

Vision for 24x7 Green Energy Grid (GEG), 2072

National Workshop

Centre for Science & Environment, New Delhi

Scaling Renewable without breaking the Grid

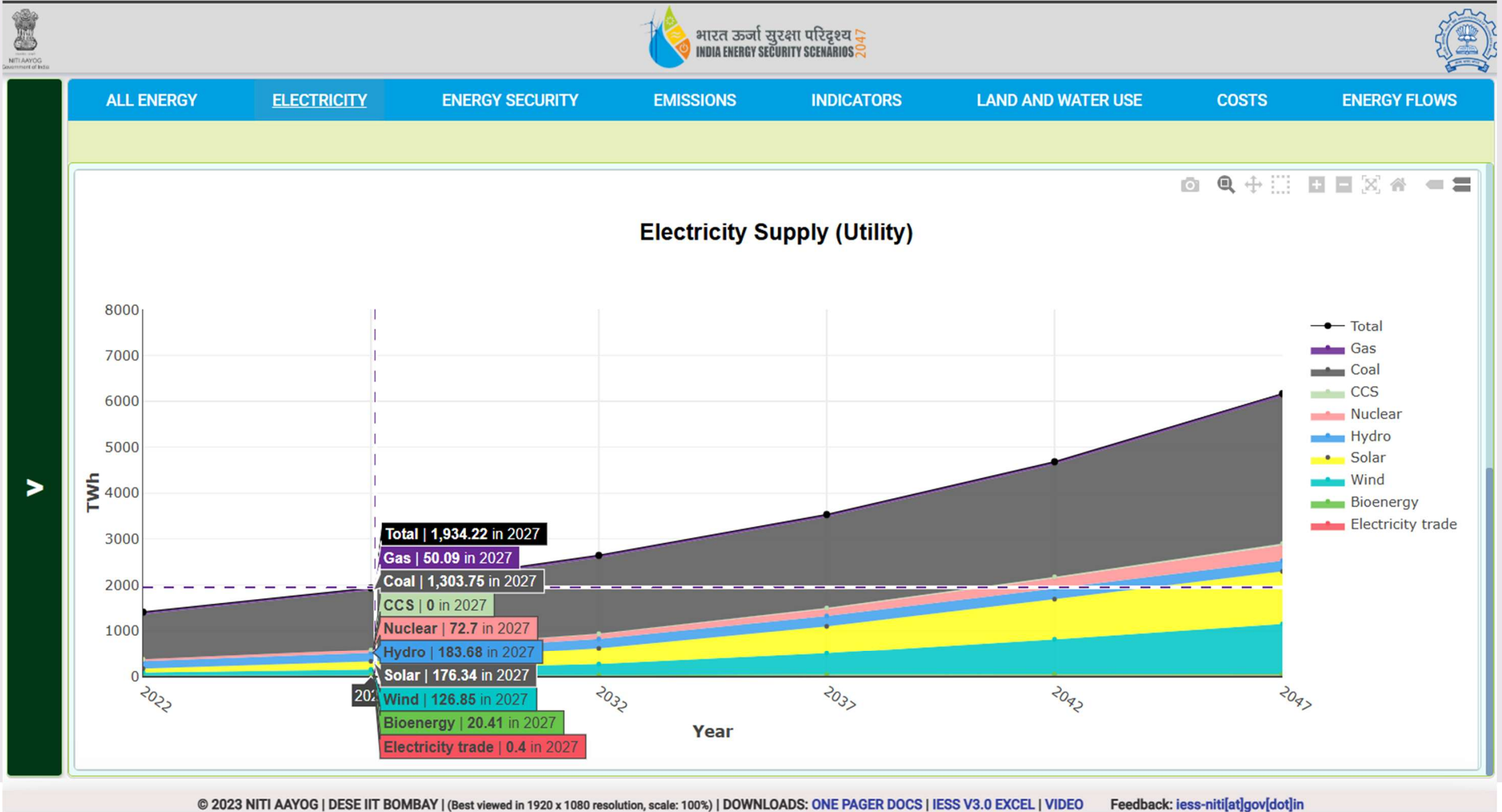
24th Sep 2026

Agenda → VISION for 24x7 Green Energy Grid (GEG) by 2072

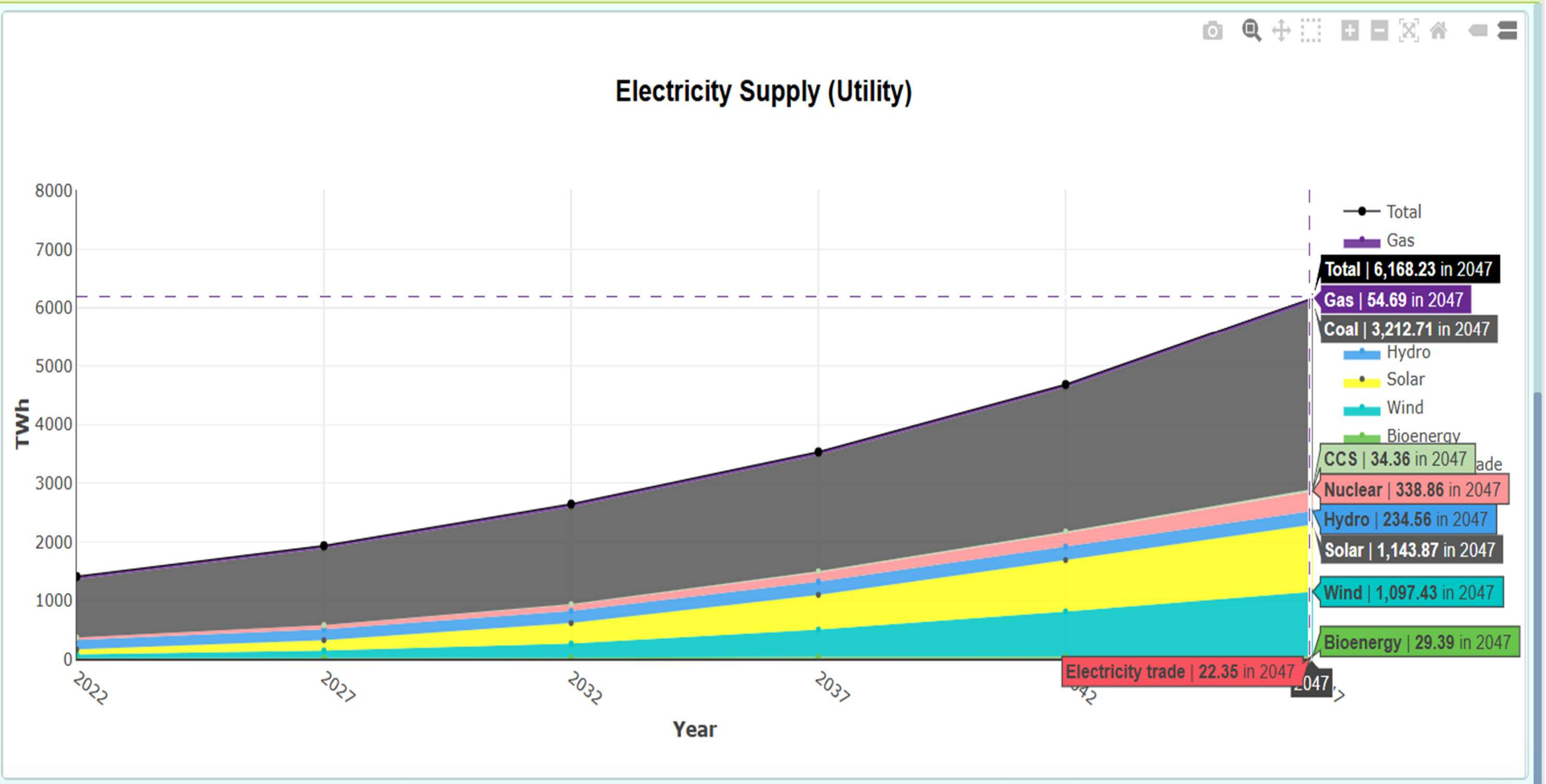
Scheme outline attempted here to achieve GEG

- 1) Grid Size estimation till 2047 by IESS by Niti Aayog ← (Ref-11)
- 2) Contributions from other Major Renewable Resources → Wind + Hydro + Nuclear + PHP (Minor resources are left out)
from <https://iess2047.gov.in/#?inputs=1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1>
- 3) All Renewables together (W+H+N+PHP) except Solar← (Ref-11)
- 4) Accounting increasing Population and increasing Electricity consumption per Capita
- 5) Average Grid size for simplicity / easier calculations until attaining GEG, which is year 2072
- 6) Gradual increase of ESS in terms of hours of consumption during Peak hours and later to gradually cover 24x7
- 7) Although we generally understand the ESS with BESS, it need NOT be and it should NOT be. For the utility scale, there are more suitable and better emerging Technologies; counter-intuitively they may NOT be as efficient as the BESS, but they are the most suitable ones at that scale
- 8) With such Ultra Mega Storage Plants (with alternate Technologies) we can re-purpose the Retired and old Thermal Power Plants with all the huge Infra associated with it; but avoiding the digression here
- 9) Remaining Grid (avg) Size needed to cover 24 hours
- 10) The planned ESS capacity for the gradual cum increasing hours of Stored Energy over the years
- 11) Equivalent Solar capacity to be deployed
- 12) All the rest from Thermal until to make them to ZERO by year 2072, for achieving 24x7 GEG

Ref (11) IESS 2027 :: for Electricity demand in TWh (per Annum)



Ref (11) IESS 2047 :: for Electricity demand in TWh (per Annum)



Estimation of Nuclear Energy

Ref : India Energy Security Scenarios 2047 - IESS_v3_one_pagers.pdf

India's Nuclear Energy Mission Targets 100 GW for 2047

REF (11)	2020		2027					
	TWh	Avg-GW	TWh	Avg-GW				
5	47	5	72.7	8.3				
		BASE				NEP		
Year		50.0%	CAGR for Five years			62.0%		
2027		8.3	Nuclear			8.3		
2032		12.4				13.4		
2037		18.7				21.8		
2042		28.0				35.3		
2047		42.0				57.2		
2052		63.0				92.6		
2057		94.5				150.0		
2062		141.8				243.0		
2067		212.7				393.7		
2072		319.0				637.8		
REF (11)	Level - 1		Level - 2		Level - 3		Level - 4	
	TWh	Avg-GW	TWh	Avg-GW	TWh	Avg-GW	TWh	Avg-GW
2047	380	43	498	57	775	88	1100	126
Installed		54		64.5		100.5		142.5
CUF in %		80.3%		88.1%		88.0%		88.1%

LEVEL 1

Level 1 assumes that the present reactors under construction will not be commissioned due to delay in administrative clearances. Also, the present public sentiment regarding nuclear power results in a limited capacity addition in nuclear power, while a few of the older reactors get decommissioned. The cumulative nuclear capacity is expected to grow at 8% p.a. and reach up to 54 GW by 2047 from 6.78 GW in 2020 at a PLF of 78%. The corresponding electricity generation will increase up to 380 TWh by 2047 from 47 TWh in 2020.

LEVEL 2

Level 2 assumes that new reactors will be developed apart from the already identified sites and under-construction projects. New LWR reactors are also expected to be introduced. In this scenario, the cumulative nuclear power installed capacity is expected to increase up to 64.5 GW by 2047. The corresponding electricity generation will increase up to 498 TWh by 2047 from 47 TWh in 2020.

LEVEL 3

Level 3 is an optimistic trajectory and assumes that all the new PHWR sites are fully utilized with new reactors. In addition, the spent fuel from thermal reactors is used to build more FBR capacity. Thus, new reactors are developed taking the installed capacity up to 100.5 GW by 2047. The electricity generation will increase steeply up to 775 TWh by 2047.

LEVEL 4

Level 4 is aligned with the ambitious vision of Department of Atomic Energy. It assumes that over and above level-1, 2&3 projects, 10x1000 MW IPWRs and 6x1000 MW Metallic Fuel Fast Breeder Reactors (MFBRs) would be launched and progressively completed by 2047. Required sites will have to be selected and acquired. The cumulative nuclear power installed capacity is expected to increase up to 160 GW by 2047 from 6.8 GW in 2020. Electricity generation increases to 1100 TWh by 2047.

Estimation of Hydro Energy

Ref : India Energy Security Scenarios 2047 - IESS_v3_one_pagers.pdf

REF (11)	2027							
	TWh	Avg-GW						
5	184	21						
	BASE				NEP			
Year	5.00%	CAGR for Five years		15.00%				
2027	21.0	Hydro		21.0				
2032	22.0			24.1				
2037	23.1			27.7				
2042	24.3			31.9				
2047	25.5			36.7				
2052	26.8			42.2				
2057	28.1			48.5				
2062	29.5			55.8				
2067	31.0			64.1				
2072	32.5			73.8				
REF (11)	Level - 1		Level - 2		Level - 3		Level - 4	
	TWh	Avg-GW	TWh	Avg-GW	TWh	Avg-GW	TWh	Avg-GW
2047	221	25	285	33	363	41	491	56
Installed		63.3		81.6		104.2		140.9
CUF in %		39.9%		39.9%		39.8%		39.8%

LEVEL 1

V

In this trajectory, a low growth scenario has been considered. Only the power plants which are currently under construction and have been approved are assumed to materialize. The installed capacity grows at a CAGR of 2.1% and reaches 63.3 GW in 2047. No new plants are constructed after reaching that capacity. Electricity generation from large hydro plants increases to 221 TWh by 2047.

LEVEL 2

V

In the BAU trajectory, the installed capacity grows at a rate of 2.17% which was the decadal growth rate observed between 2010-20. It continues to grow at the same pace till 2047. The total installed capacity of large hydro plants in 2047 is 81.6 GW. The electricity generation from large hydro plants increases from 155 TWh in 2020 to 285 TWh by 2047.

LEVEL 3

V

In addition to the achievement of Government plans and targets, Level 3 includes the benefits from the completion of Renovation and Modernisation (R&M) and Life Extension (LE) efforts, and the effect of National R&R Policy 2007 (rehabilitation and resettlement processes), which will help to increase the hydropower plant capacity in the country. Total installed capacity grows at a CAGR of 3.10% till 2047 and cumulative capacity reaches 104.2 GW in 2047. Electricity generation increases to 363 TWh by 2047.

LEVEL 4

V

In this scenario, technology advancements are assumed to result in the exploitation of the maximum potential of large hydro. It is assumed that advanced technology development, integration of regional grids, rehabilitation, and issues related to hydropower will be resolved. In this trajectory, the final capacity of large hydro plants reaches 140.9 GW by 2047, close to the estimated potential of hydropower in the country. Electricity generation in this trajectory increases to 491 TWh by 2047 from 155 TWh in 2020.

Estimation of Wind Energy (On-shore & Off-Shore)

Ref : India Energy Security Scenarios 2047 - IESS v3 one pagers.pdf

REF (11)		2027					
		TWh	Avg-GW				
5		127	14.5				

REF (11)	Level - 1		Level - 2		Level - 3		Level - 4	
	TWh	Avg-GW	TWh	Avg-GW	TWh	Avg-GW	TWh	Avg-GW
2047	977	112	121	1365	156	174		
Installed		255	275	356	397			
CUF in %		43.7%	43.8%	43.8%	43.8%	43.8%		

LEVEL 1

Level 1 assumes a pessimistic growth of the wind power sector. This trajectory misses the goal of 60 GW installed capacity of wind in 2022 by a long margin and achieves that goal in the year 2030. The total installed capacity reaches 255 GW in 2047. The net electricity generation from wind turbines increases to 977 TWh by 2047 from 65 TWh in 2020

LEVEL 2

Level 2 assumes that some additional investments will be made to improve the power evacuation infrastructure in the country. The installed capacity reaches 80 GW in 2030. The wind power sector experiences steady growth and the total installed capacity reaches 275 GW in 2047.

LEVEL 3

Level 3 assumes the introduction of novel policy regulations along with technological improvements. Issues related to land acquisition & environmental constraints will be resolved. As a result, the sector is able to reach 90 GW in 2030. 356 GW onshore wind capacity is achieved in 2047. The net electricity generation from onshore wind power plants increases to 1365 TWh by 2047 in this trajectory.

LEVEL 4

Onshore wind power technology saw a 13% growth rate in the last decade (2010-20). It is assumed that the sector is able to witness a similar growth between 2020-30, and cumulative installed capacity will reach 110 GW by 2030 in Level 4. Cumulative installed capacity will reach 397 GW in 2047.

REF (11)		2027			
		TWh	Avg-GW		
5		7	0.8		
	BASE			NEP	
Year	100%	CAGR for Five years		150%	
2027	0.8	OFF-Shore Wind		0.8	
2032	1.6			2.0	
2037	3.2			5.0	
2042	6.4			12.5	
2047	12.8			31.2	
2052	20.0			45.0	
2057	30.0			60.0	
2062	40.0			75.0	
2067	50.0			90.0	
2072	60.0		110.0		

REF (11)	Level - 1		Level - 2		Level - 3		Level - 4	
	TWh	Avg-GW	TWh	Avg-GW	TWh	Avg-GW	TWh	Avg-GW
2047	116	13	251	29	386	44	483	55
Installed		30	65	100	120			
CUF in %		44.1%	44.1%	44.1%	44.1%	45.9%		

LEVEL 1

Level 1 assumes a slow growth for offshore wind technology, mainly due to the high costs and other technological barriers. It assumes that 2 GW capacity will be installed in 2027 and final capacity reaches 30 GW in 2047. The corresponding electricity generation would be 7 TWh in 2027 and it will increase to 116 TWh in 2047.

LEVEL 2

Level 2 assumes a slightly higher growth rate with installed off-shore wind power capacity reaching 3 GW by 2027. Total capacity reaches 65 GW in 2047. The corresponding annual electricity generation from offshore wind plants will increase up to 251 TWh by 2047 from 10 TWh in 2027.

LEVEL 3

Level 3 assumes that with the improvement in potential offshore site identification and cost reductions along with significant investments in the transmission and evacuation systems, India would gradually build up its offshore wind capacity to 4 GW by 2027 which is expected to further reach 100 GW by 2047. The corresponding annual electricity generation will increase up to 386 TWh by 2047 from 14 TWh in 2027.

LEVEL 4

Level 4 assumes that offshore wind power does not face many economic or physical constraints. It is assumed that 4 GW capacity is installed in 2027, and it increases upto 22 GW by 2030. Final capacity reaches 120 GW in 2047. A significant amount of investment is required to achieve this level of growth in offshore wind sector. The corresponding annual electricity generation will increase up to 483 TWh by 2047 from 14 TWh in 2027.

Actual Electricity Consumption in TWh (per Annum) till 2025 Extrapolated till 2027 and the CAGR

Actual Electricity Consumption in TWh (per Annum)			
Actual Electricity Consumption Growth till 2025 & Template Values for different CAGR			
Baseline Values obtained from Ref (10) till 2025-26 (as 2025) and extrapolated till 2027			
Year	Actual Size, Grid (Twh)	Real Growth Y-O-Y	CAGR for Five years
2020	1373		5.55%
2021	1484	8.08%	
2022	1618	9.03%	100
2023	1734	7.17%	106
2024	1824	5.19%	111
2025	1840	0.88%	118
2026	1930	4.89%	124
2027	2000	3.63%	131
(Avg across years) CAGR		5.55%	31.02%

Template Values for different CAGR in steps of Five years

Actual Electricity Consumption in TWh (per Annum)					
Actual Electricity Consumption Growth till 2025 & Template Values for different CAGR					
Template for Growth (CAGR) for many rates					
Here, we would use for :: Five years from 2022 to 2027					
Year	CAGR for Five years	CAGR for Five years	CAGR for Five years	CAGR for Five years	CAGR for Five years
	3.00%	4.00%	5.00%	6.00%	7.00%
2022	100	100	100	100	100
2027	103	104	105	106	107
2032	106	108	110	112	114
2037	109	112	116	119	123
2042	113	117	122	126	131
2047	116	122	128	134	140
	15.93%	21.67%	27.63%	33.82%	40.26%

Population & Consumption Estimation

For Base Scenario till 2047

The Population is expected to be 1.6 Billions (160 Crores) by year 2047

And, Per Capita Consumption is expected to reach 4000 KWh per Annum by 2047

Ref : 2 (IESS-Niti), 6 (Ember), 7 (Raj), 4, 8 & 9 (PIB)

Base S

5% YOY

Till 2047

27.63%

5

1694 Ref (6)

Year

Grid (Twh)

2024

1824

2025

1840

2026

1930

2027

2000

5% / Yr : High
Growth of Grid
with EV & AI
Servers Adoption
till 2047

2032

2553

2037

3258

2042

4158

2047

5307

2052

2057

2062

2067

2072

Population & Consumption Estimation

For Base Scenario till 2072

The Population is expected to be 1.6 Billions (160 Crores) by year 2047

And, Per Capita Consumption is expected to reach 4000 KWh per Annum by 2047

Ref : 2 (IESS-Niti), 6 (Ember), 7 (Raj), 4, 8 & 9 (PIB)

Base Scenario

		5% YOY	Population in Billions	Consumption per Capita in KWH per Annum	3% YOY	
		Till 2047			After 2047	
		27.63%			15.93%	
5		1694 Ref (6)			31st Mar 2025	
Year		Grid (Twh)			Grid (Twh)	Grid (Avg) GW
2024		1824			From Growth	
2025		1840	2.2%		Template	
2026		1930	1.45	1331	Values	
2027	5% / Yr : High	2000	1.47	1365	2000	228
2032	Growth of Grid	2553	1.50	1705	2553	291
2037	with EV & AI	3258	1.53	2129	3258	372
2042	Servers Adoption	4158	1.56	2659	4158	475
2047	till 2047	5307	1.60	3320	5307	606
2052					6152	702
2057			3% / Yr : Growth of		7132	814
2062			Grid thereafter from		8268	944
2067			2047 till 2072		9584	1094
2072					11111	1268

Population & Consumption Estimation till 2072

For Base & NEP Scenarios

The Population is expected to be 1.6 Billions (160 Crores) by year 2047

And, Per Capita Consumption is expected to reach 4000 KWh per Annum by 2047

Ref : 2 (IESS-Niti), 6 (Ember), 7 (Raj), 4, 8 & 9 (PIB)

NEP Scenario						
Year		7% YOY	Population in Billions	Consumption per Capita in KWH per Annum	3% YOY	
		Till 2047			After 2047	
		40.26%			15.93%	
5		1460 Ref (8,10)			2000 Ref (7)	6400 Ref (7&9)
Year		Grid (Twh)			Grid (Twh)	Grid (Avg) GW
2024		1824				
2.2%	2025	1840	2.2%			
1.45	2026	1930	1.45	1331		
1.47	2027	2000	1.47	1365	2000	228
1.50	2032	2805	1.50	1874	2805	320
1.53	2037	3934	1.53	2571	3934	449
1.56	2042	5518	1.56	3529	5518	630
1.60	2047	7739	1.60	4842	7739	883
	2052				8972	1024
	2057				10401	1187
	2062				12058	1376
	2067				13978	1596
	2072				16205	1850

Estimation of ESS required till 2072

For Base line Scenario → Estimation of Grid (Average) Size

Vision 2072		27.63%
After 2047 : 3% / Yr		15.93%
5		
	Ref (5)	With CAGR
Year	Grid (Avg) GW	(Base) Grid (Avg) GW
2027	228	228
2032	291	291
2037	372	372
2042	475	475
2047	606	606
2052	702	702
2057	814	814
2062	944	944
2067	1094	1094
2072	1268	1268
Battery & Solar : For both Degradation & Replacement after End Of Life are NOT accounted; If added, they will be about 12% more each year		

Estimation of ESS required till 2072

For Base line Scenario → Contribution from W+H+N+P

Vision 2072		27.63%	5% / Yr : Growth of Grid with EV & AI Servers				
After 2047 : 3% / Yr		15.93%	Base Scenario				
5							
	Ref (5)	With CAGR	To Power Grid for 2072				
Year	Grid (Avg) GW	(Base) Grid (Avg) GW	*Wind (GW) 4	# Hydro (GW) 4	Nuclear (GW)	PHP (GW)	W+H+N+P HP (GW)
2027	228	228	15.3	21.0	8.3	1.5	46.0
2032	291	291	17.5	22.0	12.4	2.0	54.0
2037	372	372	20.7	23.1	18.7	2.5	65.0
2042	475	475	25.7	24.3	28.0	3.0	80.9
2047	606	606	34.0	25.5	42.0	3.5	105.0
2052	702	702	43.3	26.8	63.0	4.0	137.1
2057	814	814	55.7	28.1	94.5	4.5	182.8
2062	944	944	68.2	29.5	141.8	5.0	244.5
2067	1094	1094	81.0	31.0	212.7	5.5	330.2
2072	1268	1268	94.1	32.5	319.0	6.0	451.7
Battery & Solar : For both Degradation & Replacement after End Of Life are NOT accounted; If added, they will be about 12% more each year							

Estimation of ESS required till 2072

For Base line Scenario → After accounting other Sources, Required Grid (Avg) Size

Vision 2072		27.63%	5% / Yr : Growth of Grid with EV & AI Servers Adoption till 2072					
After 2047 : 3% / Yr		15.93%	Base Scenario					
5								
	Ref (5)	With CAGR	To Power Grid for 24 Hours					
Year	Grid (Avg) GW	(Base) Grid (Avg) GW	*Wind (GW) 4	# Hydro (GW) 4	Nuclear (GW)	PHP (GW)	W+H+N+P HP (GW)	Remaining Avg (GW) needed for Grid 24 Hrs
2027	228	228	15.3	21.0	8.3	1.5	46.0	182
2032	291	291	17.5	22.0	12.4	2.0	54.0	237
2037	372	372	20.7	23.1	18.7	2.5	65.0	307
2042	475	475	25.7	24.3	28.0	3.0	80.9	394
2047	606	606	34.0	25.5	42.0	3.5	105.0	501
2052	702	702	43.3	26.8	63.0	4.0	137.1	565
2057	814	814	55.7	28.1	94.5	4.5	182.8	631
2062	944	944	68.2	29.5	141.8	5.0	244.5	699
2067	1094	1094	81.0	31.0	212.7	5.5	330.2	764
2072	1268	1268	94.1	32.5	319.0	6.0	451.7	817

Battery & Solar : For both Degradation & Replacement after End Of Life are NOT accounted; If added, they will be about 12% more each year

Estimation of ESS required till 2072

For Base line Scenario → Hours of Storage Planned

Vision 2072		27.63%	5% / Yr : Growth of Grid with EV & AI Servers Adoption till 2072									
After 2047 : 3% / Yr		15.93%		Base Scenario								
5												
	Ref (5)	With CAGR	To Power Grid for 24 Hours								Hrs /Day	
Year	Grid (Avg) GW	(Base) Grid (Avg) GW	*Wind (GW) 4	# Hydro (GW) 4	Nuclear (GW)	PHP (GW)	W+H+N+P HP (GW)	Remaining Avg (GW) needed for Grid 24 Hrs		Hours of Storage Planned		
2027	228	228	15.3	21.0	8.3	1.5	46.0	182		0.20		
2032	291	291	17.5	22.0	12.4	2.0	54.0	237		1.00		
2037	372	372	20.7	23.1	18.7	2.5	65.0	307		2.00		
2042	475	475	25.7	24.3	28.0	3.0	80.9	394		3.00		
2047	606	606	34.0	25.5	42.0	3.5	105.0	501		4.10		
2052	702	702	43.3	26.8	63.0	4.0	137.1	565		5.80		
2057	814	814	55.7	28.1	94.5	4.5	182.8	631		7.80		
2062	944	944	68.2	29.5	141.8	5.0	244.5	699		10.70		
2067	1094	1094	81.0	31.0	212.7	5.5	330.2	764		14.50		
2072	1268	1268	94.1	32.5	319.0	6.0	451.7	817		19.70		
Battery & Solar : For both Degradation & Replacement after End Of Life are NOT accounted; If added, they will be about 12% more each year												

Estimation of ESS required till 2072

For Base line Scenario → Hours of Cumulative Storage required as per Plan

Vision 2072		27.63%	5% / Yr : Growth of Grid with EV & AI Servers Adoption till 2072							
After 2047 : 3% / Yr		15.93%	Base Scenario						RTE	
5									Hrs /Day	88%
		Ref (5)	With CAGR	To Power Grid for 24 Hours					24	3.784
Year	Grid (Avg) GW	(Base) Grid (Avg) GW	*Wind (GW) 4	# Hydro (GW) 4	Nuclear (GW)	PHP (GW)	W+H+N+P HP (GW)	Remaining Avg (GW) needed for Grid 24 Hrs	Hours of Storage Planned	Usable Storage (GWh) required: Cumulative
2027	228	228	15.3	21.0	8.3	1.5	46.0	182	0.20	36
2032	291	291	17.5	22.0	12.4	2.0	54.0	237	1.00	237
2037	372	372	20.7	23.1	18.7	2.5	65.0	307	2.00	614
2042	475	475	25.7	24.3	28.0	3.0	80.9	394	3.00	1181
2047	606	606	34.0	25.5	42.0	3.5	105.0	501	4.10	2053
2052	702	702	43.3	26.8	63.0	4.0	137.1	565	5.80	3278
2057	814	814	55.7	28.1	94.5	4.5	182.8	631	7.80	4924
2062	944	944	68.2	29.5	141.8	5.0	244.5	699	10.70	7482
2067	1094	1094	81.0	31.0	212.7	5.5	330.2	764	14.50	11076
2072	1268	1268	94.1	32.5	319.0	6.0	451.7	817	19.70	16088
Battery & Solar : For both Degradation & Replacement after End Of Life are NOT accounted; If added, they will be about 12% more each year										

Estimation of ESS required till 2072

For Base line Scenario → Hours of Storage (Five-years wise) required as per Plan

Vision 2072		27.63%	5% / Yr : Growth of Grid with EV & AI Servers Adoption till 2072						Base Scenario			
After 2047 : 3% / Yr		15.93%									RTE	just a start Ref
5										Hrs /Day	88%	0
	Ref (5)	With CAGR	To Power Grid for 24 Hours							24	3.784	
Year	Grid (Avg) GW	(Base) Grid (Avg) GW	*Wind (GW) 4	# Hydro (GW) 4	Nuclear (GW)	PHP (GW)	W+H+N+P HP (GW)	Remaining Avg (GW) needed for Grid 24 Hrs		Hours of Storage Planned	Usable Storage (GWh) required: Cumulative	Five Years-wise Storage (GWh)
2027	228	228	15.3	21.0	8.3	1.5	46.0	182		0.20	36	36
2032	291	291	17.5	22.0	12.4	2.0	54.0	237		1.00	237	201
2037	372	372	20.7	23.1	18.7	2.5	65.0	307		2.00	614	376
2042	475	475	25.7	24.3	28.0	3.0	80.9	394		3.00	1181	567
2047	606	606	34.0	25.5	42.0	3.5	105.0	501		4.10	2053	872
2052	702	702	43.3	26.8	63.0	4.0	137.1	565		5.80	3278	1225
2057	814	814	55.7	28.1	94.5	4.5	182.8	631		7.80	4924	1646
2062	944	944	68.2	29.5	141.8	5.0	244.5	699		10.70	7482	2558
2067	1094	1094	81.0	31.0	212.7	5.5	330.2	764		14.50	11076	3594
2072	1268	1268	94.1	32.5	319.0	6.0	451.7	817		19.70	16088	5012
Battery & Solar : For both Degradation & Replacement after End Of Life are NOT accounted; If added, they will be about 12% more each year												

Estimation of ESS required till 2072

For Base line Scenario → Solar in GW required for Planned Storage

Vision 2072		27.63%	5% / Yr : Growth of Grid with EV & AI Servers Adoption till 2072						Base Scenario	Equivalent generation of Only Solar in Hours				
After 2047 : 3% / Yr		15.93%											RTE	just a start Ref
5											Hrs /Day	88%	0	
	Ref (5)	With CAGR	To Power Grid for 24 Hours								4.3	24	3.784	
Year	Grid (Avg) GW	(Base) Grid (Avg) GW	*Wind (GW) 4	# Hydro (GW) 4	Nuclear (GW)	PHP (GW)	W+H+N+P HP (GW)	Remaining Avg (GW) needed for Grid 24 Hrs			(Base) Solar needed (GW) : incl. for Storage	Hours of Storage Planned	Usable Storage (GWh) required: Cumulative	Five Years-wise Storage (GWh)
2027	228	228	15.3	21.0	8.3	1.5	46.0	182			217	0.20	36	36
2032	291	291	17.5	22.0	12.4	2.0	54.0	237			333	1.00	237	201
2037	372	372	20.7	23.1	18.7	2.5	65.0	307			511	2.00	614	376
2042	475	475	25.7	24.3	28.0	3.0	80.9	394			760	3.00	1181	567
2047	606	606	34.0	25.5	42.0	3.5	105.0	501			1112	4.10	2053	872
2052	702	702	43.3	26.8	63.0	4.0	137.1	565			1508	5.80	3278	1225
2057	814	814	55.7	28.1	94.5	4.5	182.8	631			2019	7.80	4924	1646
2062	944	944	68.2	29.5	141.8	5.0	244.5	699			2772	10.70	7482	2558
2067	1094	1094	81.0	31.0	212.7	5.5	330.2	764			3795	14.50	11076	3594
2072	1268	1268	94.1	32.5	319.0	6.0	451.7	817			5180	19.70	16088	5012
Battery & Solar : For both Degradation & Replacement after End Of Life are NOT accounted; If added, they will be about 12% more each year														

Estimation of ESS required till 2072

For Base line Scenario → Solar (Avg) GW (accounting 24 hrs) for Planned Storage, with RTE

Vision 2072		27.63%	5% / Yr : Growth of Grid with EV & AI Servers Adoption till 2072						Base Scenario	Conservative : 3320 KWh per Capita in 2047	Equivalent generation of Only Solar in Hours				
After 2047 : 3% / Yr		15.93%											RTE	just a start Ref	
5												Hrs /Day	88%	0	
		Ref (5)	With CAGR	To Power Grid for 24 Hours							4.3	24	3.784		
Year	Grid (Avg) GW	(Base) Grid (Avg) GW	*Wind (GW) 4	# Hydro (GW) 4	Nuclear (GW)	PHP (GW)	W+H+N+P HP (GW)	Remaining Avg (GW) needed for Grid 24 Hrs			Equ.Solar Avg GW (for 24 hrs)	(Base) Solar needed (GW) : incl. for Storage	Hours of Storage Planned	Usable Storage (GWh) required: Cumulative	Five Years-wise Storage (GWh)
2027	228	228	15.3	21.0	8.3	1.5	46.0	182			34	217	0.20	36	36
2032	291	291	17.5	22.0	12.4	2.0	54.0	237			52	333	1.00	237	201
2037	372	372	20.7	23.1	18.7	2.5	65.0	307			81	511	2.00	614	376
2042	475	475	25.7	24.3	28.0	3.0	80.9	394			120	760	3.00	1181	567
2047	606	606	34.0	25.5	42.0	3.5	105.0	501			175	1112	4.10	2053	872
2052	702	702	43.3	26.8	63.0	4.0	137.1	565			238	1508	5.80	3278	1225
2057	814	814	55.7	28.1	94.5	4.5	182.8	631			318	2019	7.80	4924	1646
2062	944	944	68.2	29.5	141.8	5.0	244.5	699			437	2772	10.70	7482	2558
2067	1094	1094	81.0	31.0	212.7	5.5	330.2	764			598	3795	14.50	11076	3594
2072	1268	1268	94.1	32.5	319.0	6.0	451.7	817			817	5180	19.70	16088	5012
Battery & Solar : For both Degradation & Replacement after End Of Life are NOT accounted; If added, they will be about 12% more each year															

Estimation of ESS required till 2072

For Base Scenario → All the rest from Thermal (Avg) GW; which will be ZERO for 2072

Vision 2072		27.63%	5% / Yr : Growth of Grid with EV & AI Servers Adoption till 2047						Conservative : 3320 KWh per Capita in 2047	Equivalent generation of Only Solar in Hours				
After 2047 : 3% / Yr		15.93%	Base Scenario									RTE	just a start Ref	
5											Hrs /Day	88%	0	
	Ref (5)	With CAGR	To Power Grid for 24 Hours							4.3	24	3.784		
Year	Grid (Avg) GW	(Base) Grid (Avg) GW	*Wind (GW) 4	# Hydro (GW) 4	Nuclear (GW)	PHP (GW)	W+H+N+P HP (GW)	Remaining Avg (GW) needed for Grid 24 Hrs	All the rest from Thermal (GW)	Equ.Solar Avg GW for 24 hrs	(Base) Solar needed (GW) : incl. for Storage	Hours of Storage Planned	Usable Storage (GWh) required: Cumulative	Five Years-wise Storage (GWh)
2027	228	228	15.3	21.0	8.3	1.5	46.0	182	148	34	217	0.20	36	36
2032	291	291	17.5	22.0	12.4	2.0	54.0	237	185	52	333	1.00	237	201
2037	372	372	20.7	23.1	18.7	2.5	65.0	307	226	81	511	2.00	614	376
2042	475	475	25.7	24.3	28.0	3.0	80.9	394	274	120	760	3.00	1181	567
2047	606	606	34.0	25.5	42.0	3.5	105.0	501	326	175	1112	4.10	2053	872
2052	702	702	43.3	26.8	63.0	4.0	137.1	565	327	238	1508	5.80	3278	1225
2057	814	814	55.7	28.1	94.5	4.5	182.8	631	313	318	2019	7.80	4924	1646
2062	944	944	68.2	29.5	141.8	5.0	244.5	699	262	437	2772	10.70	7482	2558
2067	1094	1094	81.0	31.0	212.7	5.5	330.2	764	166	598	3795	14.50	11076	3594
2072	1268	1268	94.1	32.5	319.0	6.0	451.7	817	0	817	5180	19.70	16088	5012
Battery & Solar : For both Degradation & Replacement after End Of Life are NOT accounted; If added, they will be about 12% more each year														

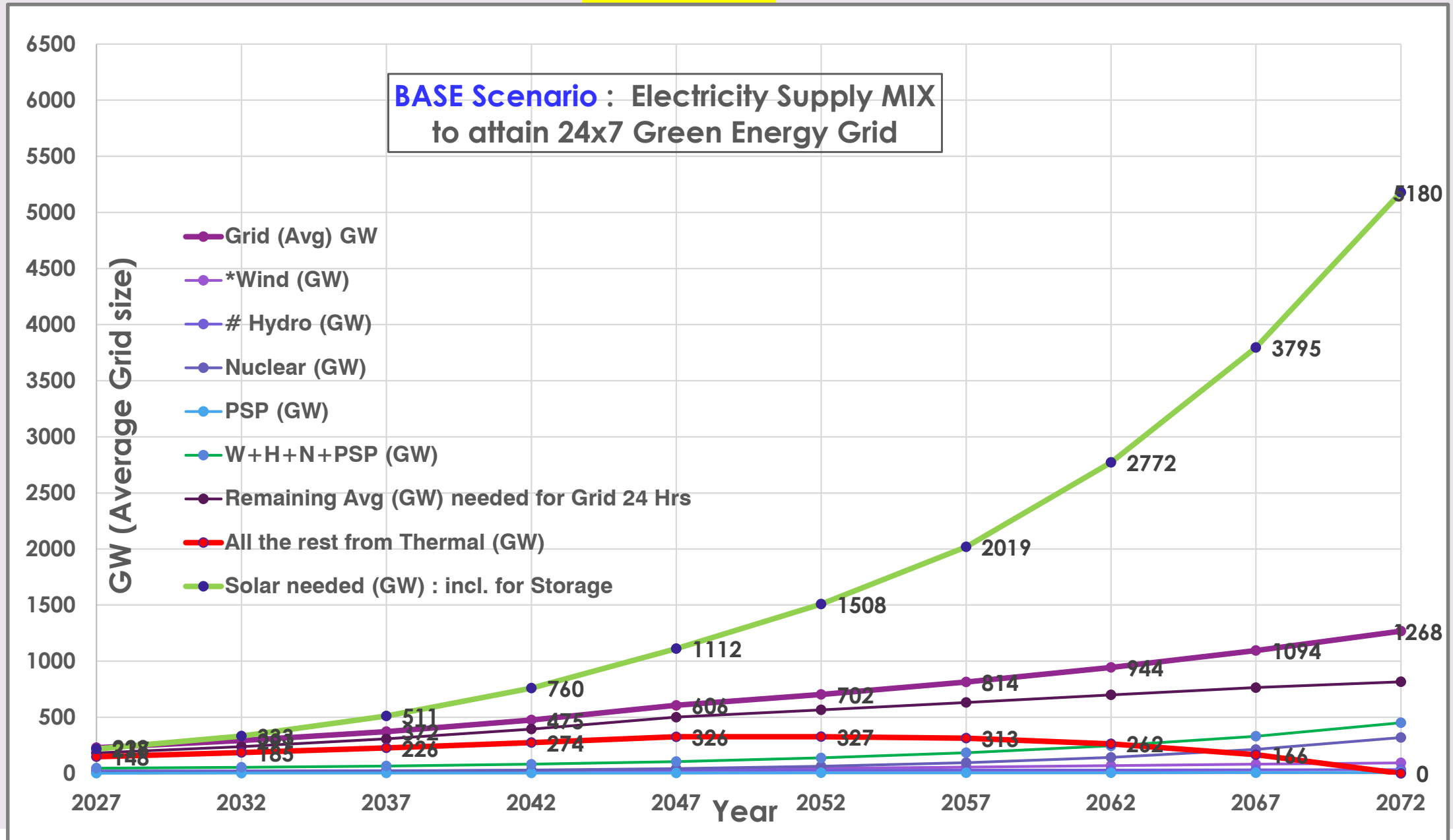
Estimation of ESS required till 2072

For Base Scenario → Total Finance / Budget required in Lakhs of Crores

Vision 2072		27.63%	5% / Yr : Growth of Grid with EV & AI Servers Adoption till 2047								Conservative : 3320 KWh per Capita in 2047	Equivalent generation of Only Solar in Hours				
After 2047 : 3% / Yr		15.93%	Base Scenario											RTE	just a start Ref	
5														Hrs /Day	88%	0
	Ref (5)	With CAGR	To Power Grid for 24 Hours									4.3	24	3.784		1
Year	Grid (Avg) GW	(Base) Grid (Avg) GW	*Wind (GW) 4	# Hydro (GW) 4	Nuclear (GW)	PHP (GW)	W+H+N+P HP (GW)	Remaining Avg (GW) needed for Grid 24 Hrs	All the rest from Thermal (GW)	Equ.Solar Avg GW (for 24 hrs)	(Base) Solar needed (GW) : incl. for Storage	Hours of Storage Planned	Usable Storage (GWh) required: Cumulative	Five Years-wise Storage (GWh)	INR Lakhs of Crores for five years	
2027	228	228	15.3	21.0	8.3	1.5	46.0	182	148	34	217	0.20	36	36	0.4	
2032	291	291	17.5	22.0	12.4	2.0	54.0	237	185	52	333	1.00	237	201	2.0	
2037	372	372	20.7	23.1	18.7	2.5	65.0	307	226	81	511	2.00	614	376	3.8	
2042	475	475	25.7	24.3	28.0	3.0	80.9	394	274	120	760	3.00	1181	567	5.7	
2047	606	606	34.0	25.5	42.0	3.5	105.0	501	326	175	1112	4.10	2053	872	8.7	
2052	702	702	43.3	26.8	63.0	4.0	137.1	565	327	238	1508	5.80	3278	1225	12.2	
2057	814	814	55.7	28.1	94.5	4.5	182.8	631	313	318	2019	7.80	4924	1646	16.5	
2062	944	944	68.2	29.5	141.8	5.0	244.5	699	262	437	2772	10.70	7482	2558	25.6	
2067	1094	1094	81.0	31.0	212.7	5.5	330.2	764	166	598	3795	14.50	11076	3594	35.9	
2072	1268	1268	94.1	32.5	319.0	6.0	451.7	817	0	817	5180	19.70	16088	5012	50.1	
Battery & Solar : For both Degradation & Replacement after End Of Life are NOT accounted; If added, they will be about 12% more each year															160.9	

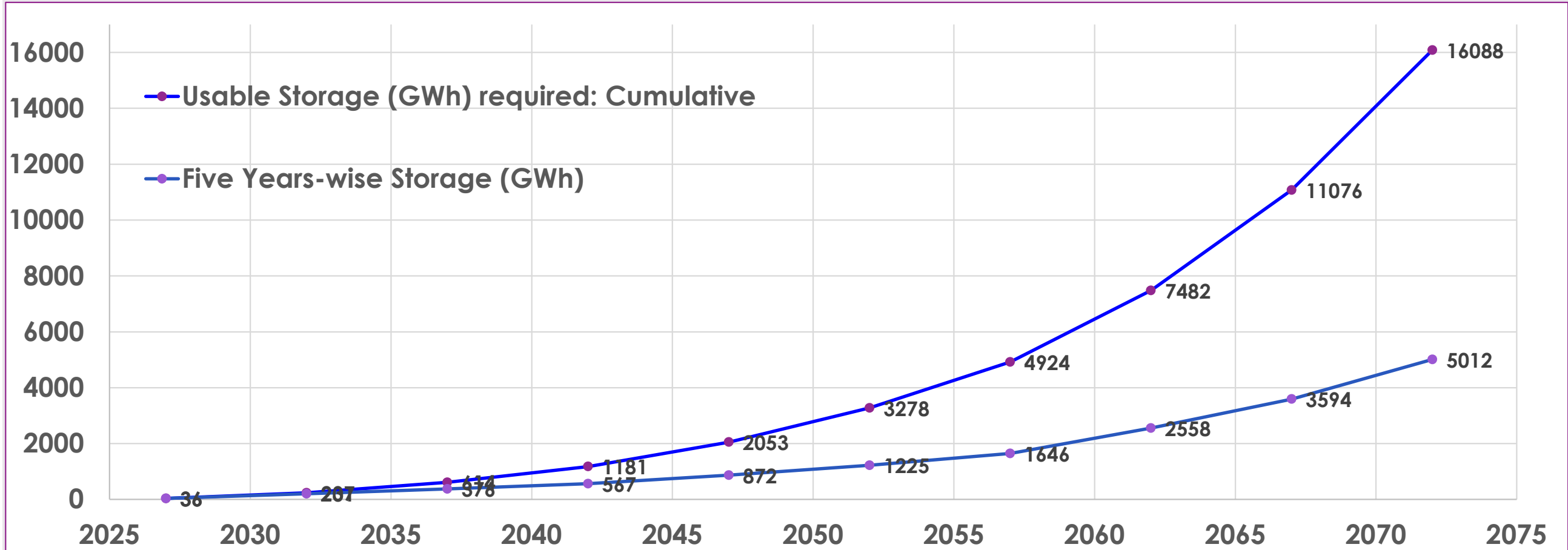
Estimation of ESS required till 2072

For Base line Scenario



Estimation of ESS required till 2072

For Base line Scenario



Estimation of ESS required till 2072

For NEP Scenario

Vision 2072		40.26%	7% / Yr : Accelerated Growth of Grid : EV & AI servers Adopt					
After 2047 : 3% / Yr		15.93%	NEP Scenario					
5								
	Ref (7)	With CAGR	To Power Grid for 24 Hours					
Year	Grid (Avg) GW	(NEP) Grid (Avg) GW	*Wind (GW) 4	# Hydro (GW) 4	Nuclear (GW)	PHP (GW)	W+H+N+P HP (GW)	Remaining Avg (GW) needed for Grid 24 Hrs
2027	228	228	15.3	21.0	8.3	1.5	46.0	182
2032	320	320	18.7	24.1	13.4	2.0	58.2	262
2037	449	449	24.1	27.7	21.8	2.5	76.2	373
2042	630	630	34.5	31.9	35.3	3.0	104.7	525
2047	883	883	56.5	36.7	57.2	3.5	153.9	730
2052	1024	1024	74.1	42.2	92.6	4.0	212.9	811
2057	1187	1187	93.5	48.5	150.0	4.5	296.5	891
2062	1376	1376	113.5	55.8	243.0	5.0	417.3	959
2067	1596	1596	134.3	64.1	393.7	5.5	597.6	998
2072	1850	1850	160.9	73.8	637.8	6.0	878.5	971
Battery & Solar : For both Degradation & Replacement after End Of Life are NOT accounted; If added, they will be about 15% more each year								

Estimation of ESS required till 2072

For NEP Scenario

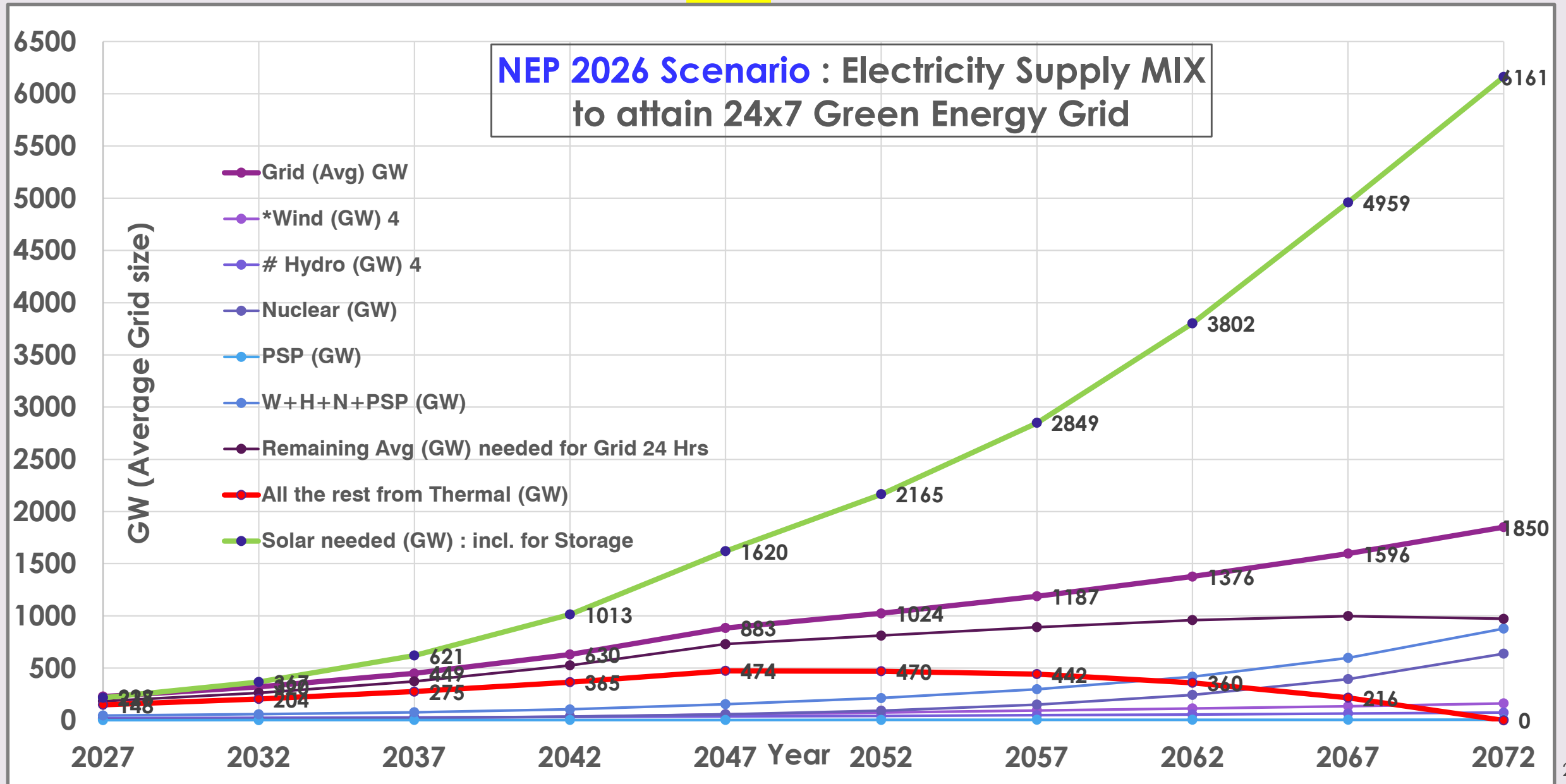
Vision 2072	40.26%
After 2047 : 3% / Yr	15.93%
5	
	Ref (7)
	With CAGR
Year	Grid (Avg) GW
	(NEP) Grid (Avg) GW
2027	228
2032	320
2037	449
2042	630
2047	883
2052	1024
2057	1187
2062	1376
2067	1596
2072	1850

Equivalent generation of Only Solar in Hours				
		RTE	just a start Ref	
	Hrs /Day	88%	0	Crores per MW
4.3	24	3.784		1
(NEP) Solar needed (GW) : incl. for Storage	Hours of Storage Planned	Usable Storage (GWh) required : Cumulative	Five Years-wise Storage (GWh)	INR Lakhs of Crores for five years
217	0.20	36	36	0.4
367	1.00	262	226	2.3
621	2.00	746	484	4.8
1013	3.00	1576	830	8.3
1620	4.10	2991	1416	14.2
2165	5.80	4706	1714	17.1
2849	7.80	6948	2243	22.4
3802	10.70	10263	3314	33.1
4959	14.50	14472	4209	42.1
6161	19.70	19136	4664	46.6

Battery & Solar : For both Degradation & Replacement after End Of Life are NOT accounted; If added, they will be about 15% more each year **191.4**

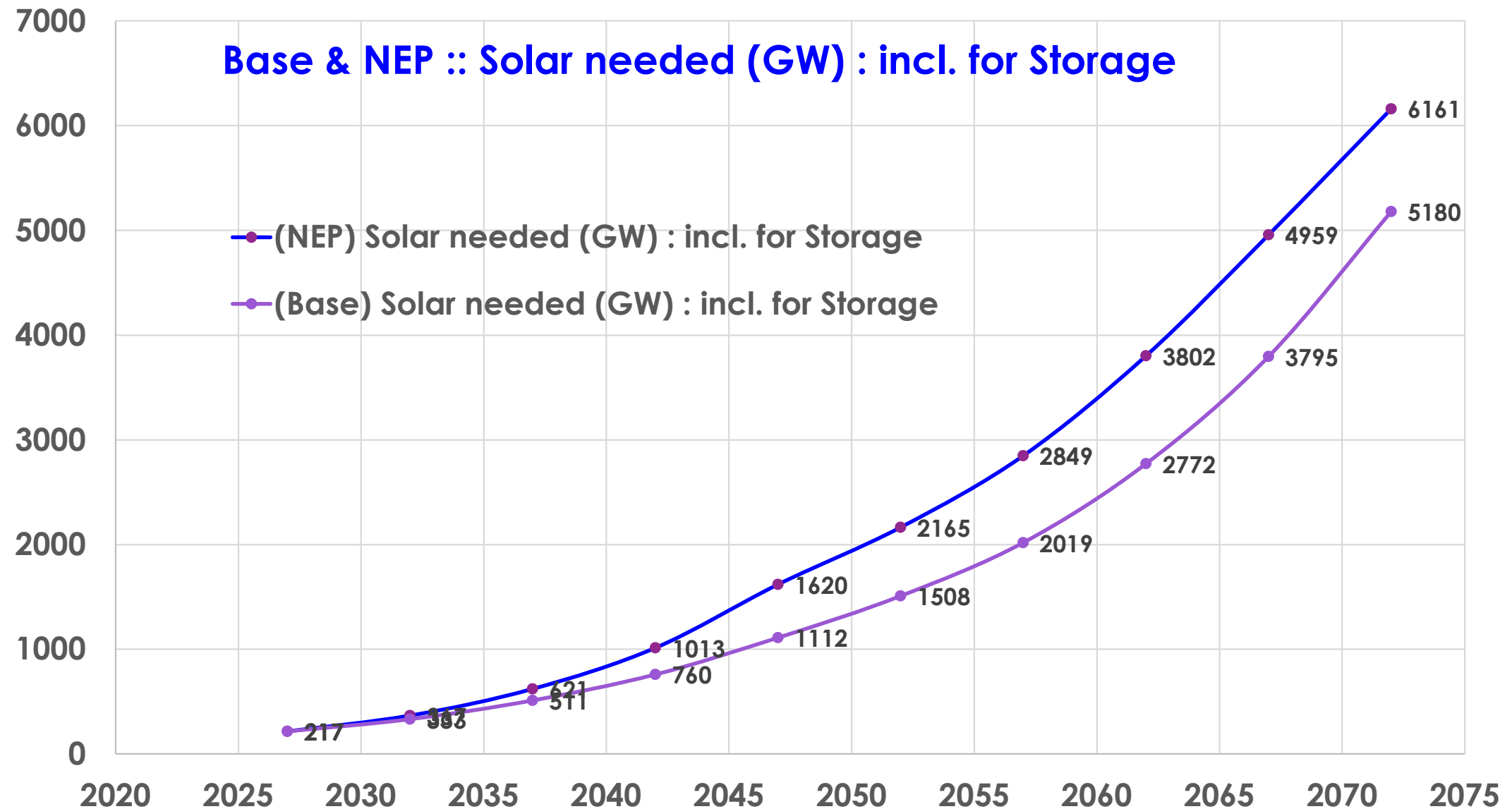
Estimation of ESS required till 2072

For NEP Scenario



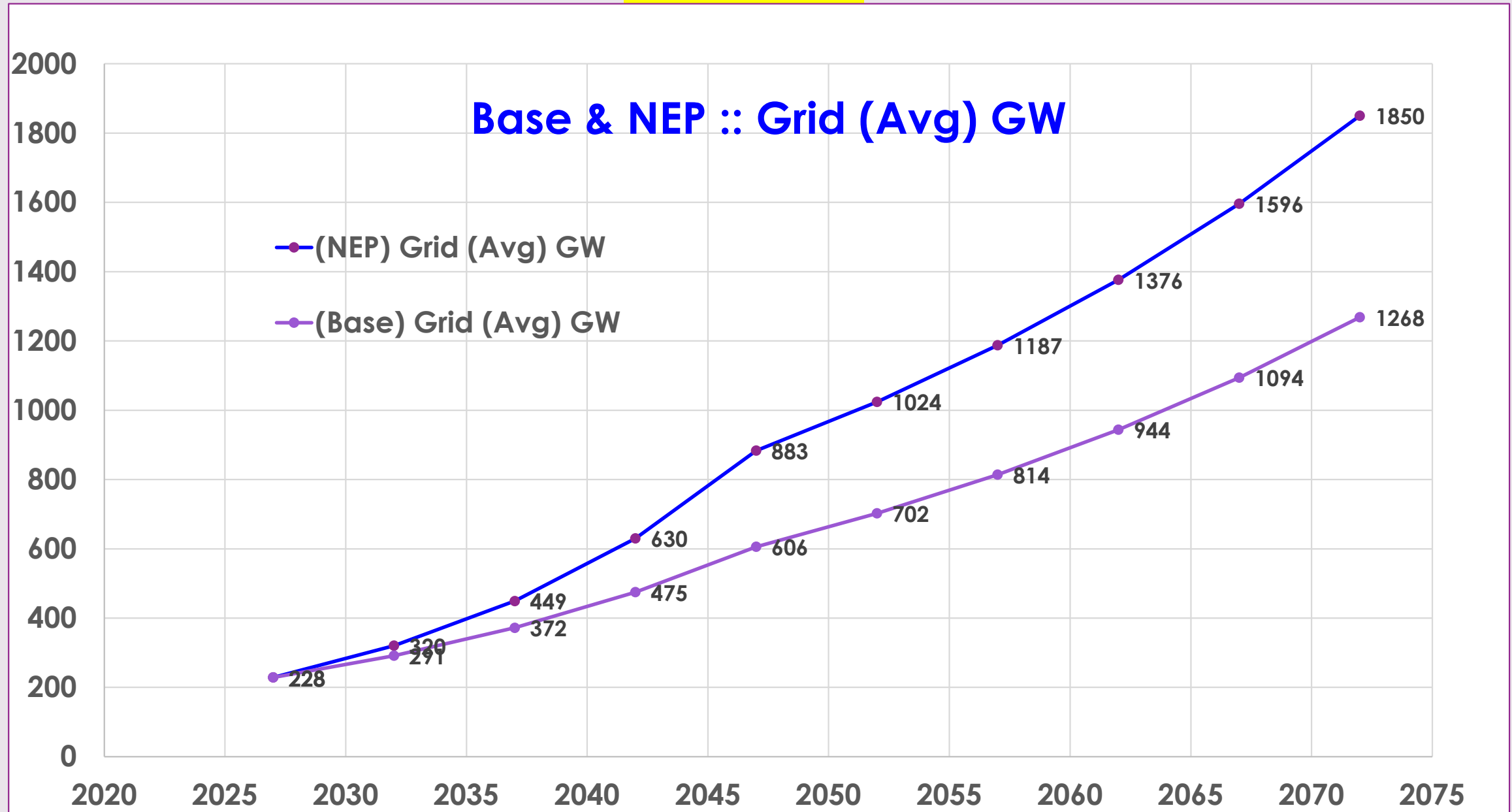
Estimation of ESS required till 2072

For both **Base & NEP** Scenarios



Estimation of Solar required till 2072

For both **Base & NEP** Scenarios

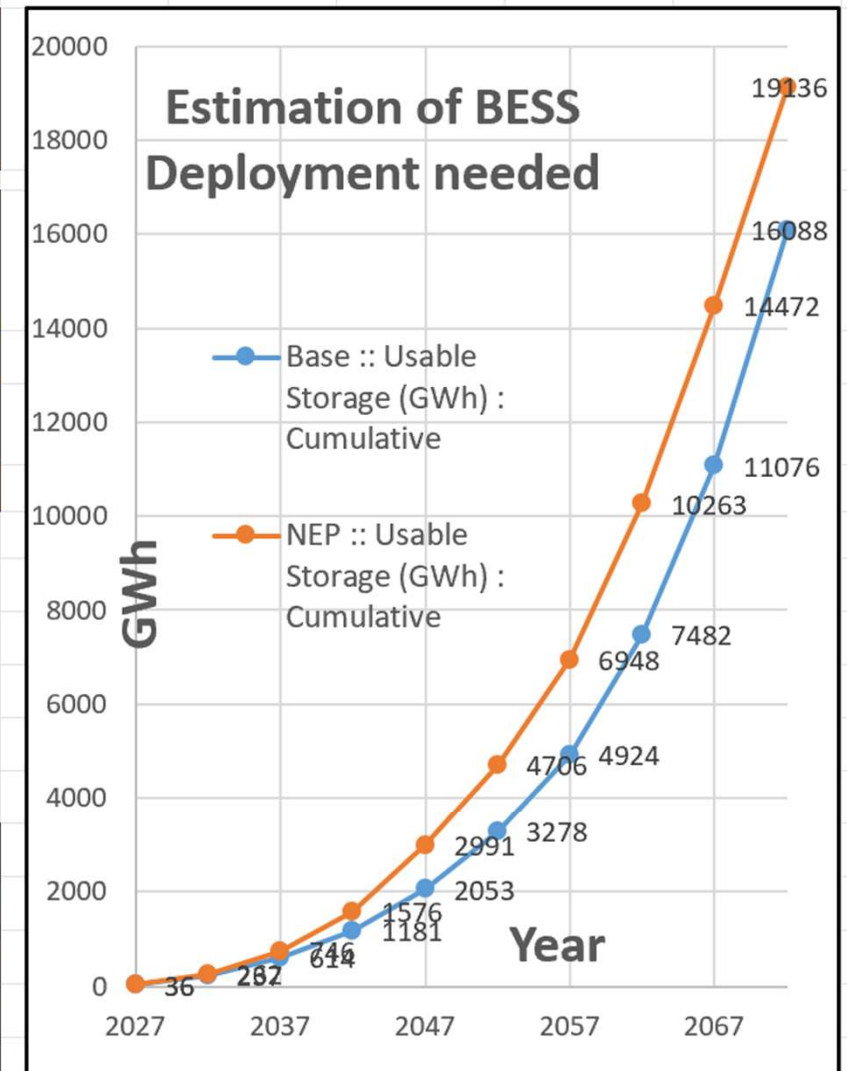


Estimation of ESS required till 2072

For Base & NEP Scenarios

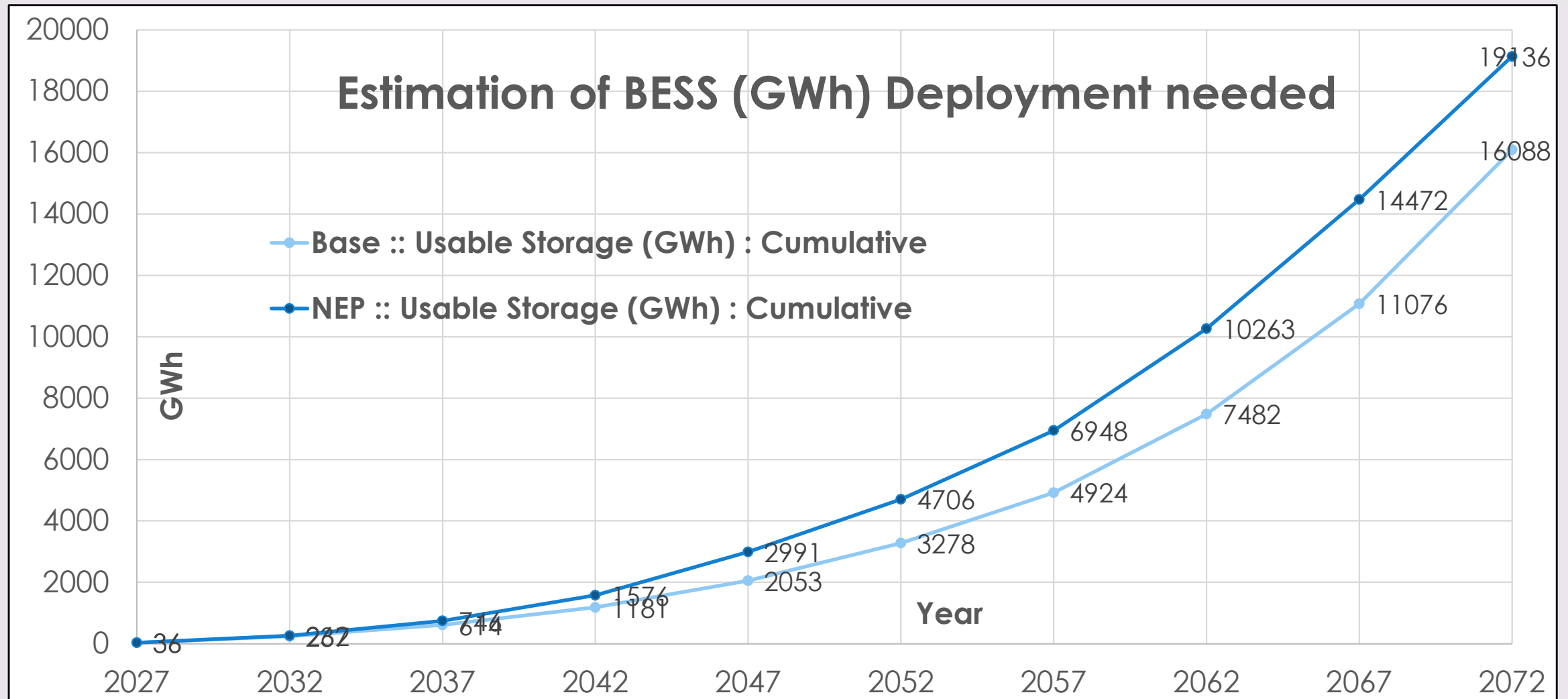
Estimation of BESS Deployment needed & CAGR for both Base & NEP Scenarios

	Base :: Usable Storage (GWh) : Cumulative	75%	52%		NEP :: Usable Storage (GWh) : Cumulative	90%	45%
	Y-O-Y CAGR	11.84%	8.73%		Y-O-Y CAGR	13.70%	7.71%
	Base Scenario				NEP Scenario		
Year	CAGR	Till 2047	Till 2072	Year	CAGR	Till 2047	Till 2072
	0	2			0	2	
2027	36	0		2027	36	0	
2032	237	64		2032	262	69	
2037	614	415		2037	746	498	
2042	1181	1074		2042	1576	1417	
2047	2053	2067		2047	2991	2994	
2052	3278		3142	2052	4706		4341
2057	4924		4775	2057	6948		6295
2062	7482		7259	2062	10263		9127
2067	11076		11033	2067	14472		13234
2072	16088		16770	2072	19136		19190



Estimation of ESS required till 2072

For year 2072 → Base (16088 GWh) & NEP (19136 GWh) Scenarios



Reference Sources used for data and Assumptions

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