Energy [MWh]	Solar [MWh]	Wind [MWh]	BESS [MWh]
GFL config.	1 440.5	166.7	77.4	867.6	--	84.8	114.9	113.	16.1
GFM config.	1 454.1	47.4	77.4	867.6	--	84.9	137.7	210.2	18.9

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Terceira

Description of the base case

SIGLA (nº unidades): potência nominal

[1] 3. TER_info_centrais.xlsx

[2] CARE_EDA_2021.pdf

[3] Sistemas de Armazenamento.xlsx

Cenários de Oferta

21
CTBJ (9): 58116 kW
CGPA (1): 3500 kW**
CHTE (3): 1432 kW
PESC (10): 9000 kW
PESN (4): 3600 kW
TERAMB (RSU): 2600 kW

22
CTBJ (8): 68770 kW
CGPA (1): 3500 kW**
CHTE (3): 1432 kW
PESC (12): 15000 kW
PESN (4): 3600 kW
TERAMB (RSU): 2600 kW
CFTE: 2000 kW
Autoconsumo: 1504.5 kW

23
CTBJ (8): 68770 kW
CGPA (1): 3500 kW**
CHTE (3): 1432 kW
PESC (10): 9000 kW
PESN (4): 3600 kW
TERAMB (RSU): 2600 kW
CFTE: 2000 kW

24
CTBJ (8): 68770 kW
CGPA (1): 3500 kW**
CHTE (3): 1432 kW
PESC (10): 9000 kW
PESN (4): 3600 kW
TERAMB (RSU): 2600 kW
CFTE: 2000 kW
Autoconsumo: 1504.5 kW

25
CTBJ (8): 68770 kW
CGPA (2): **65000 kW*****
CHTE (3): 1432 kW
PESC (12): 15000 kW
PESN (4): 3600 kW
TERAMB (RSU): 2600 kW
CFTE: 2000 kW
Autoconsumo: 3009 kW

26 27 28 29 30 31 32 33

Sistema de armazenamento EDA*

BESS: 15000 kW / 10500 kWh (em dezembro)

** Potência considerada. de acordo com informação fornecida pela EDA (ao invés de 4675 kW)

*** Consideraram-se 2 geradores (3500 kW + 6500 kW) com perfis de produção diferentes

* Permitirá substituir a reserva girante dos grupos geradores térmicos e colaborar na regulação da tensão e frequência da rede. permitindo reduzir o número de unidades térmicas em serviço.

Para efeitos de simulação considerou-se a sua entrada em operação em **janeiro de 2023**.

Parâmetros dos Geradores

* Potência considerada. de acordo com informação fornecida pela EDA (ao invés de 4675 kW)

** Consideraram-se 2 geradores (3500 kW + 6500 kW) com perfis de produção diferentes

Nome	Sigla	Fonte primária	Grupo / Nº unidades	Pot. inst. (kW)	Pot. min. (kW)	Pot. max. (kW)	TPP (min)	TDP (min)	Ordem de mérito		
									2023	2025	2026
Belo Jardim	CTBJ	Fuel	V	6100	2440	5800	60	120	3		
			VI						2		
			VII						4		
			VIII						1		
			IX	12300	4920	11000	120		1		
			X						2		
			XI	9885	3950	9800			2		
			XII						1		
Pico Alto	CGPA	Geotérmica	1	3500*	-	3500*	-	-	1		-
			2**	10000		10000			-		1
Centrais Hídricas (agregadas)	CHTE	Hídrica	3	1432	-	1432	-	-	1		
Serra do Cume	PESC	Eólica	10	9000	-	9000	-	-	2	-	
			12	15000		15000			-	2	
Serra do Cume Norte	PESN	Eólica	4	3600	-	3600	-	-	3		
TERAMB	TERAMB	RSU	1	2600	-	2100	-	-	1		
Terceira	CFTE	Fotovoltaica	-	2000	-	2000	-	-	4		

Nome e sigla adotados no estudo

[1] 3. TER_info_centrais.xlsx

Regras de Operação

- Número mínimo de grupos térmicos em serviço na CTBJ [4]:
  - Sem sistema BESS: **2 grupos** → 1 grupo de 9.89 MW (mínimo: 3.95 MW) + 1 grupo de 6.10 MW (mínimo: 2.44 MW)
  - Com sistema BESS: **1 grupo** de 9.89 MW (mínimo: 3.95 MW)

- Regras para cálculo da reserva girante [4]: não aplicável

- Considerações:
  - Incerteza da procura a curto-prazo (%): 1.5
  - Método de persistência para a previsão da potência eólica e solar nos próximos 30 min

- Ordem de mérito:
  - Mínimo técnico térmica > Hídrica > Geotérmica > Resíduos > Eólica > Solar > Térmica (restante)
  - Autoconsumo é subtraído diretamente à carga.

Description of the simulation scenarios and results

BESS – 15MWh

Simulation scenario updates

Terceira

- **Autoconsumo:** 6.7 GWh/year
- **Solar:** 25.48 GWh/year – 19.3 GWh/year (FA) + 6.2 GWh/year
- **Geothermal:** 10 000 * (1 – 0.2) MW → 15 GWh/year
- **Load:** 212.6 GWh/year. peak 35MW
- **BESS FA:**
  - Power: 7.5 MW (inj./abs.)
  - Capacity: 15MWh
  - Range: 20% - 95%

INESCTEC

Share of annual average production

Technology	Without FA	Without FA's BESS	BESS GFL configuration	BESS GFM configuration
Thermal	55.27%	49.24%	47.24%	44.63%
BESS	--	--	1.30%	1.05%
Renewables + Waste to Energy	44.73%	50.76%	51.47%	54.32%

Renewable energy curtailment

(% of Production Capacity)

Technology	Without FA	Without FA's BESS	BESS GFL configuration	BESS GFM configuration
Solar	16.13%	29.49%	22.39%	11.51%
Wind	9.26%	9.26%	7.11%	1.99%
Total	9.90%	15.31%	11.68%	4.84%

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Solar Production

	Without FA	Without FA's BESS	BESS GFL configuration	BESS GFM configuration
Production	5 160.37	17 973.53	19 782.71	22 555.54
Curtailment	992.25	7 515.88	5 706.71	2 933.87
Curtailment (% of Production Capacity)	16.13%	29.49%	22.39%	11.51%

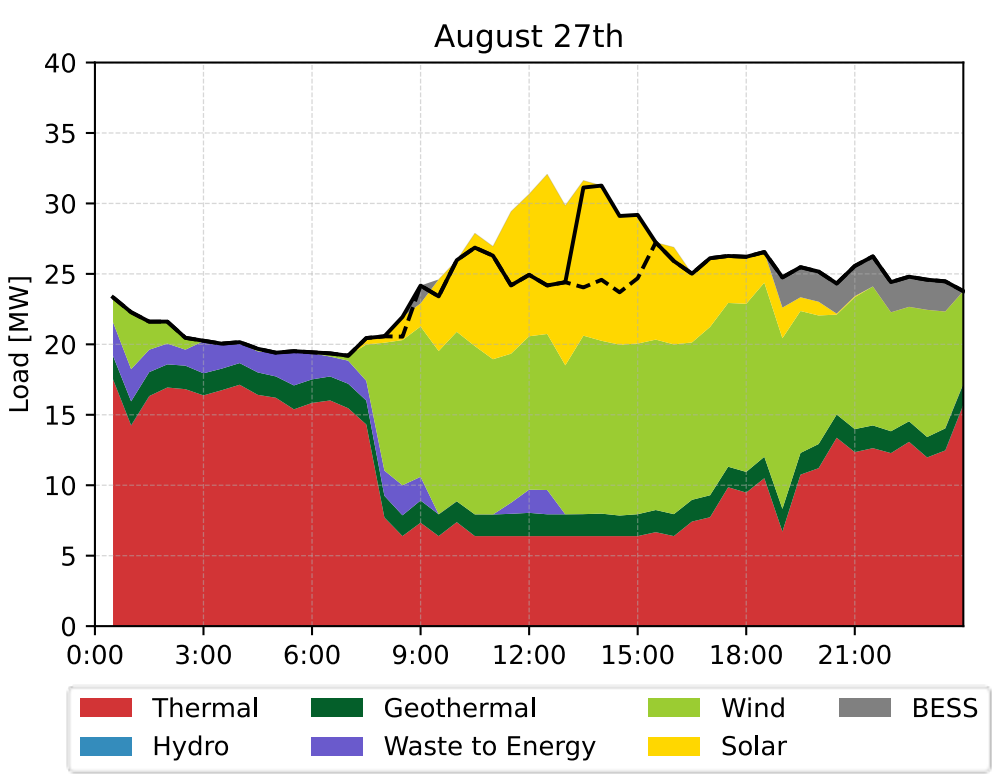
Wind Production

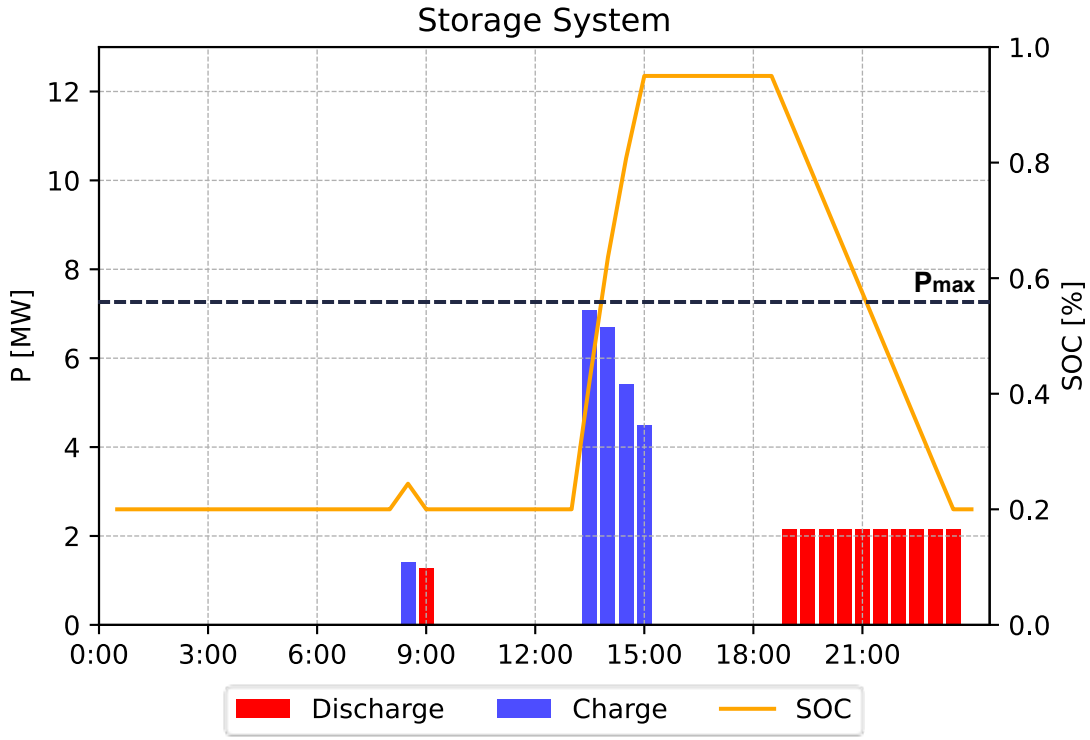
	Without FA	Without FA's BESS	BESS GFL configuration	BESS GFM configuration
Production	54 237.86	54 237.86	55 525.81	58 582.48
Curtailment	5 536.74	5 536.74	4 248.79	1 192.13
Curtailment (% of Production Capacity)	9.26%	9.26%	7.11%	1.99%

Average annual production per technology (MWh/year)

Technology	Without FA	Without FA's BESS	BESS GFL configuration	BESS GFM configuration
Autoconsumo	6 679.98	6 679.98	6 679.98	6 679.98
Solar	5 160.37	17 973.53	19 782.71	22 555.54
Wind	54 237.86	54 237.86	55 525.81	58 582.48
Thermal	117 501.55	104 688.5	101 893.38	96 005.31
Geothermal	15 036.91	15 036.91	15 036.91	15 036.91
Waste to Energy	12 541.95	12 541.95	12 541.95	12 541.95
Hydro	1 441.2	1 441.2	1 441.2	1 441.2
BESS discharge	--	--	2 795.15	2 253.27
Total Production	**212 599.84**	**212 599.93**	**215 697.09**	**215 096.64**
Total Load	**212 600.**	**212 600.**	**215 697.12**	**215 096.7**
BESS charge	--	--	3 097.12	2 496.7
BESS losses	--	--	301.97	243.43

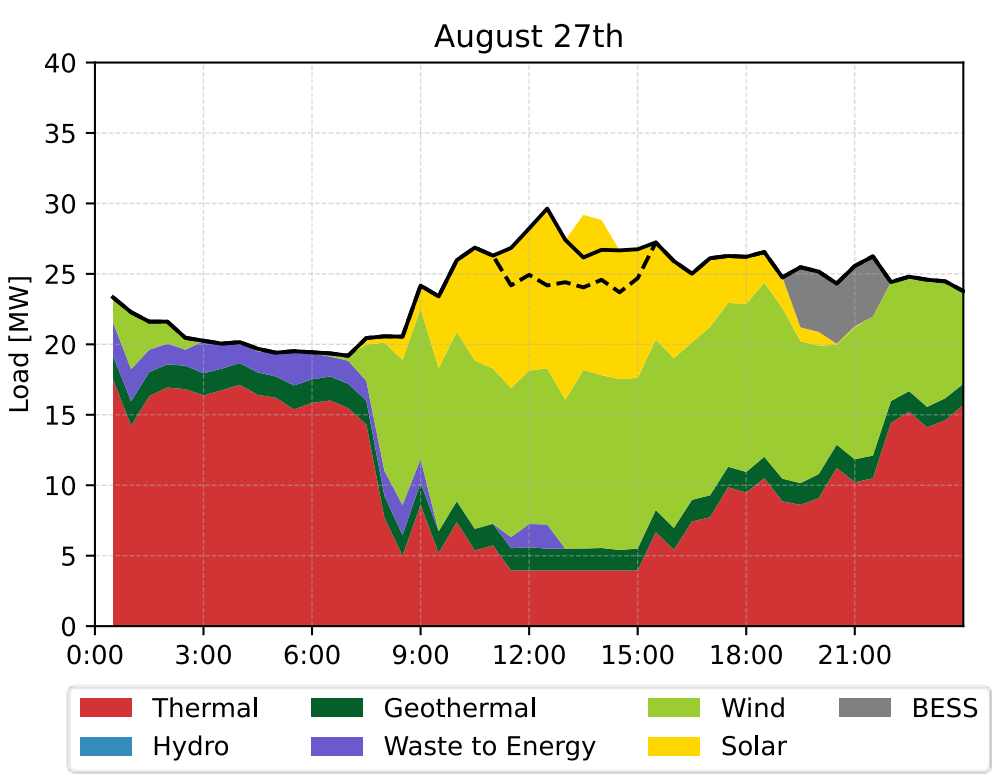
BESS GFL configuration
August

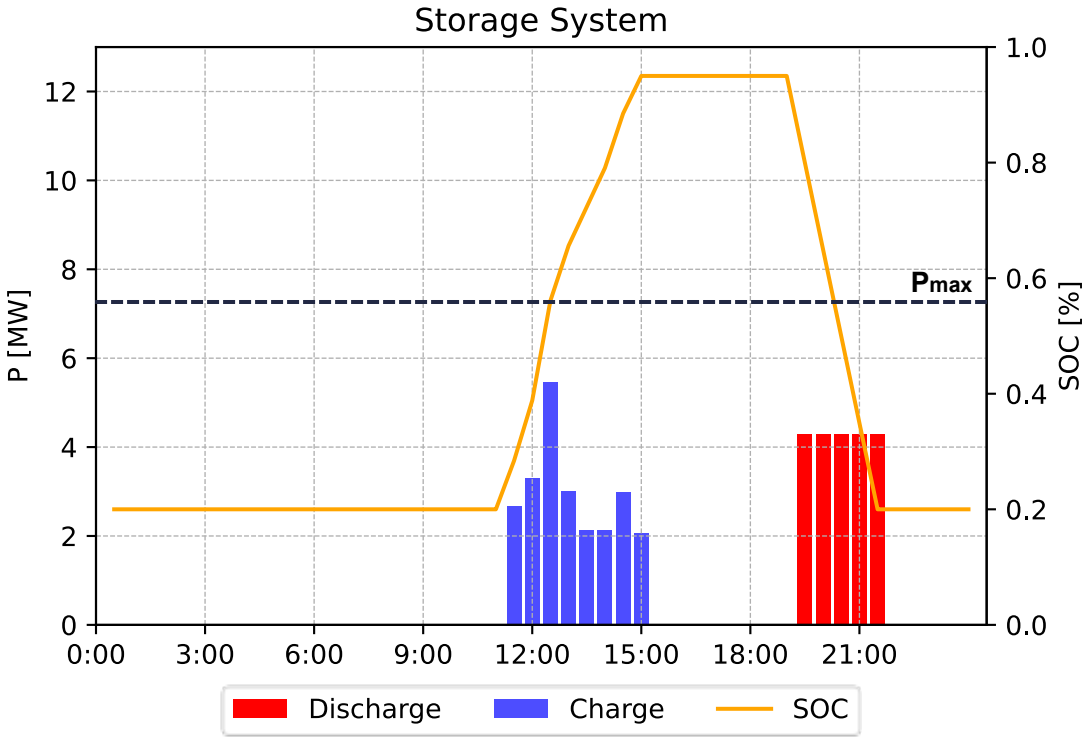




Test Case	Load [MWh]	Thermal [MWh]	Hydro [MWh]	Geothermal [MWh]	Waste to Energy [MWh]	Wind [MWh]	Solar [MWh]	BESS [MWh]
GFL config.	575.6	265.7	--	37.9	18.0	182.0	60.8	11.3

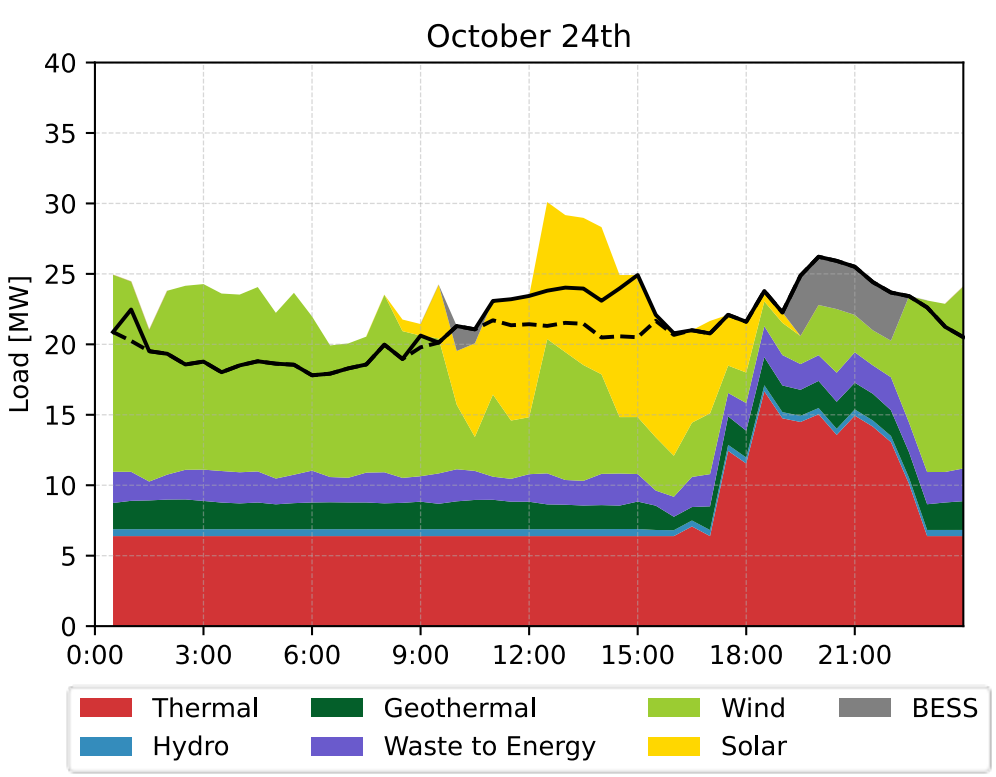
BESS GFM configuration
August

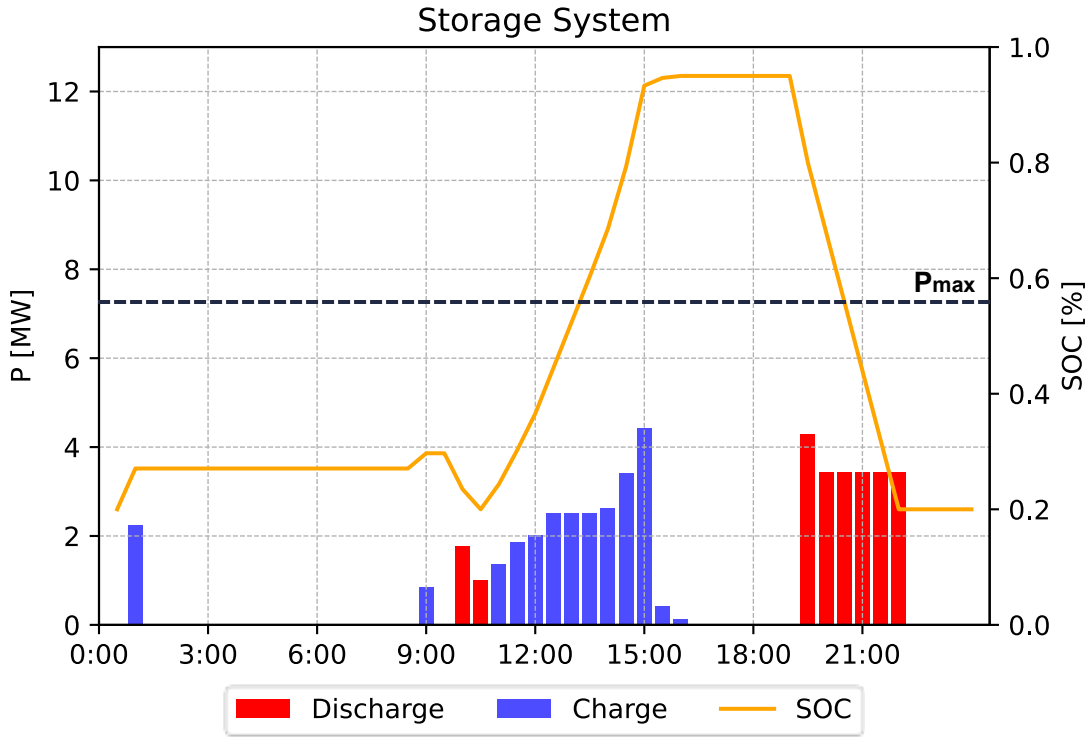




Test Case	Load [MWh]	Thermal [MWh]	Hydro [MWh]	Geothermal [MWh]	Waste to Energy [MWh]	Wind [MWh]	Solar [MWh]	BESS [MWh]
GFL config.	575.6	265.7	--	37.9	18.0	182.0	60.8	11.3
GFM config.	574.9	254.0	--	37.9	18.0	182.0	72.4	10.7

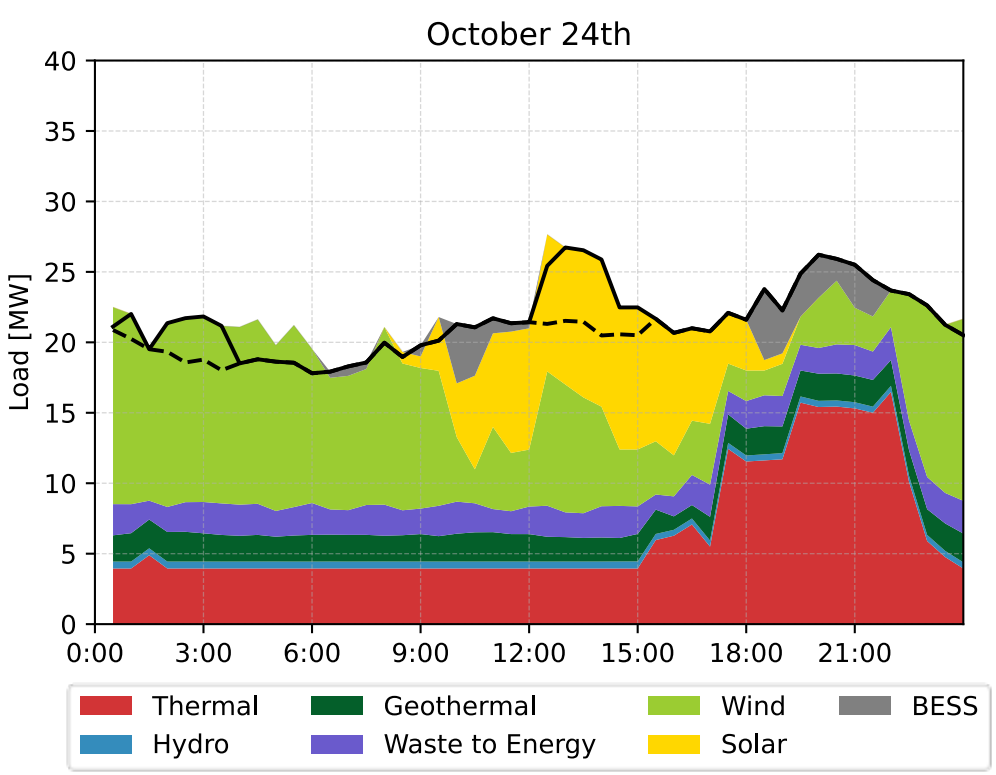
BESS GFL configuration
October

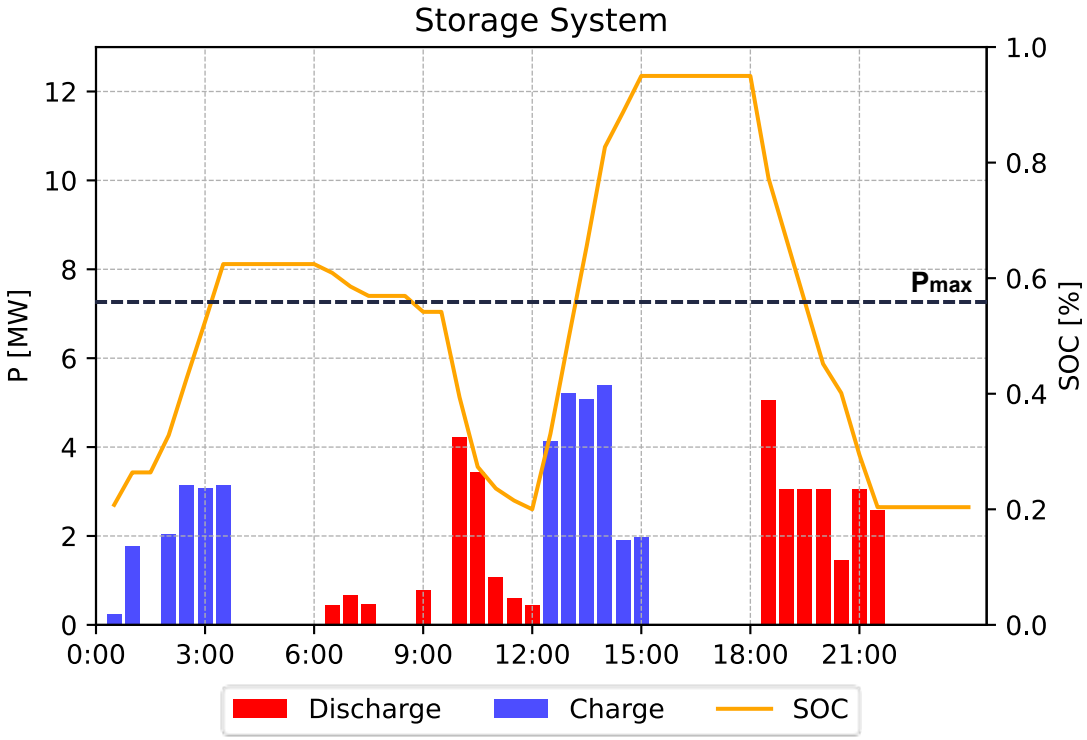




Test Case	Load [MWh]	Thermal [MWh]	Hydro [MWh]	Geothermal [MWh]	Waste to Energy [MWh]	Wind [MWh]	Solar [MWh]	BESS [MWh]
GFL config.	516.5	193.9	11.3	44.5	47.9	151.6	55.2	12.1

BESS GFM configuration
October





Test Case	Load [MWh]	Thermal [MWh]	Hydro [MWh]	Geothermal [MWh]	Waste to Energy [MWh]	Wind [MWh]	Solar [MWh]	BESS [MWh]
GFL config.	516.5	193.9	11.3	44.5	47.9	151.6	55.2	12.1
GFM config.	521.6	154.8	11.3	44.5	47.9	178.8	67.6	16.7

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