DDCA Project Final Report

September 12, 2019

Contents

1 Objective

The objective of this report is to showcase results from the Demand-Driven Cycamore Archetypes project (NEUP-FY16-10512).

2 Eg01-Eg23

Figure 1 shows the flow of Eg01-Eg23.

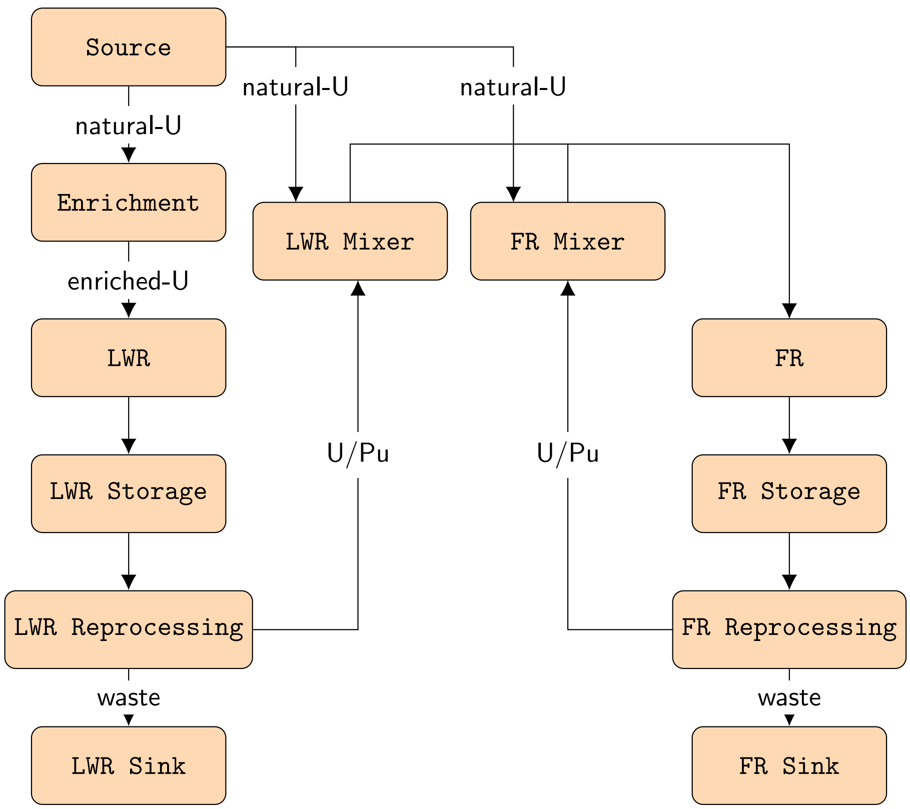


Figure 1: EG01-EG23.

2.1 Flat Power Demand

This section presents plots of power for all the prediction methods. The power demand is 60000 MW throughout the whole simulation. Table 1 shows the input file values. Figures 2, 3, and 4 display the power demand supply for the Non-optimizing (NO), Deterministic-optimizing (DO), and Stochastic-optimizing methods (SO), respectively. The plots show the curves close to when the transition begins. It takes a small number of time steps in the beginning of the simulation until the supply meets the demand. Table 2 records the number of steps with under supply, the cumulative under supply, and the cumulative oversupply. Cumulative under supply and cumulative oversupply represent the summation of the difference between the power supplied and the power demanded for all the time steps in the simulation. This magnitude could be best understood as energy. The cumulative under supply represents the energy not provided during the time steps in which the supply did not meet the demand. Likewise, the oversupply is the excess of energy produced. In table 2 we see that the smallest cumulative under supply and smallest amount of under supply time steps are for poly and fft.

Table 1: EG01-EG23 input file values.

Parameter	Value
Demand equation	60e3
Installed Capacity	1
Buffer	0
Forward Steps	1
Backward Steps	2

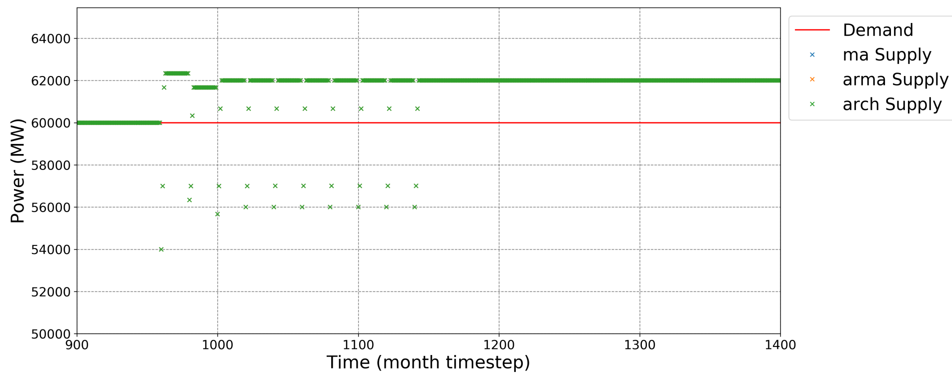


Figure 2: Constant power demand of 60GW and power supply obtained with the NO algorithms.

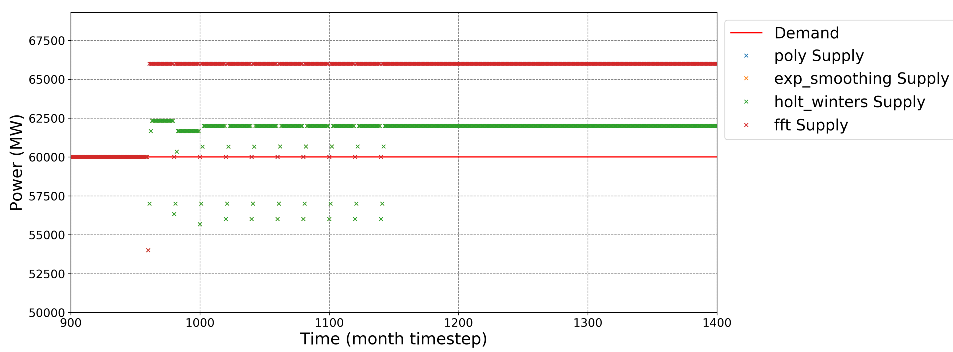


Figure 3: Constant power demand of 60GW and power supply obtained with the DO algorithms.

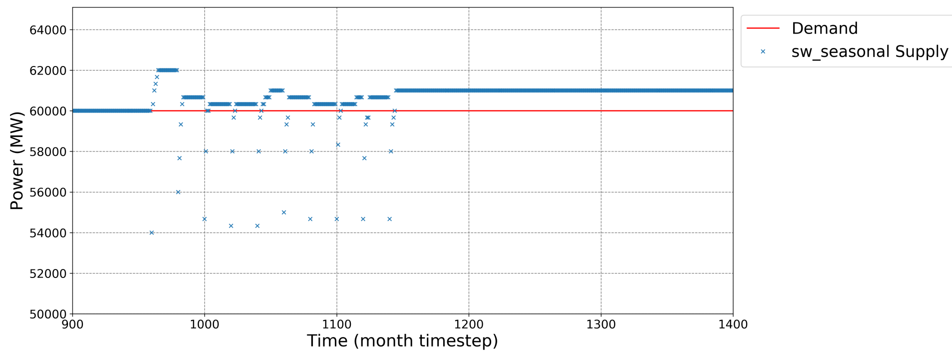


Figure 4: Constant power demand of 60GW and power supply obtained with the SO algorithms.

Table 2: Under supply and oversupply of Power for the different prediction algorithms used to calculate EG01-EG23.

Algorithm	Undersupplied Timesteps	Cumulative Undersupply [GW.mo]	Cumulative Oversupply [GW.mo]
MA	26	306.0	907.8
ARMA	26	306.0	907.8
ARCH	26	306.0	907.8
POLY	6	235.0	2820.5
EXP_SMOOTHING	27	366.0	907.8
HOLT-WINTERS	27	366.0	907.8
FFT	8	307.0	2820.5
SW_SEASONAL	36	308.0	398.1

2.2 Buffer

This section presents a sensitivity analysis for different values of the buffer. Figure 5 shows a comparison of the cumulative under supply for different buffer sizes for different prediction methods. The cumulative under supply, remains constant for some of the methods and decreases with the increase of the buffer for others. Figure 6 displays the power demand and supply for different values of the buffer using poly. For this last case, the under supply remains constant. Figure 6 helps to understand the observed behavior. During at the transition we can see that even for the buffer with size 0 MW there is no under supply. Then, increasing the buffer will not decrease an under supply that is already zero.

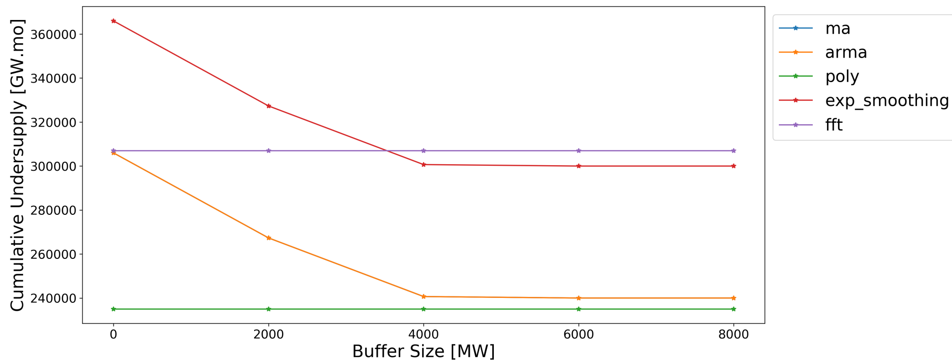


Figure 5: Sensitivity analysis for different buffer sizes for different prediction algorithms.

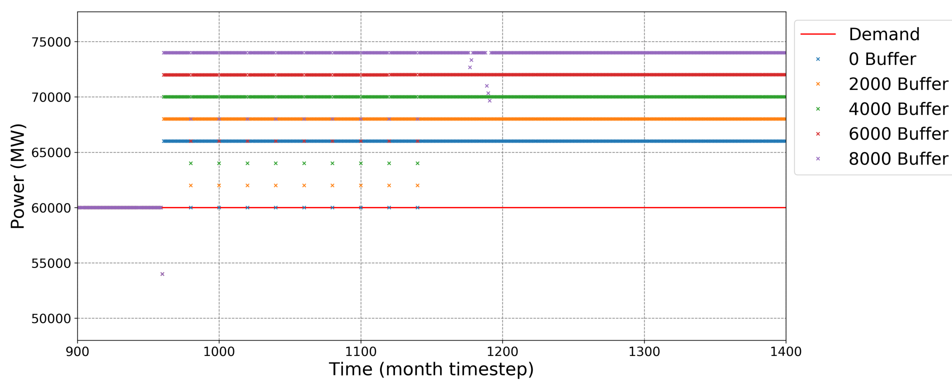


Figure 6: Power supply for different buffer sizes using poly.

2.3 Forward Steps

This section presents a sensitivity analysis for different values of forward steps chosen for the input files. Figure 7 shows a plot of the cumulative under supply for different values of forward steps using poly. Slightly increasing the number of forward steps decreases the under supply. Increasing the number of forward steps too much has a negative impact on the results. Figures 8 displays the plots for power supply for different number of forward steps. For 4 and 5 forward steps, the under supply increases. Increasing the number of forward steps enlarges the production of power, more reactors are deployed and consequently, the new reactors require more fuel. As they require more fuel, the available fuel will not be enough, and the scenario will fail. Figure 9 helps to understand this behavior. This figure shows that the demand of fuel for the FRs is larger than the supply of the same commodity. The forward steps capability should be used only with small number of forward steps to avoid this under supply from happening.

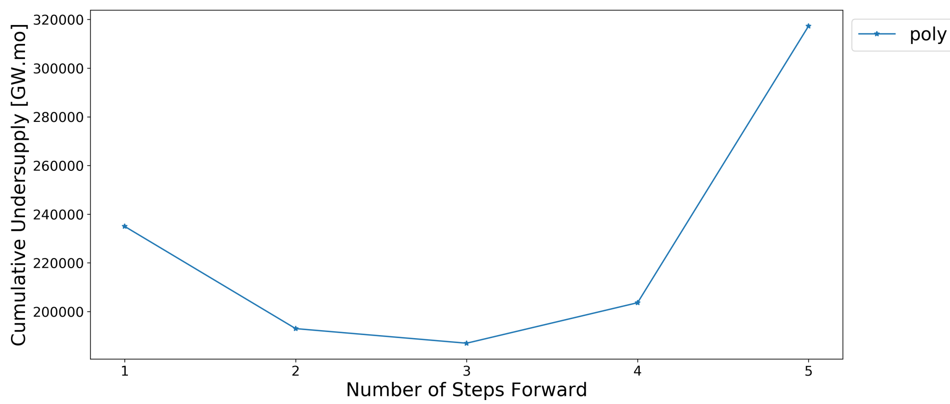


Figure 7: Cumulative under supply varying the number of forward steps using poly.

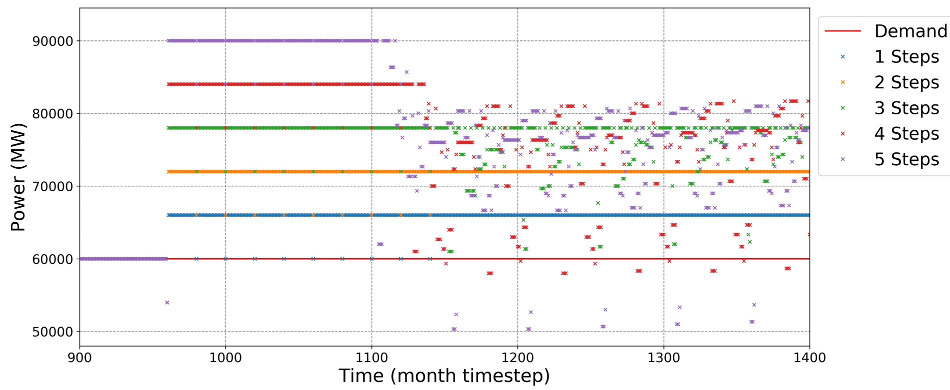


Figure 8: Power supply varying the number of forward steps using poly.

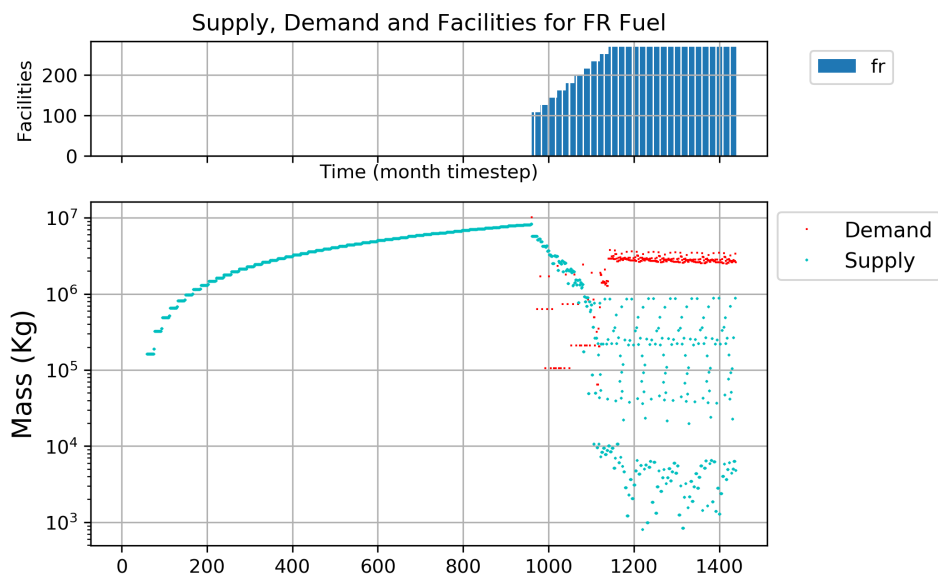


Figure 9: Power supply for 5 forward steps using poly.

2.4 Different commodities

Since the prediction algorithm poly performed the best, this section presents plots for the supply and demand of the most meaningful commodities in the scenario. Table 3 summarizes the figures in this section and the respective commodities. Table 4 presents the number of steps of under supply, cumulative under supply, and cumulative oversupply of such commodities.

Table 3: Commodity names used in the simulation of EG01-EG23.

Commodity	Figure
Power	10
Natural-U	11a
Enriched-U	11b
FR fuel	12
Reprocessed Pu from spent fuel of LWRs	13a
Reprocessed Pu from spent fuel of FRs	13b

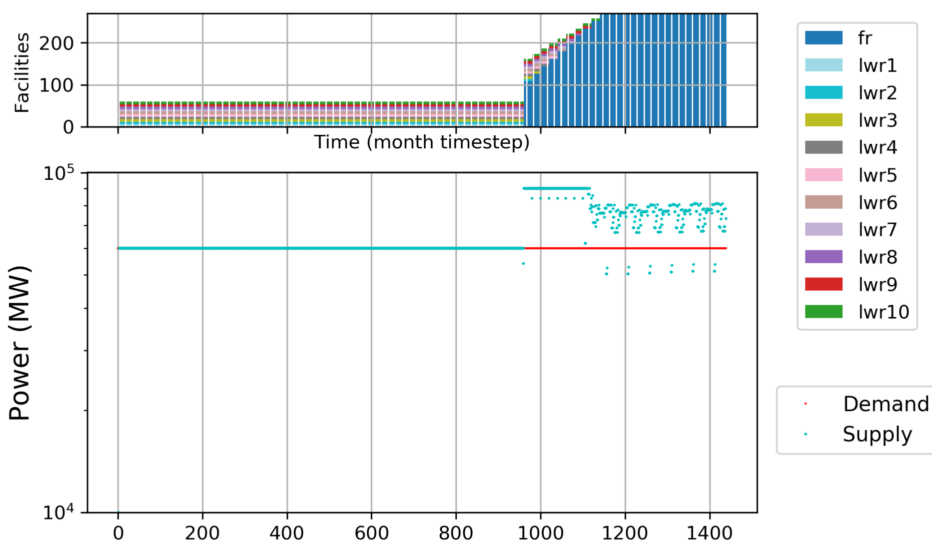
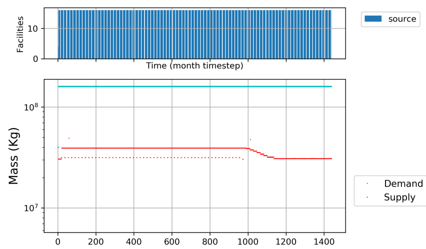
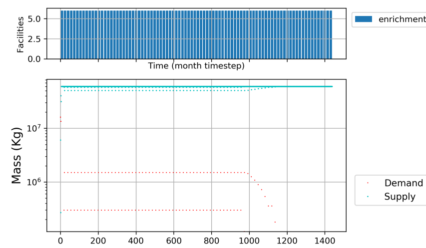


Figure 10: Demand and supply of Power and number of reactors deployed.



(a) Natural-U.



(b) Enriched-U.

Figure 11: Demand and supply of different commodities and number of facilities that produce them.

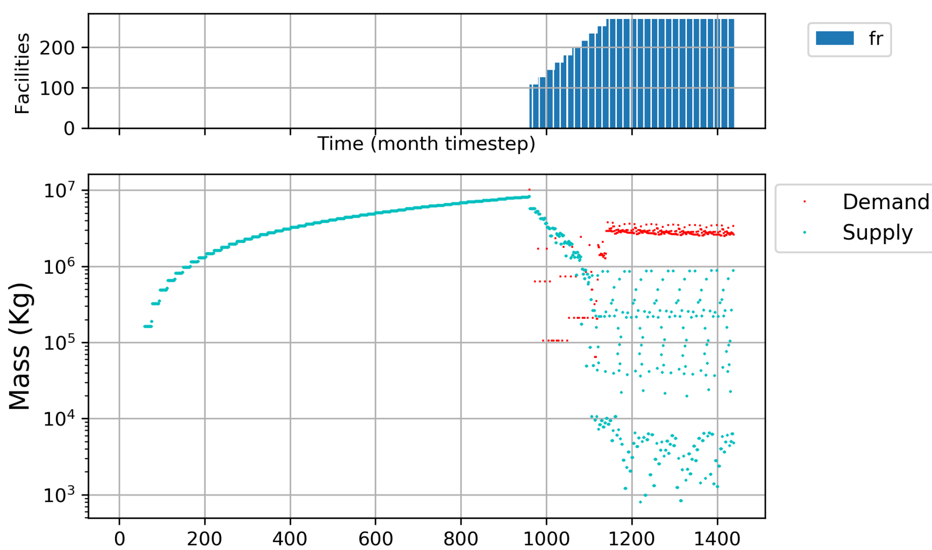
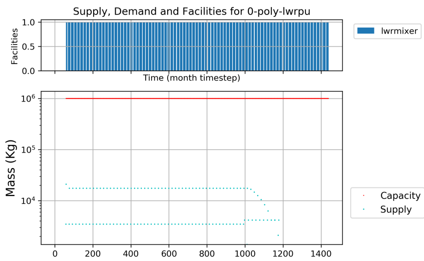
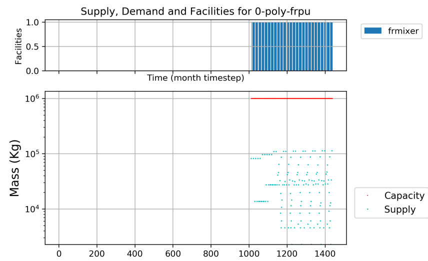


Figure 12: Demand and supply of FR fuel and number of FR reactors.



(a) Reprocessed Pu from spent fuel of LWRs.



(b) Reprocessed Pu from spent fuel of FRs.

Figure 13: Demand and supply of different commodities and number of facilities supplied with them.

Table 4: Under supply and oversupply of different commodities using poly to calculate EG01-EG23.

Commodity	Undersupplied Timesteps	Cumulative Undersupply [10^3Kg]	Cumulative Oversupply [10^6Kg]
Natural-U	2	4713	35648
Enriched-U	4	$48.5.10^3$	42259
Reprocessed Pu from spent fuel of LWRs	1	1.7	-
Reprocessed Pu from spent fuel of FRs	1	27.4	-

3 Eg01-Eg24

Figure 14 shows the flow of Eg01-Eg24.

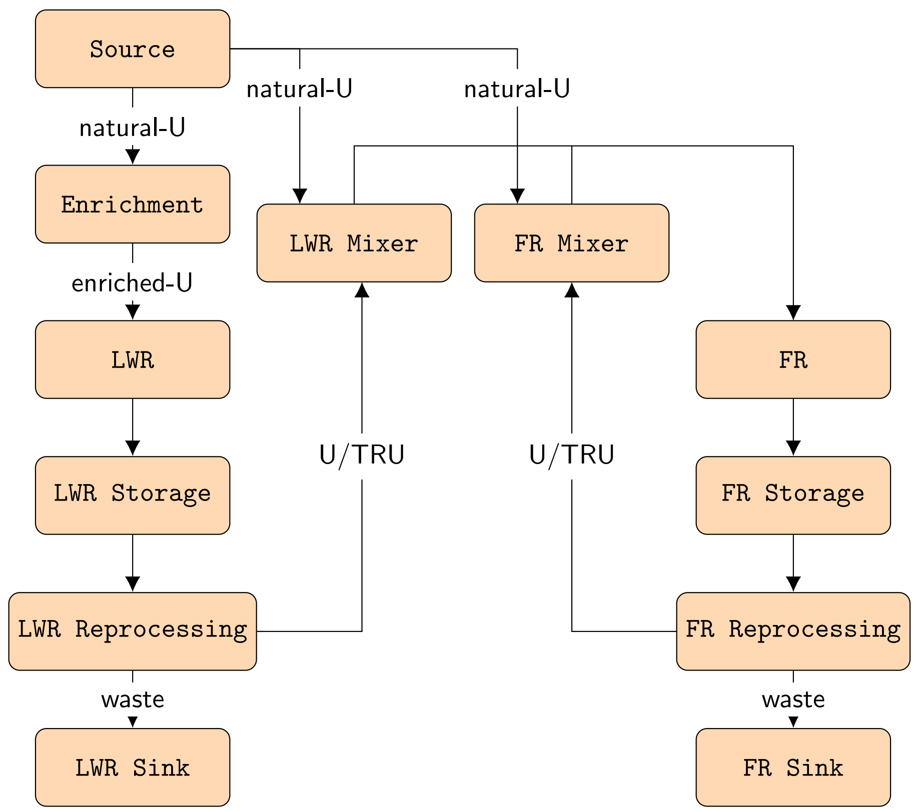


Figure 14: EG01-EG24.

3.1 Linearly increasing Power Demand

This section presents plots of power for all the prediction methods. The power demand increases linearly with the expression $60000MW + 250 * tMW/year$. Table 5 shows the input file values. Figures 15, 16, and 17 display the power demand supply for the Non-optimizing (NO), Deterministic-optimizing (DO), and Stochastic-optimizing methods (SO), respectively. The plots show the curves close to when the transition begins. It takes a small number of time steps in the beginning of the simulation until the supply meets the demand. Table 6 records the number of steps whit under supply, the cumulative under supply, and the cumulative oversupply. The smallest cumulative under supply and smallest amount of under supply time steps are for fft.

Table 5: EG01-EG24 input file values.

Parameter	Value
Demand equation	60GW + 250MW/year*t
Installed Capacity	1
Buffer	0
Forward Steps	1
Backward Steps	2

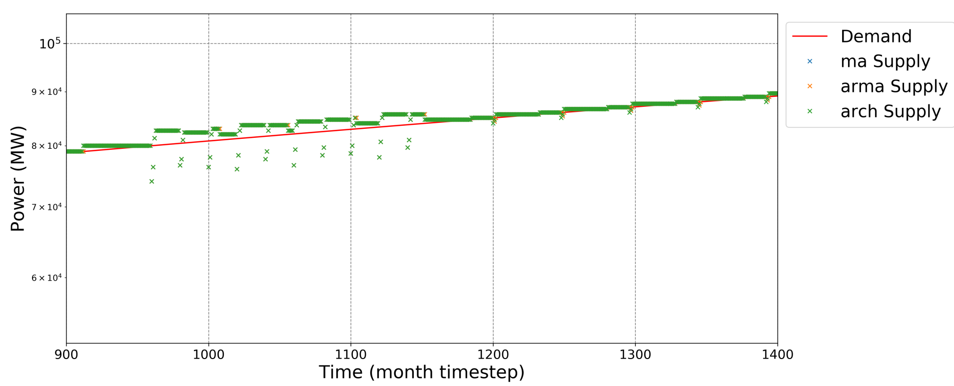


Figure 15: Linearly increasing power demand of 250MW/y and power supply obtained with the NO algorithms.

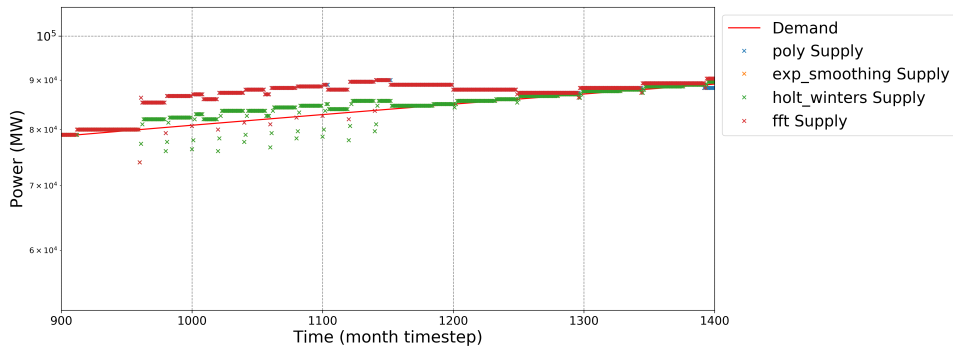


Figure 16: Linearly increasing power demand of 250MW/y and power supply obtained with the DO algorithms.

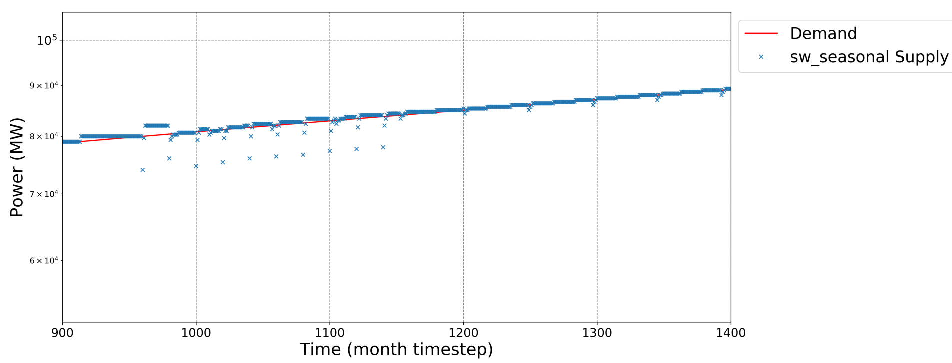


Figure 17: Linearly increasing power demand of 250MW/y and power supply obtained with the SO algorithms.

Table 6: Under supply and oversupply of Power for the different prediction algorithms used to calculate EG01-EG24.

Algorithm	Undersupplied Timesteps	Cumulative Undersupply [GW.mo]	Cumulative Oversupply [GW.mo]
MA	36	313.7	840.9
ARMA	36	313.7	840.9
ARCH	36	316.8	859.0
POLY	65	282.4	1974.7
EXP_SMOOTHING	37	373.4	828.7
HOLT-WINTERS	37	373.4	828.7
FFT	20	315.1	2019.1
SW_SEASONAL	107	318.8	579.09

3.2 Buffer

This section presents a sensitivity analysis for different values of the buffer. Figure 18 shows a comparison of the cumulative under supply for different buffer sizes using fft. Figure 19 displays the power demand and supply for different values of the buffer using fft. The cumulative under supply decreases with the increase of the buffer, reaching an asymptotic value. That value is given by the initialization of the scenario, when the buffer does not affect considerably the under supply.

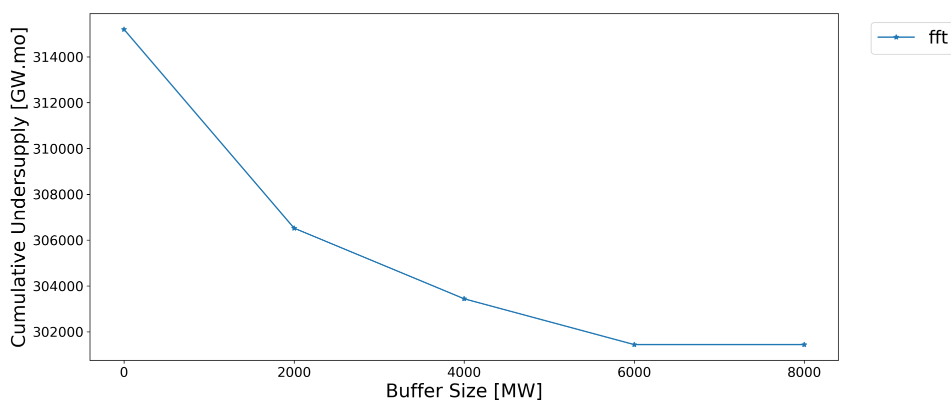


Figure 18: Sensitivity analysis for different buffer sizes using fft.

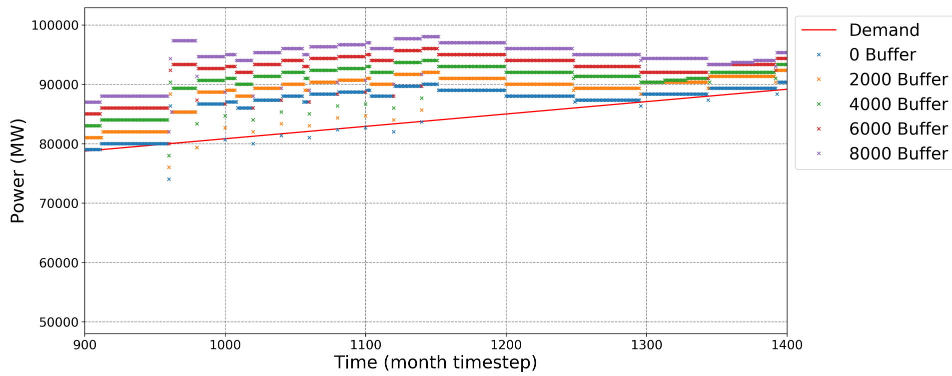


Figure 19: Power supply for different buffer sizes using fft.

4 Eg01-Eg29

Figure 20 shows the flow of Eg01-Eg29.

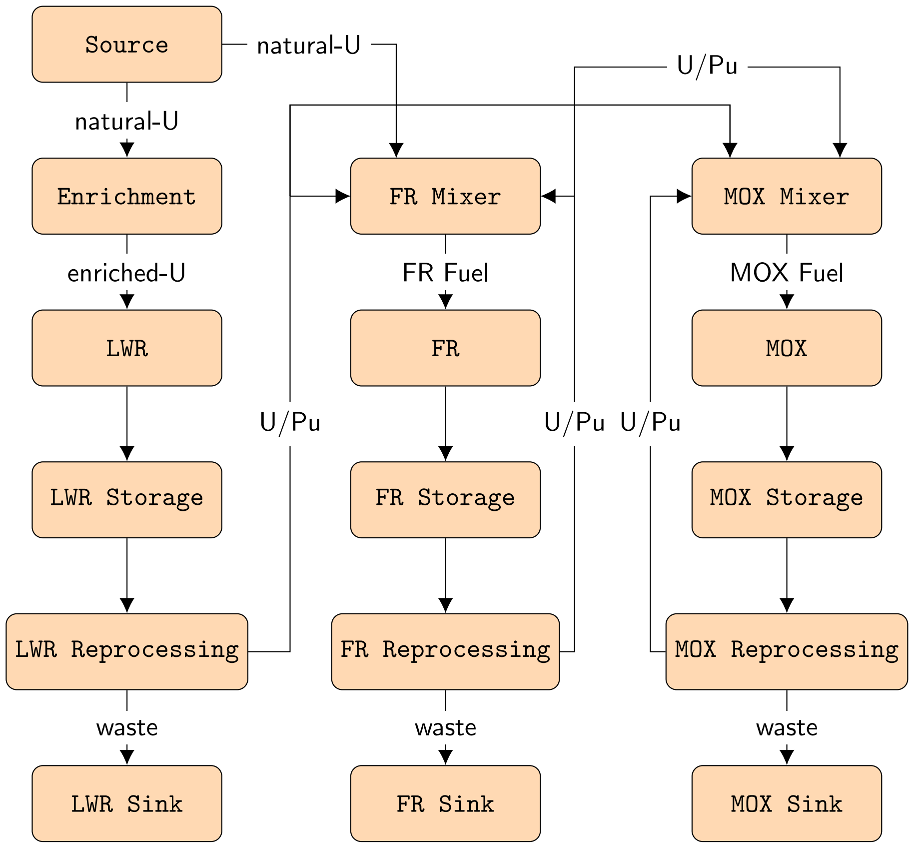


Figure 20: EG01-EG29.

4.1 Flat Power Demand

This section presents plots of power for all the prediction methods. The power demand is 60000 MW throughout the whole simulation. Table 7 shows the input file values. Figures 21, 22, and 23 display the power demand supply for the Non-optimizing (NO), Deterministic-optimizing (DO), and Stochastic-optimizing methods (SO), respectively. Table 8 records the number of steps with under supply, the cumulative under supply, and the cumulative oversupply. The smallest cumulative under supply and smallest amount of under supply time steps are for poly and fft.

Table 7: EG01-EG29 input file values.

Parameter	Value
Demand equation	60e3
Installed Capacity	1
Buffer	0
Forward Steps	1
Backward Steps	2

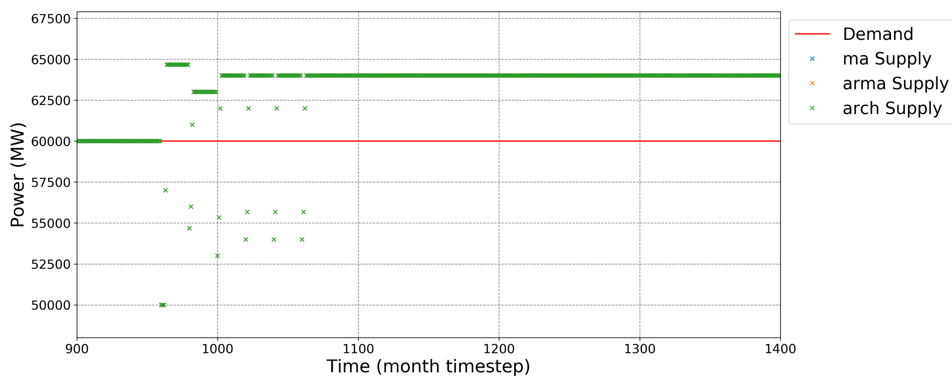


Figure 21: Constant power demand of 60GW and power supply obtained with the SO algorithms.

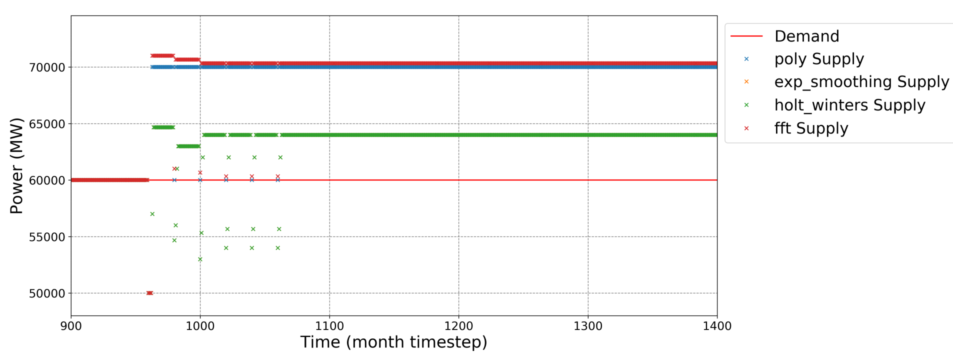


Figure 22: Constant power demand of 60GW and power supply obtained with the DO algorithms.

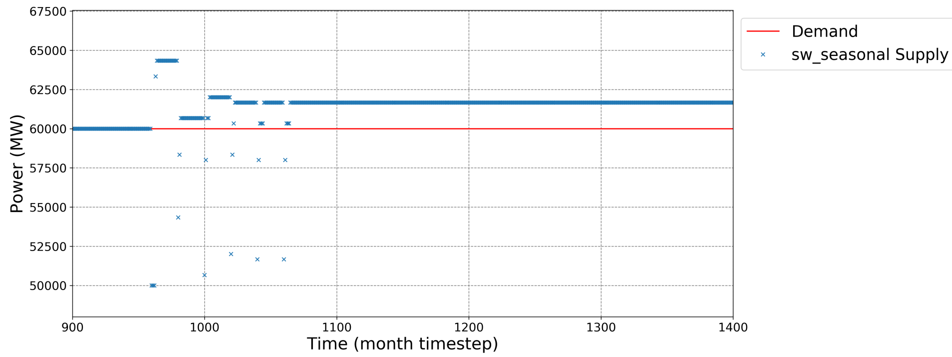


Figure 23: Constant power demand of 60GW and power supply obtained with the SO algorithms.

Table 8: Under supply and oversupply of Power for the different prediction algorithms used to calculate EG01-EG29.

Algorithm	Undersupplied Timesteps	Cumulative Undersupply [GW.mo]	Cumulative Oversupply [GW.mo]
MA	15	145.0	1847.0
ARMA	15	145.0	1847.0
ARCH	15	145.0	1846.9
POLY	4	90.0	4720.3
EXP_SMOOTHING	16	205.0	1847.0
HOLT-WINTERS	16	205.0	1847.0
FFT	5	150.0	4898.0
SW_SEASONAL	14	139.0	798.9

4.2 Different commodities

Since the prediction algorithm poly performed the best, this section presents plots for the supply and demand of the most meaningful commodities in the scenario. Table 9 summarizes the figures in this section and the respective commodities. Table 10 presents the number of steps of under supply, cumulative under supply, and cumulative oversupply of such commodities.

Table 9: Commodity names used in the simulation of EG01-EG29.

Commodity	Figure
Power	24
Natural-U	25a
Enriched-U	25b
FR fuel	26a
MOX LWR fuel	26b
Reprocessed Pu from spent fuel of LWRs	27
Reprocessed Pu from spent fuel of FRs	28a
Reprocessed Pu from spent fuel of MOX LWRs	28b

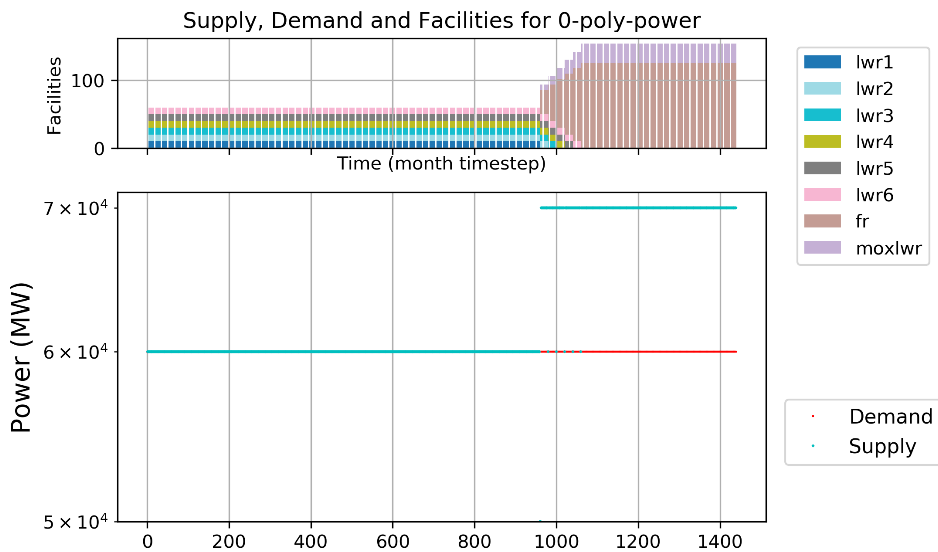
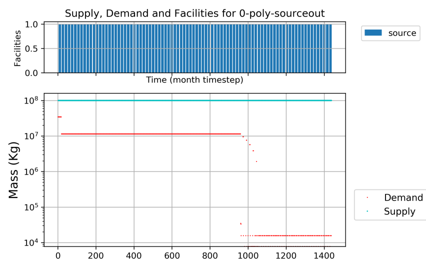
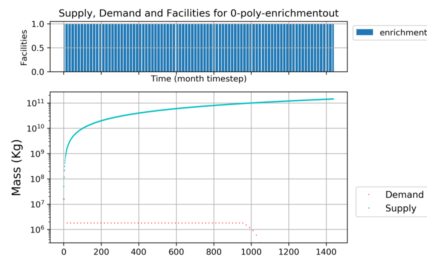


Figure 24: Demand and supply of Power and number of reactors deployed.

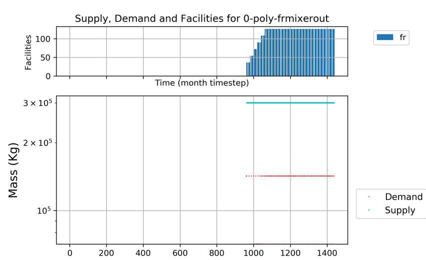


(a) Natural-U.

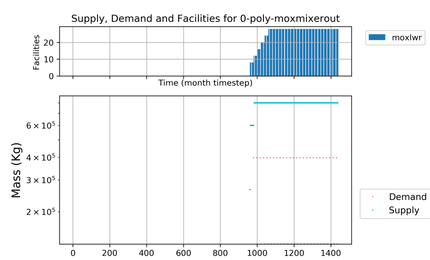


(b) Enriched-U.

Figure 25: Demand and supply of different commodities and number of facilities that produce them.



(a) FR Fuel.



(b) MOX LWR Fuel.

Figure 26: Demand and supply of fuel and number of reactors.

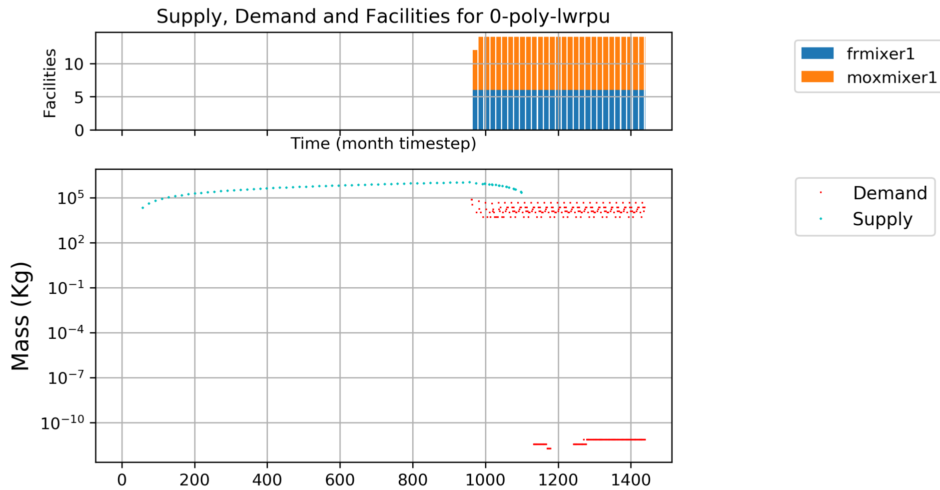
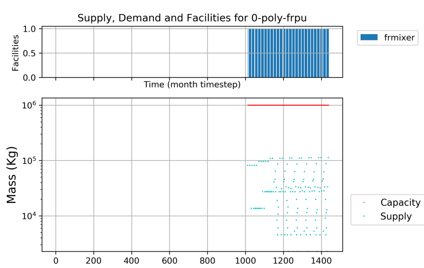
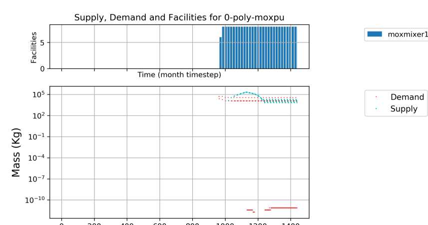


Figure 27: Demand and supply of reprocessed Pu from spent fuel of LWRs and number of facilities supplied with them.



(a) Reprocessed Pu from spent fuel of FRs.



(b) Commodity moxpu.

Figure 28: Demand and supply of different commodities and number of facilities supplied with them.

Table 10: Under supply and oversupply of different commodities using poly to calculate EG01-EG29.

Commodity	Undersupplied Timesteps	Cumulative Undersupply [10^3Kg]	Cumulative Oversupply [10^6Kg]
Natural-U	1	34394.0	132319869.5
Enriched-U	1	16126.1	102751545581.6
FR Fuel	2	284.4	124827.3
MOX LWR Fuel	2	530.1	354541.5

5 Eg01-Eg30

Figure 29 shows the flow of Eg01-Eg30.

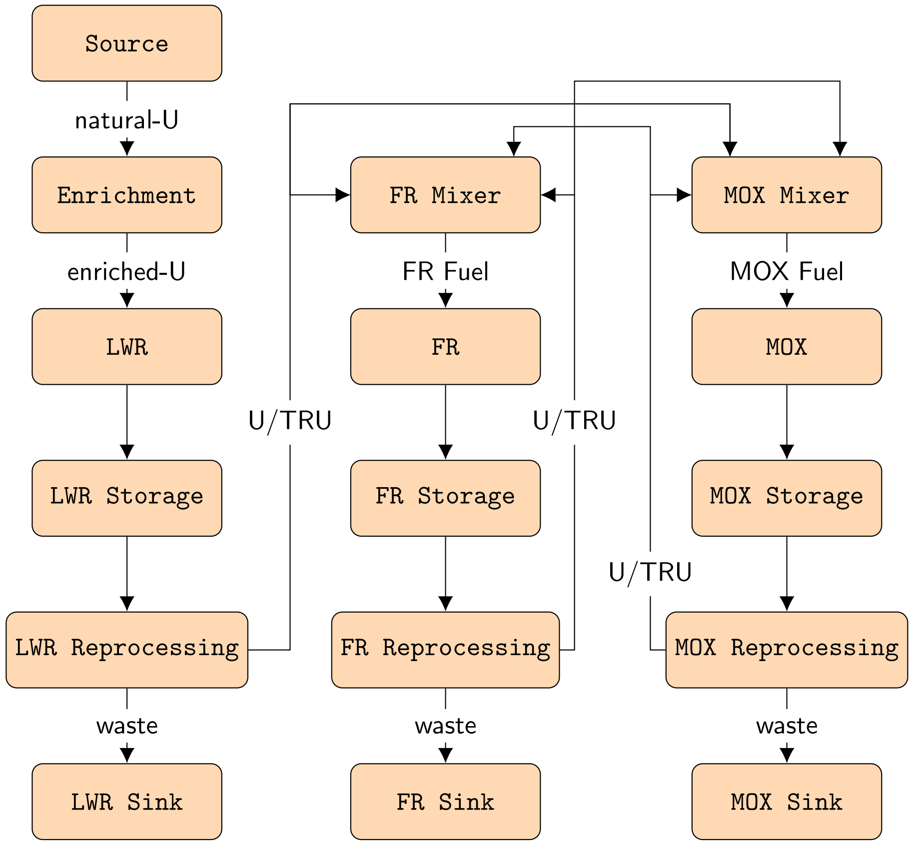


Figure 29: EG01-EG30.

5.1 Linearly increasing Power Demand

This section presents plots of power for all the prediction methods. The power demand increases linearly with the expression $60000MW + 250 * tMW/year$. The input files use the installed capacity feature. Buffer is set to zero, back steps is set to two, and steps takes the default value of one. Figures 30, 31, and 32 display the power supply and demand. The plots show the curves close to when the transition begins. It takes a small number of time steps in the beginning of the simulation until the supply meets the demand. Table 12 records the number of steps whit under supply, the cumulative under supply, and the cumulative oversupply. The smallest cumulative under supply and smallest amount of under supply time steps are for poly and fft.

Table 11: EG01-EG30 input file values.

Parameter	Value
Demand equation	60GW + 250MW/year*t
Installed Capacity	1
Buffer	0
Forward Steps	1
Backward Steps	2

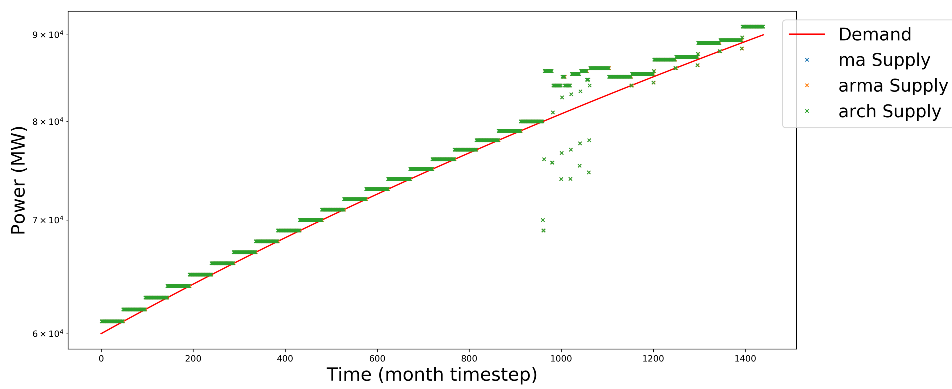


Figure 30: Linearly increasing power demand of 250MW/y and power supply obtained with the NO algorithms.

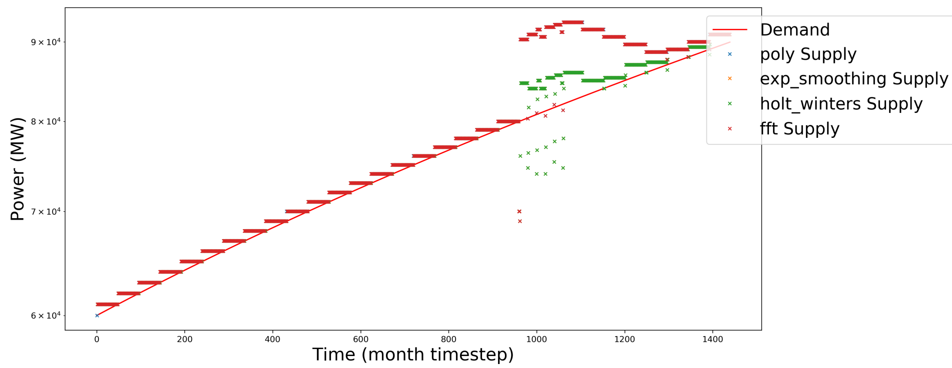


Figure 31: Linearly increasing power demand of 250MW/y and power supply obtained with the DO algorithms.

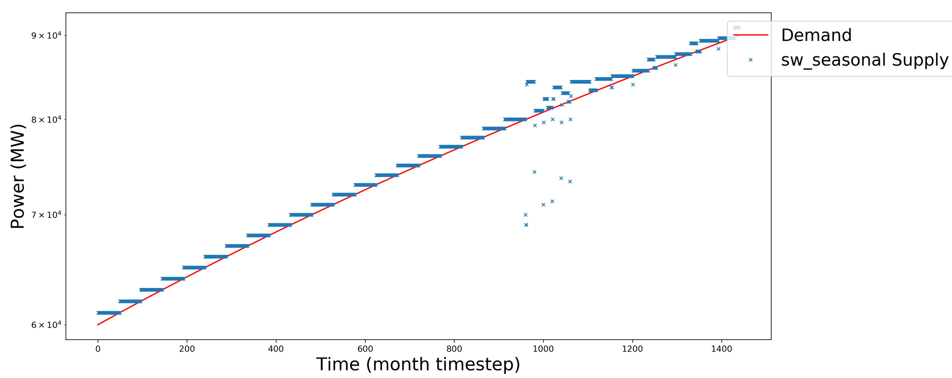


Figure 32: Linearly increasing power demand of 250MW/y and power supply obtained with the SO algorithms.

Table 12: Under supply and oversupply of Power for the different prediction algorithms used to calculate EG01-EG24.

Algorithm	Undersupplied Timesteps	Cumulative Undersupply [GW.mo]	Cumulative Oversupply [GW.mo]
MA	24	152.3	1334.1
ARMA	24	152.3	1334.1
ARCH	21	152.1	1355.9
POLY	9	92.5	3073.1
EXP_SMOOTHING	25	211.6	1317.8
HOLT-WINTERS	25	211.6	1317.8
FFT	9	152.5	3079.4
SW_SEASONAL	51	147.3	873.4