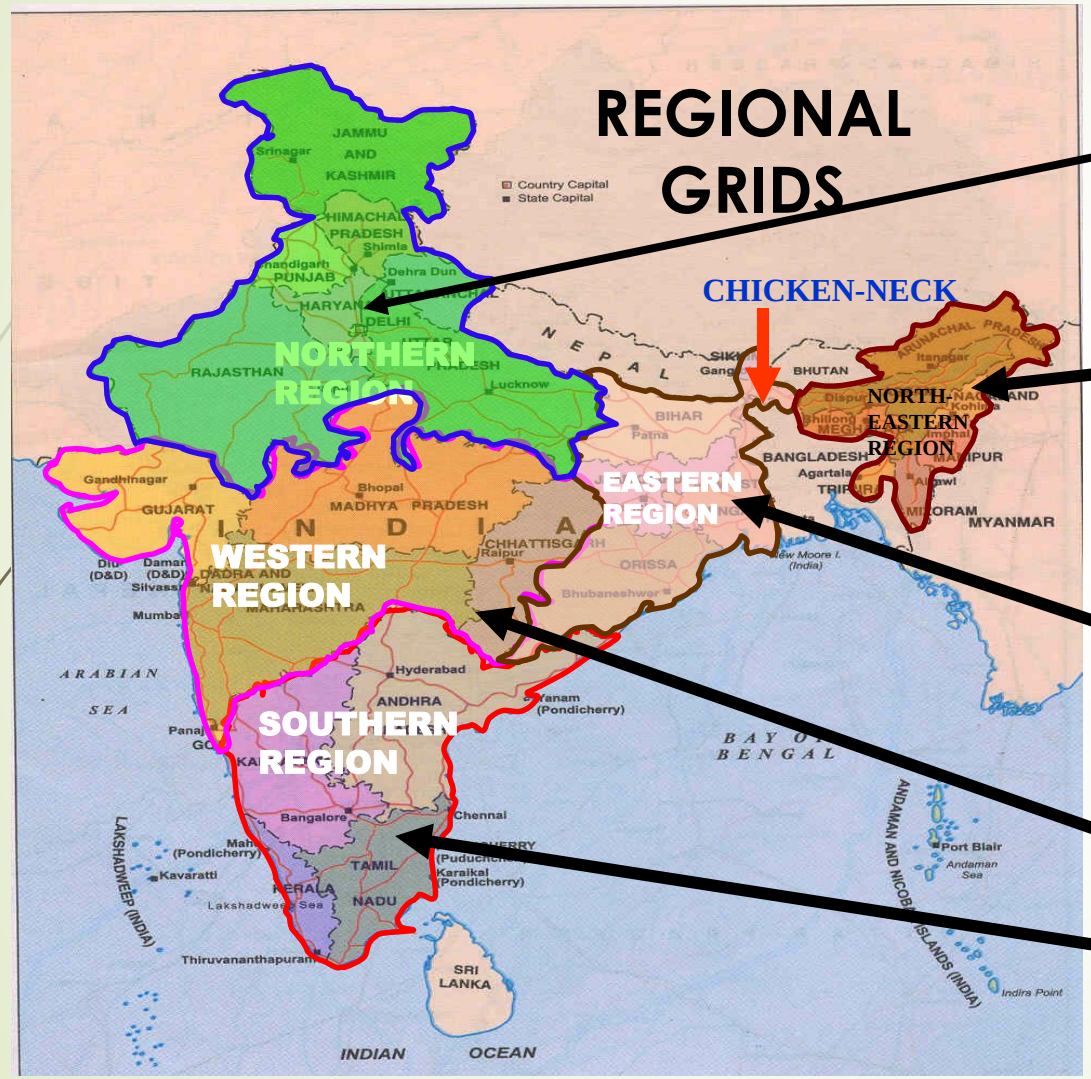
INDIAN POWER SECTOR AN OVERVIEW

P. ESTHER KAMALA
DIRECTOR(IRP)
CENTRAL ELECTRICITY AUTHORITY

Structure of Indian Electricity Sector

Policy Making	Central Government	CEA	State Government
Regulators	Central Electricity Regulatory Commission	State Electricity Regulatory Commission	
System Operators	National Load Despatch Centre	Regional Load Despatch Centres	State Load Despatch Centres
Generation	Central Generating Stations	State Generating Stations	Private Sector Players
Transmission	Central Transmission Utility	State Transmission Utilities	Private Sector Players
Distribution	State Sector Distribution Licensee	Private Sector Distribution Licensee	
Markets	Trading Licensee	Power Exchanges	Bilateral Markets

Peculiarities of Regional Grids in India



Deficit Region

Snow fed - run-of -the -river hydro

Highly weather sensitive load

Adverse weather conditions: Fog & Dust Storm

Very low load

High hydro potential

Evacuation problems

Low load

High coal reserves

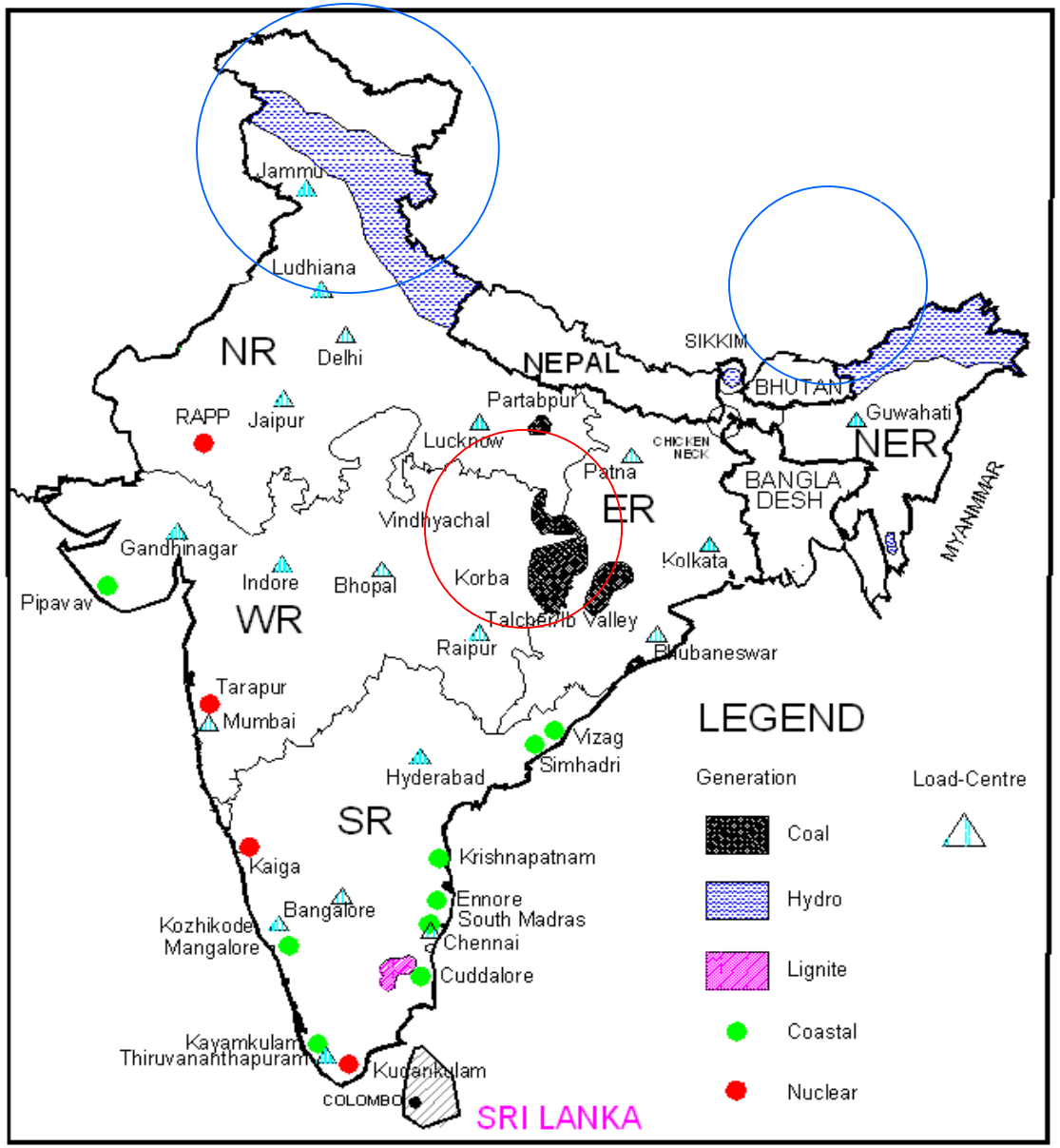
Pit head base load plants

Industrial load and agricultural load

High load (40% agricultural load)

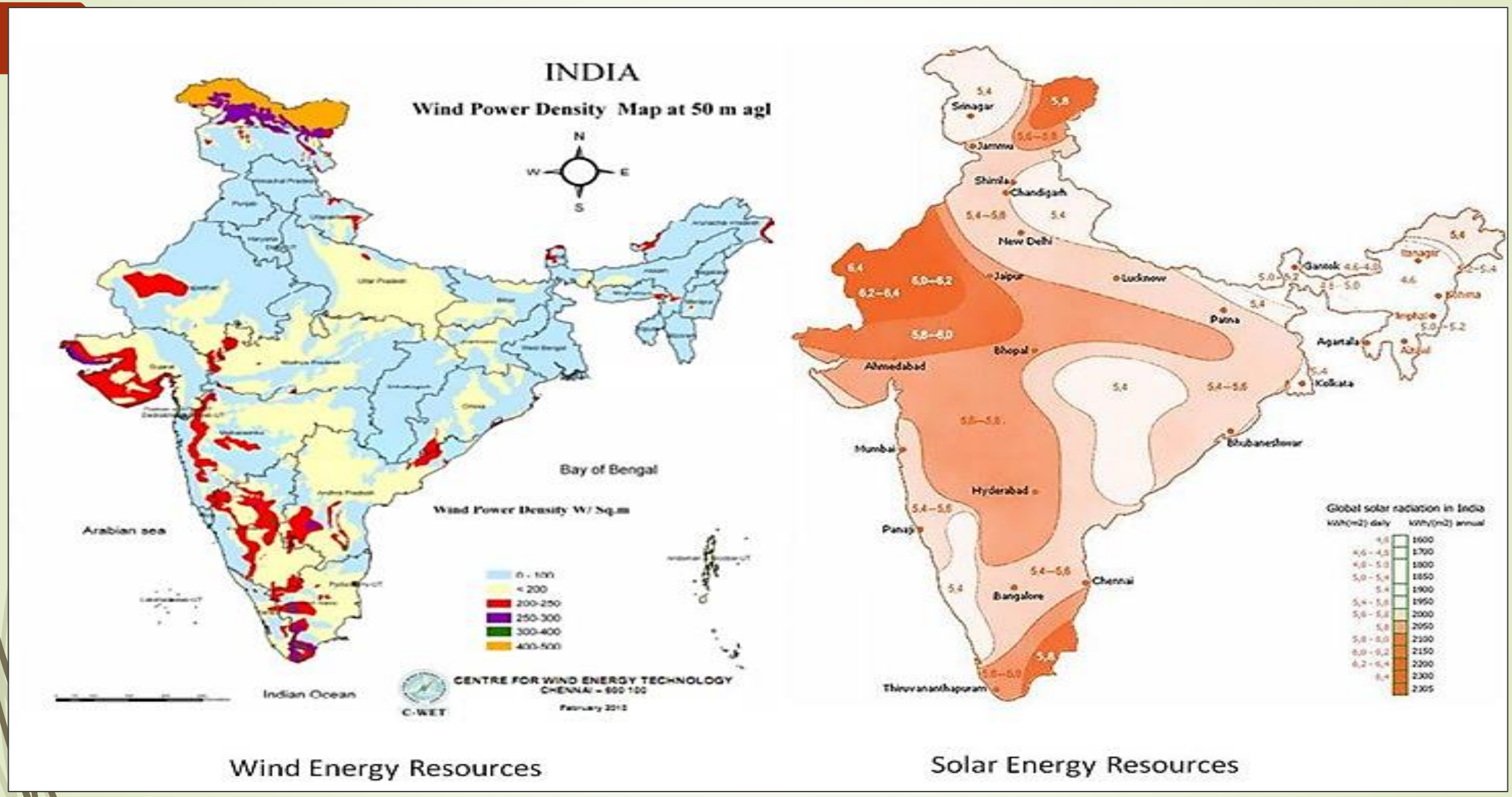
Monsoon dependent hydro

Energy Resource Map



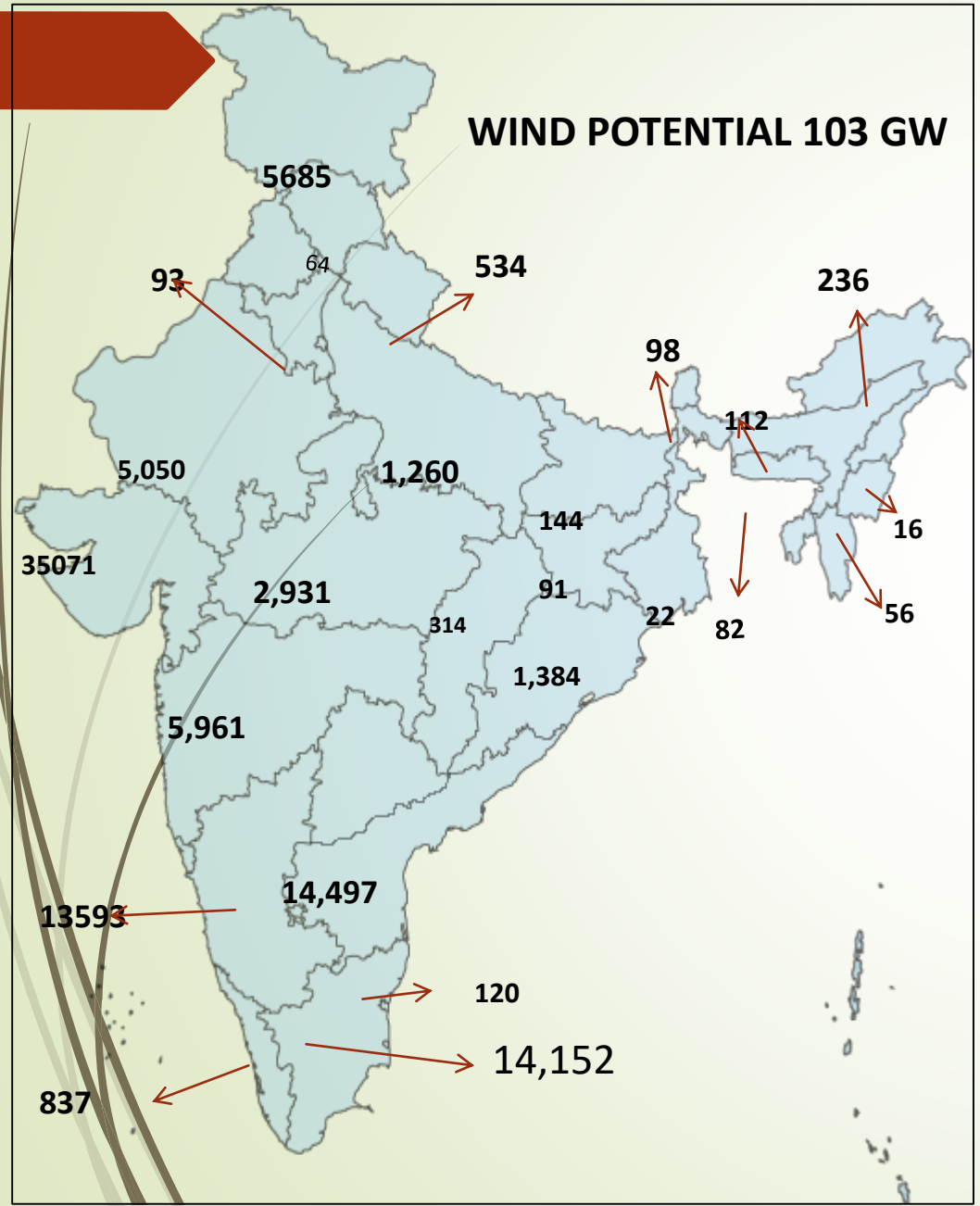
- **Hydro potential in NER and upper part of NR**
- **Coal reserves mainly in ER**

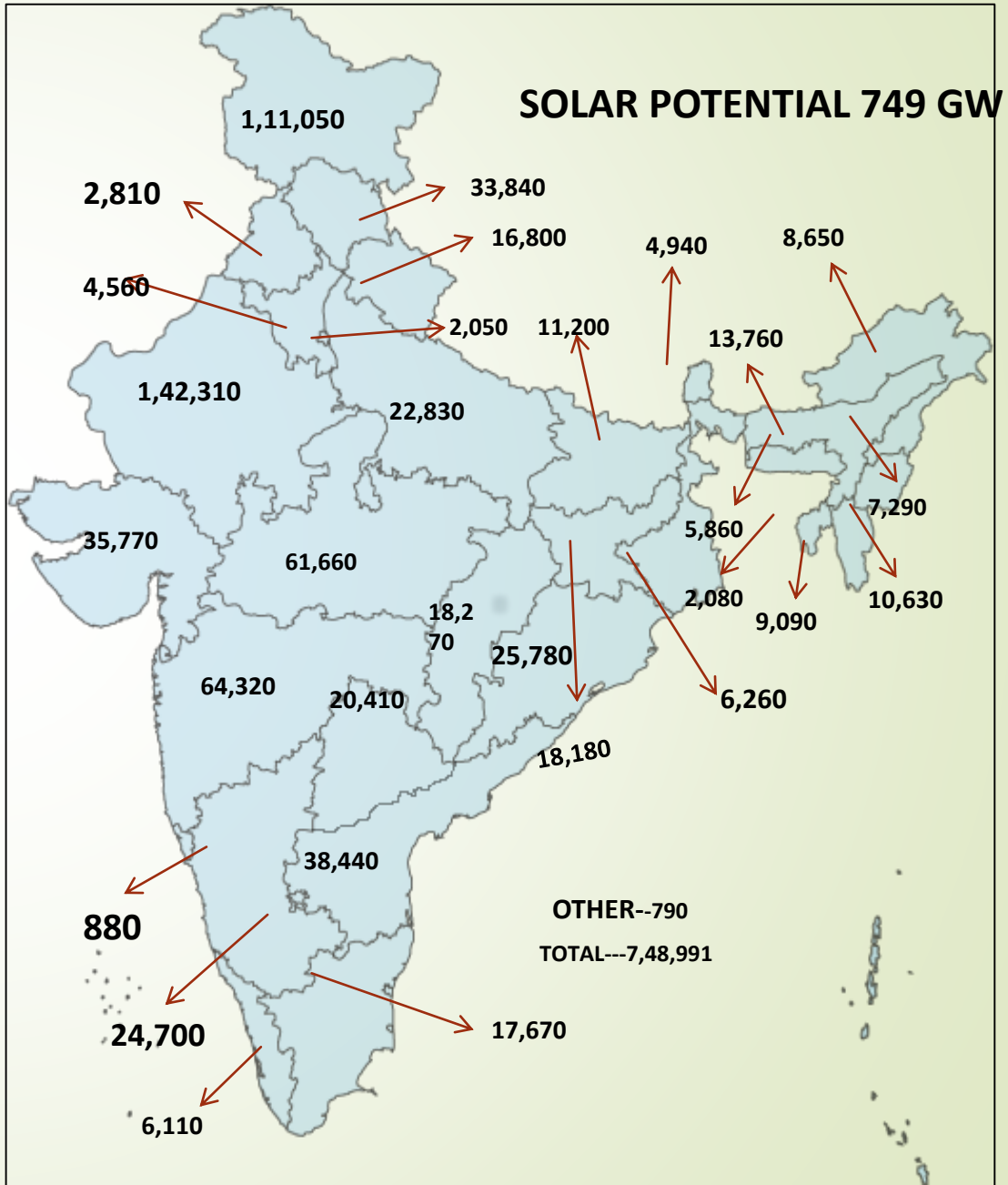
WIND AND SOLAR ENERGY RESOURCE MAP OF INDIA



(Source CWET, Chennai)

Renewable Energy Potential in India(source:MNRE)



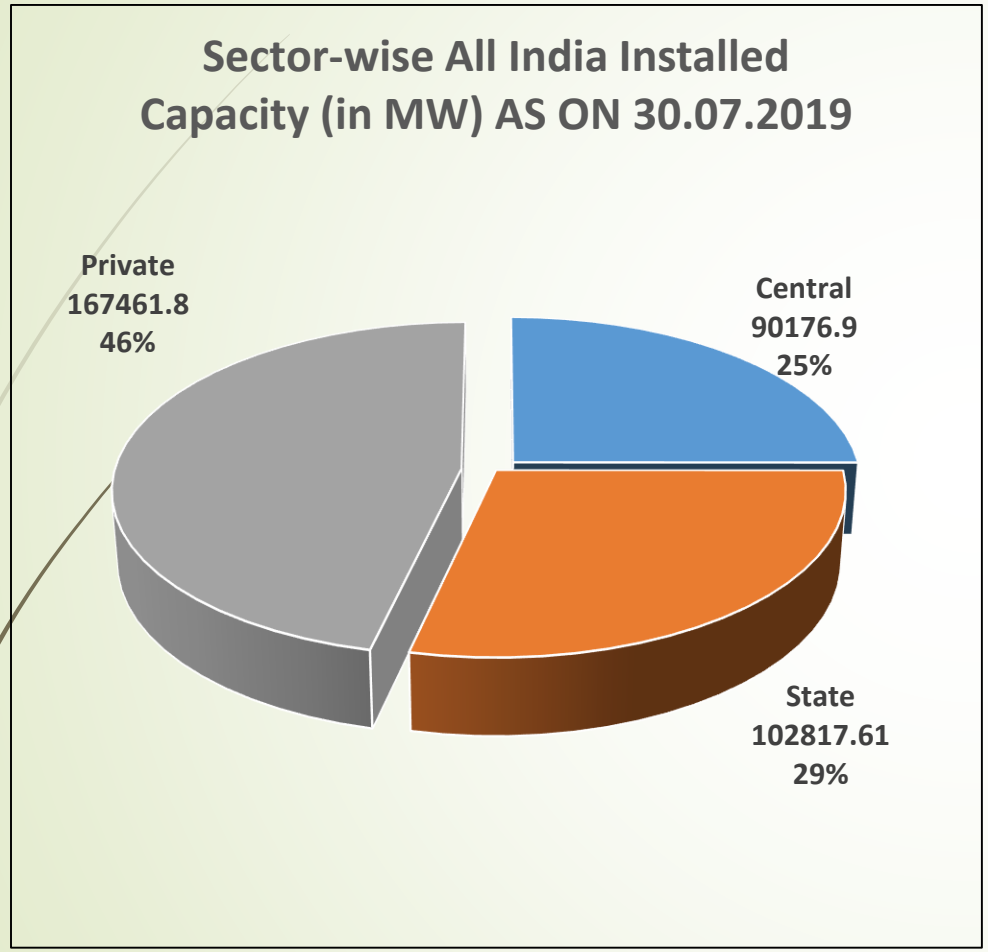


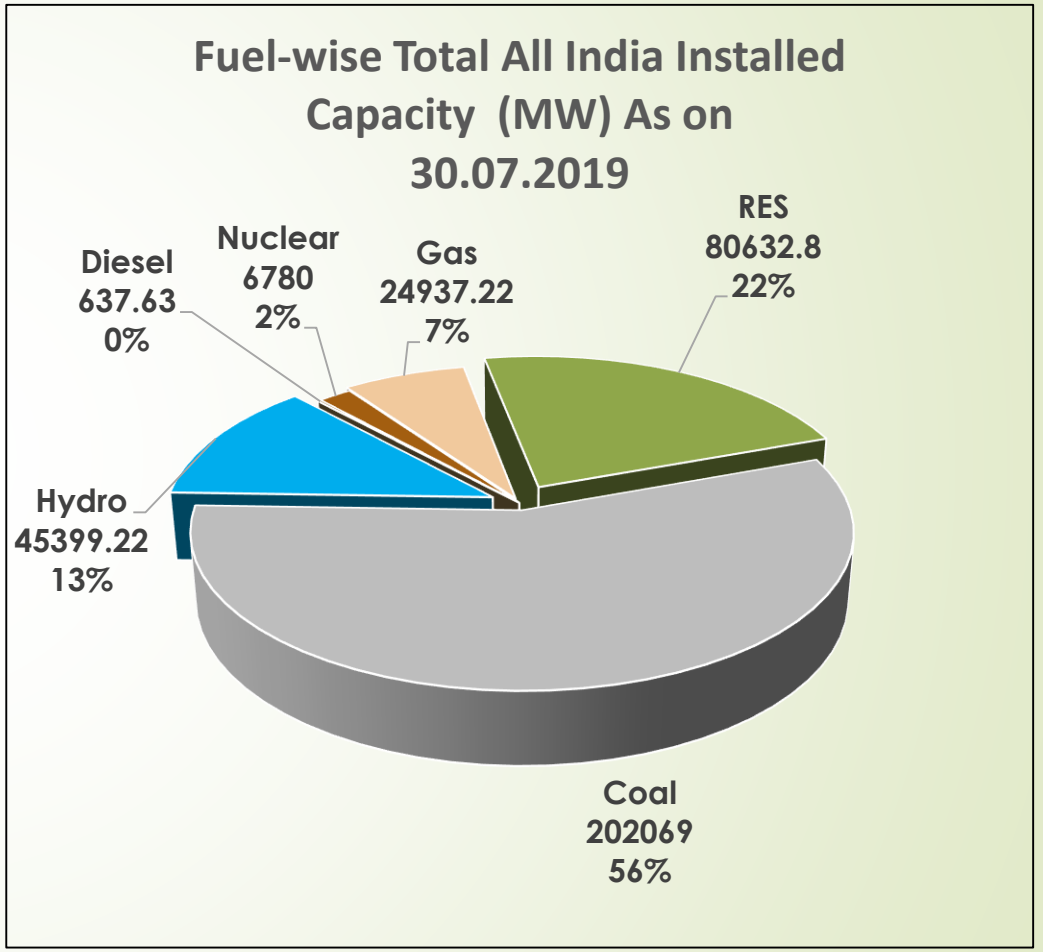
Key Dimensions of Indian Grid

Dimension	Numbers
Area Footprint	3.2 Million Km^2
Population Served	> 1.3 Billion
Peak Demand Met (2018-19)	175.5 GW
Annual Energy Met (2018-19)	1267.5 BU
Installed Capacity as on 31.07.2019	360 GW
Renewable Energy Capacity	79 GW
HVDC Transmission	15,556 CKm
Transmission Network (EHV &HVDC) as on 31.03.2019	681611 CKm
Inter-Regional Transmission Capacity	99 GW
International Exchange with Neighbouring Countries	~ 3 GW
PER CAPITA CONSUMPTION (2018-19)	1181 KWH
T&D LOSSES (2017-18)	21.04%
AT&C LOSSES (2015-16)	23.98%
Annual Trading Volume	56 TWh
Power Exchanges	2

GROWTH OF INDIAN POWER SECTOR

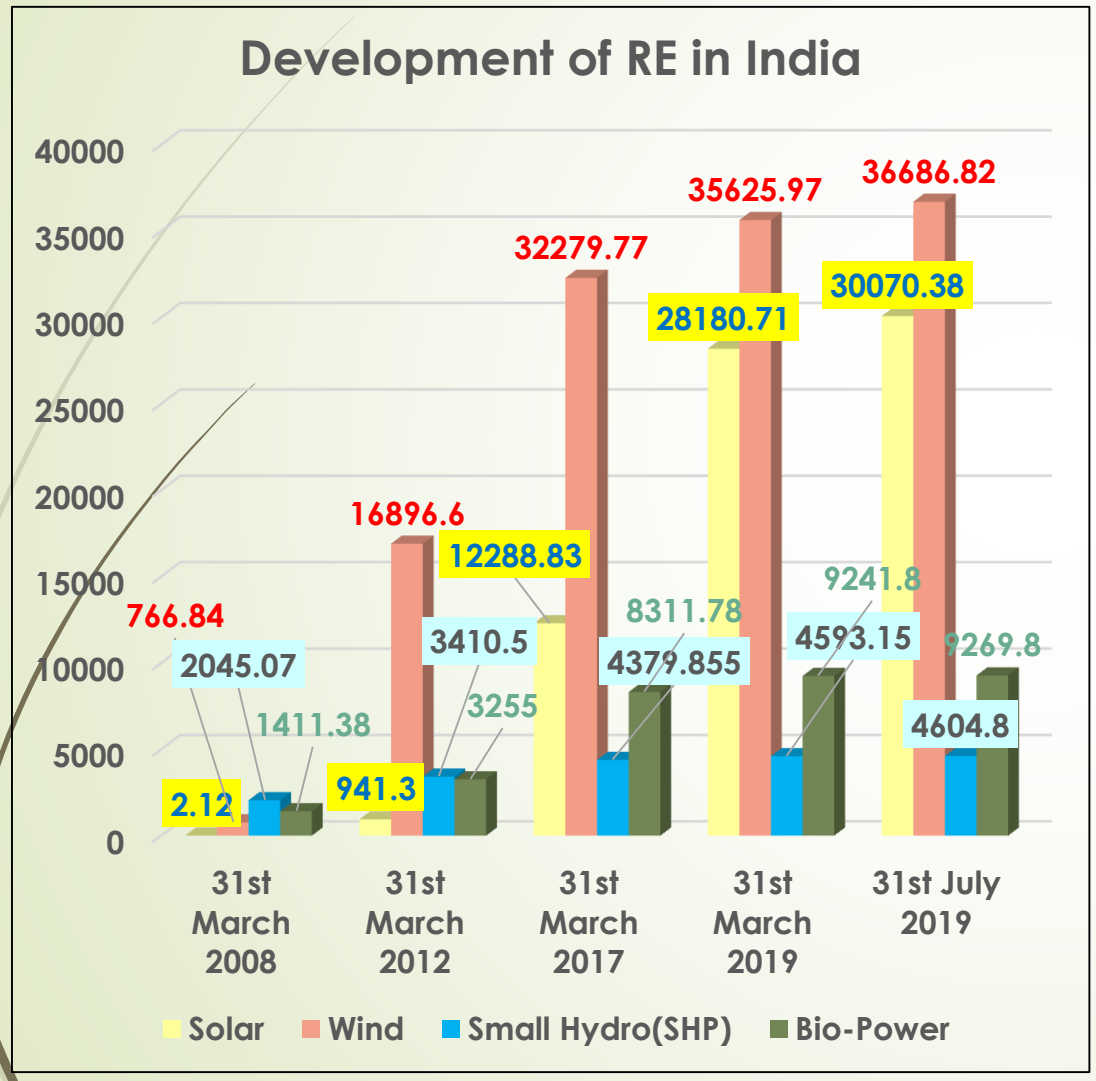
INSTALLED CAPACITY





TOTAL: 3,60,456 MW

INSTALLED CAPACITY- RES



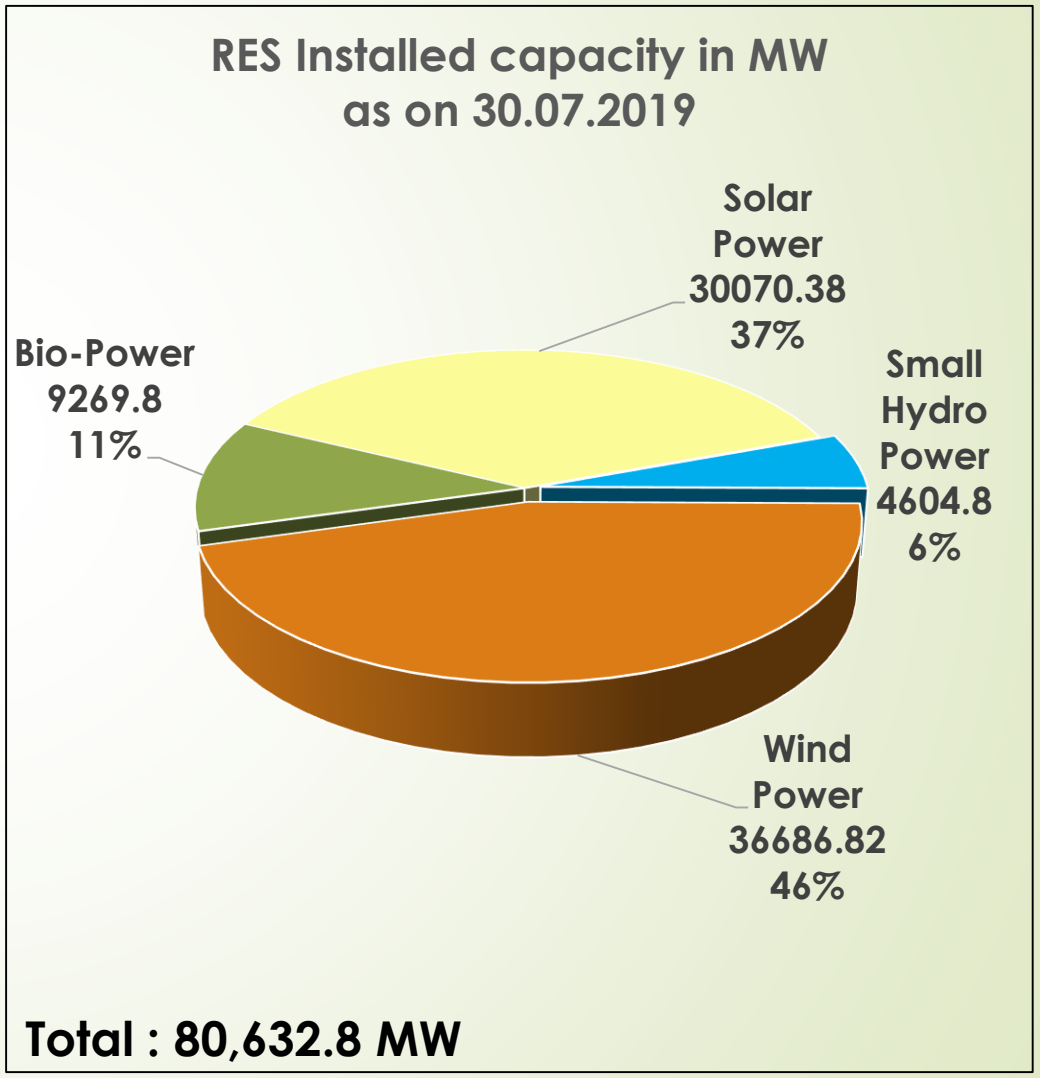
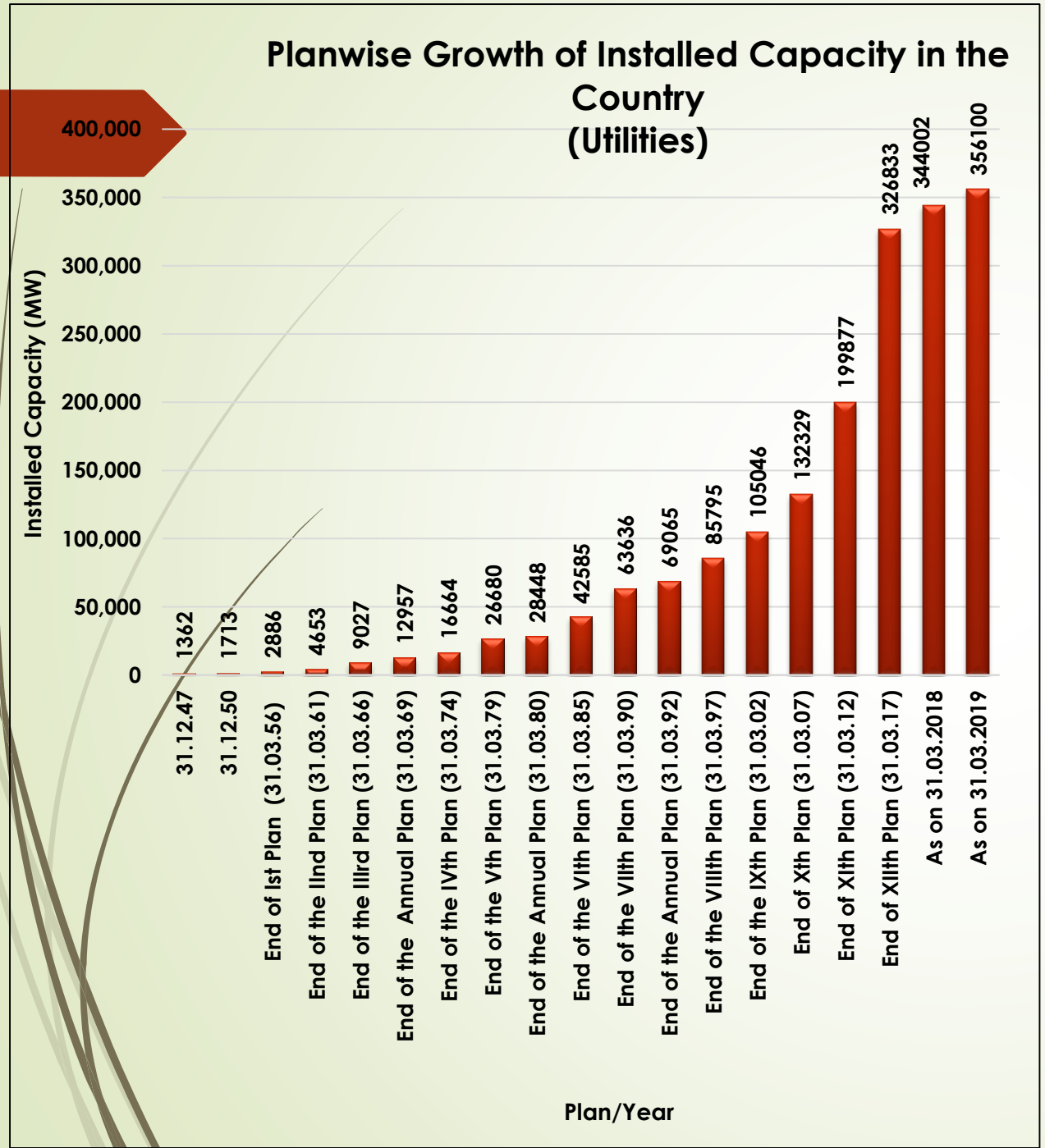
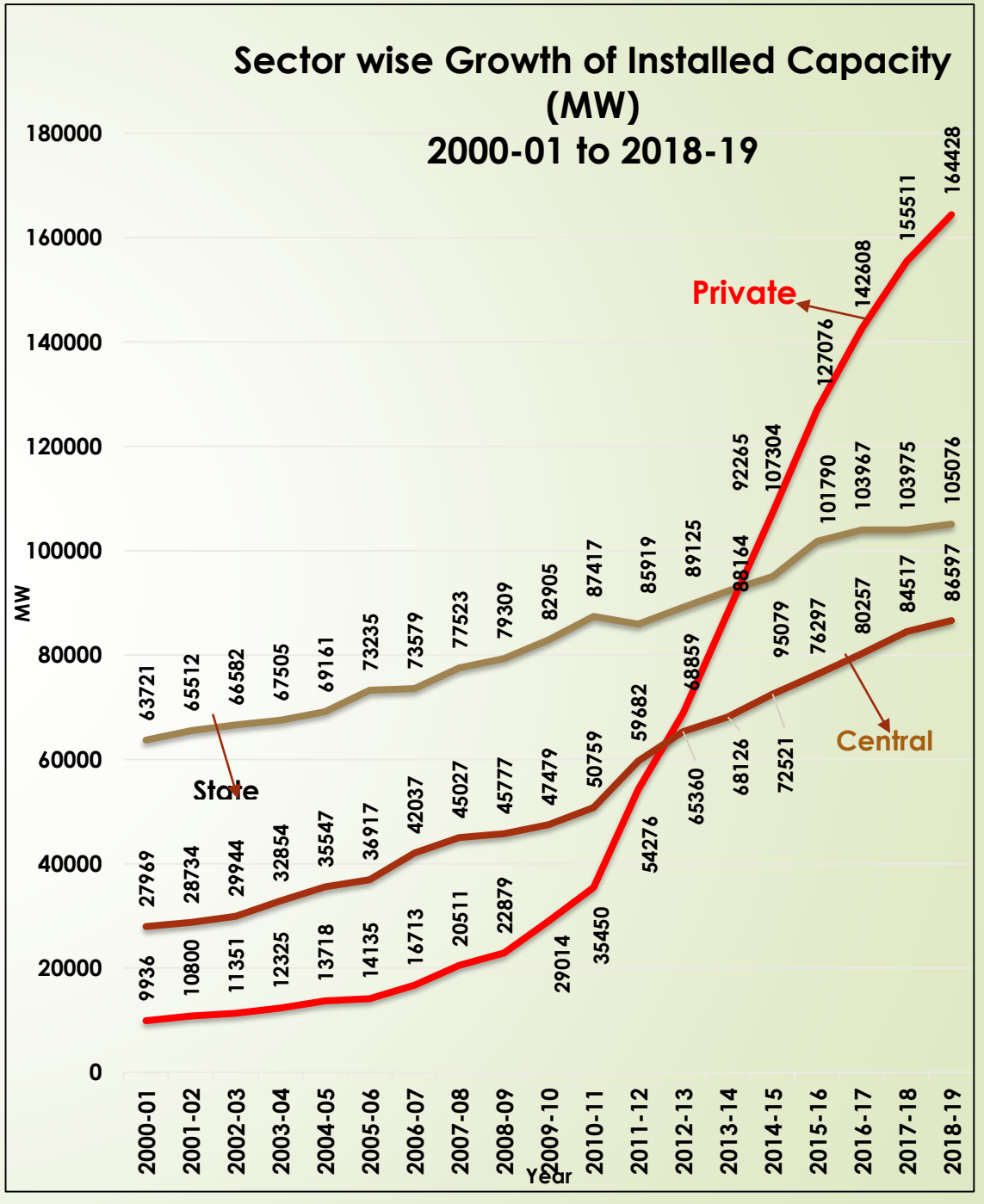
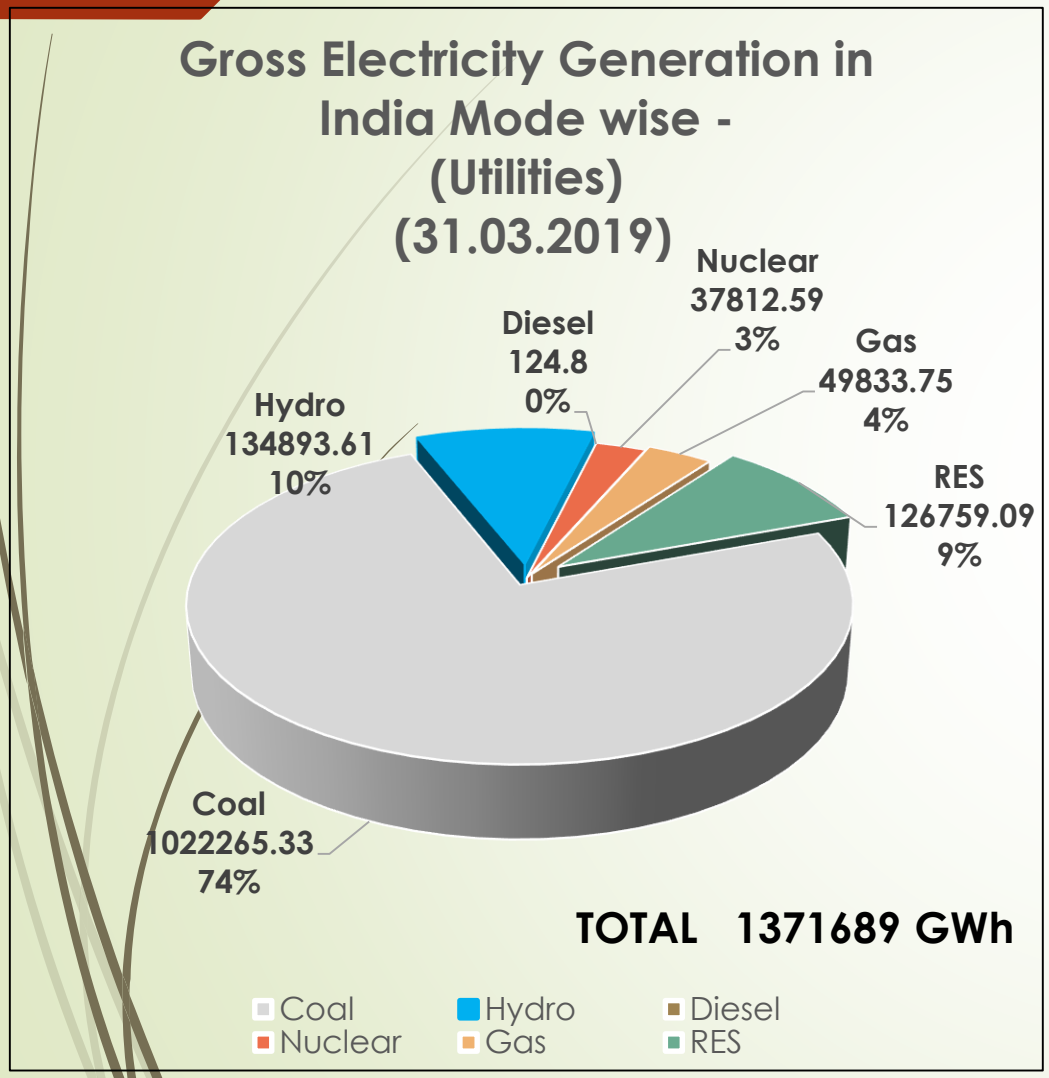


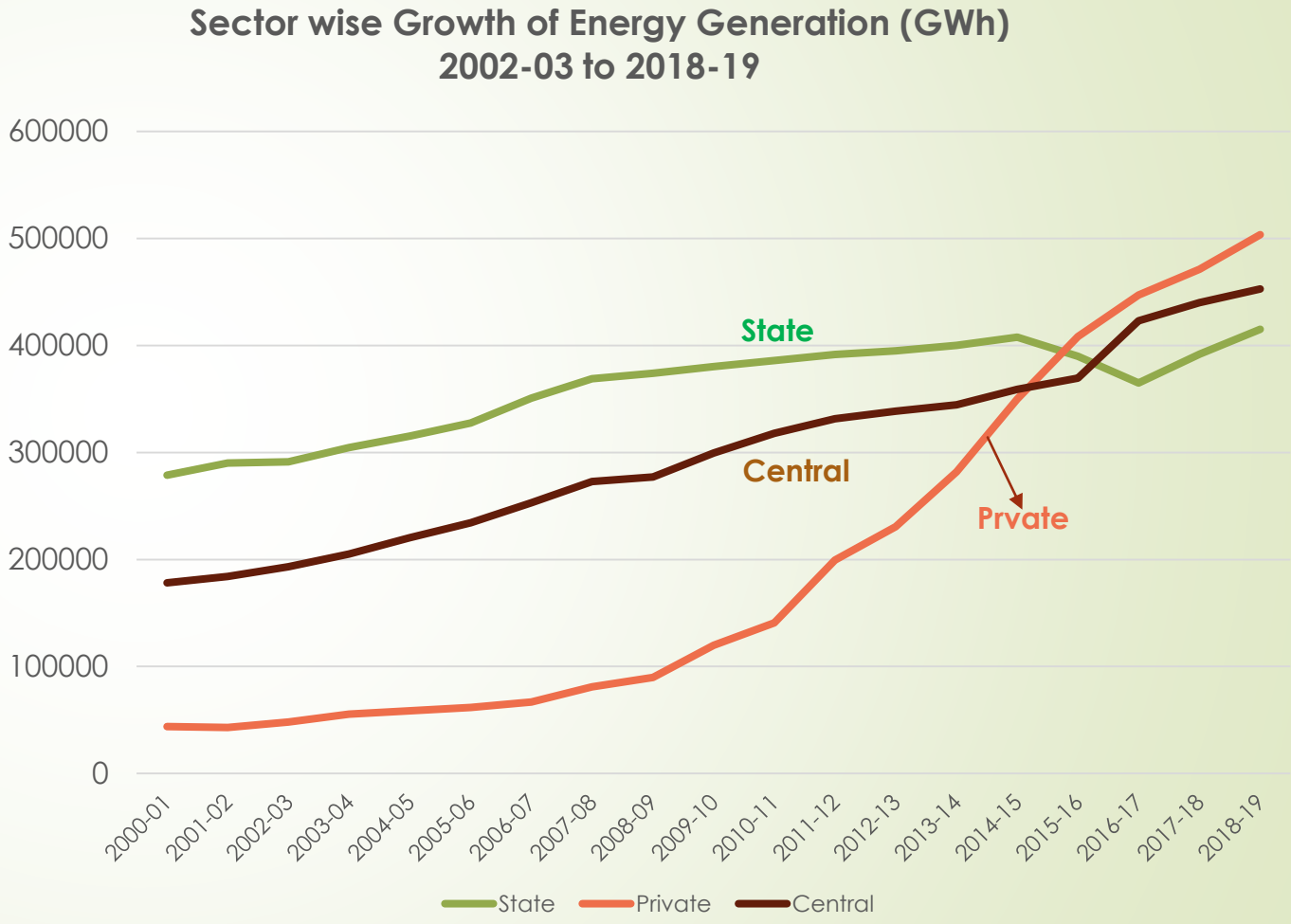
FIG IN MW


Planwise Growth of Installed Capacity in the Country
(Utilities)
Installed Capacity (MW)
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1362
1713
2886
4653
9027
12957
16664
26680
28448
42585
63636
69065
85795
105046
132329
199877
326833
344002
356100
31.12.47
31.12.50
End of Ist Plan (31.03.56)
End of the IInd Plan (31.03.61)
End of the IIIrd Plan (31.03.66)
End of the Annual Plan (31.03.69)
End of the IVth Plan (31.03.74)
End of the Vth Plan (31.03.79)
End of the Annual Plan (31.03.80)
End of the VIth Plan (31.03.85)
End of the VIIth Plan (31.03.90)
End of the Annual Plan (31.03.92)
End of the VIIIth Plan (31.03.97)
End of the IXth Plan (31.03.02)
End of Xth Plan (31.03.07)
End of XIth Plan (31.03.12)
End of XIIth Plan (31.03.17)
As on 31.03.2018
As on 31.03.2019
Plan/Year


Sector wise Growth of Installed Capacity
(MW)
2000-01 to 2018-19
MW
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Private
State
Central
63721
65512
66582
67505
69161
73235
73579
77523
79309
82905
87417
85919
89125
92265
107304
127076
142608
155511
164428
27969
28734
29944
32854
35547
36917
42037
45027
45777
47479
50759
59682
68859
88164
101790
103967
103975
105076
9936
10800
11351
12325
13718
14135
16713
20511
22879
29014
35450
54276
65360
68126
72521
76297
80257
84517
86597
2000-01
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
Year

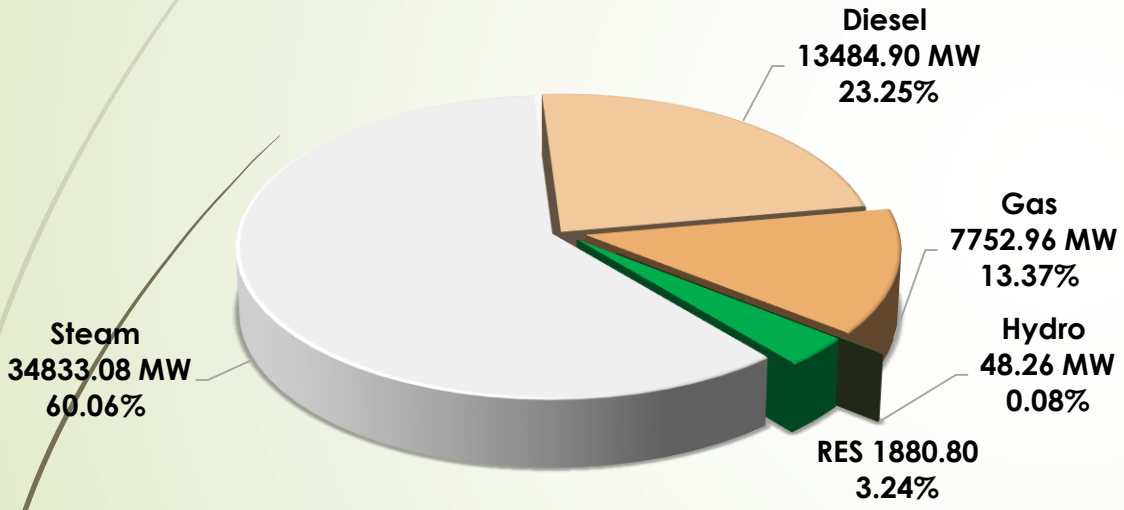
GENERATION(2018-19)





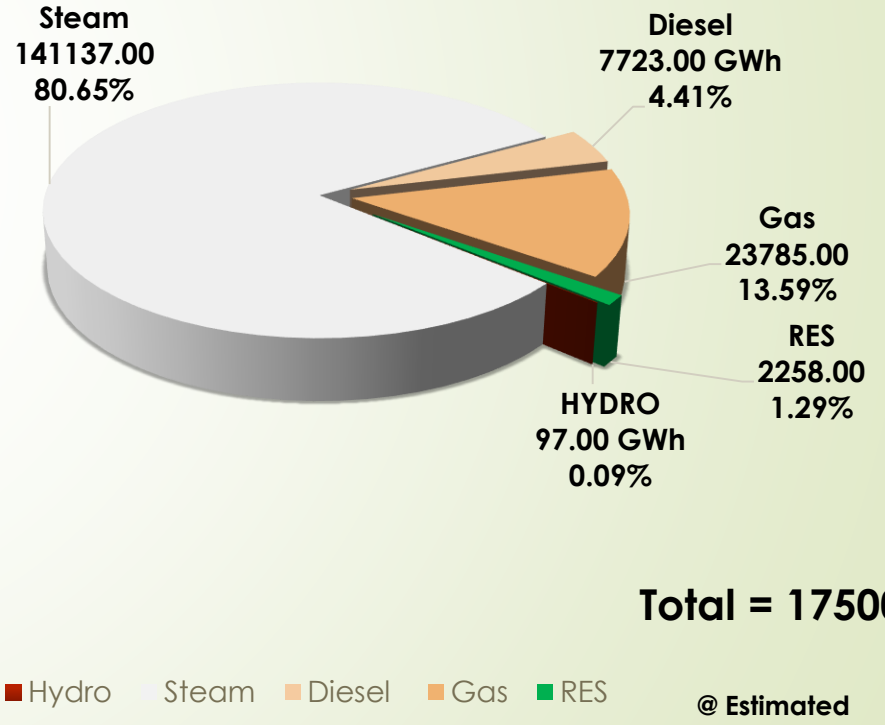
ALL FIGURES IN GWh

Installed Generating Capacity and Generation of Captive Power Plants in Industries having Demand of 1MW & Above - Mode wise (31.03.2019)@



TOTAL = 58000 MW

@-Estimated



Total = 175000

BROAD TIMELINE

1950

All India IC 1713 MW

Electricity(Supply) Act,1948
State sector Dominant.
Private Sector Participation-licensed
Constant Peak and energy deficit.
Low growth for Central sector

Central Sector IC 2507.5 MW

End of IV Plan (1973-74)

Major Challenges :
Lack of Inter-Regional Transmission Network.
Default in Payments by SEBs and lack of liquidity-Single point tariff.

Inadequate Resources led Constitution of Central companies: NTPC, NHPC , NEEPCO , NPCIL.
Large Capacities(200/210 MW)
Regional Projects-Regional grid.
Rate of growth of Central sector outpaced State Sector.

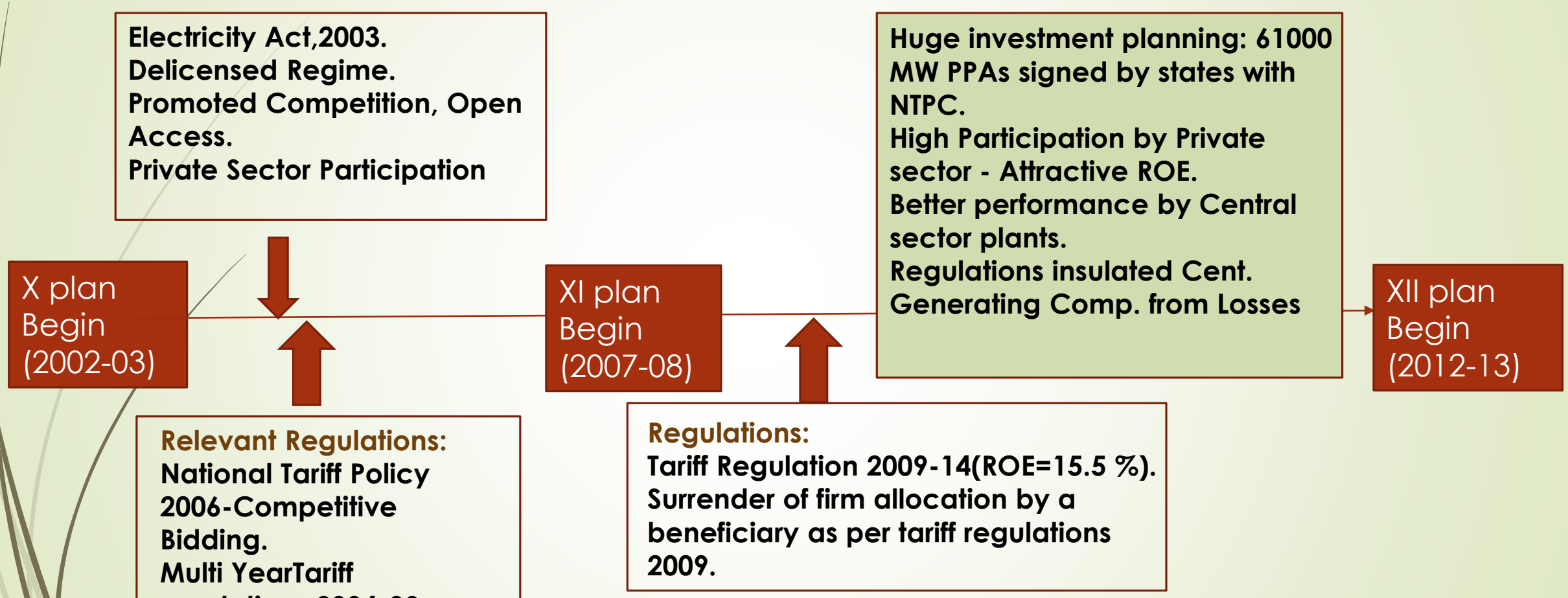
Few Regulations:
Two-part tariff introduced in 1992
CERC was established
ABT introduced in 2000

End of IX Plan (2001-02)

Central Sector IC 31605.5 MW (30%)

Huge Demand for CGS Power

Timeline: X–XII Plan (2002-2017)



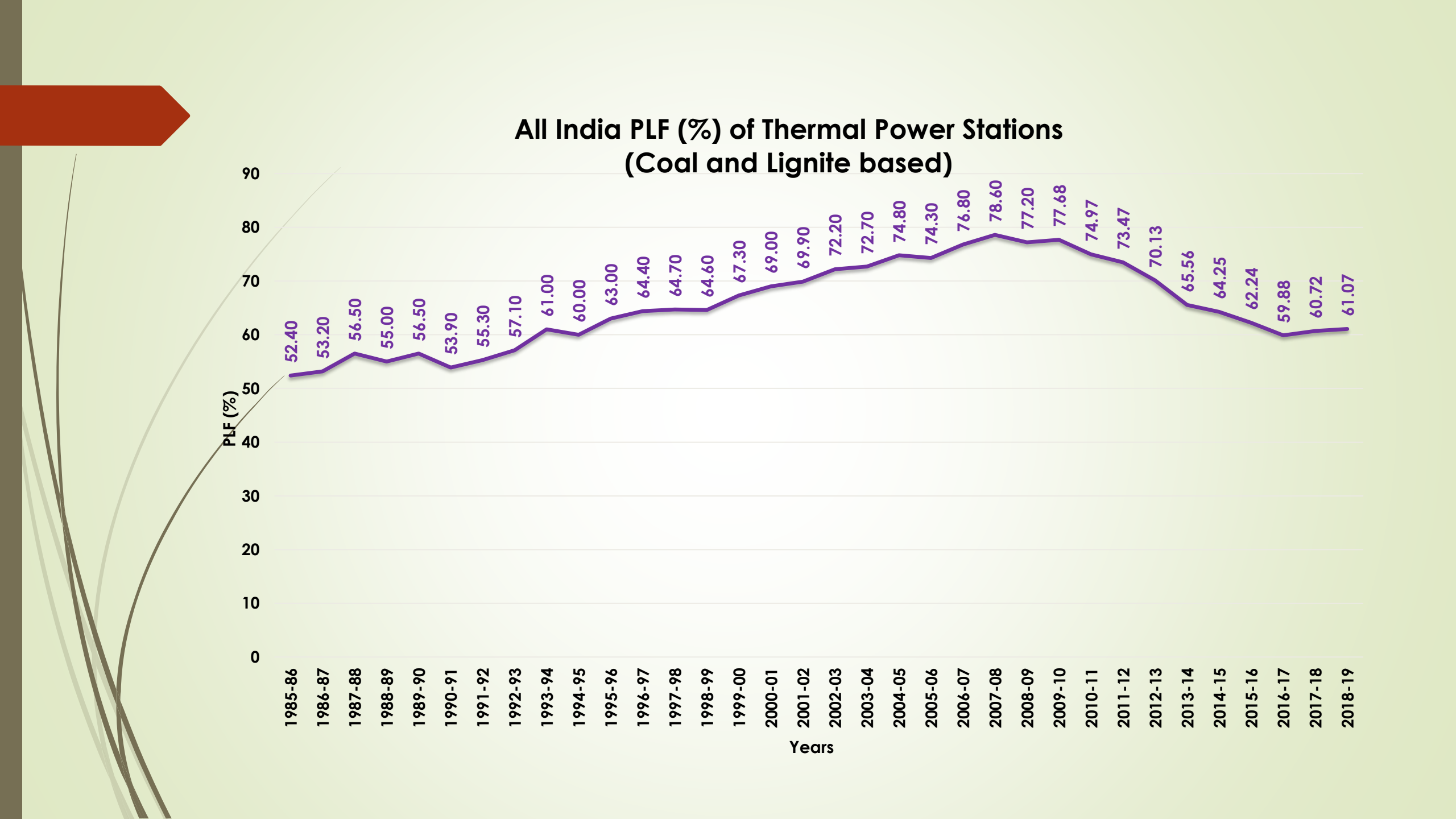
Current scenario

Surrendering of firm power by states to the tune of 3890 MW.

Highest ever capacity addition - private sector.
Power Exchanges flourished.
Power tariffs have reduced in open market.
High Tariffs for non-pit head CGSs.
Surplus power for many states.

Demand of Power from CGSs

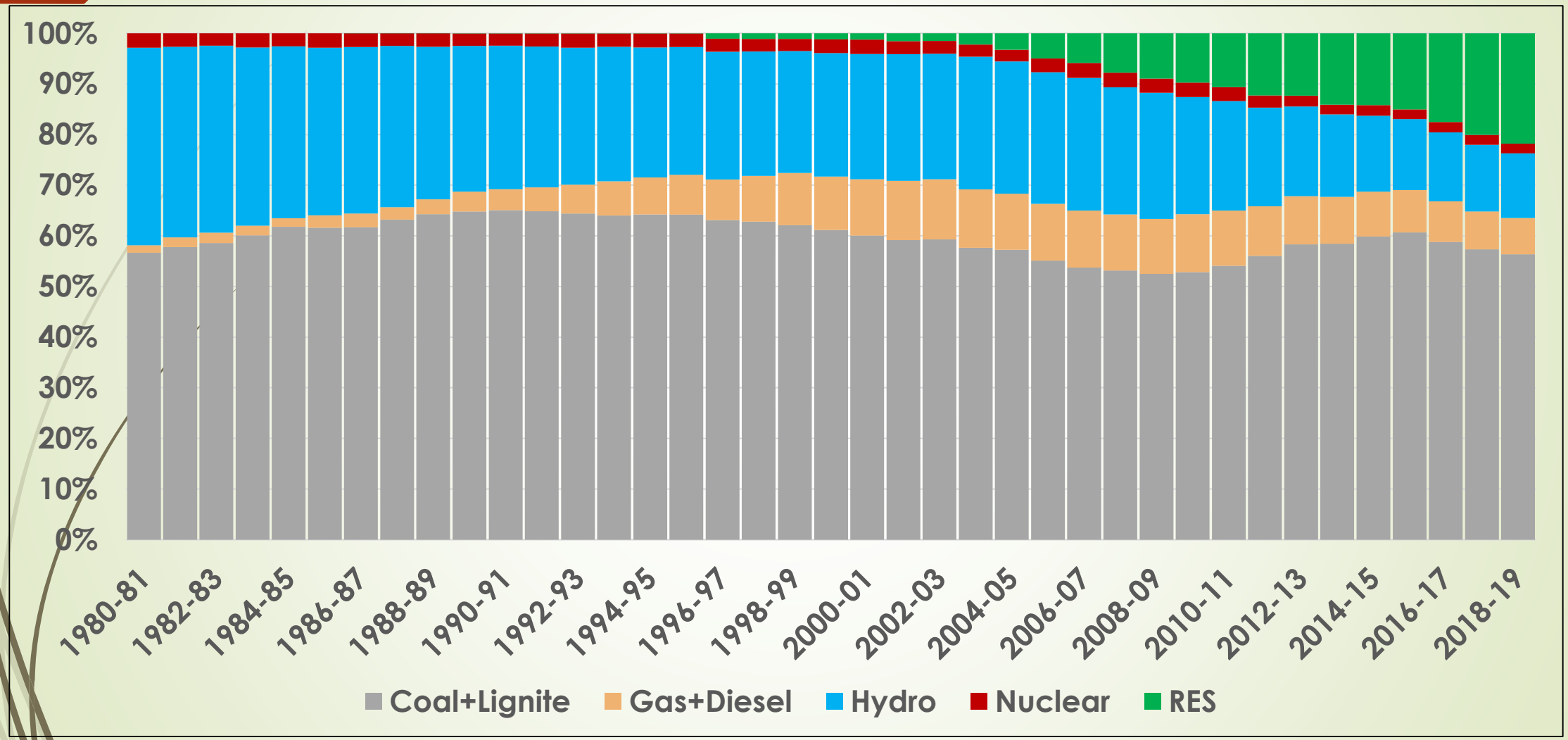
XII Plan


All India PLF (%) of Thermal Power Stations
(Coal and Lignite based)
PLF (%)
Years
0
10
20
30
40
50
60
70
80
90
52.40
53.20
56.50
55.00
56.50
53.90
55.30
57.10
61.00
60.00
63.00
64.40
64.70
64.60
67.30
69.00
69.90
72.20
72.70
74.80
74.30
76.80
78.60
77.20
77.68
74.97
73.47
70.13
65.56
64.25
62.24
59.88
60.72
61.07
1985-86
1986-87
1987-88
1988-89
1989-90
1990-91
1991-92
1992-93
1993-94
1994-95
1995-96
1996-97
1997-98
1998-99
1999-00
2000-01
2001-02
2002-03
2003-04
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19

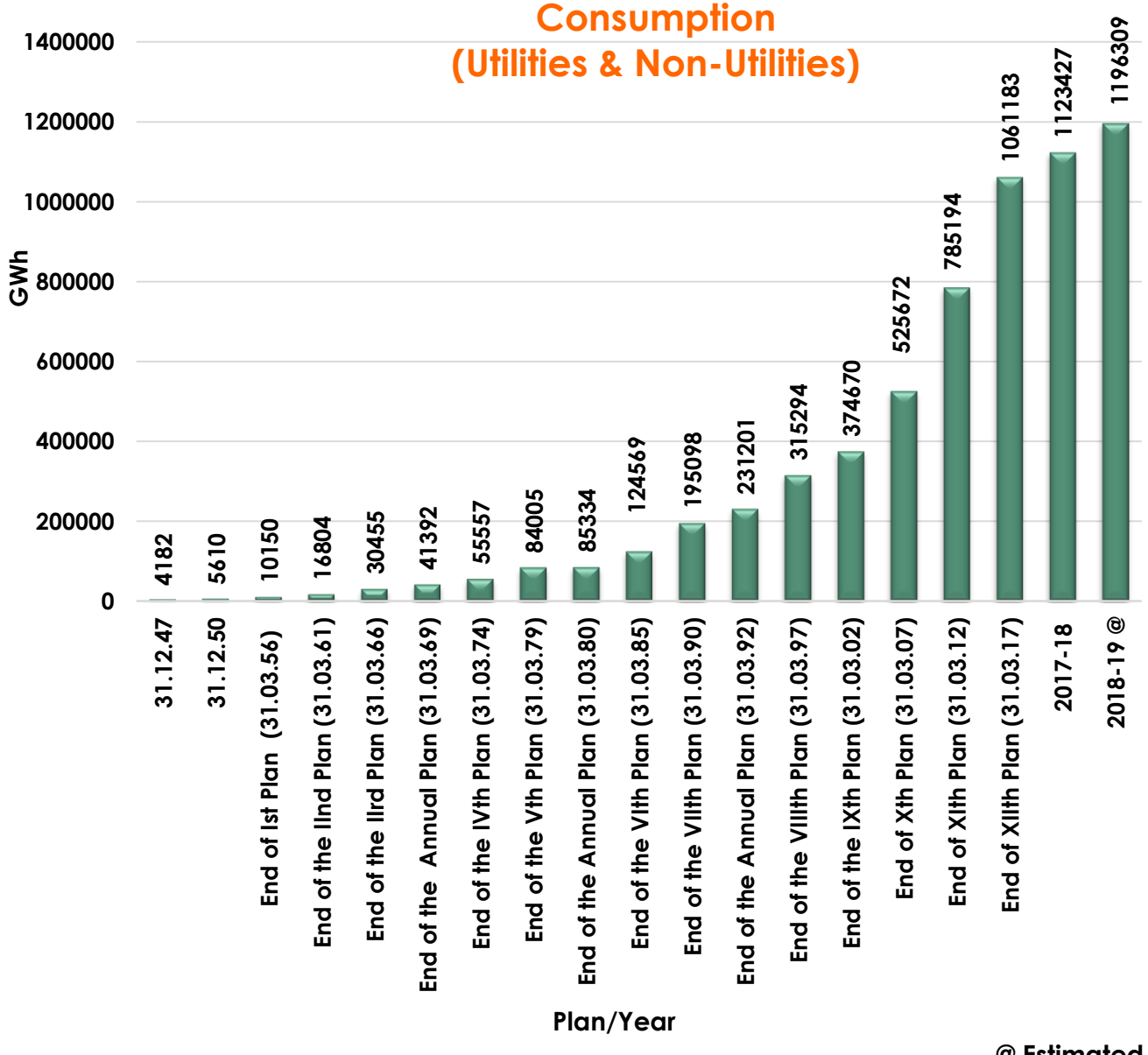
Major Unit Sizes and Steam parameters

Size MW	Efficiency (%)	Year
30-50	~31	1950
60-100	32-33	1960
110 to150	35-36	1970
200/210	36.3 -37.8	1977
250	38.3	1995
500	38.5	1984
500	38.7	2010
660	39.5	2010
660/800	40.5	2012

CAPACITY MIX (SINCE MARCH,1981)

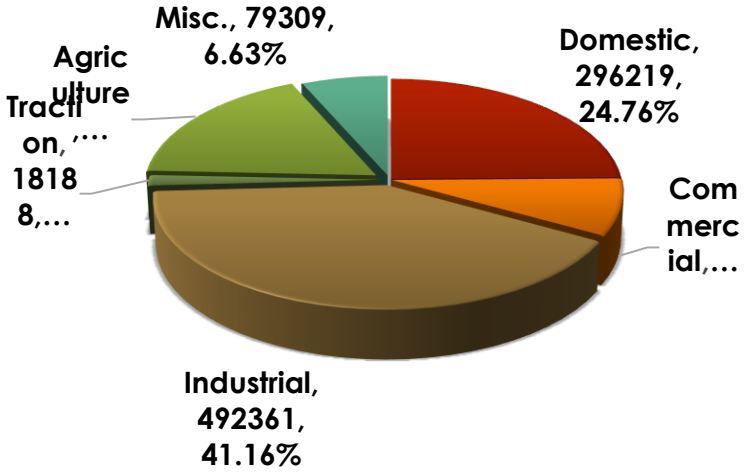


Planwise Growth of All India Total Electricity Consumption (Utilities & Non-Utilities)



@ Estimated

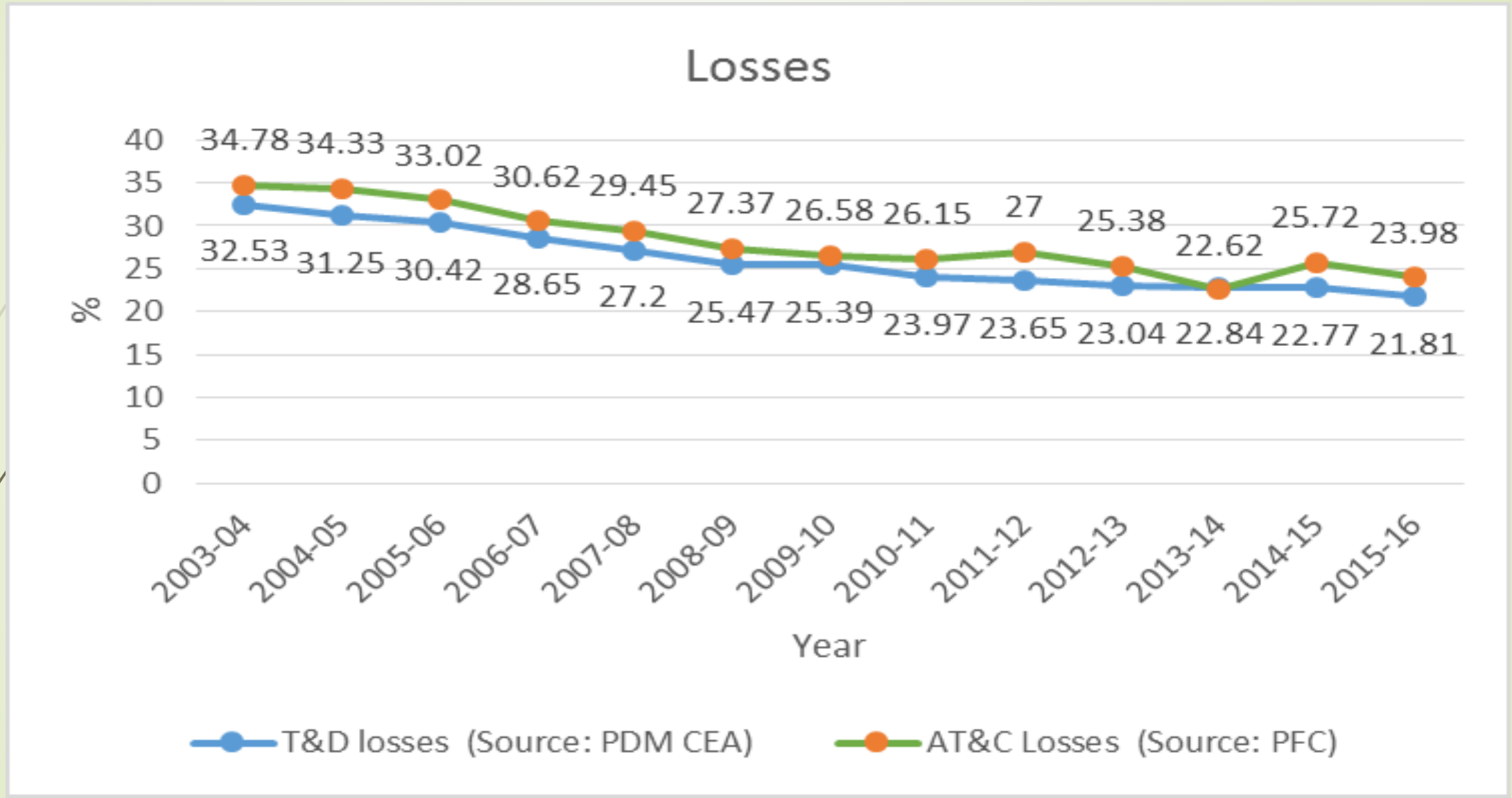
All India Electricity Consumption Sector Wise (Utilities & Non- Utilities) 2018-19@



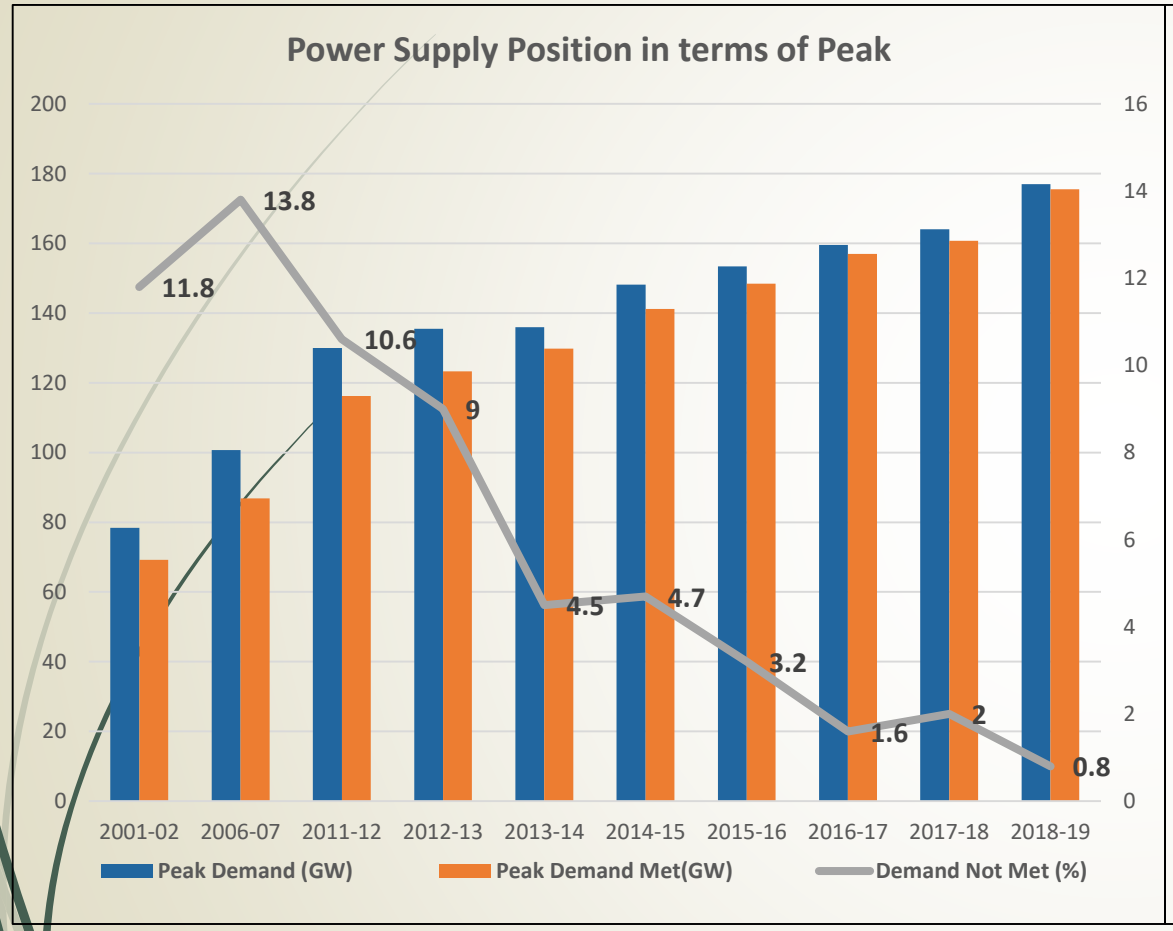
TOTAL = 1196309 GWh

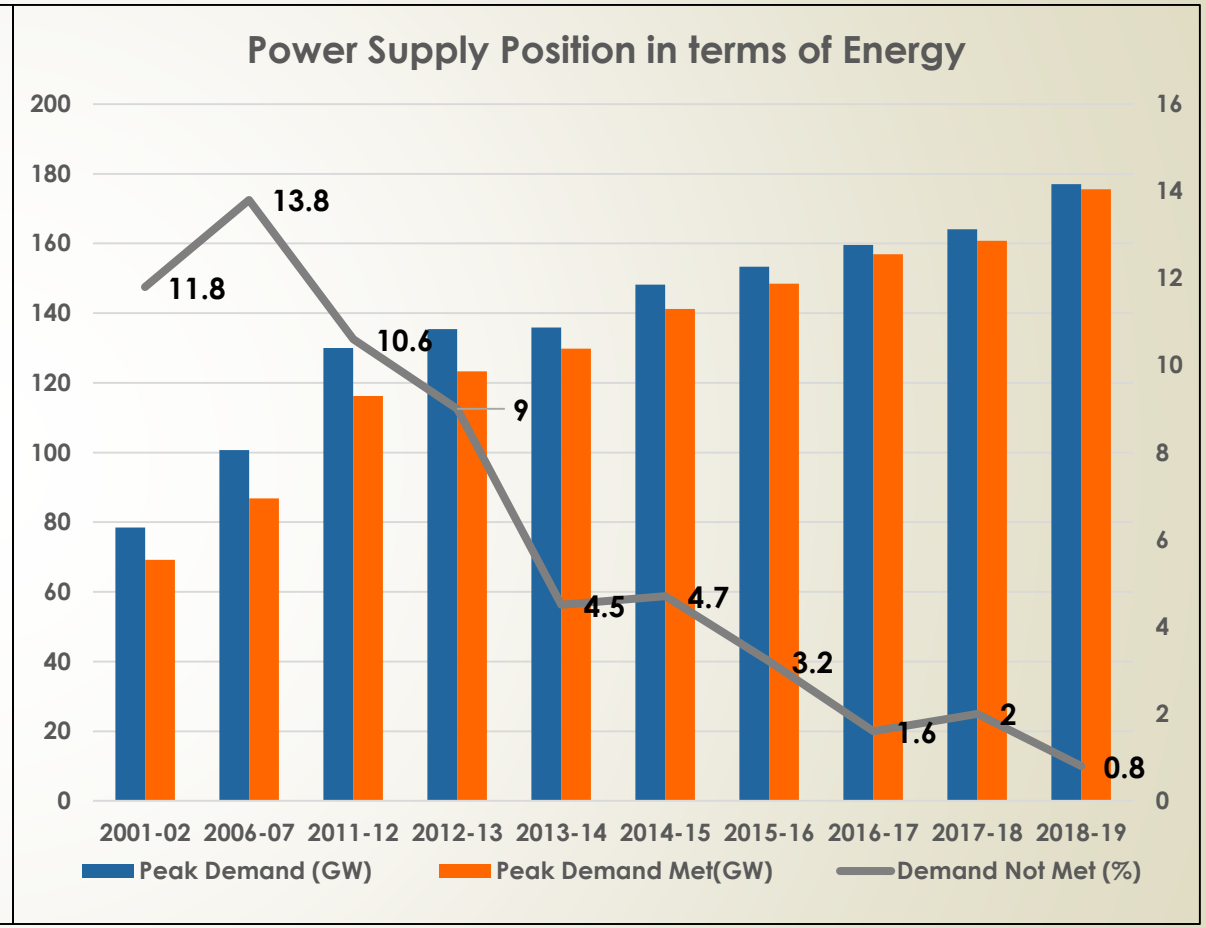
@ Estimated

Domestic Commercial Industrial Traction Agriculture Misc.


Losses
40
35
30
25
20
15
10
5
0
%
34.78
34.33
33.02
30.62
29.45
27.37
26.58
26.15
27
25.38
22.62
25.72
23.98
32.53
31.25
30.42
28.65
27.2
25.47
25.39
23.97
23.65
23.04
22.84
22.77
21.81
2003-04
2004-05
2005-06
2006-07
2007-08
2008-09
2009-10
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16
Year
T&D losses (Source: PDM CEA)
AT&C Losses (Source: PFC)

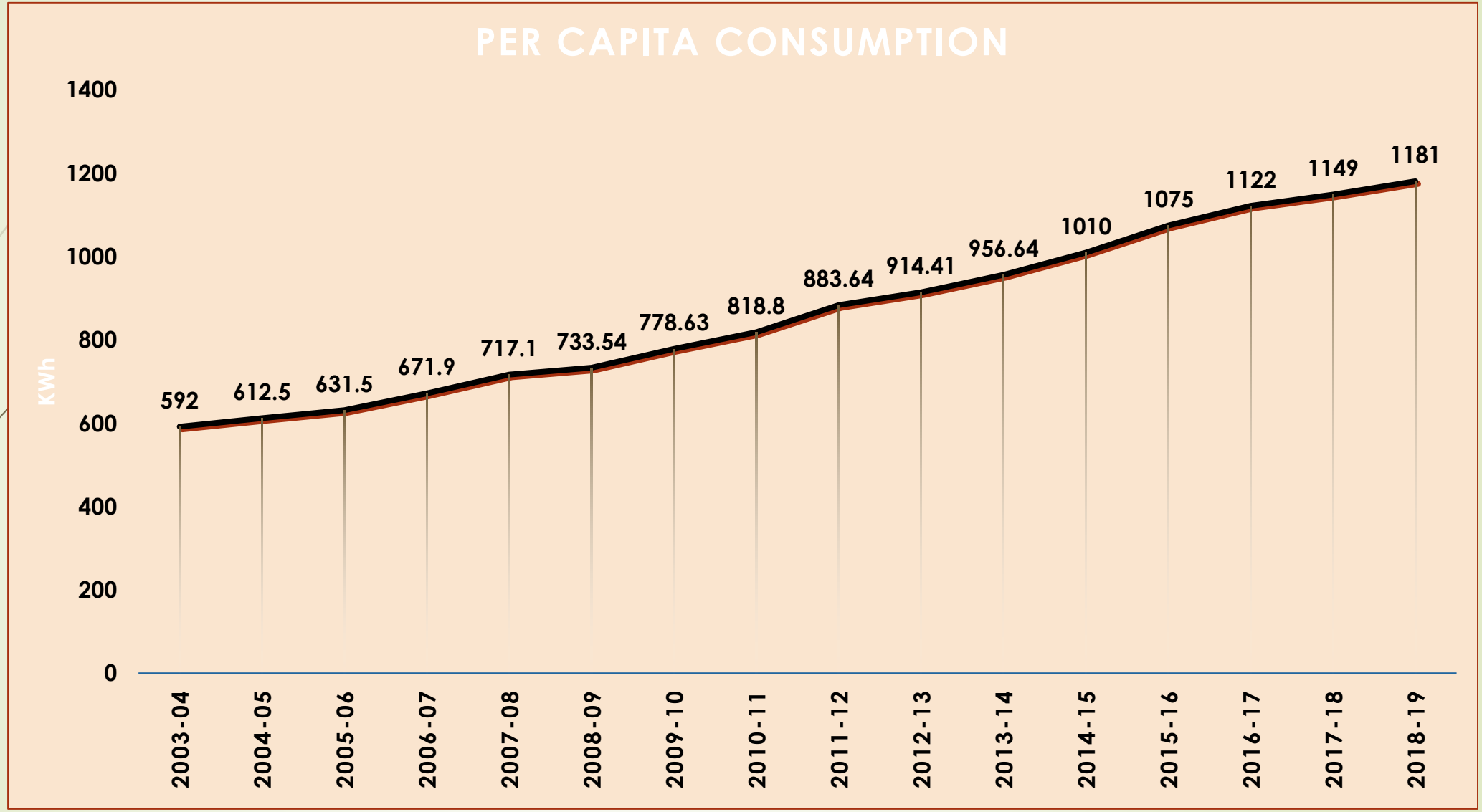
Power Supply Position in the country



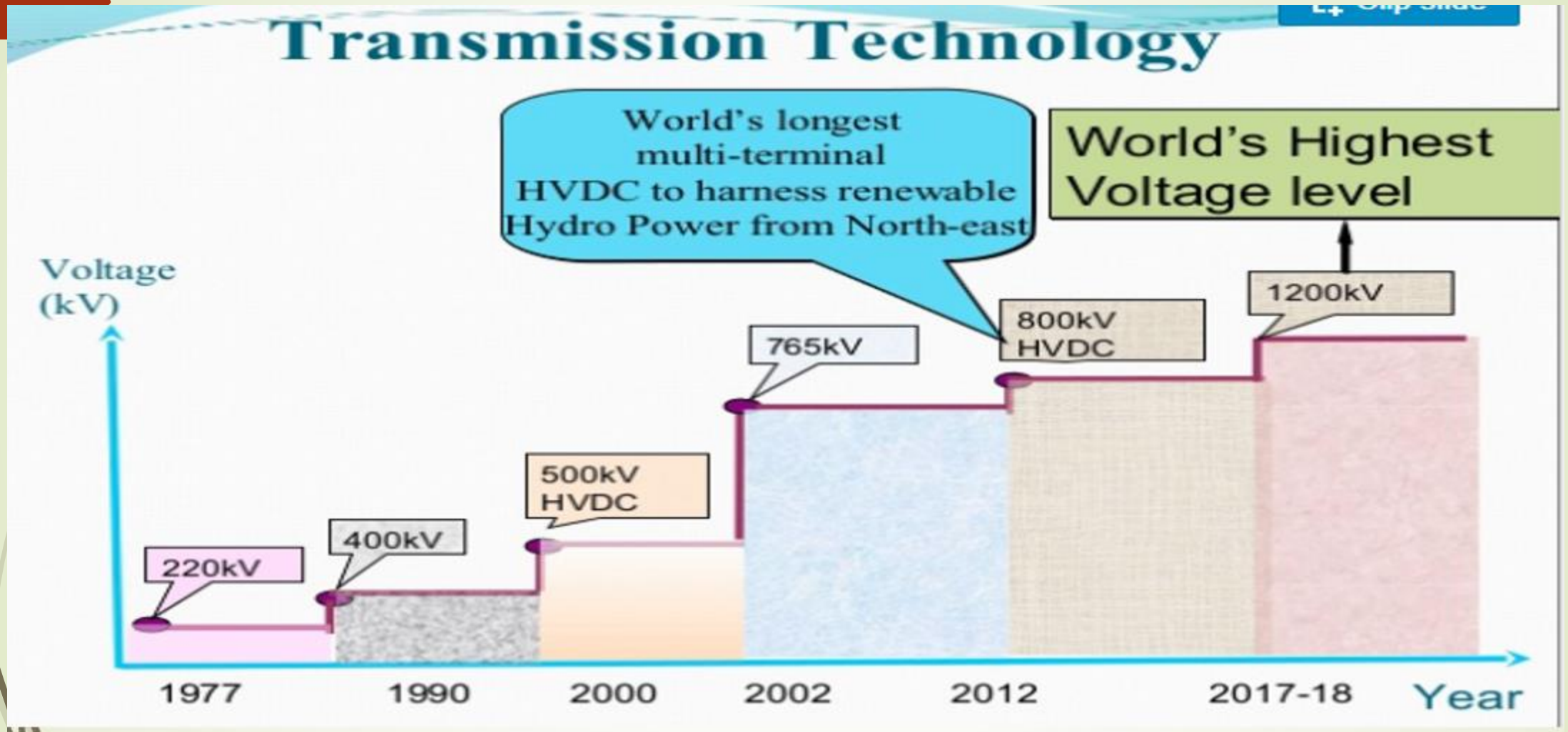


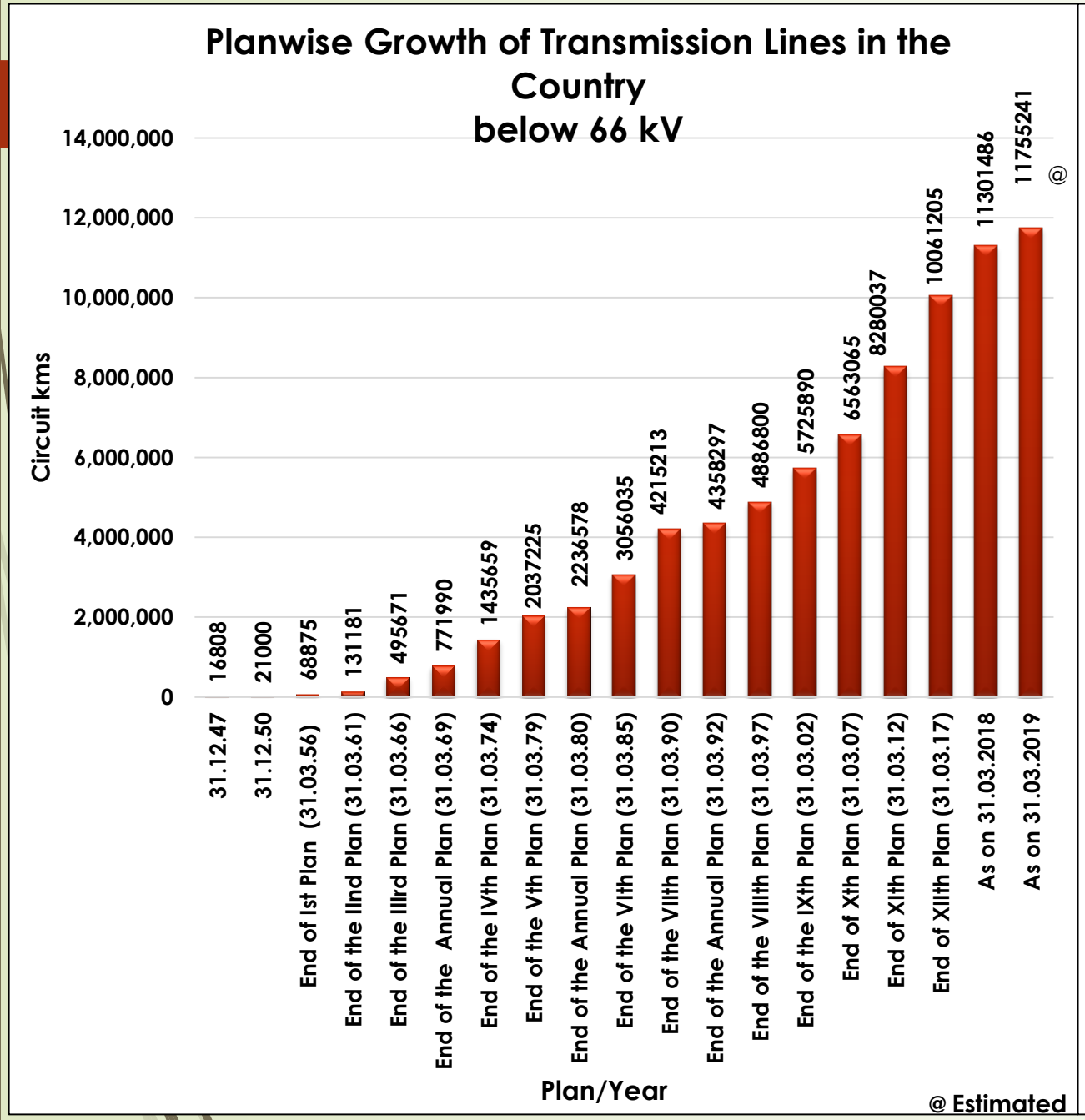
1. At present, demand supply gap at an all time low of less than 1%. This gap is on account of factors other than non-availability of power.
2. Adequate power available in the country.

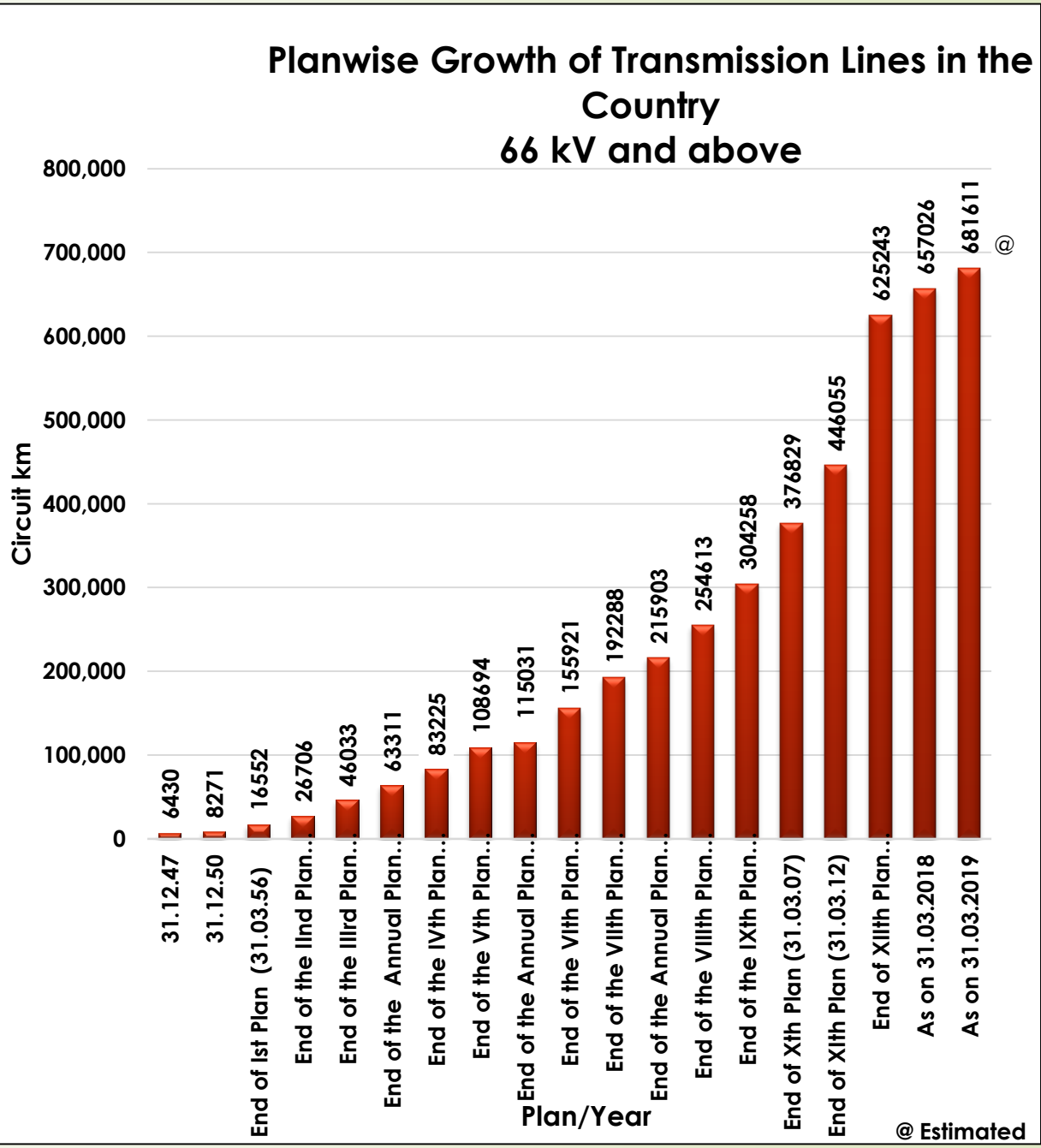
PER CAPITA CONSUMPTION



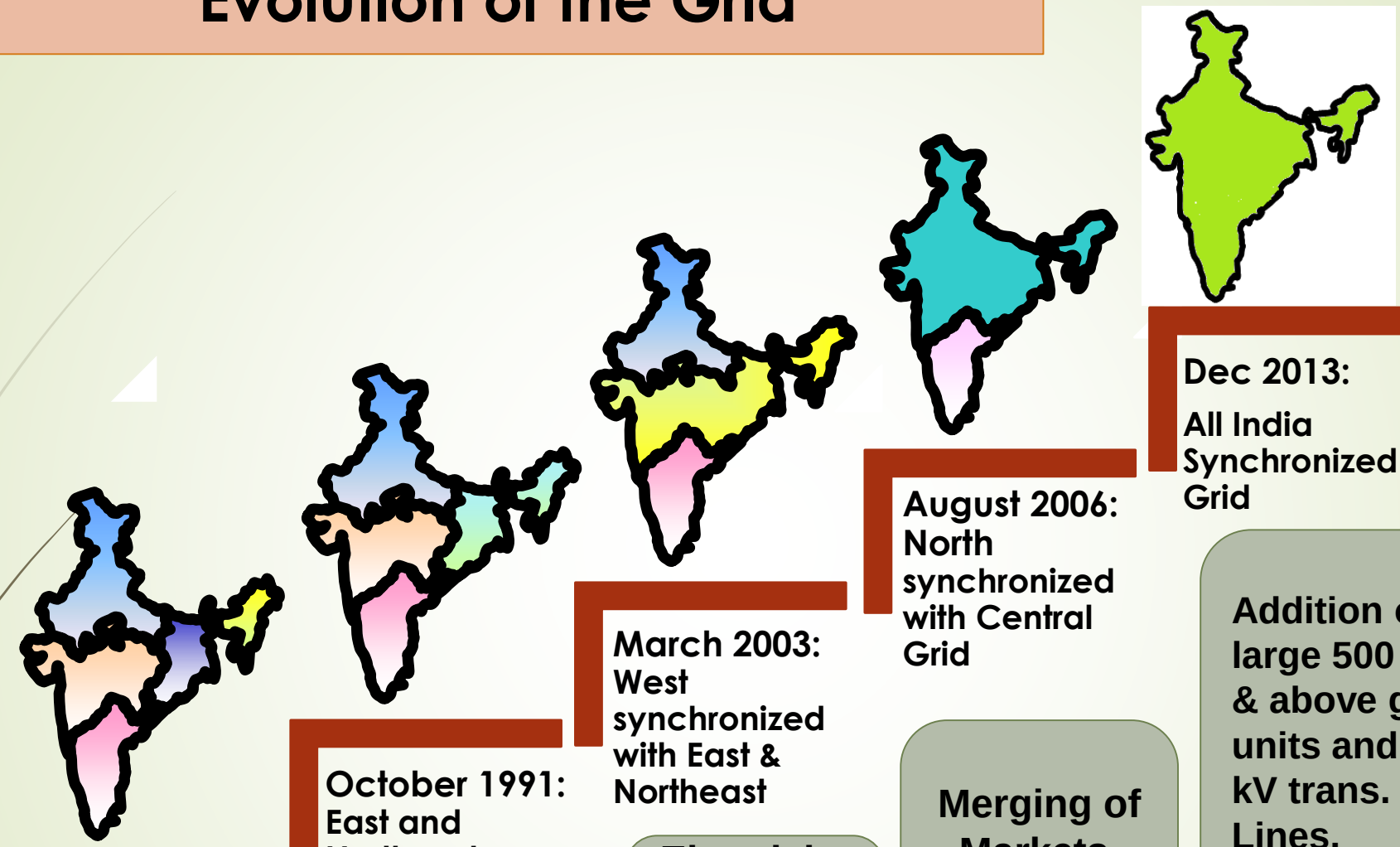
16.3 in DEC,1947


Transmission Technology
World's longest multi-terminal HVDC to harness renewable Hydro Power from North-east
World's Highest Voltage level
Voltage (kV)
220kV
400kV
500kV HVDC
765kV
800kV HVDC
1200kV
1977
1990
2000
2002
2012
2017-18
Year


Planwise Growth of Transmission Lines in the Country
below 66 kV
Circuit kms
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
16808
21000
68875
131181
495671
771990
1435659
2037225
2236578
3056035
4215213
4358297
4886800
5725890
6563065
8280037
10061205
11301486
11755241
@
31.12.47
31.12.50
End of Ist Plan (31.03.56)
End of the IInd Plan (31.03.61)
End of the IIIrd Plan (31.03.66)
End of the Annual Plan (31.03.69)
End of the IVth Plan (31.03.74)
End of the Vth Plan (31.03.79)
End of the Annual Plan (31.03.80)
End of the VIth Plan (31.03.85)
End of the VIIth Plan (31.03.90)
End of the Annual Plan (31.03.92)
End of the VIIIth Plan (31.03.97)
End of the IXth Plan (31.03.02)
End of Xth Plan (31.03.07)
End of XIth Plan (31.03.12)
End of XIIth Plan (31.03.17)
As on 31.03.2018
As on 31.03.2019
Plan/Year
@ Estimated


Planwise Growth of Transmission Lines in the Country
66 kV and above
Circuit km
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
6430
8271
16552
26706
46033
63311
83225
108694
115031
155921
192288
215903
254613
304258
376829
446055
625243
657026
681611
@
31.12.47
31.12.50
End of Ist Plan (31.03.56)
End of the IInd Plan...
End of the IIIrd Plan...
End of the Annual Plan...
End of the IVth Plan...
End of the Vth Plan...
End of the Annual Plan...
End of the VIth Plan...
End of the VIIth Plan...
End of the Annual Plan...
End of the VIIIth Plan...
End of the IXth Plan...
End of Xth Plan (31.03.07)
End of XIth Plan (31.03.12)
End of XIIth Plan...
As on 31.03.2018
As on 31.03.2019
Plan/Year
@ Estimated

Evolution of the Grid



Pre 1991:

Five Regional Grids - Five Frequencies

October 1991: East and Northeast synchronized

Merchant Power

March 2003: West synchronized with East & Northeast

Electricity Act, 2003, Open Access

August 2006: North synchronized with Central Grid

Merging of Markets, Power Exchanges

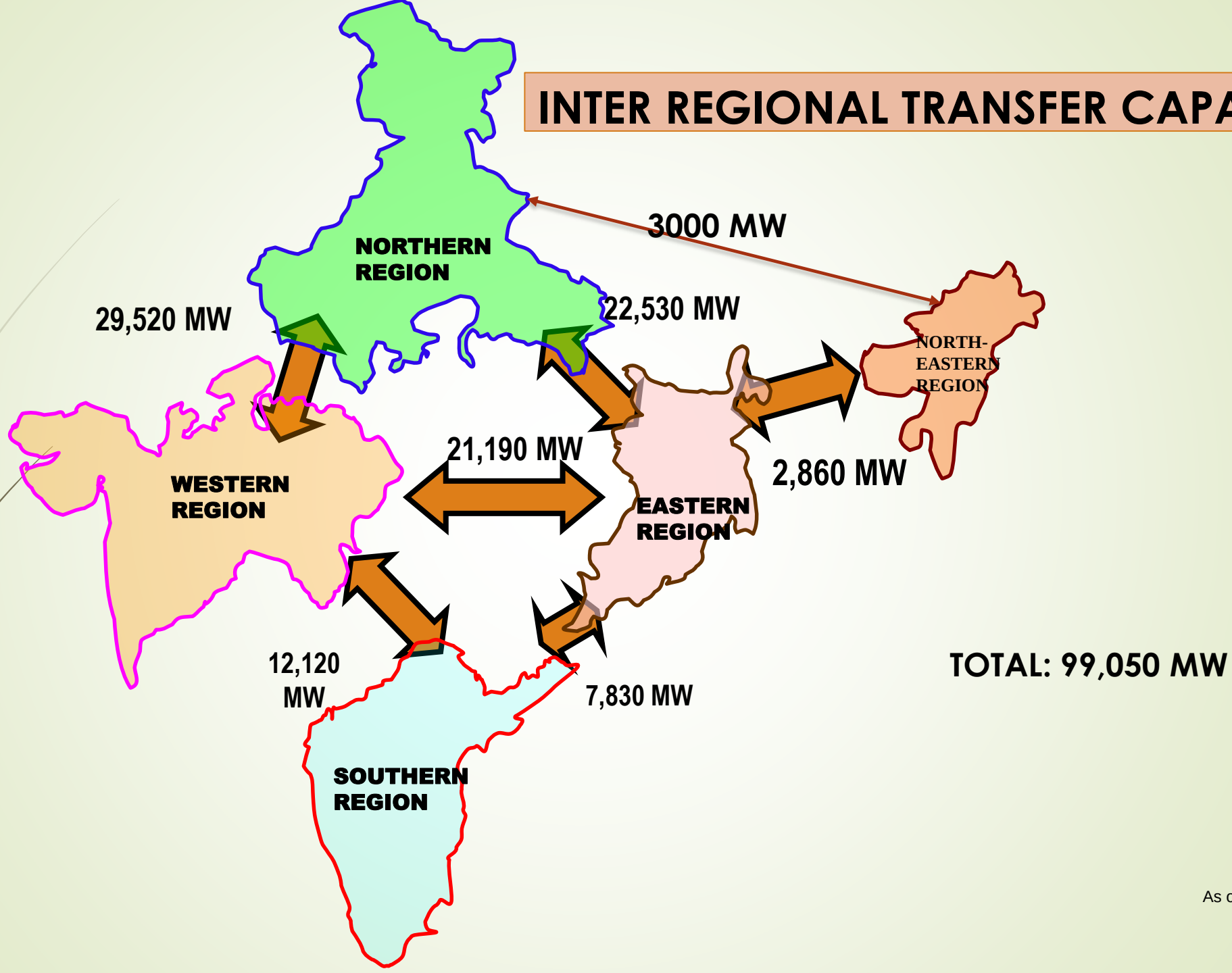
Dec 2013:

All India Synchronized Grid

Addition of large 500 MW & above gen. units and 765 kV trans. Lines, Ultra Mega Power Projects

Maps not to scale

INTER REGIONAL TRANSFER CAPACITY



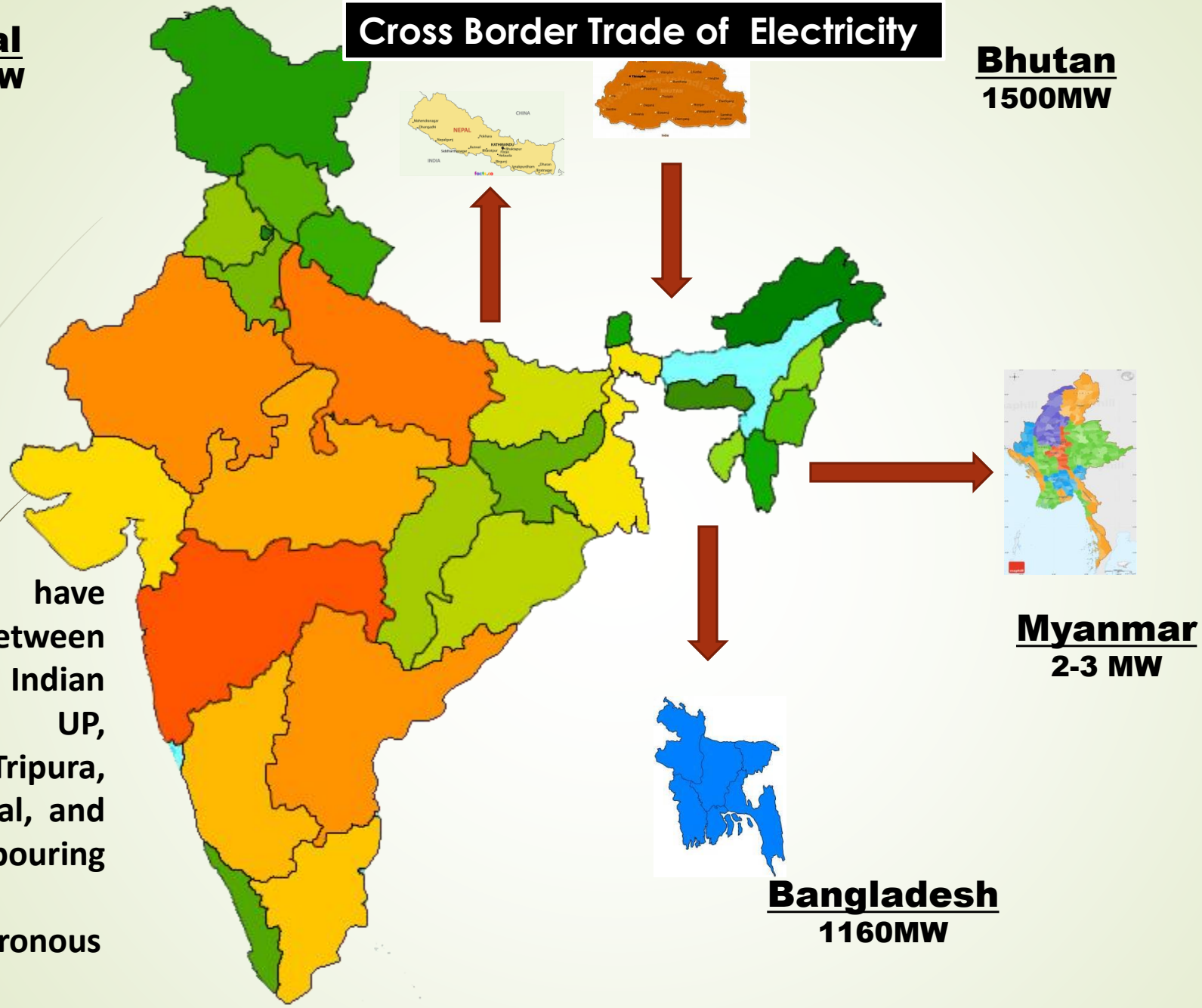
TOTAL: 99,050 MW

As on march 2017

Cross Border Trade of Electricity

Nepal
570 MW

Bhutan
1500MW



Myanmar
2-3 MW

Bangladesh
1160MW

Transmission links have been established between border states in Indian territory (Bihar, UP, Uttarakhand, Tripura, Manipur, West Bengal, and Assam) with neighbouring countries (synchronous/asynchronous /radial links).

Integrated Power Development Scheme (IPDS)

- Scheme approved on 20.11.2014 with a total outlay of Rs 32,612 crore which includes a budgetary support of Rs 25,354 crore from Govt. of India.
- The objectives of scheme are:
- Strengthening of sub-transmission and distribution networks in the urban areas;
- Metering of distribution transformers / feeders / consumers in the urban area.
- IT enablement of distribution sector and strengthening of distribution network
- The component of IT enablement of distribution sector and strengthening of distribution network approved in June, 2013 in the form of RAPDRP for 12th and 13th Plans got subsumed in this scheme and approved scheme outlay of Rs 44,011 crore including a budgetary support of Rs 22,727 crore carried over to the new scheme of IPDS.

Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY)

Scheme approved on 20.11.2014 with a total outlay of Rs 44,033 crore which includes a budgetary support of Rs 33,453 crore from Govt. of India.

The objectives of scheme are:

- Separation of agriculture and non-agriculture feeders
- Strengthening of sub-transmission and distribution networks in the rural areas;
- Metering of distribution transformers / feeders / consumers in the rural area.
- Rural Electrification

The component of Rural Electrification approved in August, 2013 in the form of RGGVY for 12th and 13th Plans got subsumed in this scheme and approved scheme cost of Rs 39275 crore including a budgetary support of Rs 35447crore carried over to the new scheme of DDUGJY.

Ujwal Discom Assurance Yojana(UDAY)

Launched by the Government of India on 20th November 2015 for operational and financial turnaround of state-owned Power Distribution Companies (DISCOMs).

Objectives

(i) Improving operational efficiency of DISCOMs;

(ii) Reduction in cost of power;

(iii) Financial Turnaround - Reduction in interest cost of DISCOMs;

(iv) Enforcing financial discipline on DISCOMs through alignment with State finances.

Ujwal Discom Assurance Yojana (SAUBHAGYA)

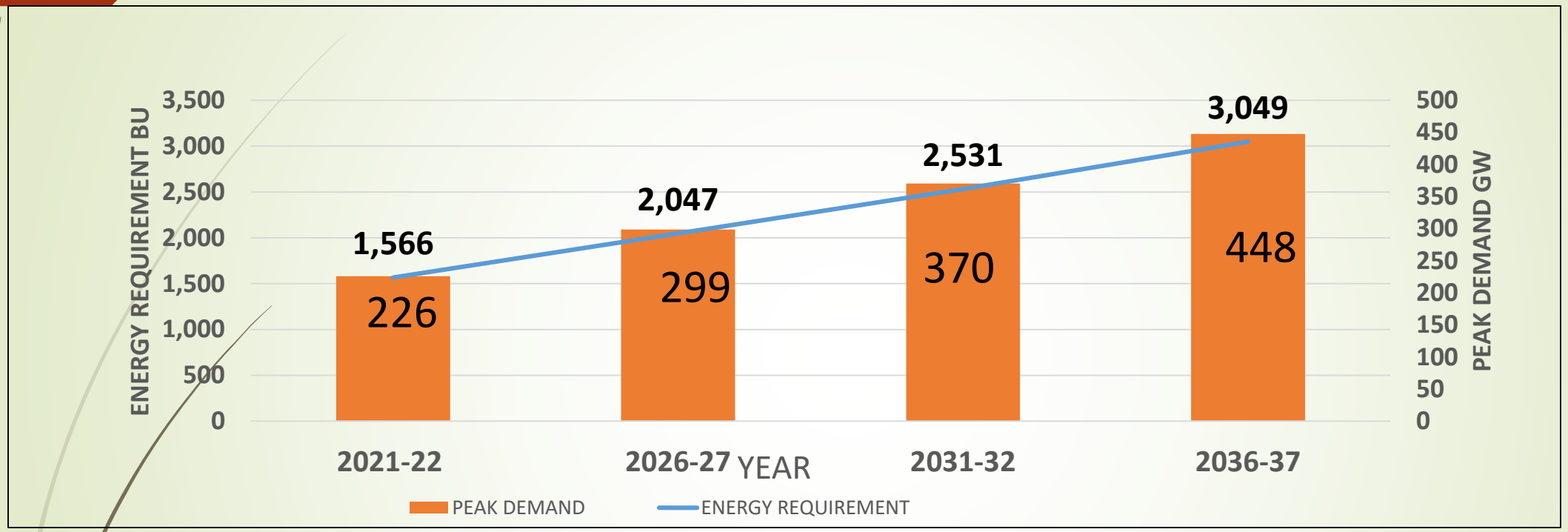
99.99% of our households are electrified

Objectives

(i) To provide electricity for every household

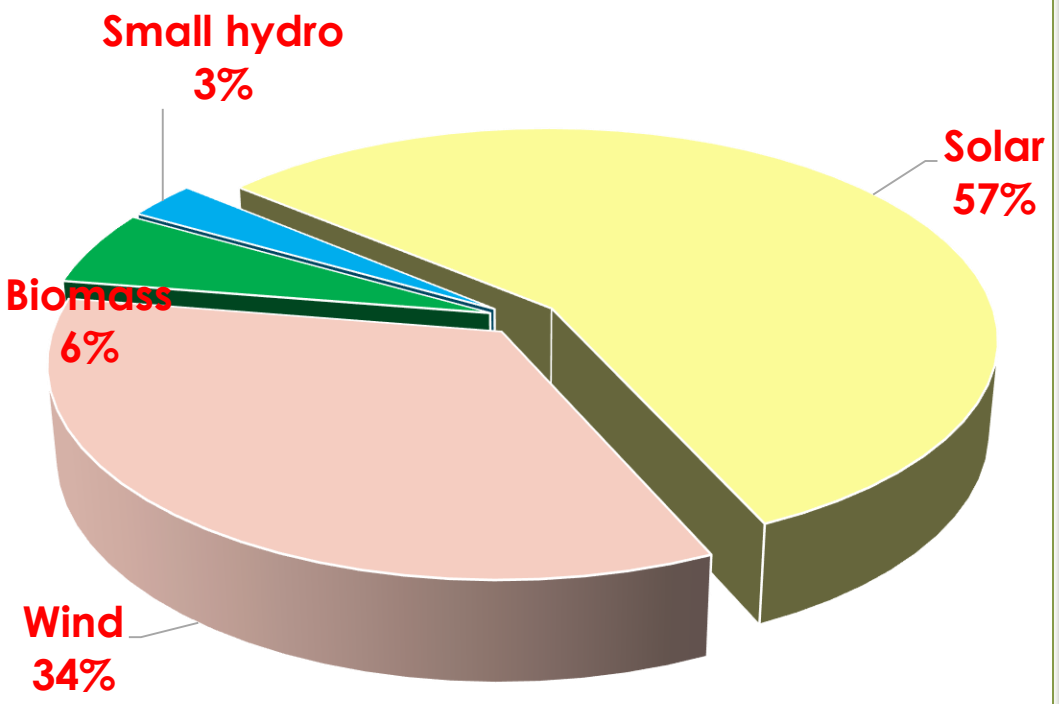
FUTURE SCENARIO

PROJECTIONS OF ELECTRICITY DEMAND-19TH ELECTRIC POWER SURVEY

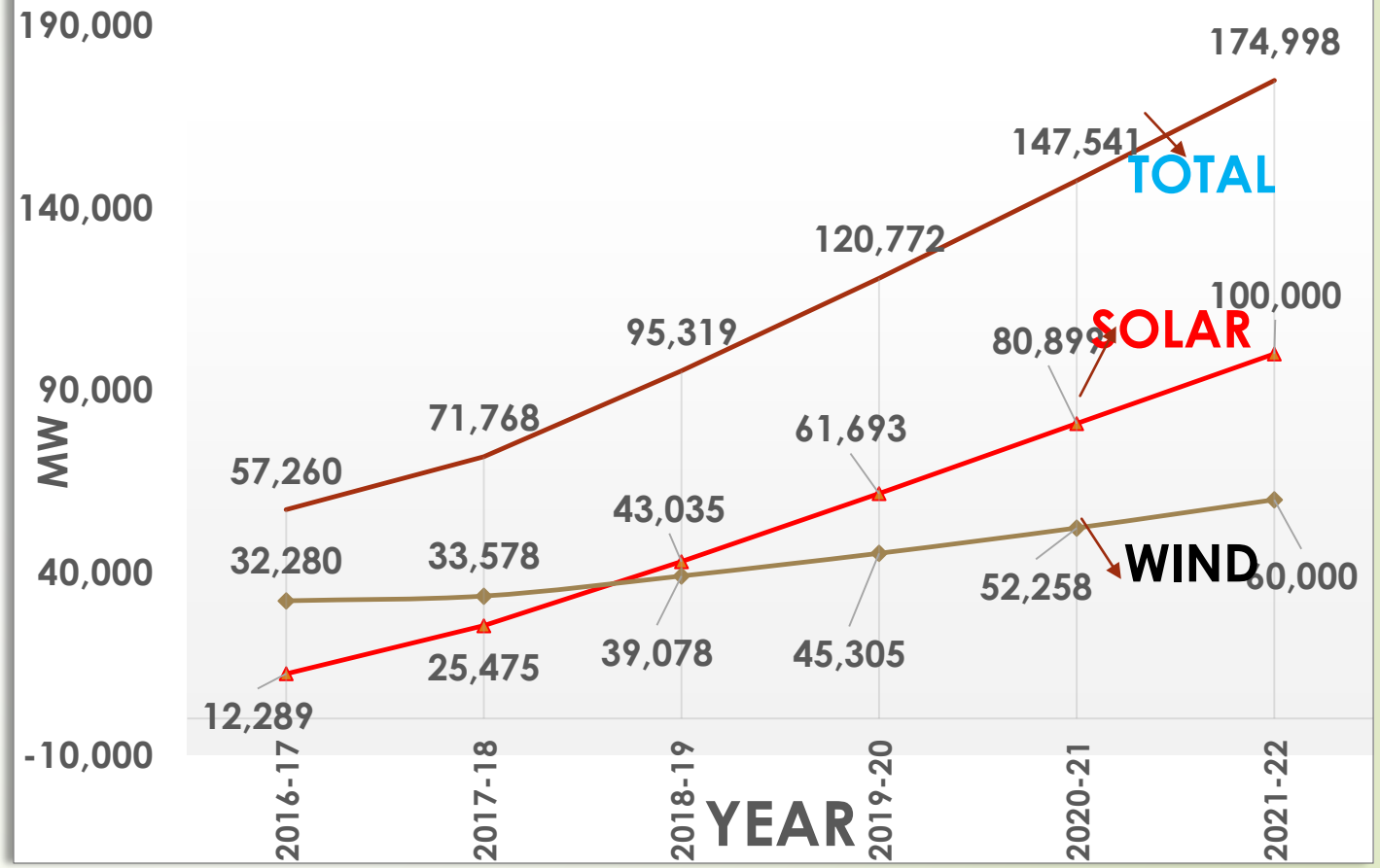


Growth Rate (%)		
	2016-17 to 2021-22	2021-22 to 2026-27
CAGR of Electrical Energy Requirement	6.18	5.51
CAGR of Peak Electricity Demand	6.88	5.77

Renewable Installed Capacity Target by 2022

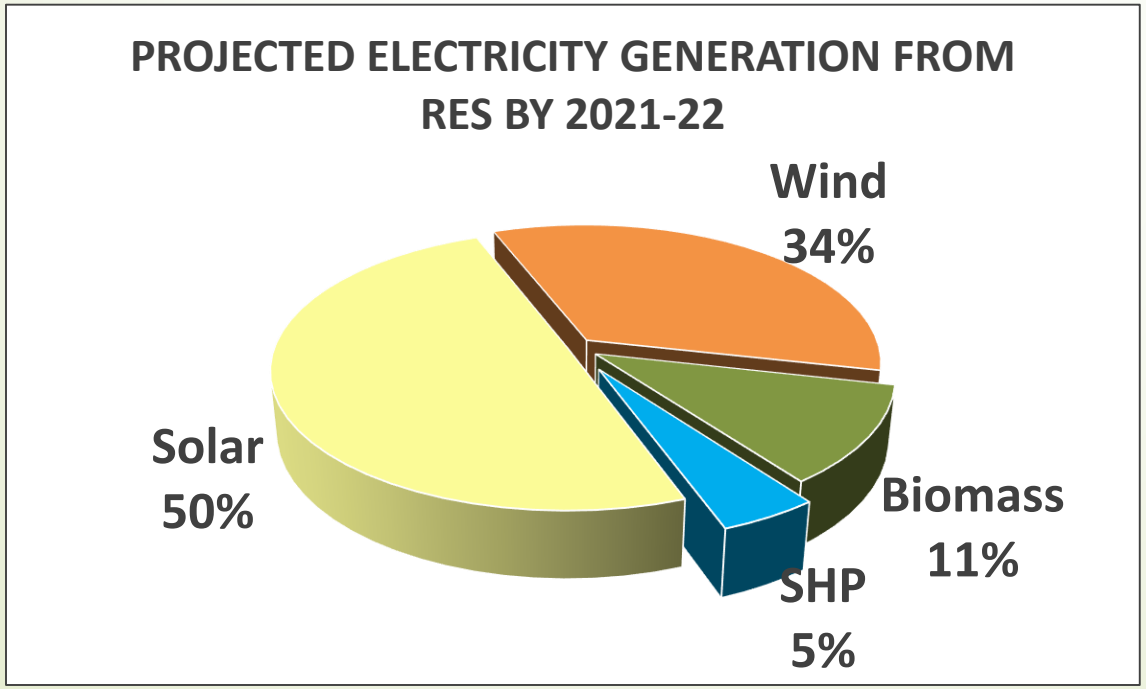


Projected Growth of RES Installed Generating Capacity (MW)

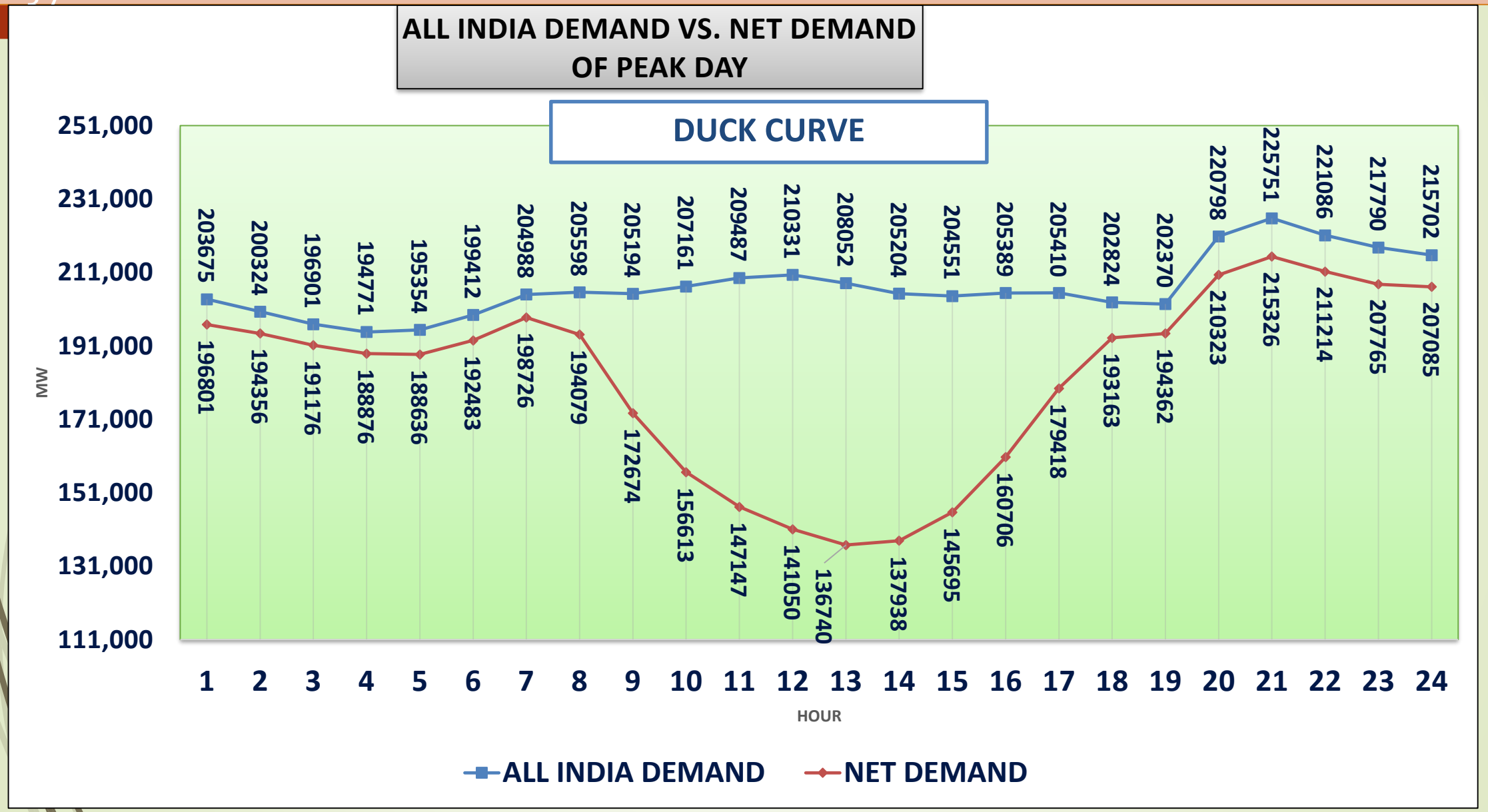


Estimated Electricity Generation from RES in years 2021-22 and 2026-27

Year	Installed capacity of RES (GW)	Expected Generation in (BU)					Total Energy Requirement (BU)	Contribution of RES to Total Energy Demand(%)
		Solar	Wind	Biomass	SHP	Total		
2021-22	175	162	112	37	15	326	1,566	**20.8%**
2026-27	275	243	188	63	24	518	2,047	**25.3%**



TYPICAL ALL INDIA DEMAND & NET LOAD CURVE (2021-22)



India's Intended Nationally Determined Contribution (INDC)

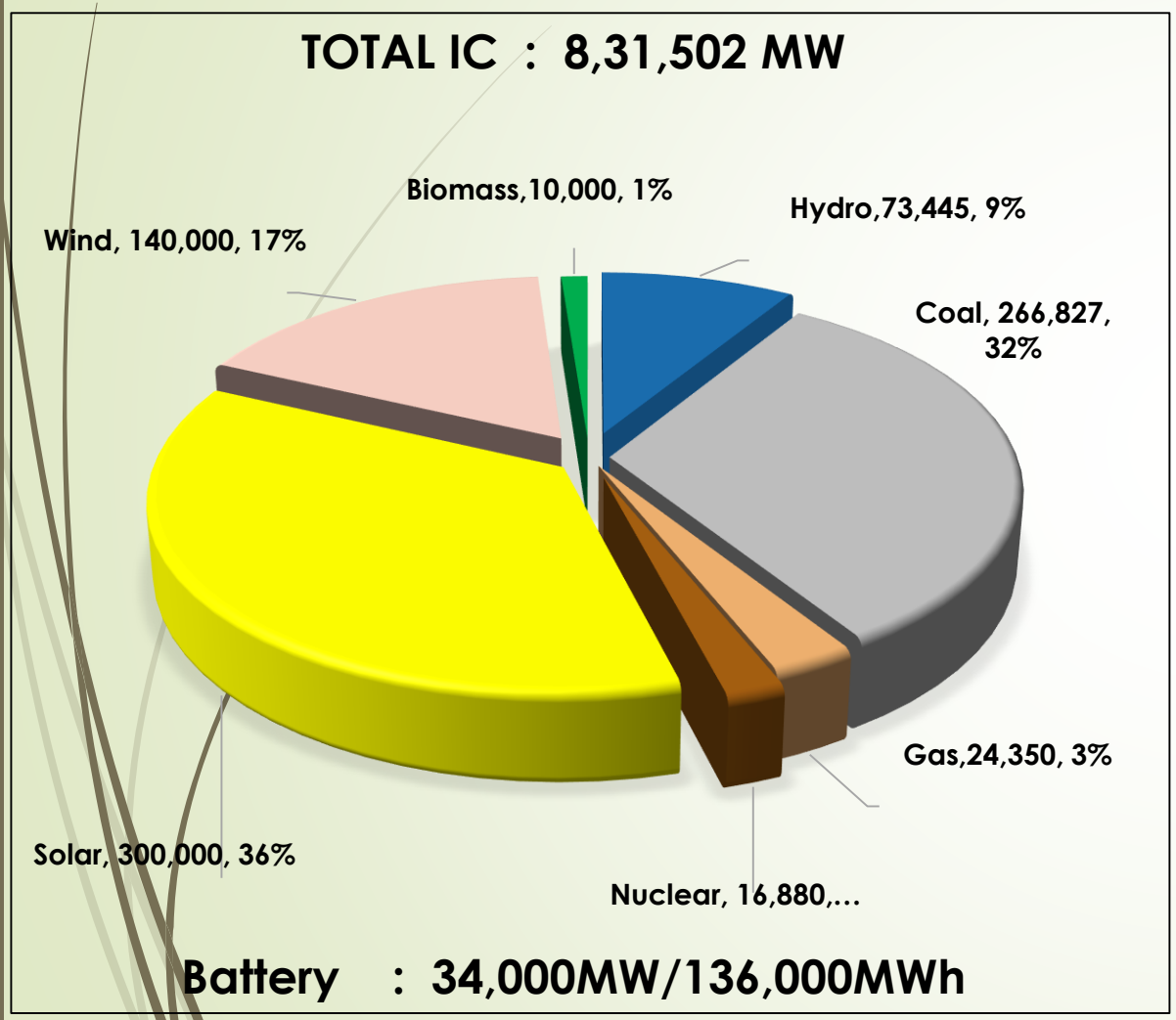
40 % cumulative power installed capacity from non-fossil fuels by 2030.

Year	Likely IC (GW)	Likely IC of Fossil Fuel (GW)	Likely IC of Non-Fossil Fuel (GW)	% of Non-Fossil Fuel in IC
March 2022	479.4	243.0	236.4	49.3%
March 2027	619.0	263.9	355.1	57.4%

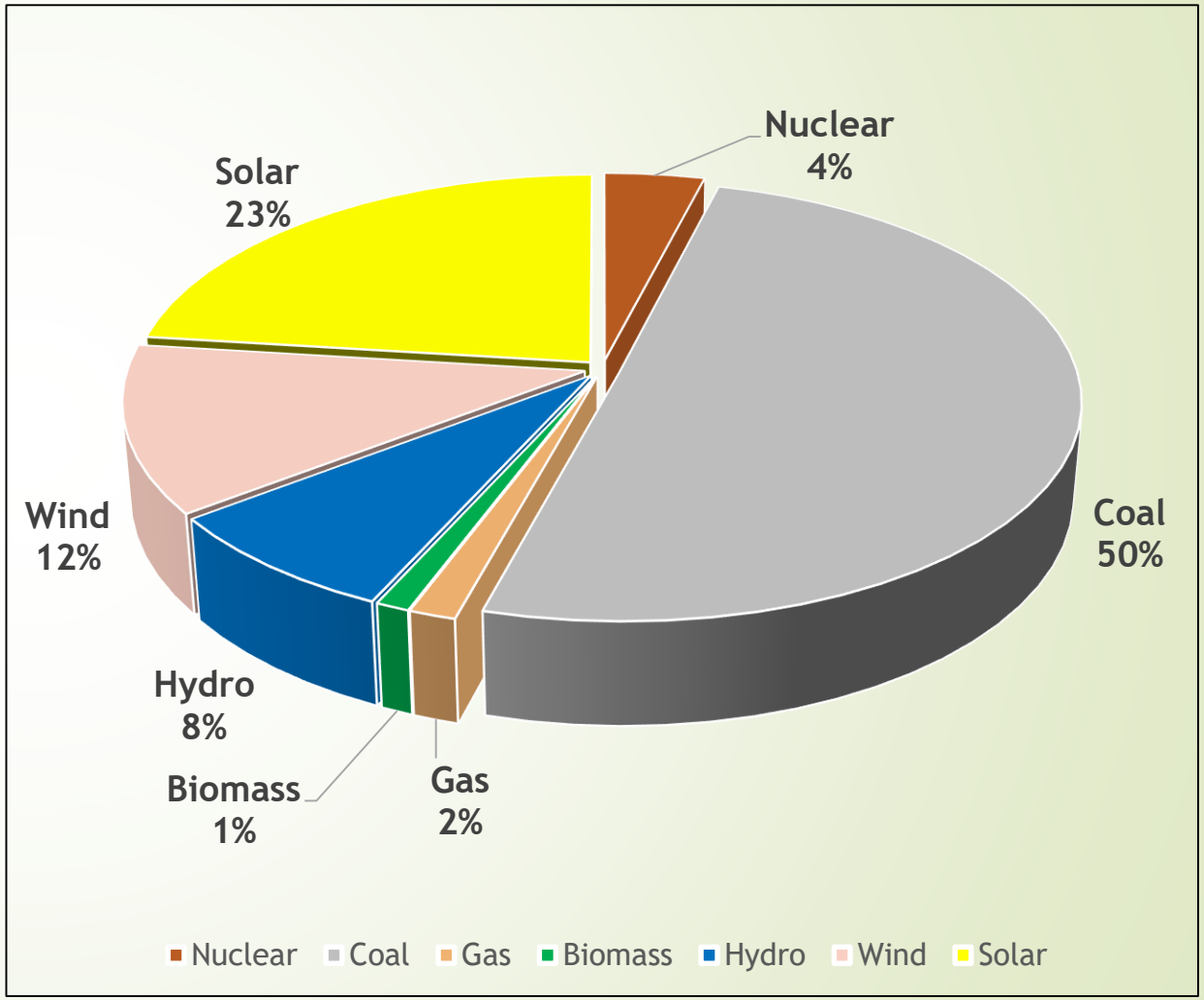
OPTIMUM GENERATION MIX IN THE YEAR 2029-30

To find out the least cost optimum generation mix in the year 2029-30 considering possible/feasible technology options, fuel constraints if any, intermittency associated with Renewable energy sources etc.

Likely Installed Capacity (MW) in 2029-30

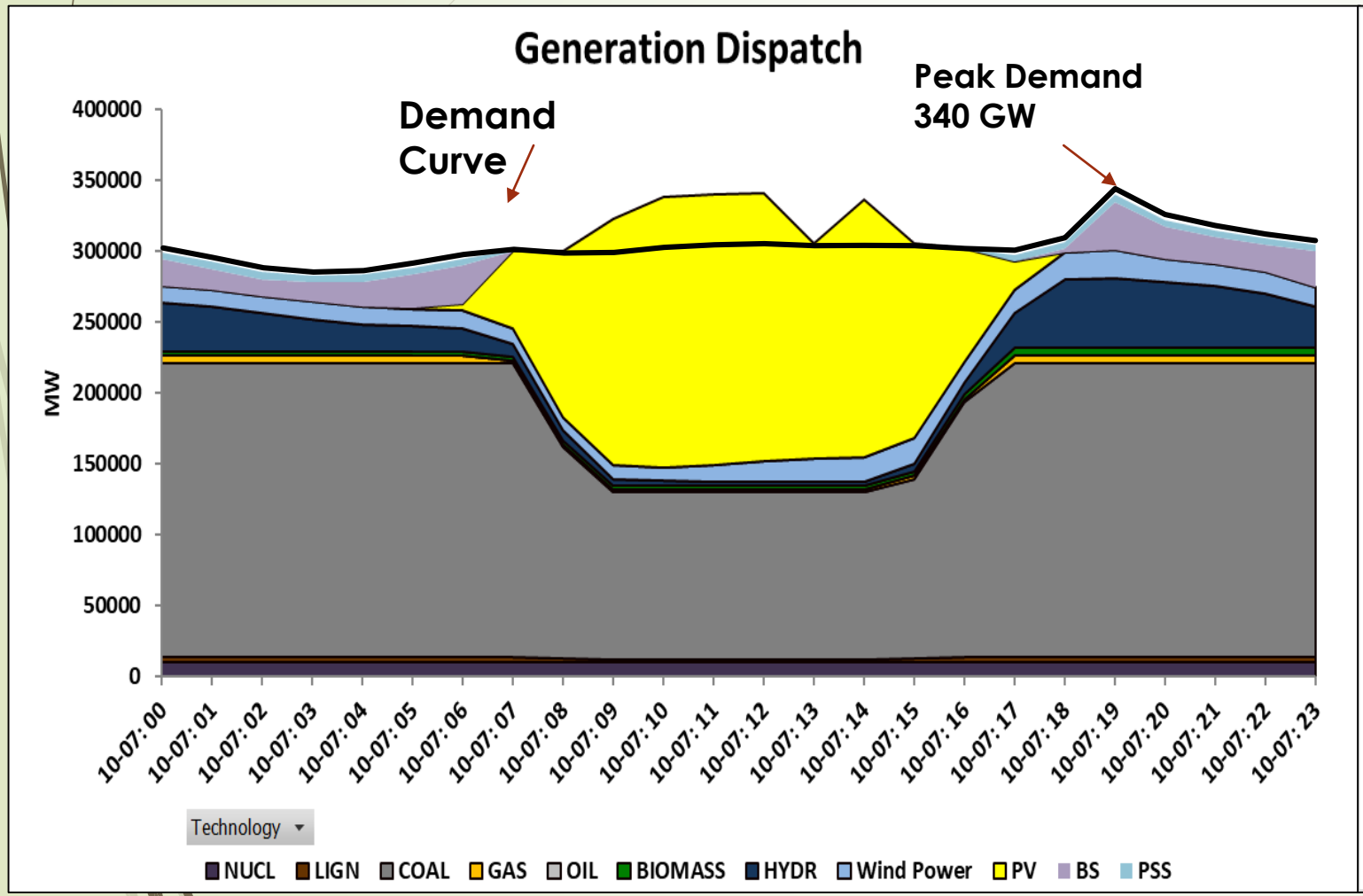


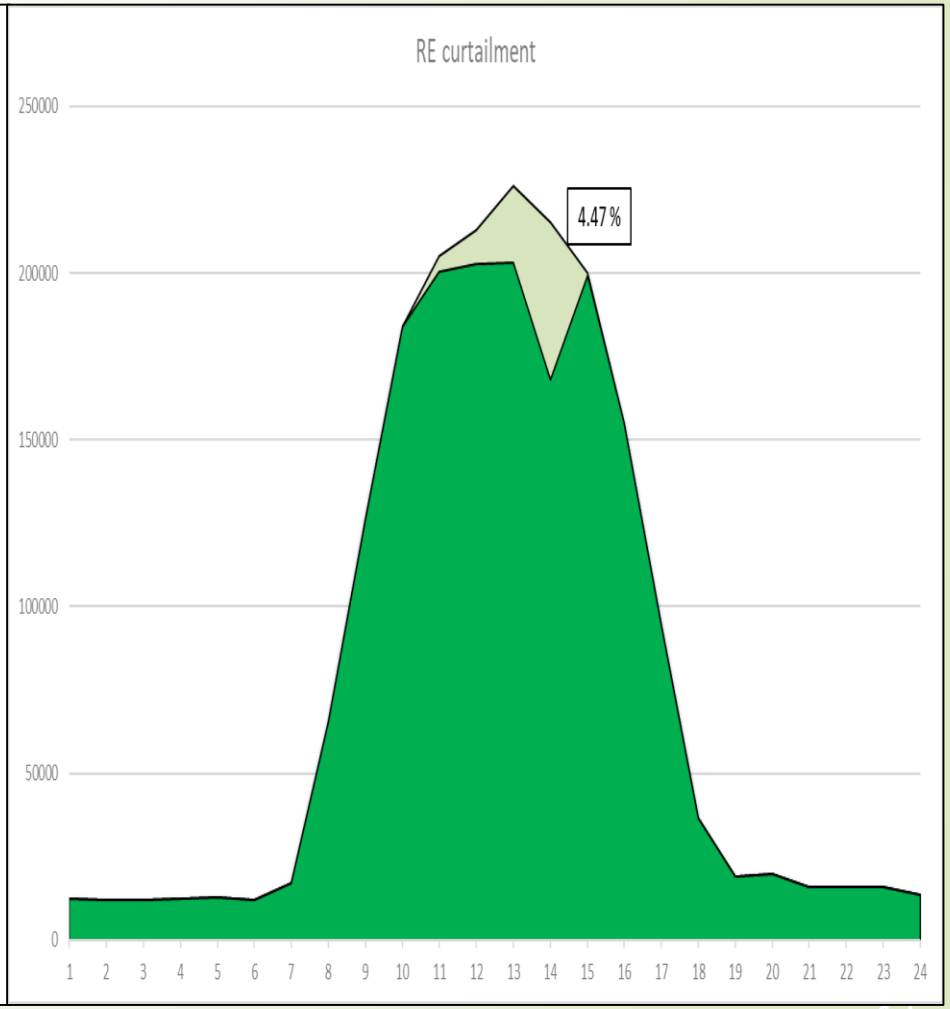
Likely Gross Generation (MU) in 2029-30



Peak Demand/ Maximum Net Demand Day (7th Oct)

Peak Demand – 340 GW, Energy Req- 7.21 BU






شكراً جزيلاً
ngiyabonga
рахмат
danke
謝謝
teşekkür ederim
Баярлалаа
спасибо
mersi
kia ora
barka
welalin
tack
spas
mahalo
tapadh leat
faafetai lava
vinaka
спасибі
blagodaram
dank je
misaotra
matondo
paldies
grazzi
kiitos
dankie
dhanyavad
nanni
nandri
thank you
gracias
хвала
asante
manana
maururu
köszönöm
aciu
obrigada
tenki
murakoze
bedankt
bayarlalaa
gràçie
hvala
dankon
akun
djiere dieuf
tau
mochchakkeram
enkosi
dziękuję
дякую
mamnun
chokrane
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gratias ago
gràcies
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go raibh maith agat
sobodi
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saģolun
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kop khun krap
taiku
obrigado
mèsi
ありがとう
arigatô
takk
dakujem
trugarez
didi madloba
najis tuke
tanemirt
grazie
kam sah hamnida
rahmat
terima kasih
rahmet
ευχαριστώ
diolch
dhanyavadagalu
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তোমাকে ধন্যবাদ
감사합니다
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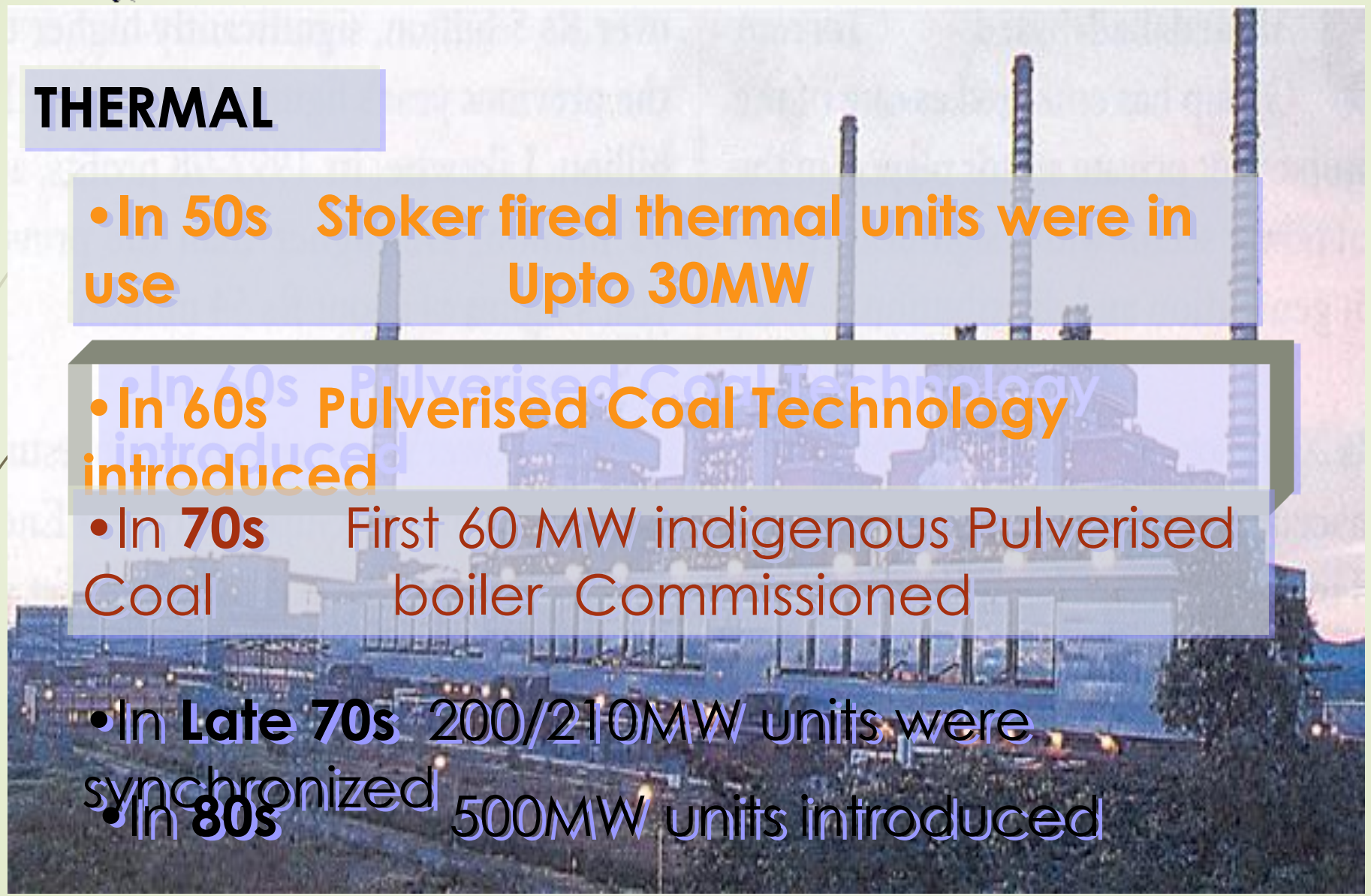
MILE STONES OF INDIAN POWER SECTOR



THERMAL

- In 50s Stoker fired thermal units were in use Upto 30MW
- In 60s Pulverised Coal Technology introduced
- In **70s** First 60 MW indigenous Pulverised Coal boiler Commissioned
- In **Late 70s** 200/210MW units were synchronized
- In **80s** 500MW units introduced

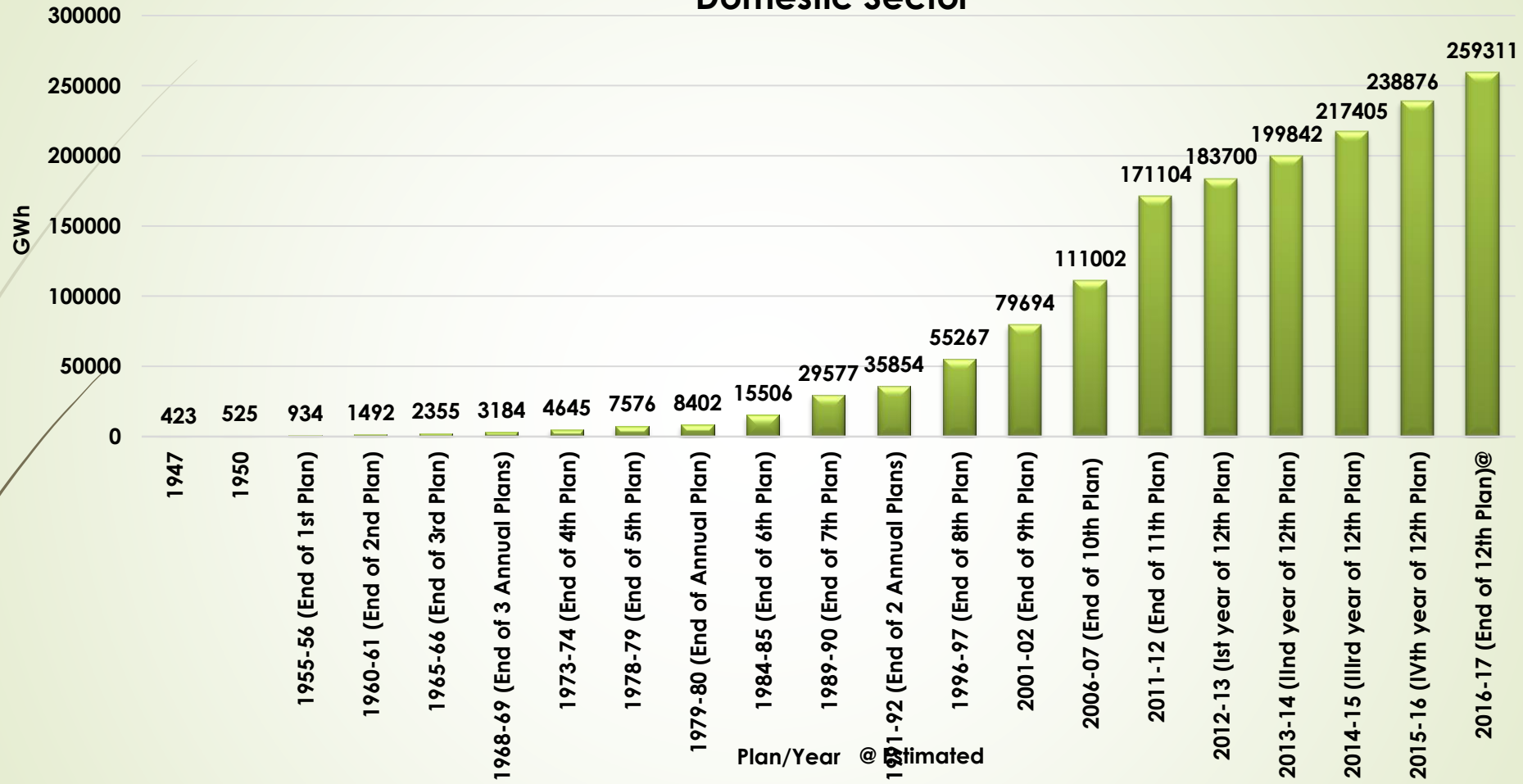
HYDRO

- In 1947 508 MW Hydro capacity
- In early 60s 1050 MW Bhakra Nangal Complex commissioned
- In 60s First Under Ground Hydro Station at Koyna commissioned
- In 70s Water from river Beas diverted to river Satluj through tunnels and Dehar Power Station (990MW) constructed
- In 80s First pump storage scheme at Kadamparai commissioned

NUCLEAR`

- In 60s First Nuclear Power Station at Tarapur (2x160MW) using enriched Uranium commissioned
- In 70s RAPP using natural Uranium (2x220MW) commissioned
- In 90s RAPP-I refueled indigenously

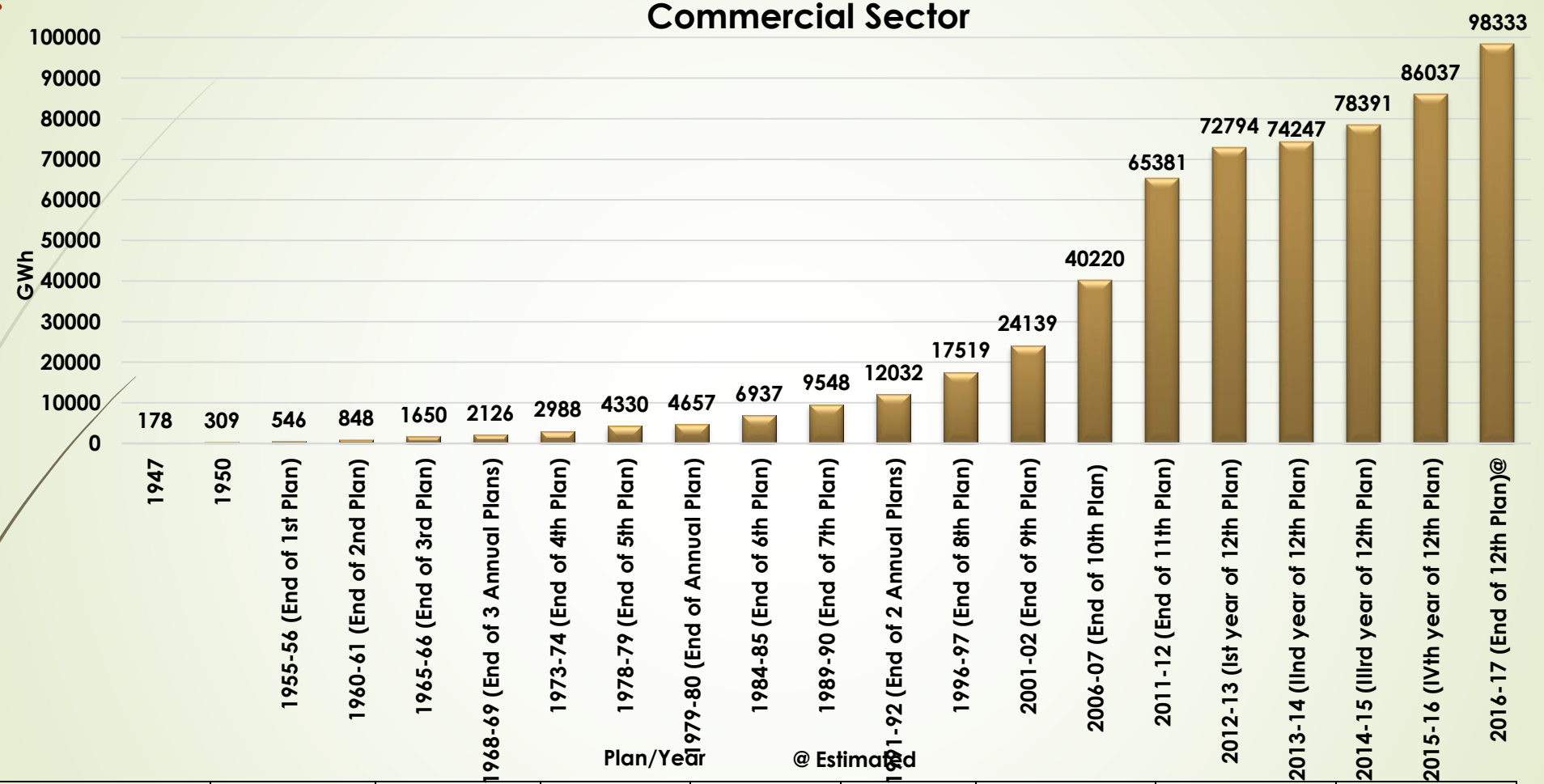
Plan wise Growth of Electricity Consumption in India
Domestic Sector



Year	1947-50	1950-60	1960-70	1970-80	1980-90	1990-2000	2000-10	2010-17
% Growth	11.87	10.14	9.73	9.18	13.41	9.08	7.21	9.57

Plan wise Growth of Electricity Consumption in India
Commercial Sector

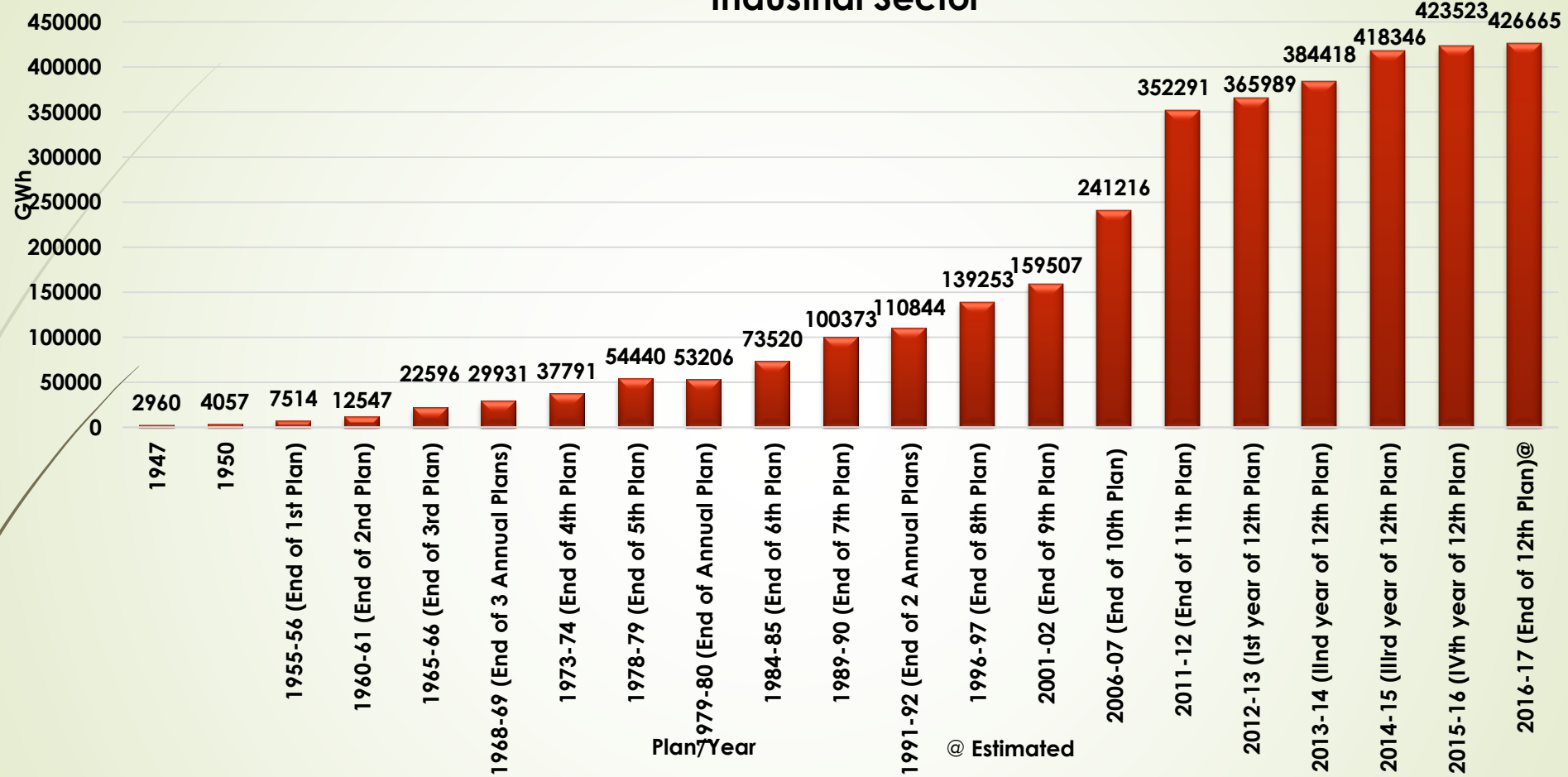
Chart : 20



Year	1947-50	1950-60	1960-70	1970-80	1980-90	1990-2000	2000-10	2010-17
% Growth	3.18	9.50	11.78	7.15	7.45	8.28	11.47	7.69

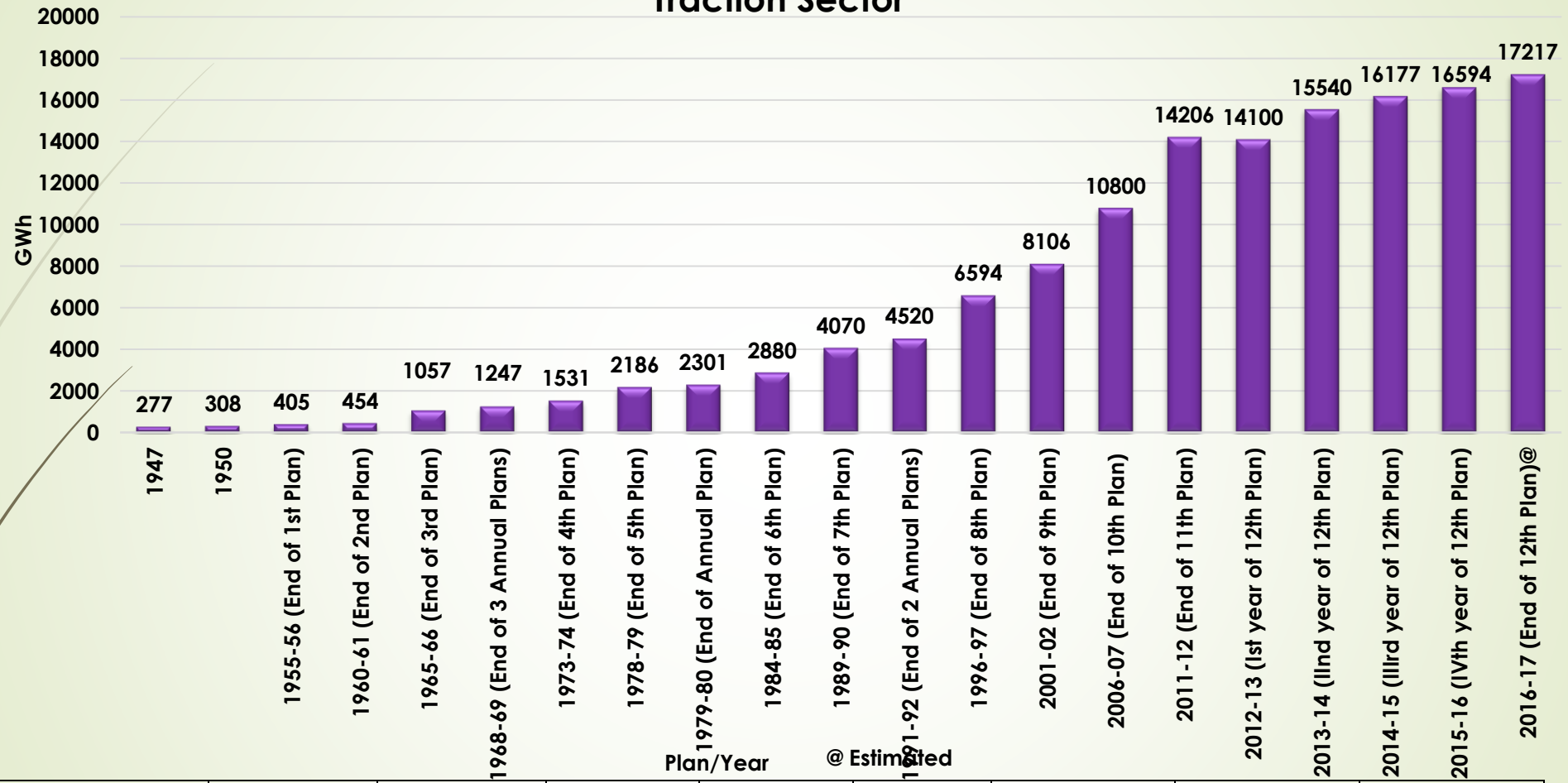
Plan wise Growth of Electricity Consumption in India
Industrial Sector

Chart : 21



Year	1947-50	1950-60	1960-70	1970-80	1980-90	1990-2000	2000-10	2010-17
% Growth	11.08	10.40	11.57	5.02	6.55	4.43	10.36	4.70

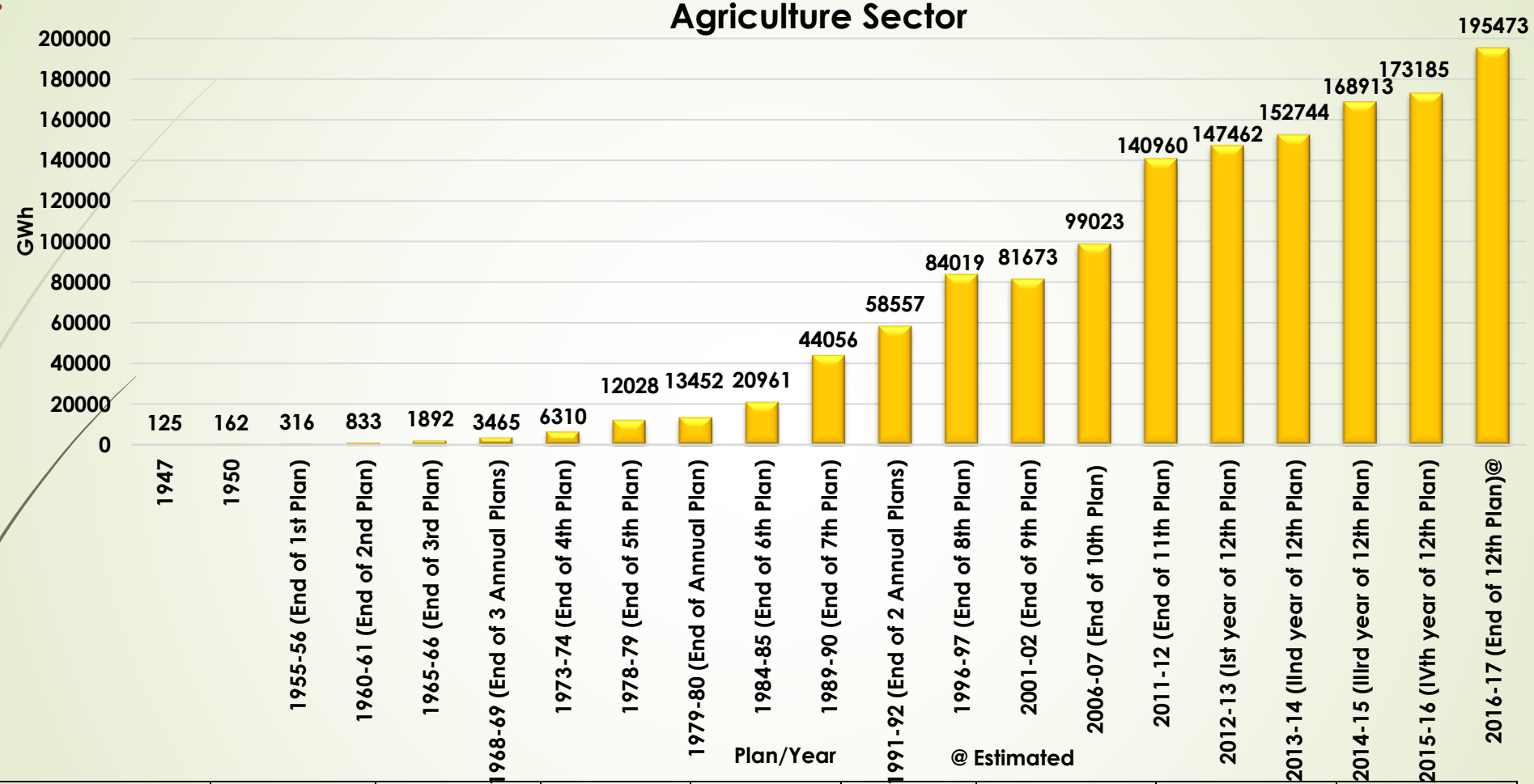
Plan wise Growth of Electricity Consumption in India
Traction Sector



Year	1947-50	1950-60	1960-70	1970-80	1980-90	1990-2000	2000-10	2010-17
% Growth	3.60	12.71	48.63	4.74	5.87	7.10	4.33	4.17

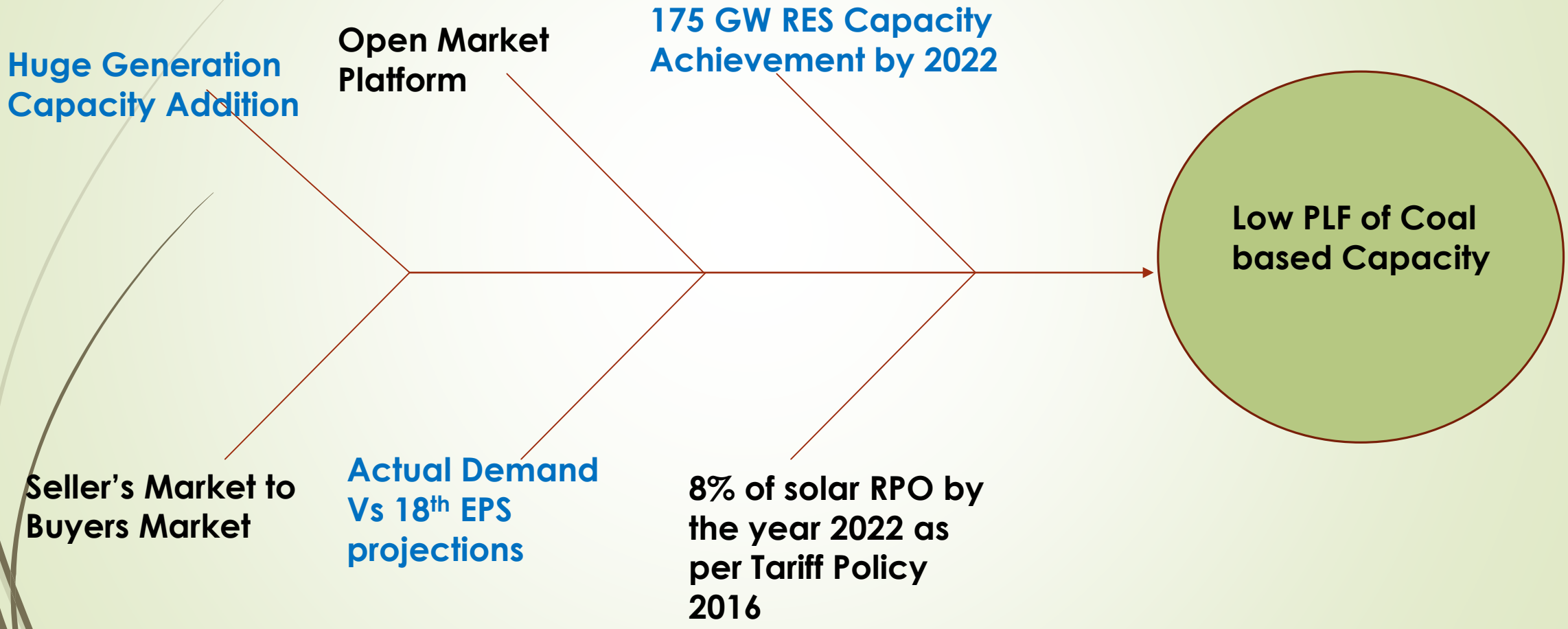
Plan wise Growth of Electricity Consumption in India Agriculture Sector

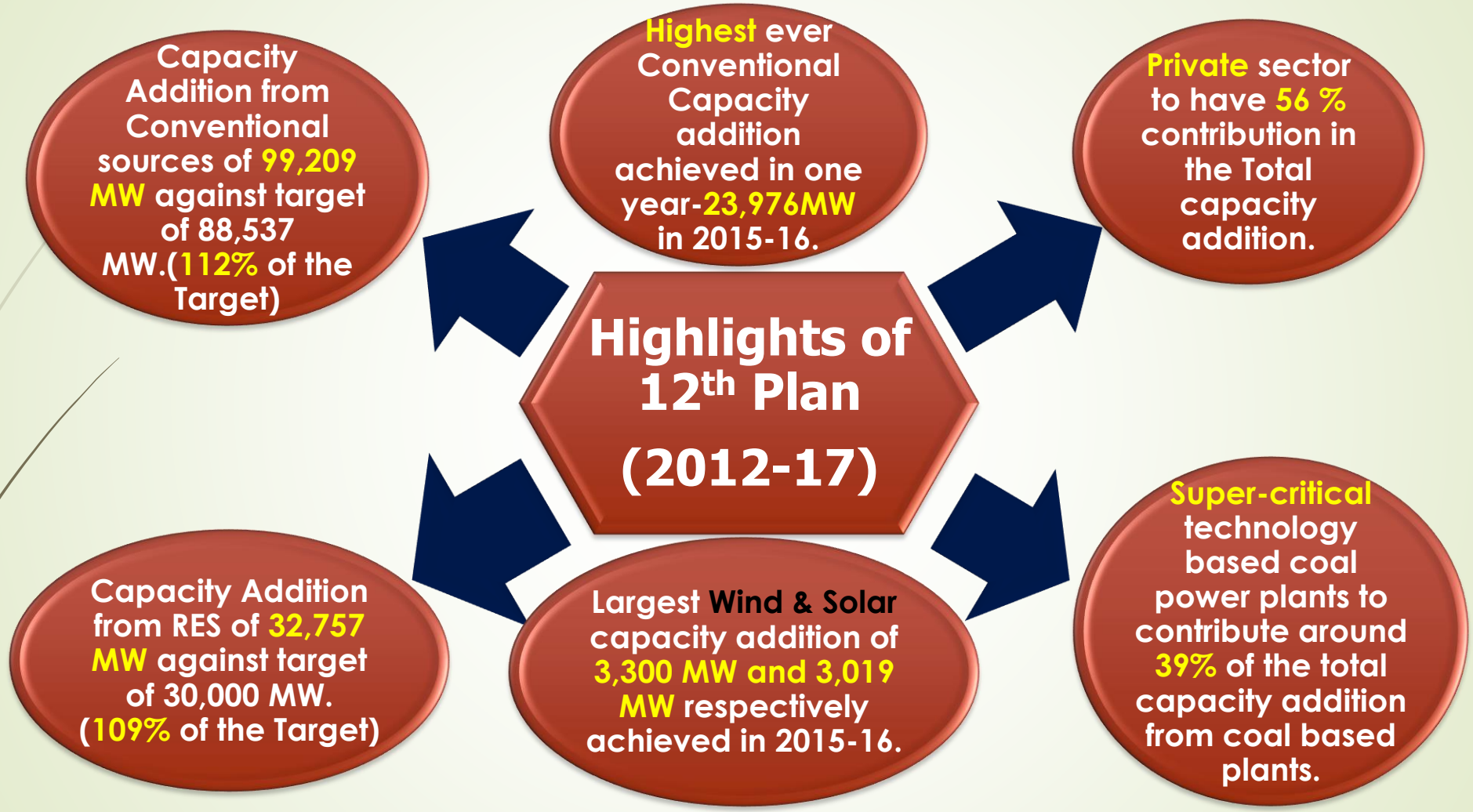
Chart : 23



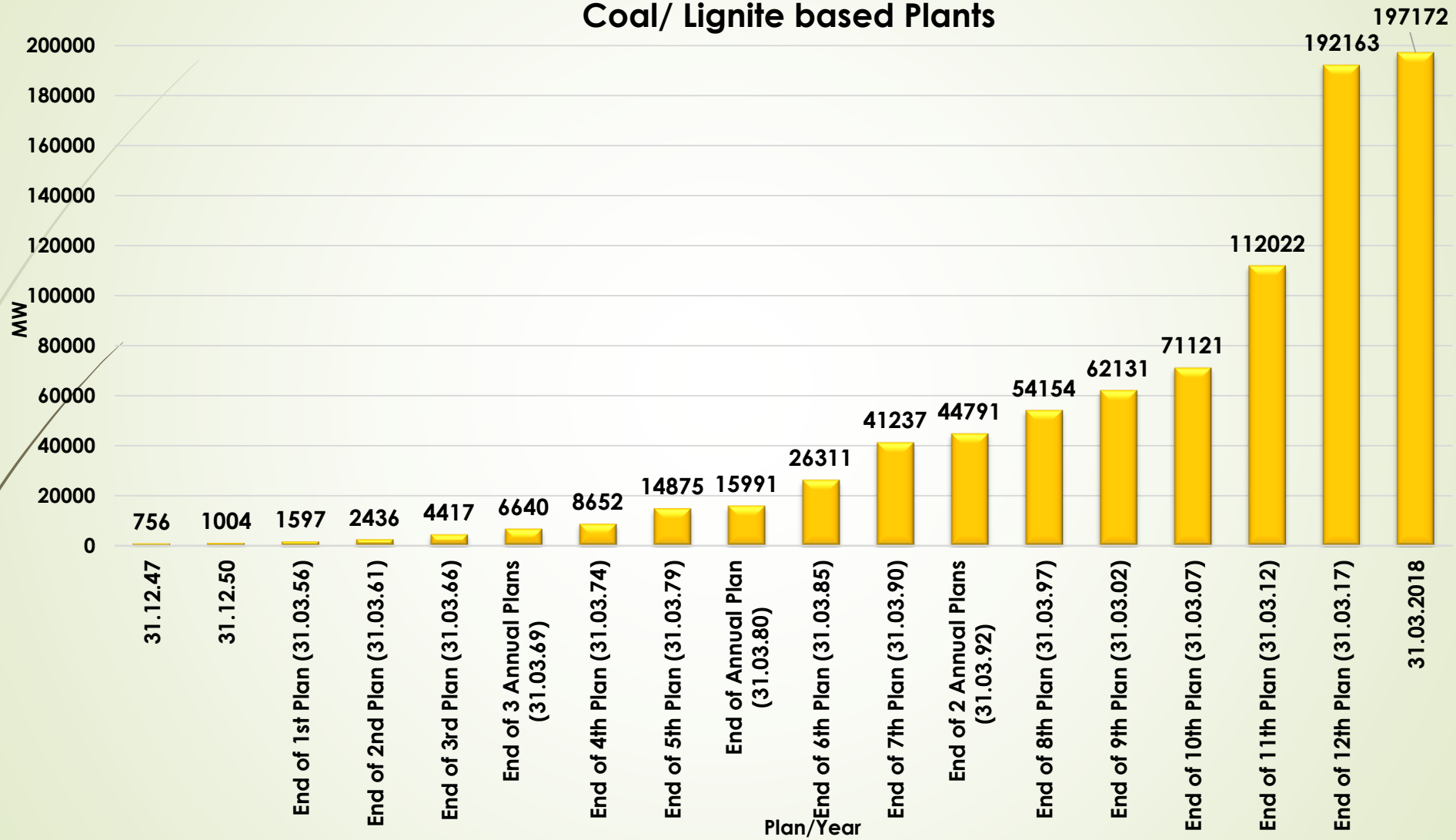
Year	1947-50	1950-60	1960-70	1970-80	1980-90	1990-2000	2000-10	2010-17
% Growth	9.03	66.96	71.06	13.55	12.60	7.52	2.05	7.81

Probable reasons for Change in scenario

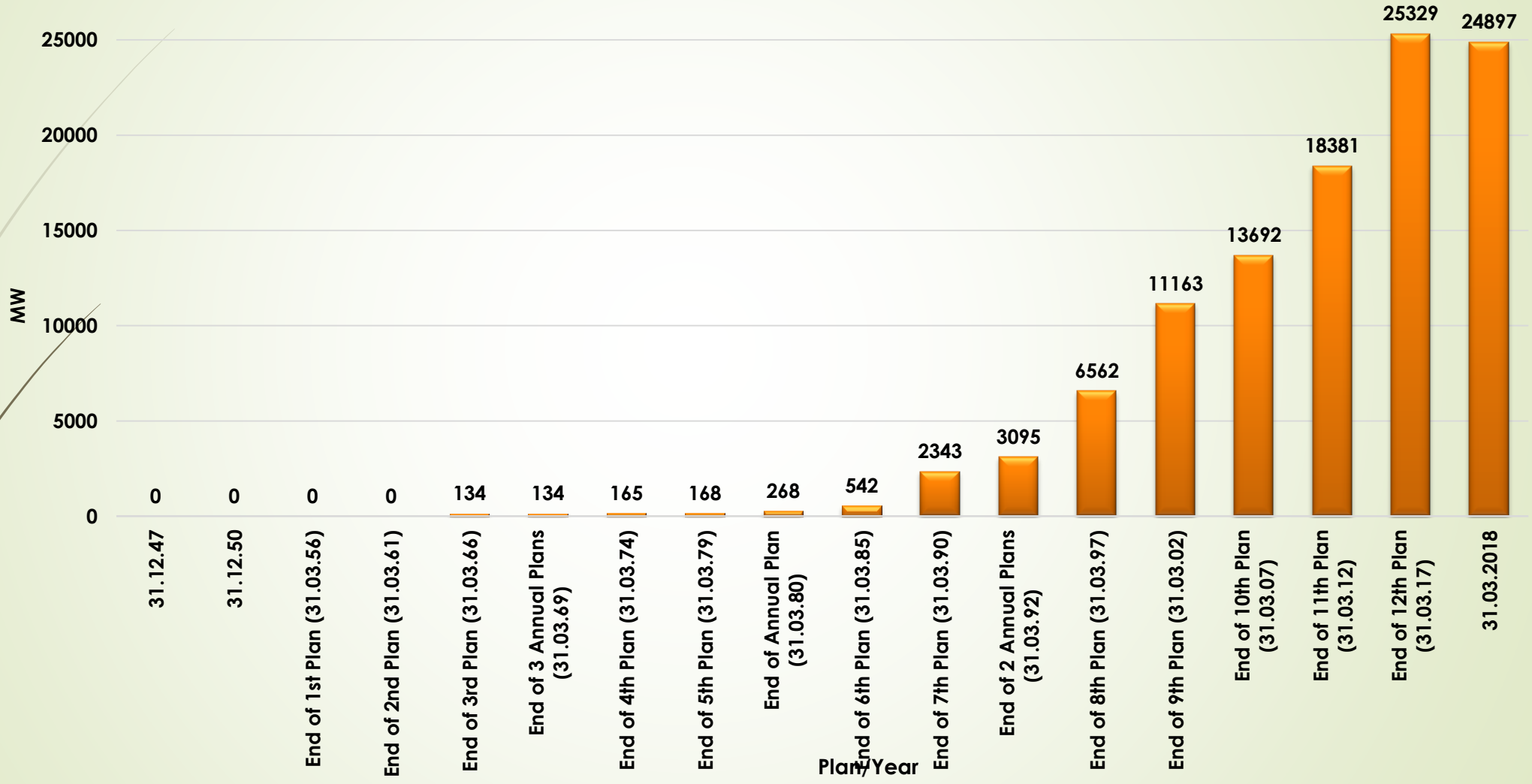



Highlights of 12th Plan (2012-17)
Capacity Addition from Conventional sources of 99,209 MW against target of 88,537 MW.(112% of the Target)
Highest ever Conventional Capacity addition achieved in one year-23,976MW in 2015-16.
Private sector to have 56 % contribution in the Total capacity addition.
Capacity Addition from RES of 32,757 MW against target of 30,000 MW. (109% of the Target)
Largest Wind & Solar capacity addition of 3,300 MW and 3,019 MW respectively achieved in 2015-16.
Super-critical technology based coal power plants to contribute around 39% of the total capacity addition from coal based plants.

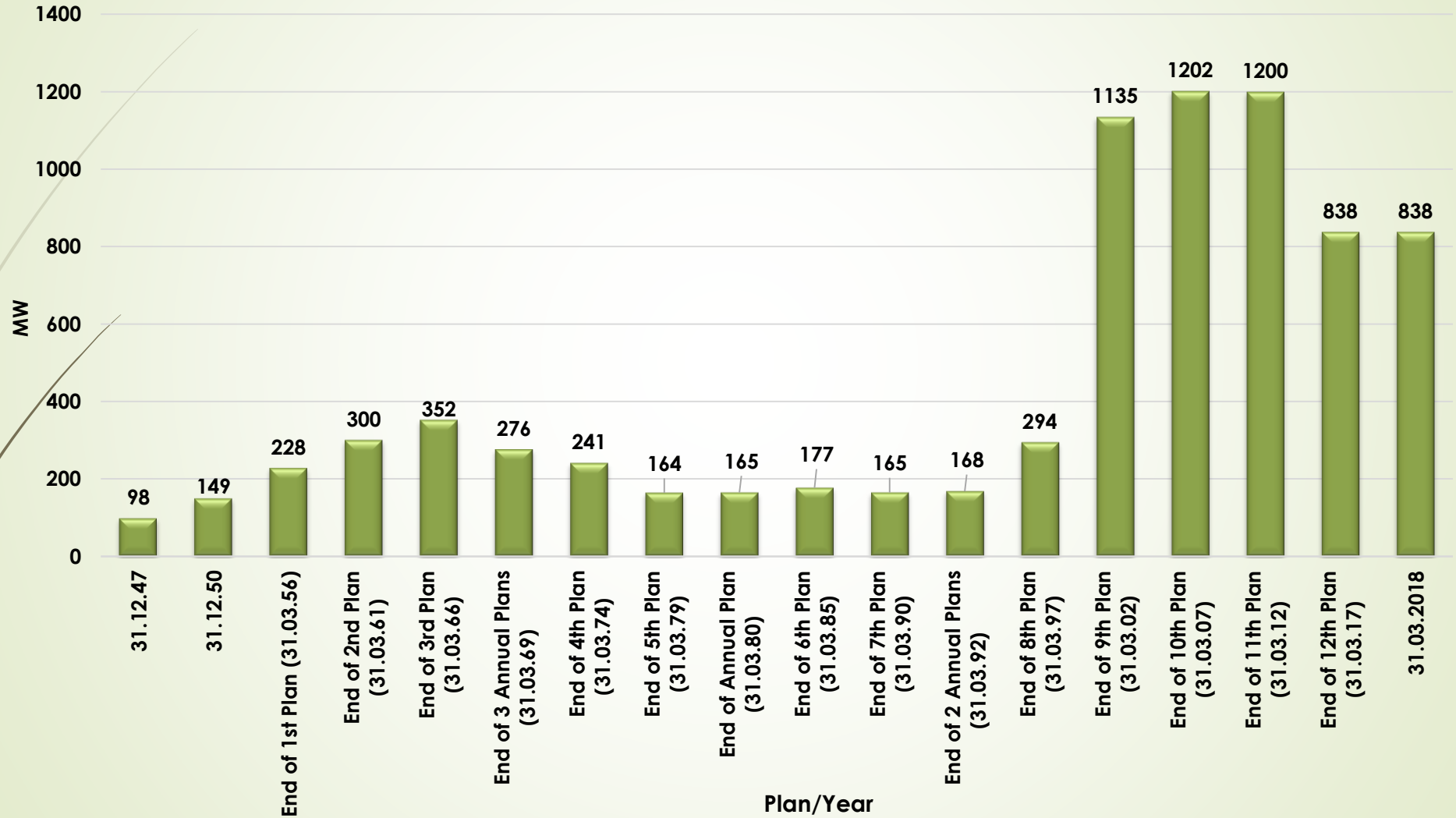
Plan wise Growth of Installed Capacity in India
Coal/ Lignite based Plants



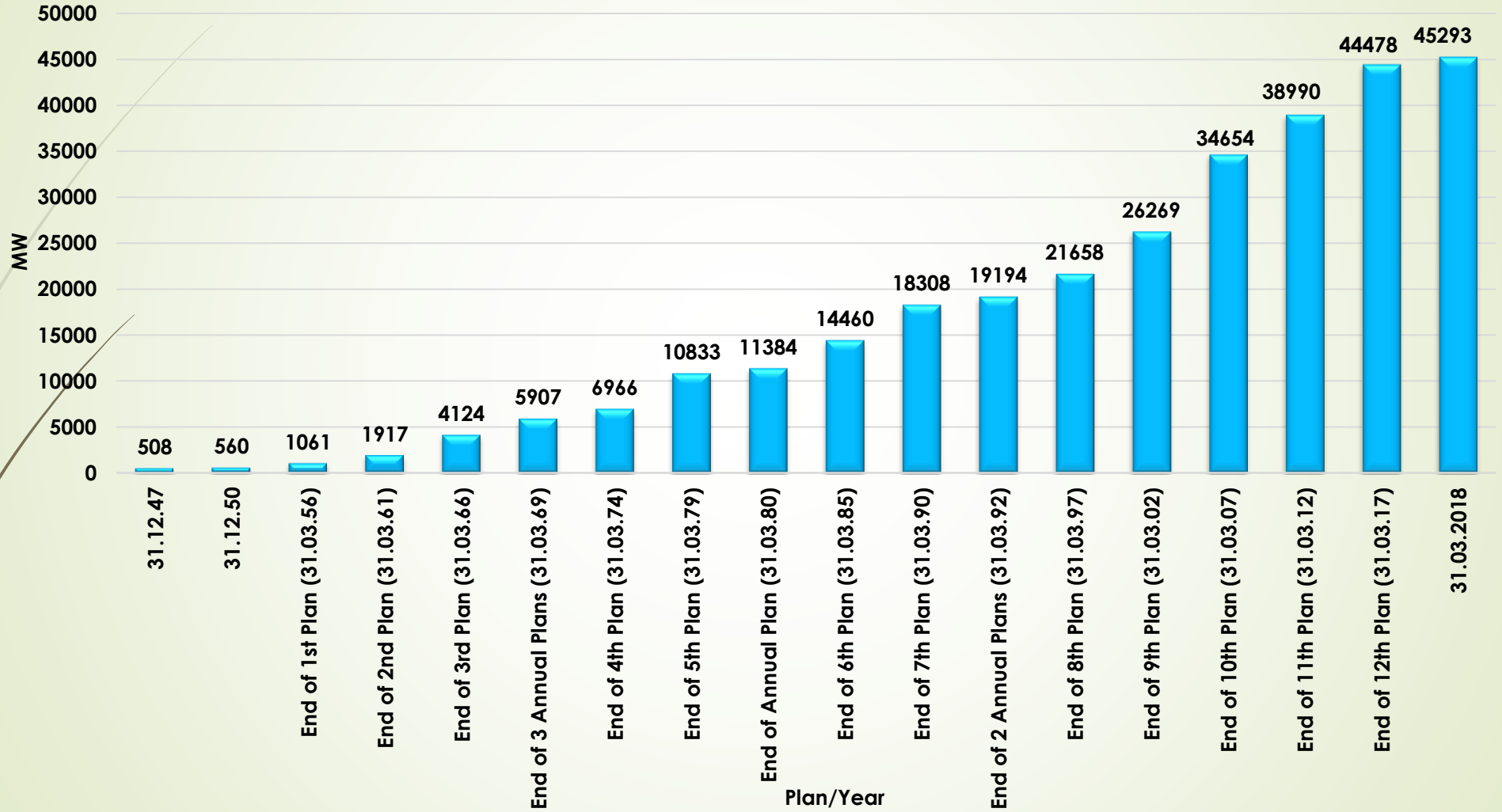
Plan wise Growth of Installed Capacity in India
Gas/ Liquid based Plants



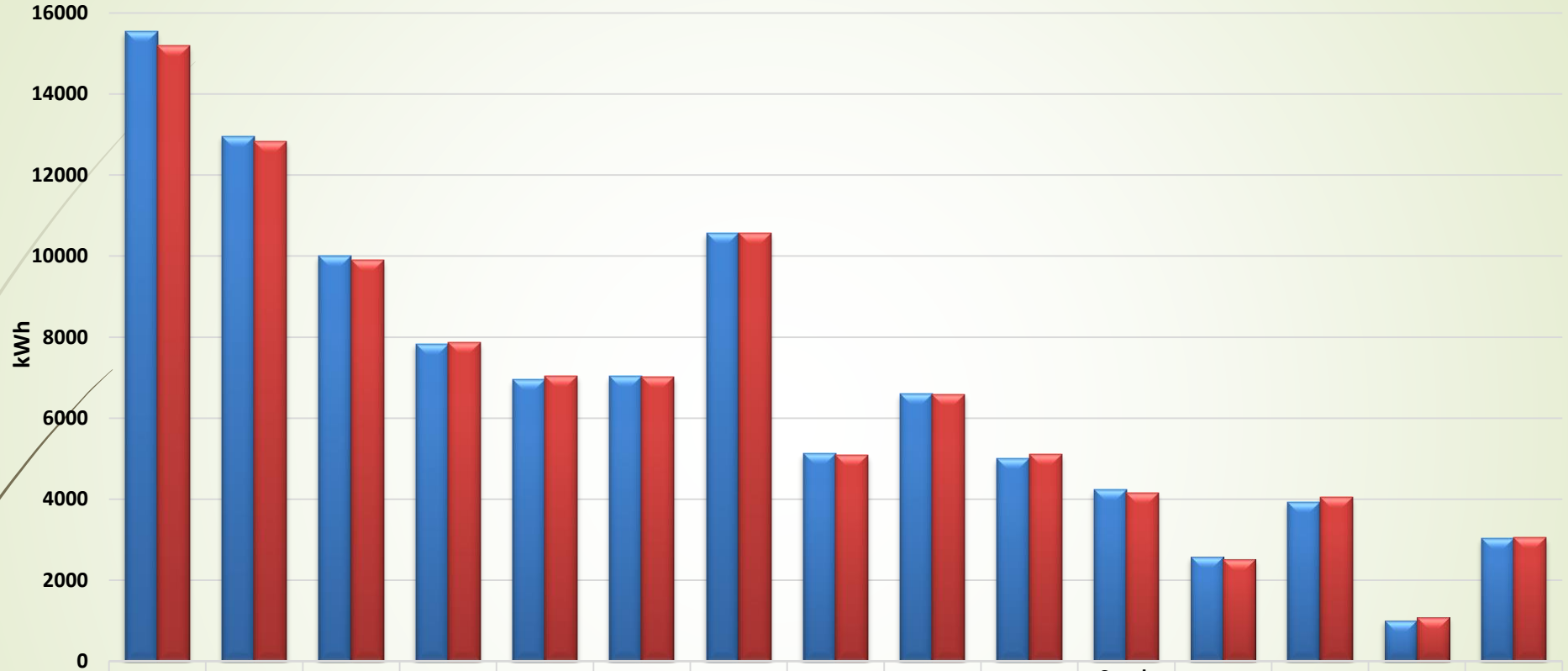
Plan wise Growth of Installed Capacity in India
Diesel based Plants



Plan wise Growth of Installed Capacity in India
Hydro Electric Power Stations



PER CAPITA ELECTRICITY CONSUMPTION IN VARIOUS COUNTRIES IN 2014 & 2015



	Canada	USA	Australia	Japan	France	Germany	Korea	UK	Russia	Italy	South Africa	Brazil	China	India*	World
2014	15544	12962	10002	7829	6955	7035	10564	5131	6603	5002	4240	2578	3927	1010	3030
2015	15188	12833	9892	7865	7043	7015	10558	5082	6588	5099	4148	2516	4047	1075	3052

Source : IEA publication 'Key World Energy Statistics 2014 website (other than India)

* Per capita consumption = (gross electrical energy avaibality /mid year population)

Salient Features of UDAY

- States shall take over 75% of DISCOM debt as on 30 September 2015 over two years - 50% in 2015-16 and 25% in 2016-17.
- Government of India will not include the debt taken over by the States as per the above scheme in the calculation of fiscal deficit (FRBM Limit) of respective States in the financial years 2015-16 and 2016-17.
- States will issue non-SLR including SDL bonds in the market or directly to the respective banks / Financial Institutions (FIs) holding the DISCOM debt to the appropriate extent.
- DISCOM debt not taken over by the State shall be converted by the Banks / FIs into loans or bonds with interest rate not more than the bank's base rate plus 0.1%. Alternatively, this debt may be fully or partly issued by the DISCOM as state-guaranteed DISCOM bonds at the prevailing market rates which shall be equal to or less than bank base rate plus 0.1%.
- UDAY is optional for all States. However, States are encouraged to take the benefit at the earliest as benefits are dependent on the performance.
- Outcomes of operational improvements will be measured through following indicators:
  - Reduction of AT&C loss to 15% by 2018-19 as per the loss reduction trajectory to be finalized by Ministry of Power (MoP) and States; and
  - Reduction in gap between Average Cost of Supply (ACS) & Average Revenue Realized (ARR) to zero by 2018-19 as finalized by MoP and States.