NIGERIA LONG TERM ENERGY PLAN USING MESSAGE CODE FOR OPTIMAL ENERGY UTILISATION

AUTHORS: Kabiru Abdullahi and MyungSub-Roh

PRESENTER: Kabiru Abdullahi

2016 10 28

Outline

BACKGROUND

- Intro
- Objective
- Nigeria
- MESSAGE Code

SCENARIOS

- Base scenario
- NPP Intro
- Enforcing penalty

CONCLUSION

- Result
- Discussion

BACKGROUND: Objective of the study

- To collect and collate relevant data required for modeling Nigeria energy resources and infrastructures as input for MESSAGE code.
- To prepare this data for use in MESSAGE CODE.
- To develop a robust energy models to meet Nigeria energy demands.
- To make intelligent analysis and provide useful recommendations for energy security of Nigeria.
- Ultimately to provide an informed guide to Nigerian energy crises.
- To serve as reference for future studies in energy planning

NIGERIA LONG TERM ENERGY PLAN

KINGS

BACKGROUND

GDP: Purchasing power parity;$1.105 trillion (2015 est.)

GDP: Per capita:$6,400 (2015 est.)

CBN Discount rate 4.25% (31 December 2010)

Population: 181,562,056 inhabitants

Electricity Production: 27.27 billion kWh (2012 est.)

Electricity Consumption:24.78 billion kWh (2012 est.)

Climate: Equatorial in south, tropical in center and arid in north

BACKGROUND: Resources

Reserves

- Natural Gas reserve:5.118trillionCUM
- Crude oil reserve: 37.7bbl
- Hydro:14,750MW
- Coal reserves: 2billion Mt

Challenges

- Population:181,562,056 inhabitants
- Total installed capacity:11,165.40MW
- Carbon dioxide emission:86.4million Mt(2012est)
- Obsolete energy facilities

65.5%Gas
33.5%Hydro
1.0%Renewables

Current available capacity: 7,139.60.38MW.

BACKGROUND: Demand

Electricity demand projection per scenario(MW)..ECN IAEA

Scenario	2009	2010	2015	2020	2025	2030
Reference growth (7%)	4,052	7,440	24,380	45,490	79,798	115,674
High growth (10%)	4,052	8,420	30,236	63,363	103,859	196,875
Optimistic growth (11.5%)	4,052	9,400	36,124	76,124	145,113	251,224
Optimistic growth (13%)	4,052	10,230	41,133	88,282	170,901	315,113

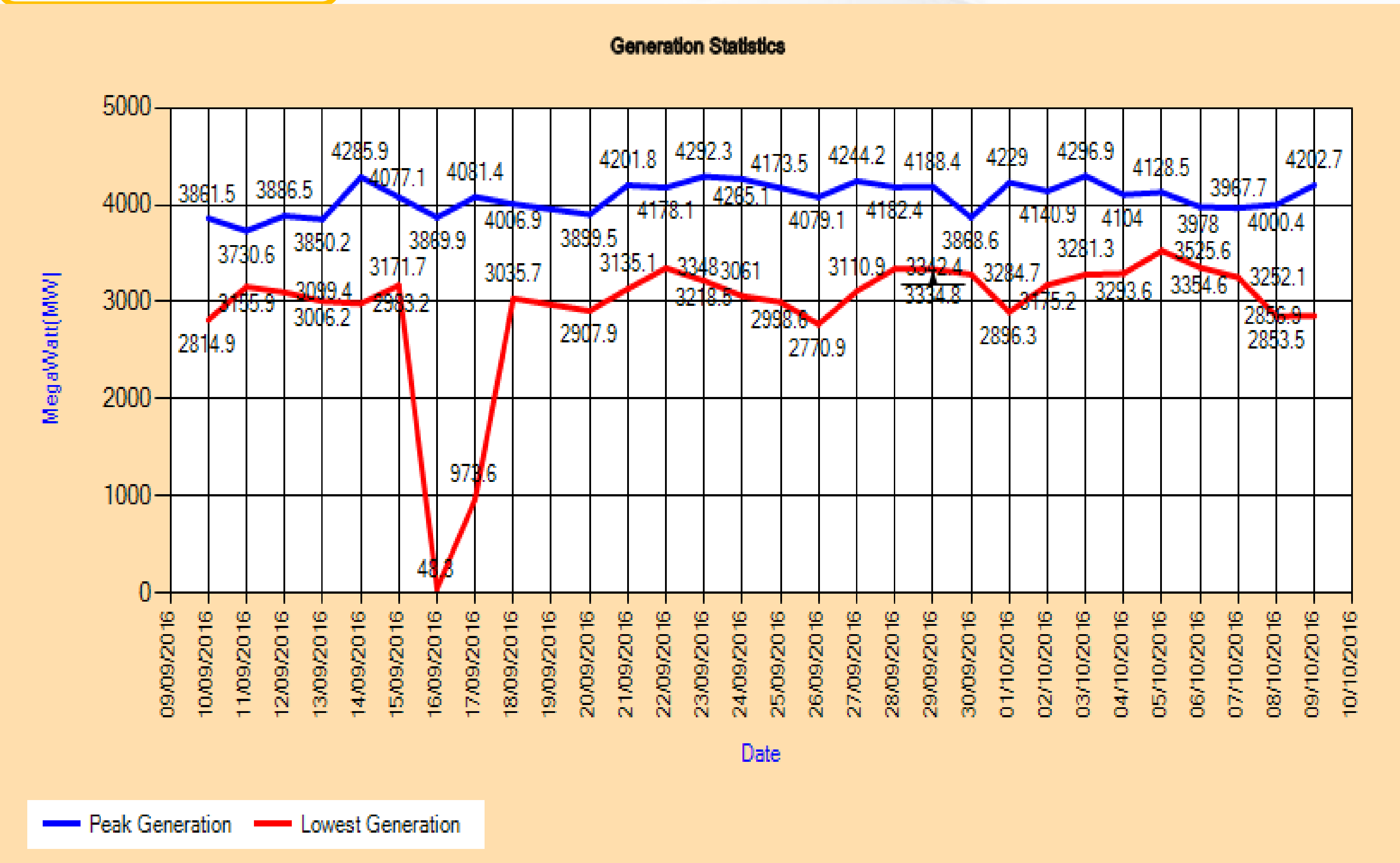
10,230MW is the base year demand for this study.

This correspond to 14,761MW demand this year 2016.

Peak generation as up 11th April 2016 is 4368.5MW!!!

BACKGROUND: Infrastructure

Generation



BACKGROUND: Infrastructure

Transmission

Voltage level	Minimum Voltage kV (pu)	Maximum Voltage kV (pu)
330 kV	313.5 (0.95)	346.5 (1.05)
132 kV	118.8 (0.9)	145.0 (1.098)
33 kV	31 (0.94)	34.98 (1.06)
16 kV	15.2 (0.95)	16.8 (1.05)
11 kV	10.45 (0.95)	11.55 (1.05)

1	Capacity 330/132kV (MVA)	6,894
2	Capacity 132/33kV (MVA)	8,882
3	Number of 330kV Substations	28
4	Number of 132kV Substations	119
5	Total Number of 330kV circuits	60
6	Total Number of 132kV circuits	153
7	Length of 330kV lines (kM)	5,650
8	Length of 132kV lines (kM)	6,687
9	National Control Centre	1
10	Supplementary National Control Centre	1
11	Regional Control Centres	3

BACKGROUND: Infrastructure

Government own power plants with their capacities

S/N	Plant	Year Commissioned	Fuel Type	Installed Capacity (MW)
1	Kainji	1968	Hydro	760
2	Jebba	1986	Hydro	578
3	Shiroro	1990	Hydro	600
4	Egbin	1985	Thermal Steam/NG, HPFO	1320
5	Sapele I	1978	Thermal Gas Turbine/NG	720
6	Sapele II	1981	Thermal Gas Turbine/NG	300
7	Ijora	1978	Thermal Gas Turbine/NG	60
8	Delta	1975	Thermal Gas Turbine/NG	912
9	Afam	1963	Thermal Gas Turbine/NG	711
10	Oji	1956	Coal	30
Total				**5991**

BACKGROUND: Infrastructure

Grid connected power plants

SUMMARY OF GENERATION CAPABILITIES OF PHCN POWER STATIONS AS OPERATED IN THE YEAR 2012(JANUARY - DECEMBER)

POWER STATION	AVAILABILITY FACTOR (MW)	AVERAGE AVAILABILITY (MW)	INSTALLED CAPACITY (LESS DE-COMMISSIONED UNITS) MW
PHCN - HYDRO STATIONS			
KAINJI HYDRO	0.39	295.38	760.00
JEBBA HYDRO	0.72	414.42	578.40
SHIRORO	0.83	497.46	600.00
SUB TOTAL	0.62	1207.26	1938.40
PHCN - THERMAL STATIONS			
EGBIN STEAM	0.77	1022.56	1320.00
AFAM (I-V) (GAS)	0.27	95.32	351.00
DELTA (GAS)	0.27	246.23	900.00
SAPELE ST	0.14	98.52	720.00
GEREGU (GAS)	0.66	274.96	414.00
OLORUNSOGO I	0.64	214.39	335.00
OMOTOSHO	0.34	113.02	335.00
SUB TOTAL	0.47	2064.99	4375.00
NIPP - THERMAL STATIONS			
OLORUNSOGO II	0.66	496.20	750.00
OMOTOSHO NIPP	0.29	144.73	500.00
SAPELE NIPP	0.58	218.26	375.00
SUB TOTAL	0.53	859.20	1625.00
IPP - THERMAL STATIONS			
RIVERS IPP	0.20	35.12	180.00
OMOKU GT	0.26	38.53	150.00
TRANS-AMADI GT	0.31	30.65	100.00
OKPAI GAS	0.92	440.86	480.00
IBOM	0.21	32.08	155.00
AFAM VI (GAS)	0.93	603.70	650.00
A.E.S (GAS)	0.68	203.99	302.00
SUB TOTAL	0.69	1384.93	2017.00
GRAND TOTAL	**0.55**	**5516.38**	**9955.40**

Technical and Economical Data

Thermal Power Plant

NAME	No of Units	Minimum operation Level (MW)	Maximum Capacity (MW)	Heat Rates (kcal/kWh)		Fuel Cost(cent/10^6 kcal)		Fuel Type	Spining reserve	Forced outage rate	Scheduled Maintenance (days/year)	Maintenance Class (MW)	Fixed O&M ($/kW-month)	Variable O&M ($/MWh)
				Minimum	Avg. Incr.	Domestic	Foreign							
AA1	0	10	26	3246	2898	47.4	0	gas	10	10	12	50	0.47	1.02
EB1	6	55	220	3068	2790	47.4	0	gas	10	10	12	200	0.42	1.02
SP1	2	60	120	3651	2482	47.4	0	gas	10	10	12	150	0.27	1.02
DL1	0	5	44	3228	2868	47.4	0	gas	10	10	12	50	0.08	2
SP2	0	20	75	3200	2871	47.4	0	gas	10	10	12	100	0.47	2
AA2	1	25	27	3902	2649	47.4	0	gas	10	10	12	50	0.84	2
AA3	1	25	75	3200	2871	47.4	0	gas	20	10	12	100	0.42	2
AA4	0	40	138	3651	2482	47.4	0	gas	10	10	12	150	0.43	2
DL2	2	5	25	3970	2610	47.4	0	gas	10	10	12	50	0.62	2
DL3	2	5	20	3970	2406	47.4	0	gas	10	10	12	50	0.62	2
DL4	6	5	100	3177	2810	47.4	0	gas	10	10	12	100	0.62	2
IJR	1	5	20	3200	2871	57.4	0	diesel	10	10	12	50	1.13	2
AS1	9	5	30	3970	2610	69.5	0	gas	10	10	12	150	0.59	2
PA1	0	10	41	3270	2810	47.4	0	gas	10	10	12	50	0.44	2
GER	0	40	138	3651	2482	47.4	0	gas	10	10	12	150	0.43	2
OMT	0	10	41	3270	2810	47.4	0	gas	10	10	12	50	0.43	2
ALJ	0	10	44	3200	2871	47.4	0	gas	10	10	12	50	0.43	2
AGP	3	25	100	3177	2810	47.4	0	gas	10	10	12	100	0.43	2
IBM	0	37	147	3132	2832	47.4	0	gas	10	10	12	150	0.59	2.2
NIG	21	5	115	3177	2810	47.4	0	gas	10	10	12	150	0.62	2.0

Candidate Power Plant

NAME	Minimum operation Level (MW)	Maximum Capacity (MW)	Heat Rates (kcal/kWh)		Fuel Cost(cent/10^6 kcal)		Fuel Type	Spining reserve	Forced outage rate	Scheduled Maintenance (days/year)	Maintenance Class (MW)	Fixed O&M ($/kW-month)	Variable O&M ($/MWh)
			Minimum	Avg. Incr.	Domestic	Foreign							
GTP1	20	50	4619	3299	47.4	0	Gas	10	12	15	50	2.5	2
GTP2	50	100	4541	3243	22.9	0	Gas	10	25	15	100	1.07	1.8
GTP3	25	150	4307	3077	47.4	0	Gas	10	12	30	150	1.08	2
CGT1	25	200	2176	1530	47.4	0	Gas	10	12	30	200	1.08	2
CGT2	25	400	2530	2430	47.4	0	Gas	10	12	30	400	1.08	2
SNG1	20	100	2980	2900	47.4	0	Gas	10	12	30	100	0.8	2
SNG2	20	200	2390	2130	47.4	0	Gas	10	12	30	200	0.68	2
FBC1	100	200	2490	2120	22.9	0	Coal	10	12	30	200	1.33	2
FBC2	200	400	2530	2490	22.9	0	Coal	10	12	30	400	1.33	2
OST1	100	200	2900	2840	49.1	0	FO	10	12	30	200	1.12	2
NUP1	150	300	2720	2440	0	697.8	Nucl	10	15	61	200	3.33	2
NUP2	300	600	2720	2440	0	697.8	Nucl	10	15	61	200	3.33	2

BACKGROUND: Technical Data

Energy supply and Economics

S/N	ITEMS	200	2004 3	2005	2006	2007	2008	2009	2010	2011	2012
1.	Electricity generation (billion kWh)	22.0	23.9 3	24.22 (503)* (10,695)**	23.8	23.3	21.27 (562)* (18,603)**	20.8	25.02	27.7 (619)* (20,407)**	29.6
2,	Energy Consumption per Capita (kgoe/Capita)	151.	125.5 3	132.6 (680)* (1,780)**	87.1	81.4	80.8 (670)* (1,830)**	83.1	77.8	73.6 (670)* (1880)**	65.7
3.	Electricity Consumption/capita (kWh/Capita)	174.	176.4 6	181.4 (563)* (2596)**	167.6	161.2	142.9 (571)* (2782)**	135.2	157.1	165 (592)* (2933)**	175.9
4.	GDP/Capita (US$/Capita)	620.	658.0 7	826.3 (2314)* (8,492)**	1030.3	1223.5	1286.3 (2540)* (9550)**	1,106.8	1440.7	1470.6 (1281)* (7520)**	1513.4
5.	Energy Intensity (kgoe/ US$)	0.24	0,191 4	0.161 (0.294)* (0.210)**	0.085	0.067	0.063 (0.264)* (0.192)**	0.075	0.054	0.050 (0.550)* (0.250)**	0.043
6.	GDP Growth Rate (%)	9.6	6.6	6.5	6.0	6.5	6.0	7.0	8.0	7.4	6.6

Base year

BACKGROUND: Challenges

Not enough Data or too much unsorted data?

MESSAGE AS A TOOL FOR ENERGY OPTIMIZATION

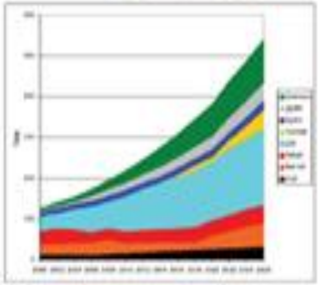
MESSAGE

Model for Energy Supply System Alternatives and their General Environmental Impacts

INPUT

- Energy system structure (including vintage of plant and equipment)
- Base year energy flows and prices
- Energy demand projections
- Technology and resource options & their techno-economic performance profiles
- Technology innovations
- Technical and policy constraints
- Environmental regulations
- Market players

OUTPUT



- Optimal energy strategies
- Primary and final energy mix
- Emissions and waste streams
- Health and environmental impacts (externalities)
- Energy trade & market prices
- Efficacy of environmental regulation
- Resource use
- Investment requirements
- Import dependence
- Land use
- Effectiveness of DSM, taxes, etc.

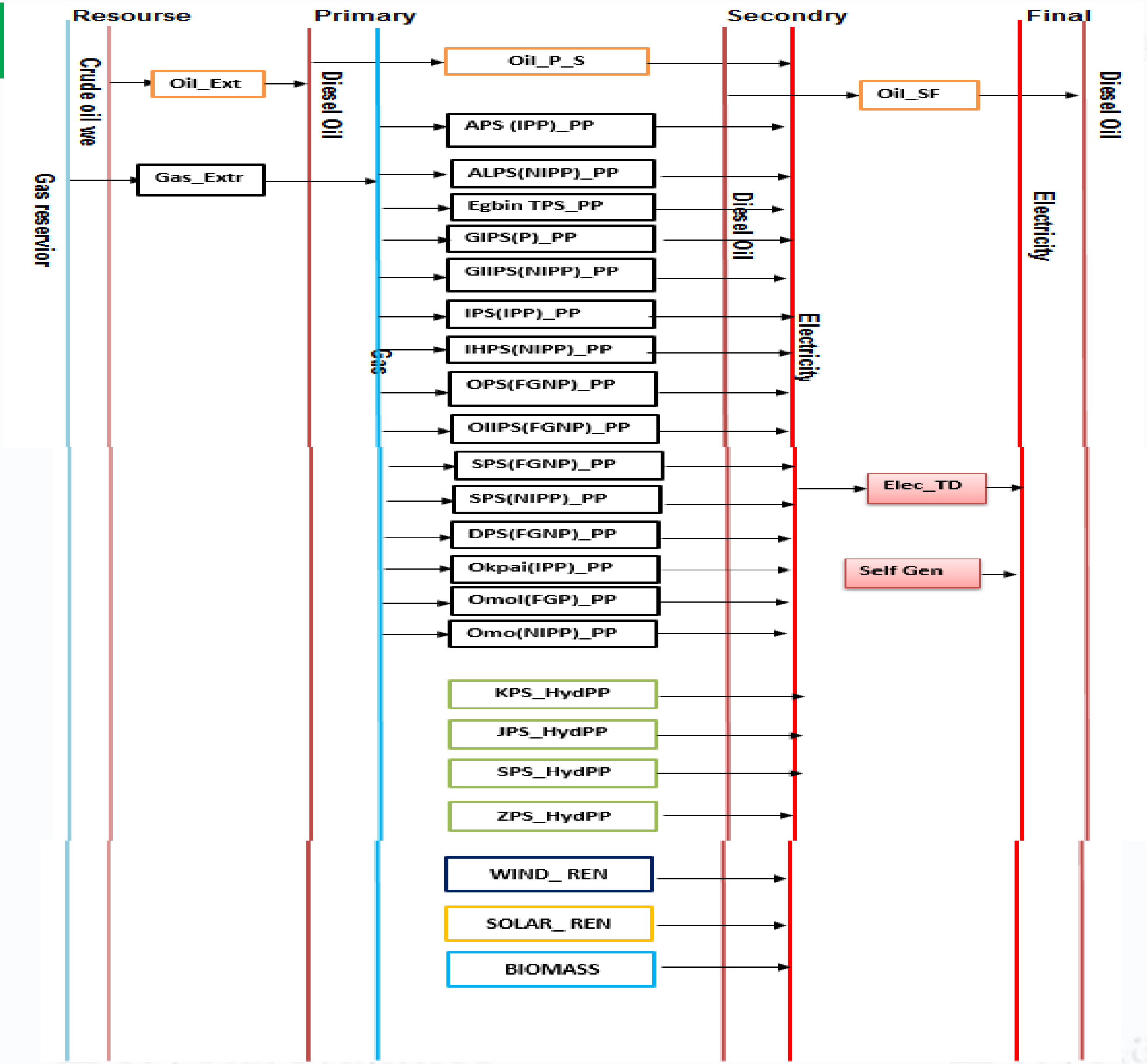
BASE SCENARIO MODEL

Base scenario is like a foundation in a building on which all floors are raised

Technically

: Is a set of basic assumptions that are expected to result in the most realistic outcome of a series of events.

NIGERIA ENERGY FLOW NETWORK



BASE SCENARIO MODEL

IAEA - MESSAGE Int_V2 NIGERIA adb

Screen

General | Load regions | Energyforms | Demands | Constraints | Technologies | Storages | Resources | Chain

General data

- country: NIGERIA
- Weekend: Sunday
- case name: NIGERIA
- language: english
- drate: 6.0
- Inv. switch: shifted
- years: 2010 2013 2016 2019 2022 2025 2028 2031
- units: energy: MWyr
- power: MW
- currency:
- units: volume: Mm3
- weight: kton
- time:
- ntrun: 6
- mixsw: no
- actint:

description

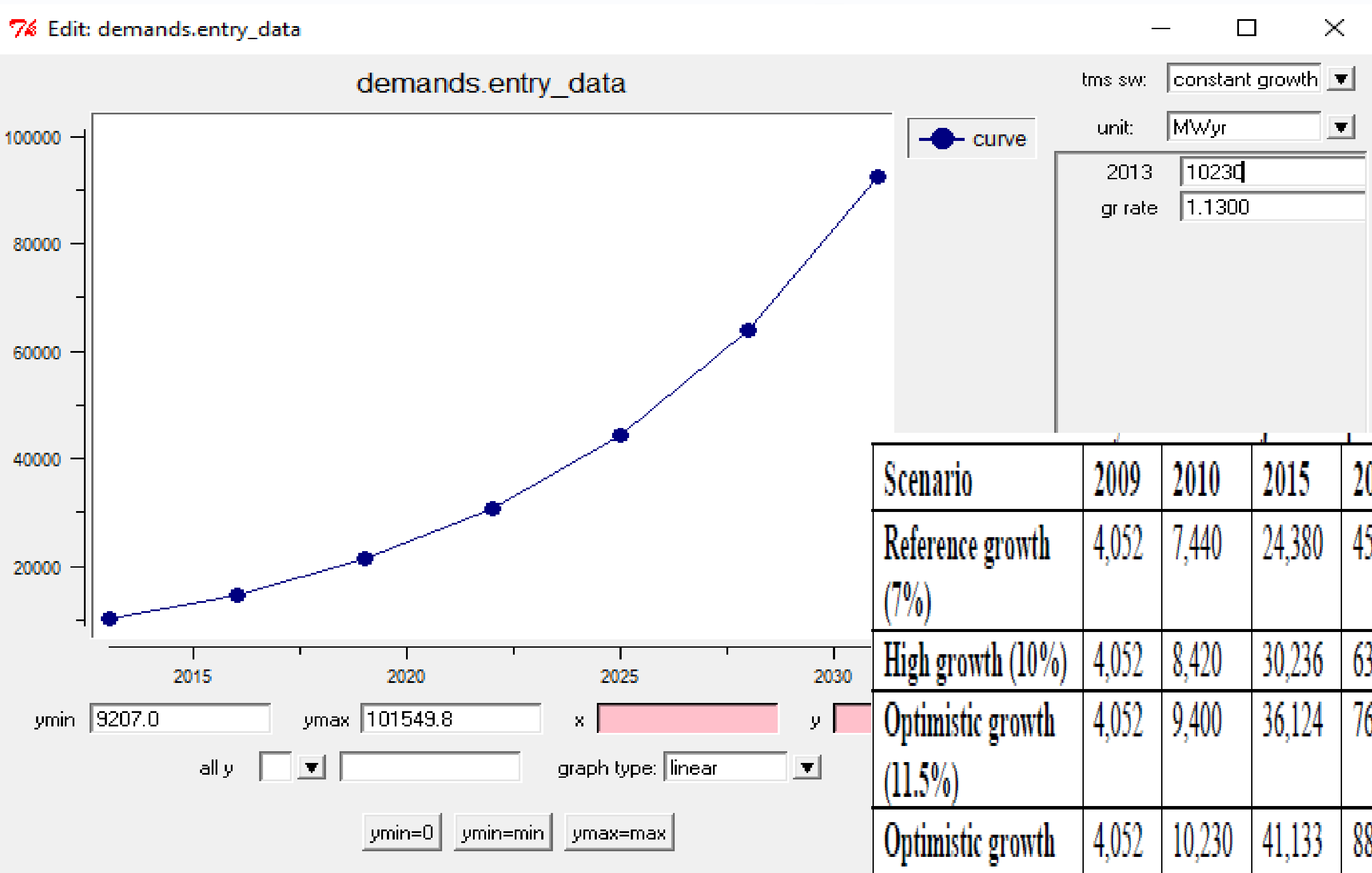
PLANTS IN OPERATION
OPERATIONAL POWER PLANTS IN NIGERIA

Technology chain select

Technologies

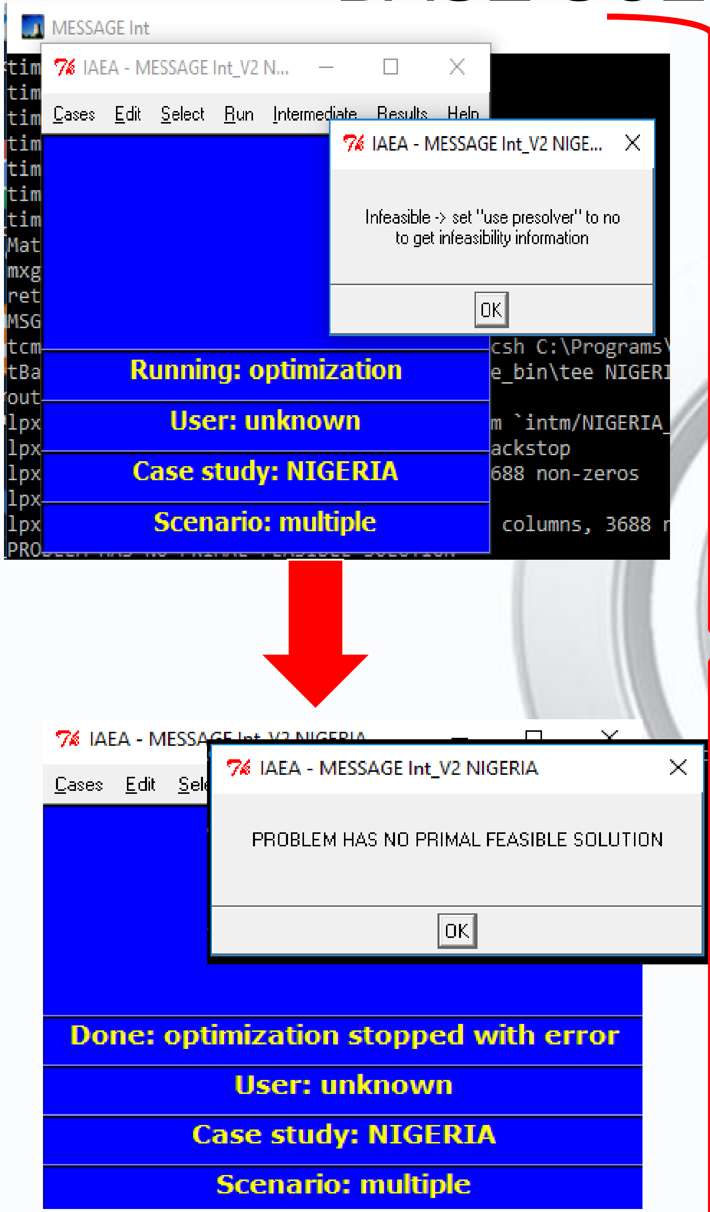
Level	Energyform	Producers	Consumers
Resource_Available	Oil		Oil_Etr
	Gas		Gas_Ext
	Coal		Coal_Extr
Primary_Energy	Oil	Oil_Etr	Oil_P_S
	Gas	Gas_Ext	Gas_AfamIV_IPP Gas_Alaoji_NIPP Gas_Egbin Gas_Gregu_PP Gas_GreguII_PP Gas_Ihovbo_PP Gas_Ibom_PP Gas_Okpai_IPP Gas_Olorunsogo_PP Gas_olorunsogoII_NIP Gas_Omotosho_FGP Gas_OmotoshiII_NIPP Gas_Sapele_FGP Gas_Sapele_NIPP Gas_Ughele_FGP
	Coal	Coal_Extr	Coal_ItobePP
Secondary_Energy	Electricity	Gas_AfamIV_IPP Gas_Alaoji_NIPP Gas_Egbin Gas_Gregu_PP Gas_GreguII_PP Gas_Ihovbo_PP Gas_Ibom_PP Gas_Okpai_IPP Gas_Olorunsogo_PP Gas_olorunsogoII_NIPP Gas_Omotosho_FGP Gas_OmotoshiII_NIPP Gas_Sapele_FGP	Elec_TD

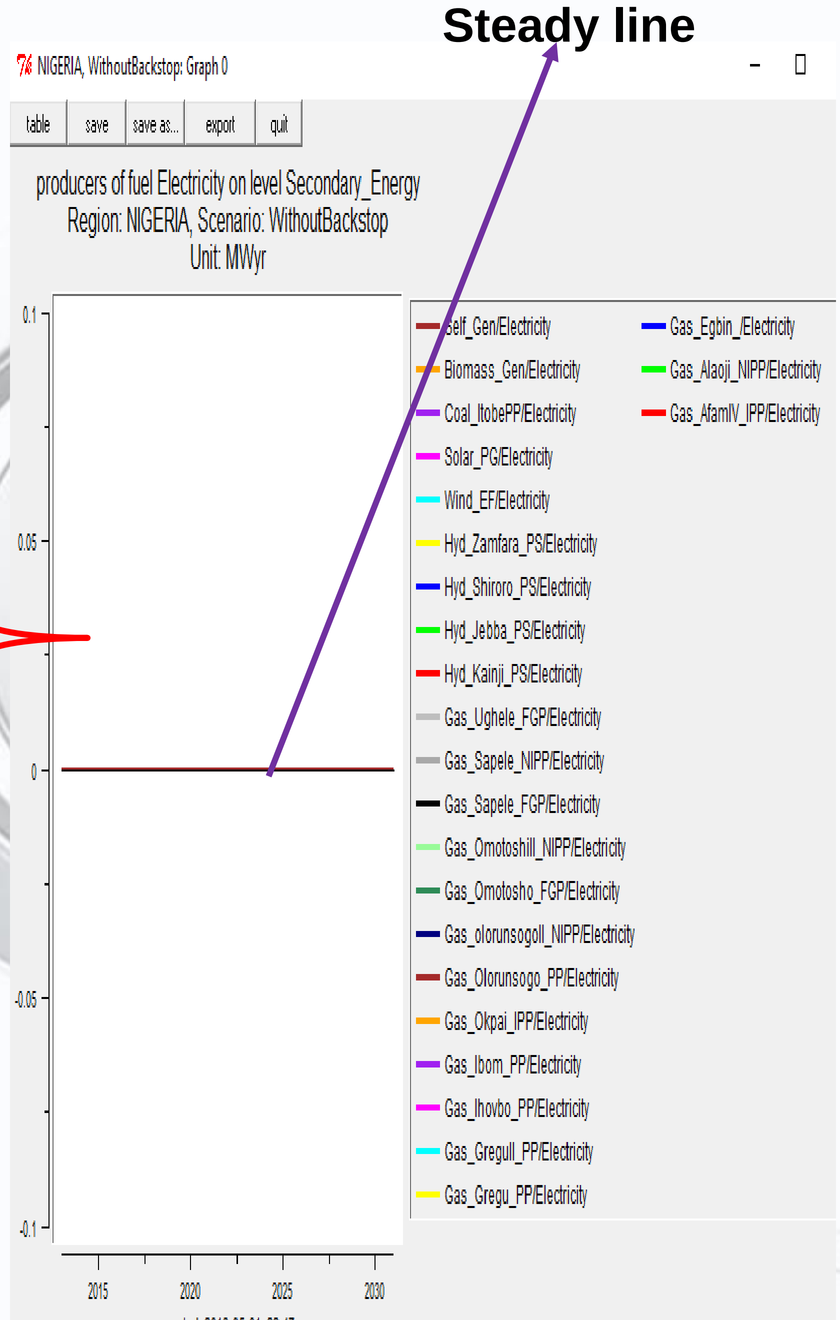
Base Scenario Demand curve



Scenario	2009	2010	2015	2020	2025	2030
Reference growth (7%)	4,052	7,440	24,380	45,490	79,798	115,674
High growth (10%)	4,052	8,420	30,236	63,363	103,859	196,875
Optimistic growth (11.5%)	4,052	9,400	36,124	76,124	145,113	251,224
Optimistic growth (13%)	4,052	10,230	41,133	88,282	170,901	315,113

BASE SCENARIO MODEL

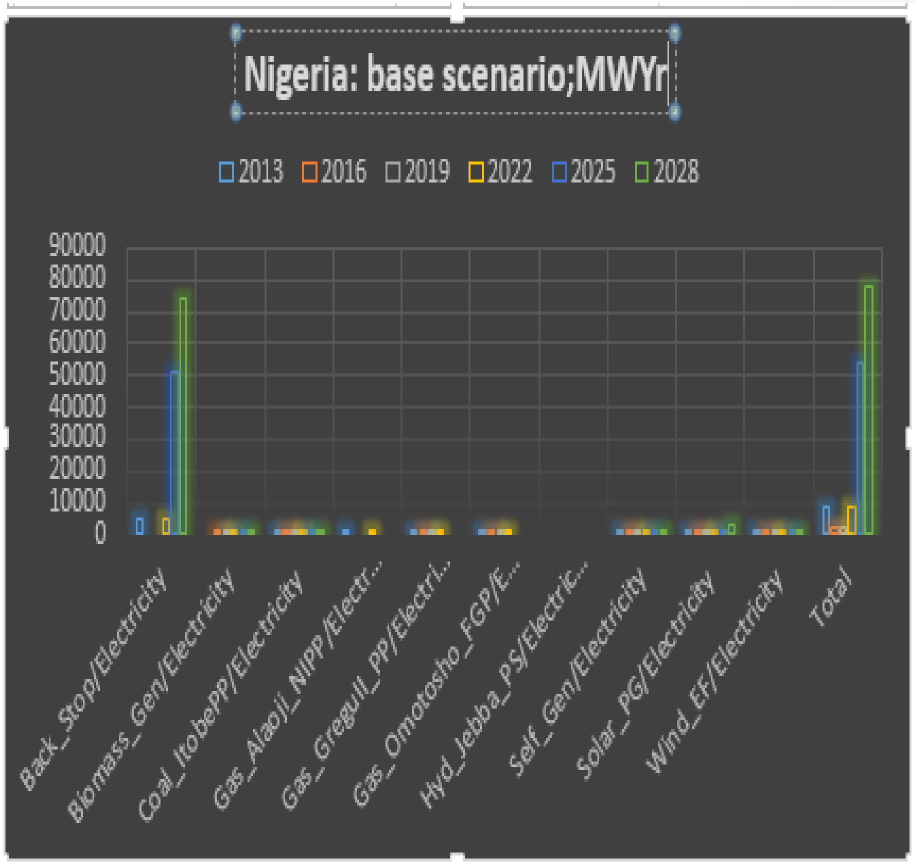


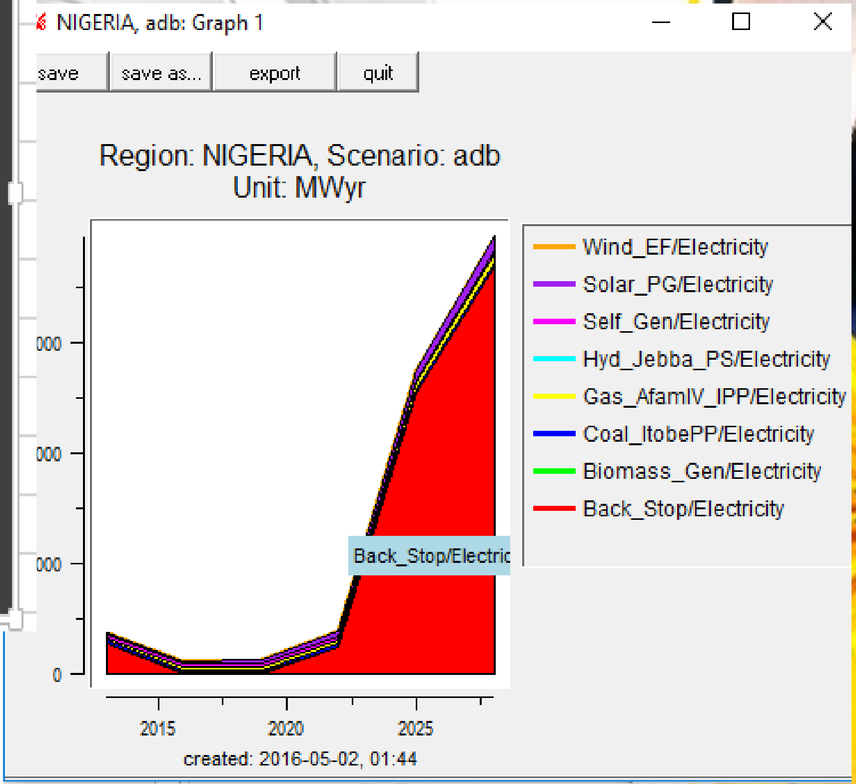


BASE SCENARIO MODEL-BACK STOP TECHNOLOGY

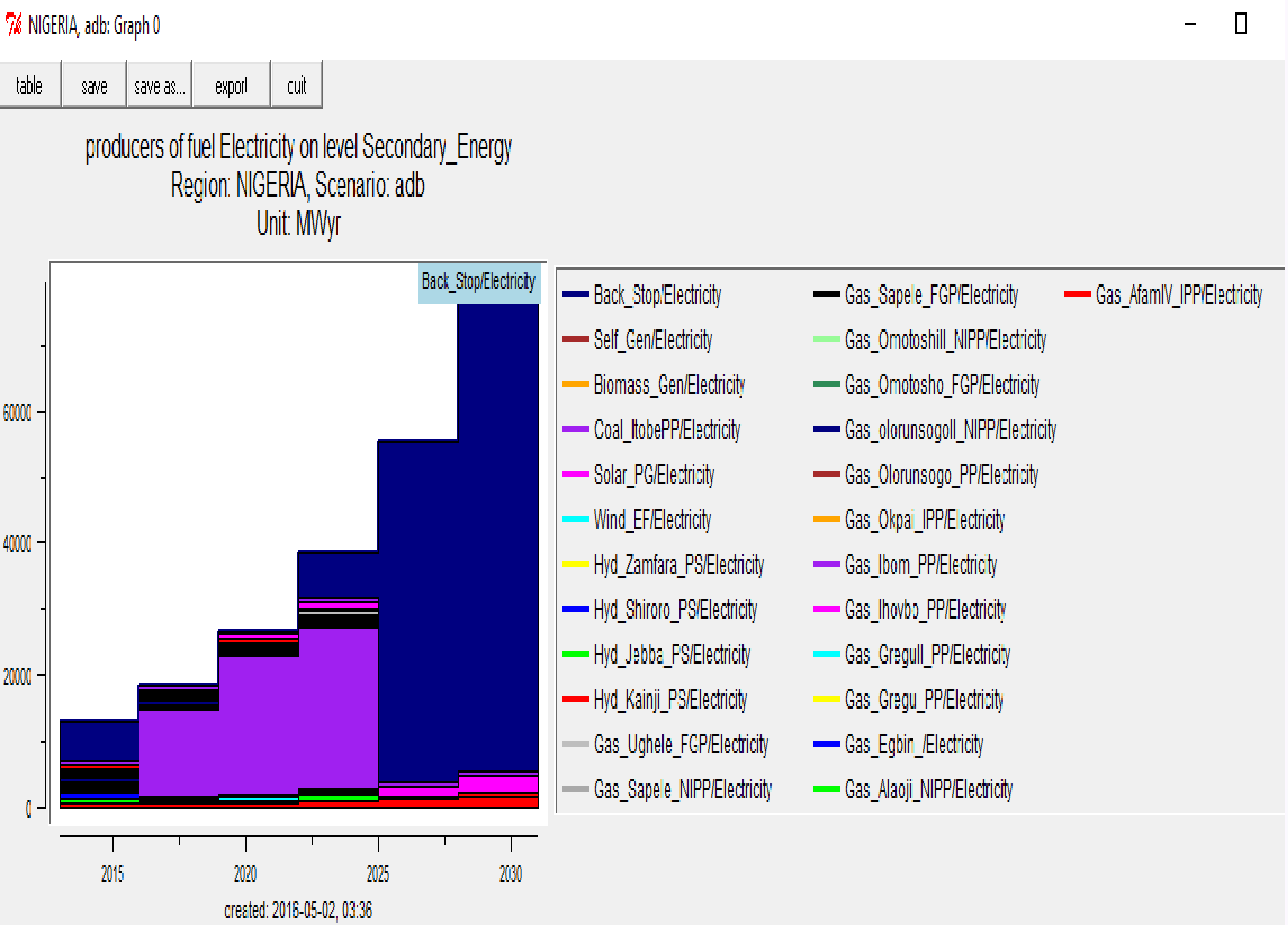
Back-stop:Resources that is essentially unlimited, and that need will cause the development of new technologies to become cost effective

BASE SCENARIO MODEL-Back Stop Technology





BASE SCENARIO MODEL



NIGERIA LONG TERM ENERGY PLAN USING MESSAGE AS ATOOL FOR OPTIMISATION

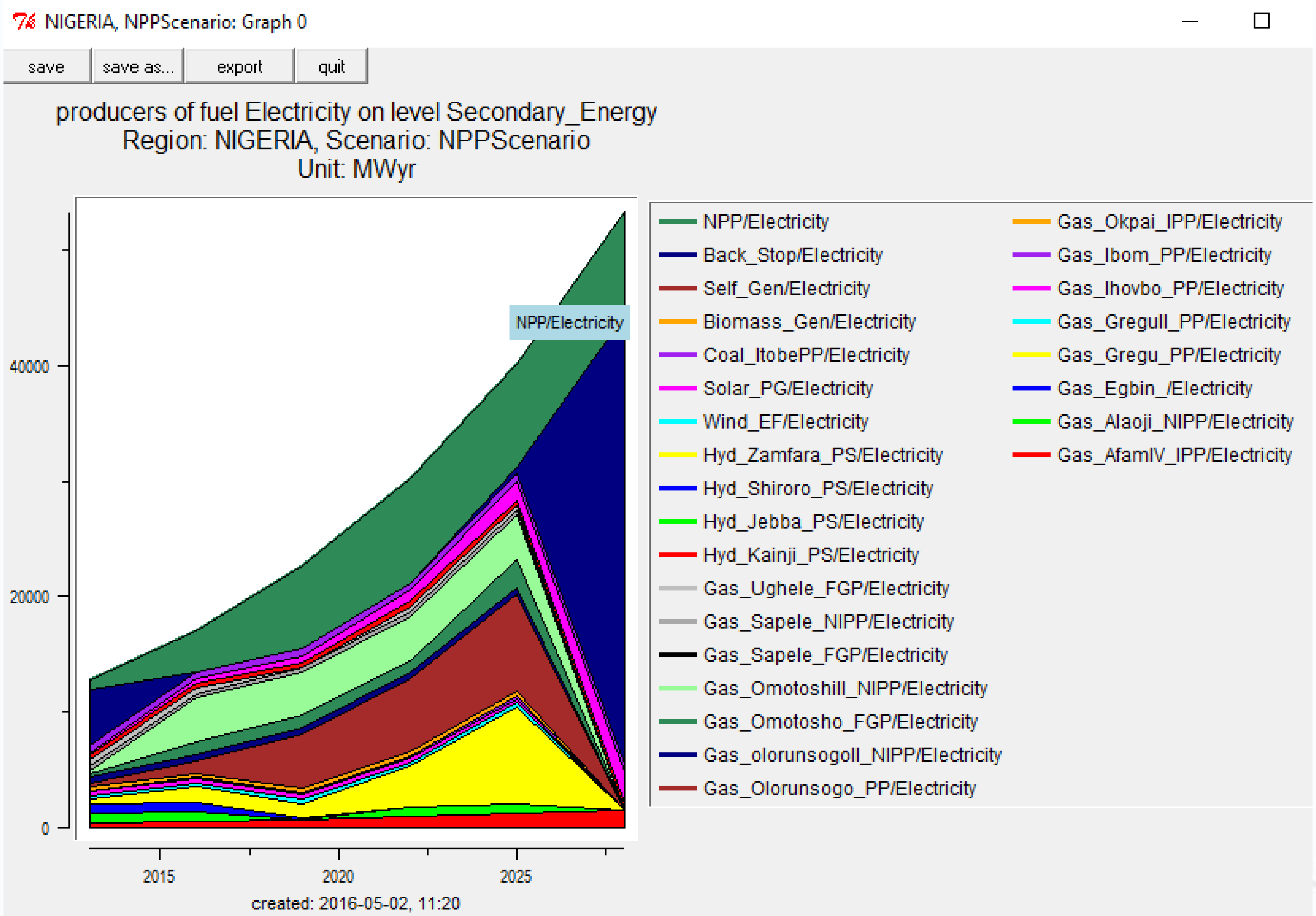
PROSPCTIVE SCENARIOS

INTRODUCING NPP

EMISSION PENALTY

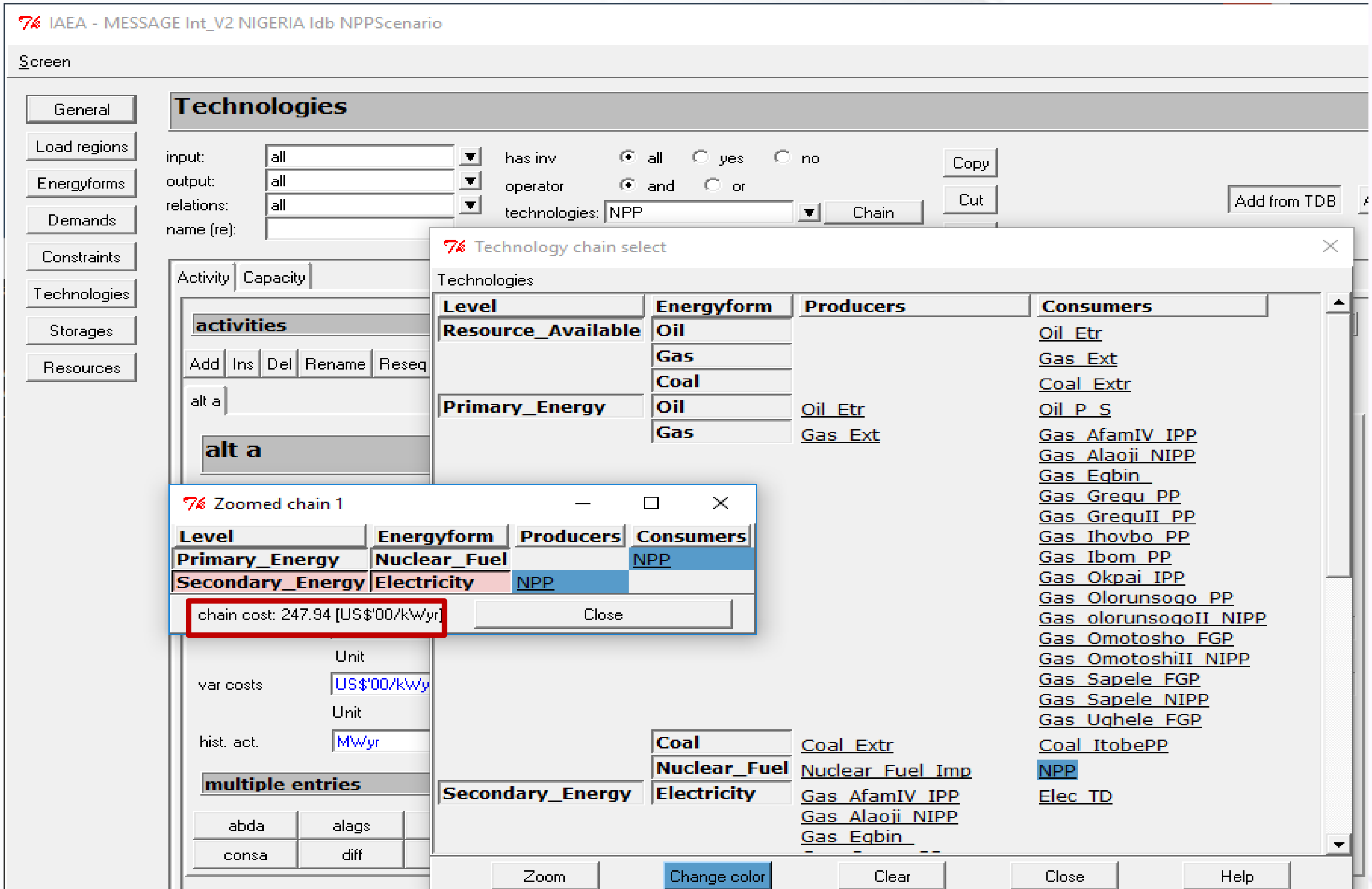
NPP SCENARIO

RESULT

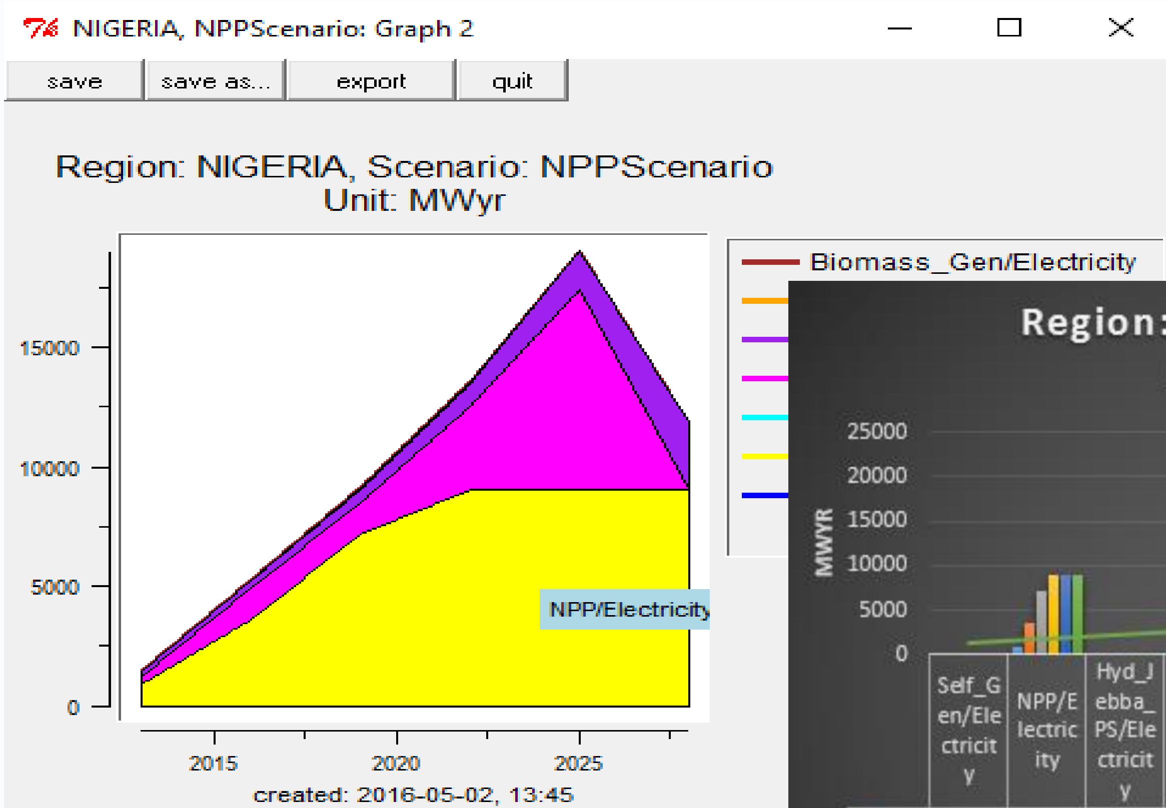


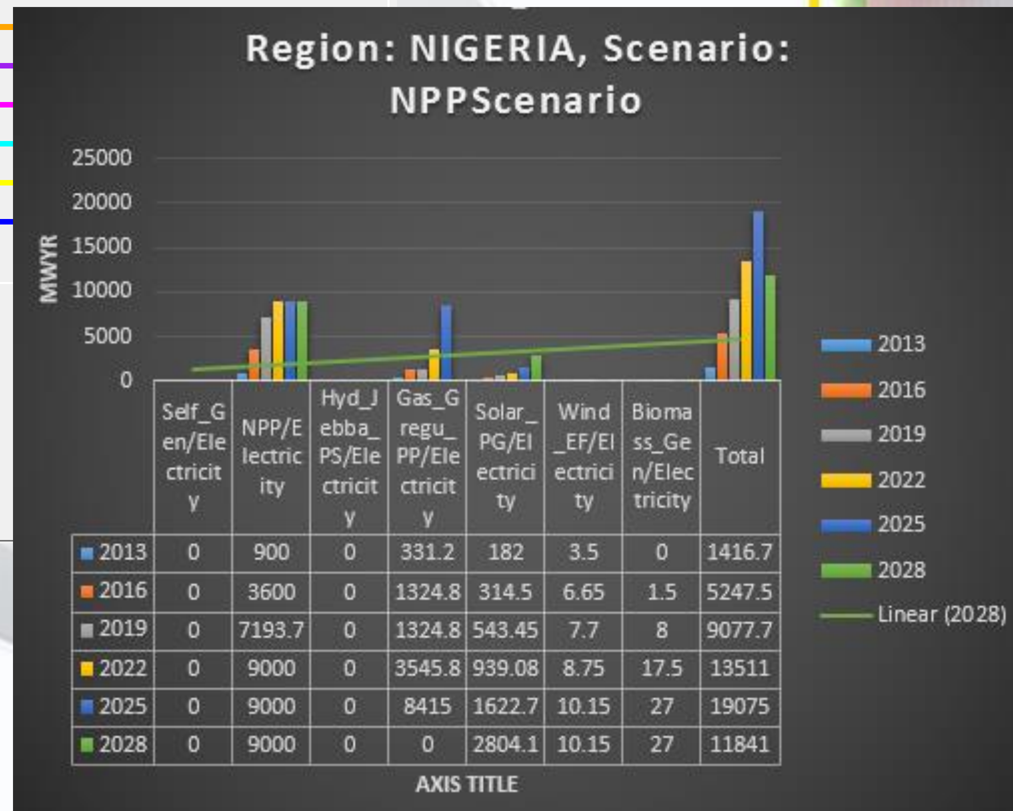
NPP SCENARIO

NPP CHAIN COST



NPP SCENARIO WITH MAJOR ENERGY PLAYERS

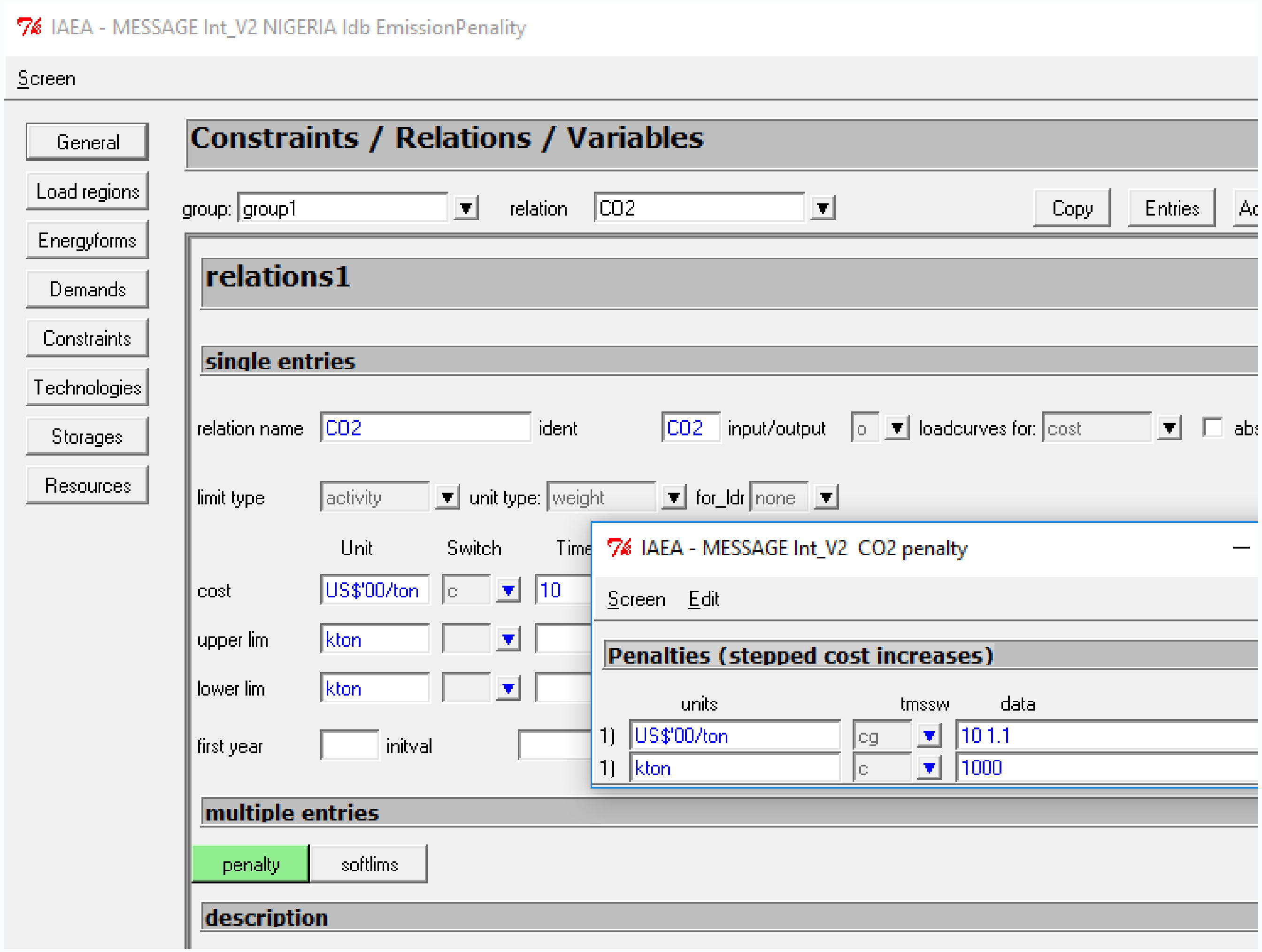




	Self_Gen/Electricity	NPP/Electricity	Hyd_Jebba_PS/Electricity	Gas_Gregu_PP/Electricity	Solar_PG/Electricity	Wind_EF/Electricity	Biomass_Gen/Electricity	Total
2013	0	900	0	331.2	182	3.5	0	1416.7
2016	0	3600	0	1324.8	314.5	6.65	1.5	5247.5
2019	0	7193.7	0	1324.8	543.45	7.7	8	9077.7
2022	0	9000	0	3545.8	939.08	8.75	17.5	13511
2025	0	9000	0	8415	1622.7	10.15	27	19075
2028	0	9000	0	0	2804.1	10.15	27	11841

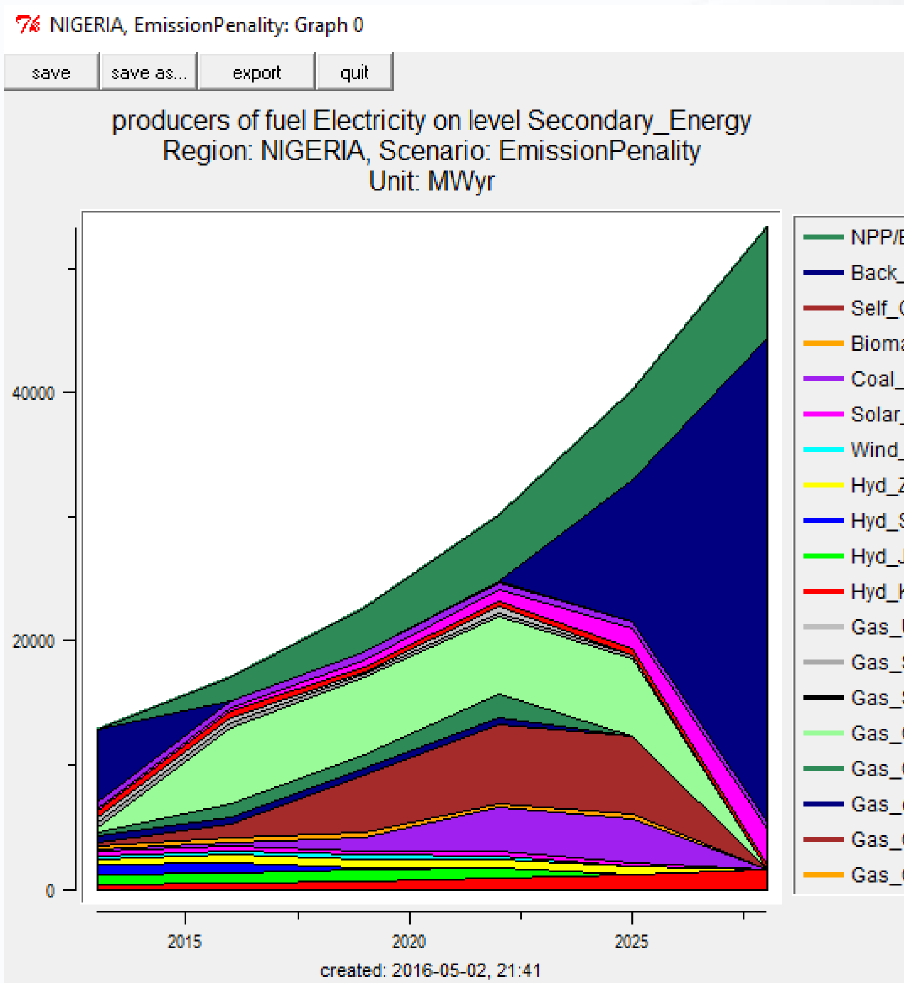
End to Self Gen!!

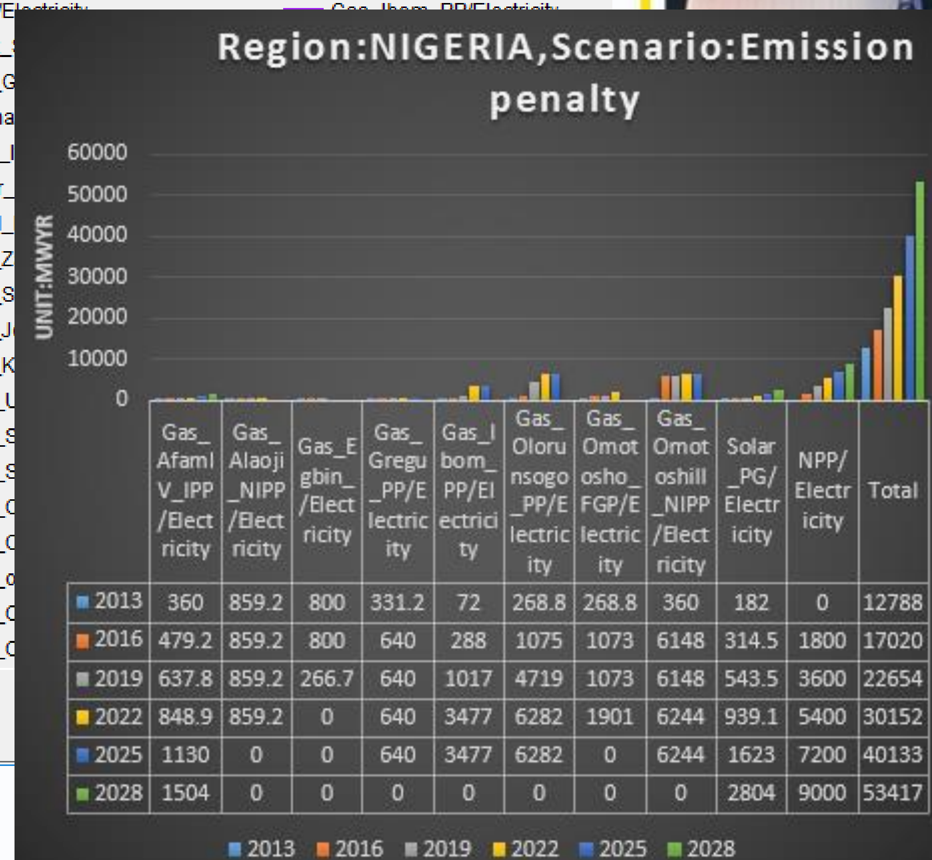
Enforcing penalty for co_2 emission



Enforcing penalty for co_2 emission

RESULT





	Gas_AfamIV_IPP/Electricity	Gas_Alaoji_NIPP/Electricity	Gas_Egbin_/Electricity	Gas_Gregu_PP/Electricity	Gas_Ibom_PP/Electricity	Gas_Olorunsogo_PP/Electricity	Gas_Omotosho_FGP/Electricity	Gas_Omotoshill_NIPP/Electricity	Solar_PG/Electricity	NPP/Electricity	Total
2013	360	859.2	800	331.2	72	268.8	268.8	360	182	0	12788
2016	479.2	859.2	800	640	288	1075	1073	6148	314.5	1800	17020
2019	637.8	859.2	266.7	640	1017	4719	1073	6148	543.5	3600	22654
2022	848.9	859.2	0	640	3477	6282	1901	6244	939.1	5400	30152
2025	1130	0	0	640	3477	6282	0	6244	1623	7200	40133
2028	1504	0	0	0	0	0	0	0	2804	9000	53417

Result discussion & Conclusion

- This study has yielded a successful base scenario that takes account of all the existing plants operating in Nigeria and depicted a closely real energy situation in the country.
- Introducing Nuclear Power Plant into the Nigerian energy Mix appears to overcome the acute energy scarcity characterised by the country.
- It became apparent that a huge reduction of green house emission has been achieved by limiting technologies with harmful environmental emissions using cleaner and cost effective energy sources.
- The country can also take advantage of available natural resources to strengthen energy production alongside with viable energy sources determined in this studies.


KINGS
Thank
You