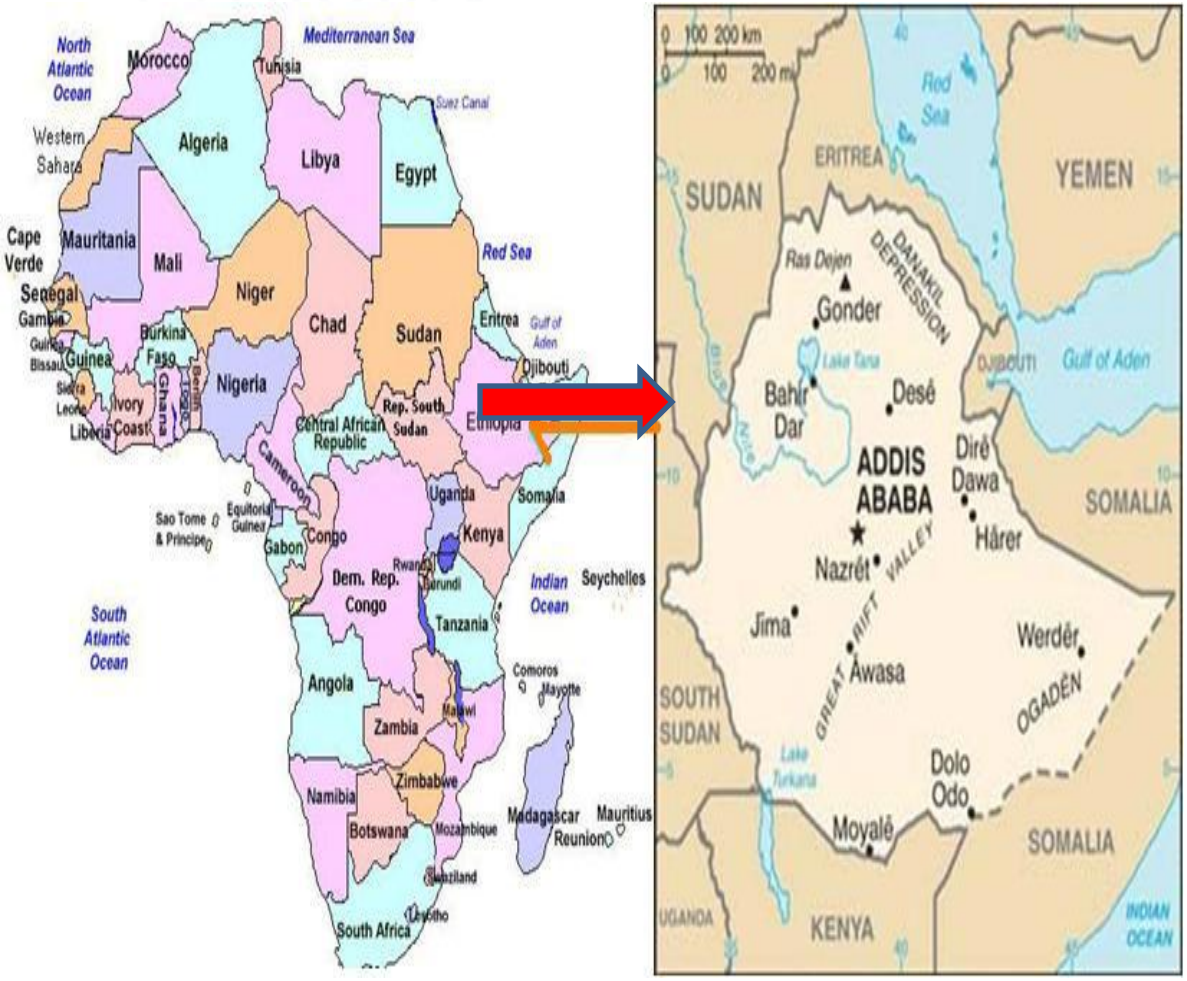
ETHIOPIAN ELECTRIC POWER

Power Sector Development

POWERING AFRICA

2014

ETHIOPIA



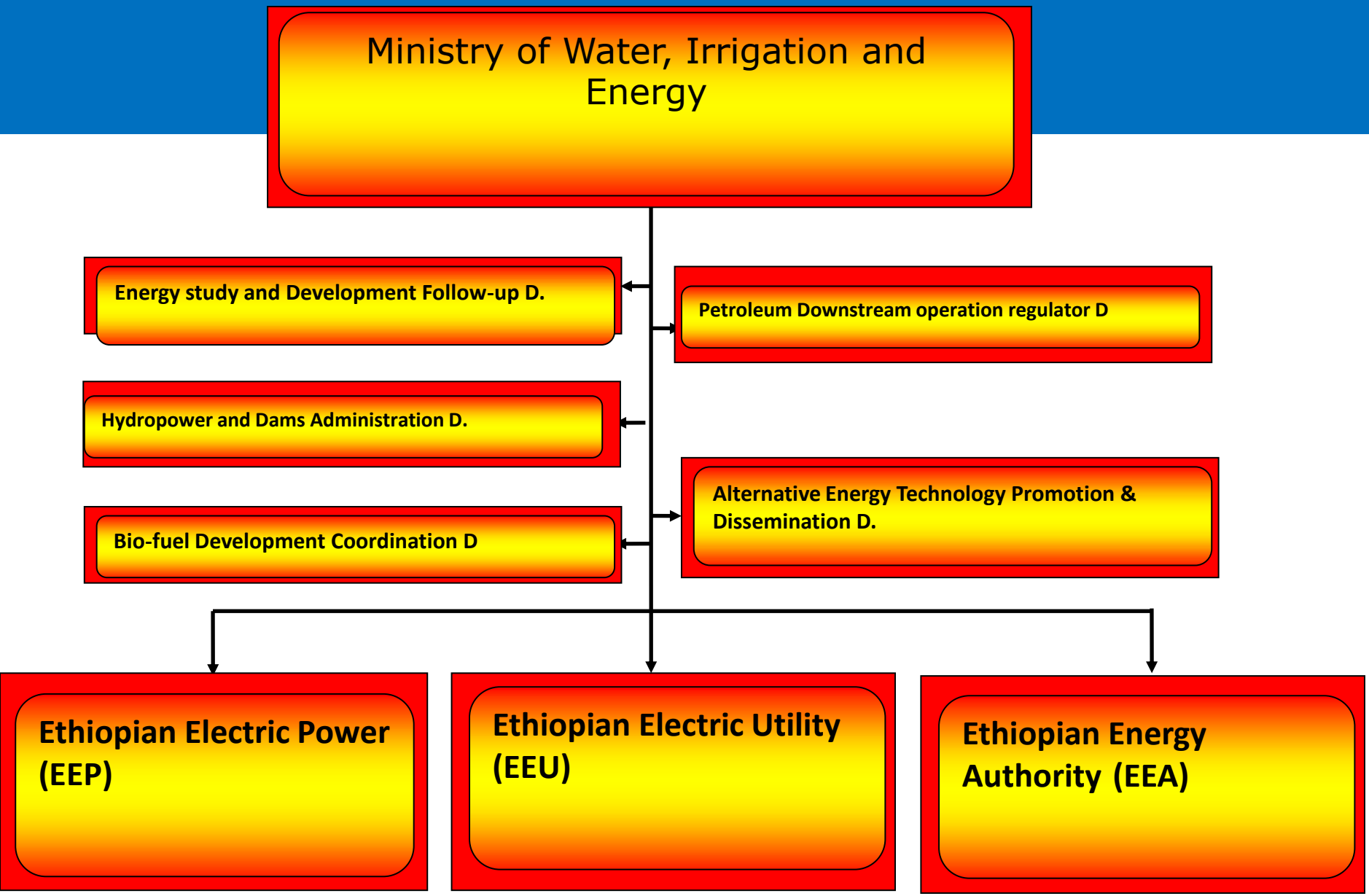
- Country in the horn of Africa
- Total area - 1.13 million square km
- 90 million inhabitants
- Population growth rate – 2.3% per year
- Average annual GDP growth rate ~ 10.7 % for the last 10 yrs

Indigenous Energy Resources

Resource	Unit	Exploitable Reserve	Exploited Percent
Hydropower	MW	45,000	<5%
Solar/day	kWh/m^2	Avg. 5.5	<1%
Wind: Power Speed	GW m/s	1,350 > 6.5	<1%
Geothermal	MW	7000	<1%
Wood	Million tons	1120	50%
Agricultural waste	Million tons	15-20	30%
Natural gas	Billion m^3	113	0%
Coal	Million tons	300	0%
Oil shale	Million tons	253	0%

Power Generation & Environment

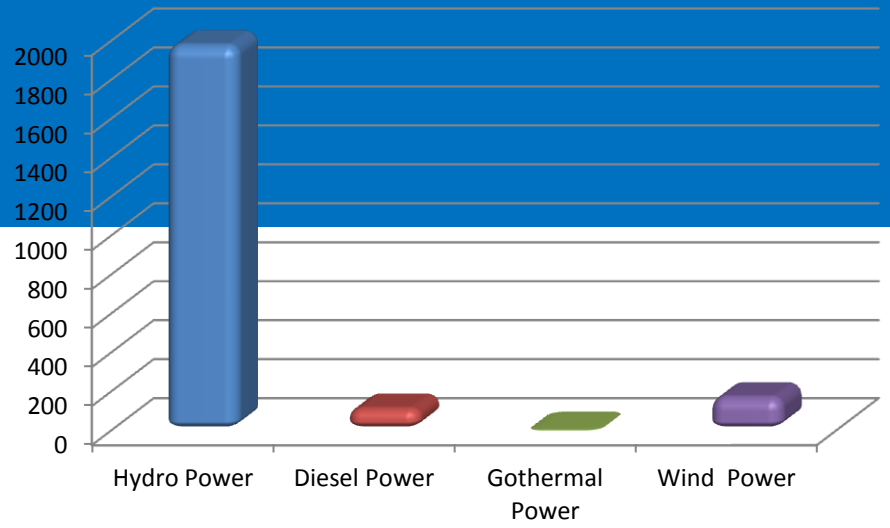
Low Level of Emission


Ministry of Water, Irrigation and Energy
Energy study and Development Follow-up D.
Petroleum Downstream operation regulator D
Hydropower and Dams Administration D.
Alternative Energy Technology Promotion & Dissemination D.
Bio-fuel Development Coordination D
Ethiopian Electric Power (EEP)
Ethiopian Electric Utility (EEU)
Ethiopian Energy Authority (EEA)

Exixting System

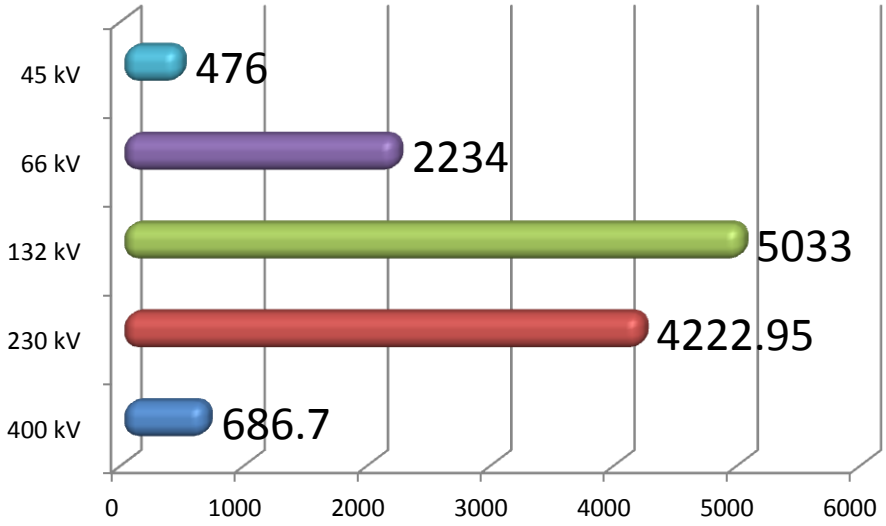
Generation

- Hydro Power 1978 MW
- Diesel Power 112 MW
- Gothermal Power 7 MW
- Wind Power 171 MW
- Total 2268 MW



Transmission Capacity

- 400 kV 686.7
- 230 kV
- 132 kV
- 66 kV
- 45 kV
- Total 12652.65 km



Existing & Future Domestic Consumption by Regional Administration

New EEP Zone	Sum of 2012	Sum of 2015	Sum of 2017	Sum of 2020	Sum of 2025	Sum of 2030	Sum of 2037
EASTERN A.A.	172	341	550	797	1038	1399	2066
NORTHERN A.A.	178	212	279	327	475	730	1207
SOUTHERN A.A.	320	513	744	846	973	1323	1956
WESTERN A.A.	81	146	189	252	365	545	880
SOUTH EASTERN	96	165	221	260	444	757	1350
SOUTHERN	95	246	374	615	1055	1654	2647
EASTERN	47	271	427	735	1245	1846	2815
JIJIGA	11	30	60	64	82	113	164
SEMERA	14	62	132	310	677	1063	1638
NORTH EASTERN	39	205	401	645	764	959	1281
NORTHERN	87	129	265	461	700	849	1128
NORTH WESTERN	66	122	178	391	907	1262	1889
WESTERN	51	58	80	159	381	504	728
ASOSA	8	14	25	33	60	88	140
GAMBELA	7	8	10	25	66	115	188
Grand Total	**1272**	**2524**	**3935**	**5918**	**9232**	**13210**	**20077**

major power sector developments

- Power plants completed in 2013
  - Ashegoda wind power – 120 MW
- Power plants under construction
  - Grand Ethiopian Renaissance Dam – 6,000MW
  - Gibe III – 1,870 MW
  - Genale Dawa III – 254 MW
  - Adama II – 153 MW
  - Solar power 300MW (US based company)
  - **Aluto Langano geothermal expansion – 70 MW**
    - **GoE, GoJ, WB, SREP**
  - Repi Waste-to-Energy power – 50 MW

Demand Forecast

Ethiopia Electricity Demand Forecast

A number of new type of consumers recently commenced or are under development identified:

1. Transport Sector developments
2. Agricultural Sector developments
3. Industrial Sector Developments
4. Large scale Dwelling house expansion Programs
5. Universal Electricity Access expansion Program
6. Electricity export consumers

Ethiopia Electricity Demand Forecast

1. Transport Sector Demand Forecast- Sources

	Freight Rail Traffic (Kton)			Passenger Rail Numbers		
	Export	Import	Total	Domestic	Internationa	Total
2015	799	6 421	7 220	214 128	32 119	246 247
2020	1 538	11 316	12 855	344 745	57 712	396 457
2025	2 711	18 225	20 936	555 040	83 256	638 296
2030	4 778	29 352	34 130	893 615	134 042	1 027 657
2035	7 695	47 271	54 966	1 438 721	215 808	1 654 529

- Passenger (per day) and freight numbers (per year)for Addis Dewele route
- Passenger and freight numbers other planned routes

	Rail freight (kton)	Passenger numbers
2017	1 500	42 826
2022	3 150	103 424
2027	6 615	222 016
2032	13 892	446 808
2037	29 172	863 233

Ethiopia Electricity Demand Forecast

Railway Demand Forecast- Assumptions

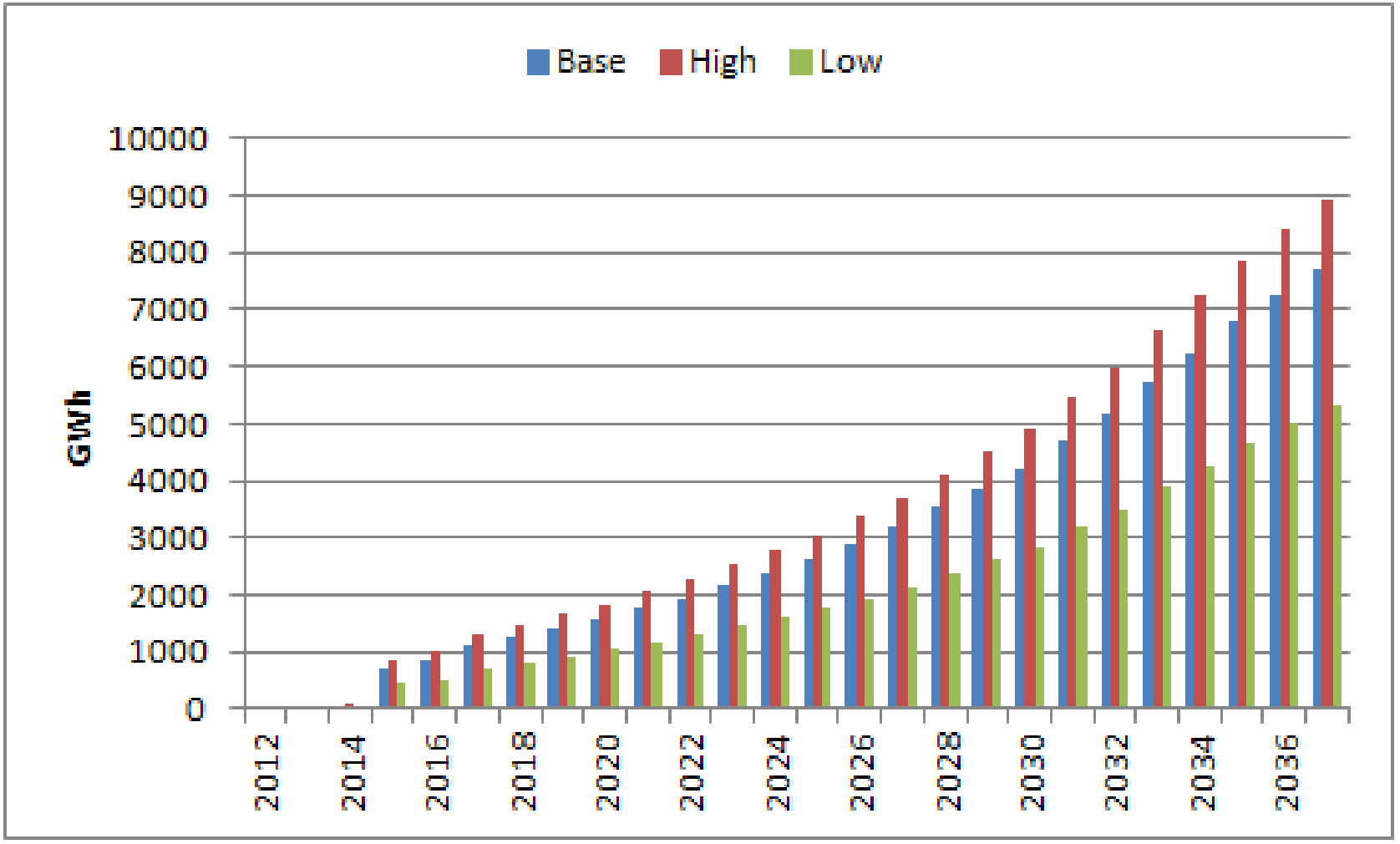
- Average number of trains per day are calculated
- Average 8 hours operation per day per freight train
- Average of 3 hours operation per day per passenger train (shorter distances and more stops than freight trains)
- Number locomotives per freight (2 x 4.5MW) passenger (1 x 4.5MW) train energy requirements calculated for the railway development
- Freight and rail passengers adjusted upwards (37%) and downwards (32%) for high and low cases
- Light rail system developed from 2015 to 2030, from 5 to 42 trains in operation, 16 hours per day, two locomotives 3MW

Ethiopia Electricity Demand Forecast

Transport Sector Demand Forecast Reference Scenario-Results

year	Sales (GWh)	Gen. (GWh)	Peak (MW)
2015	404	513	97
2020	1477	1711	319
2025	2583	2976	553
2030	4123	4739	879
2035	6398	7354	1365
2037	7331	8427	1564

Ethiopia Electricity Demand Forecast



Ethiopia Electricity Demand Forecast

2. Large new irrigation developments- Source Data 2.

- Main source of data were regional Offices - Agriculture and Rural Development Bureau

Region	Hectar Value	
	GTP1	After GTP1
SNNP	120,500	60,000
BENShangul	64,000	64,000
Gambela	1,510	107,304
Oromia	7,240	821,750
Somalia	60,000	918,250
Afar	40000	540,000
Tigray	16,000	18,000
Amhara	74,000	91,000
	383,250.0	2,620,304

Ethiopia Electricity Demand Forecast

2. Agricultural Sector

Power consumption rates derived from 0.34 – 5.4 kW/ha across locations in different regions

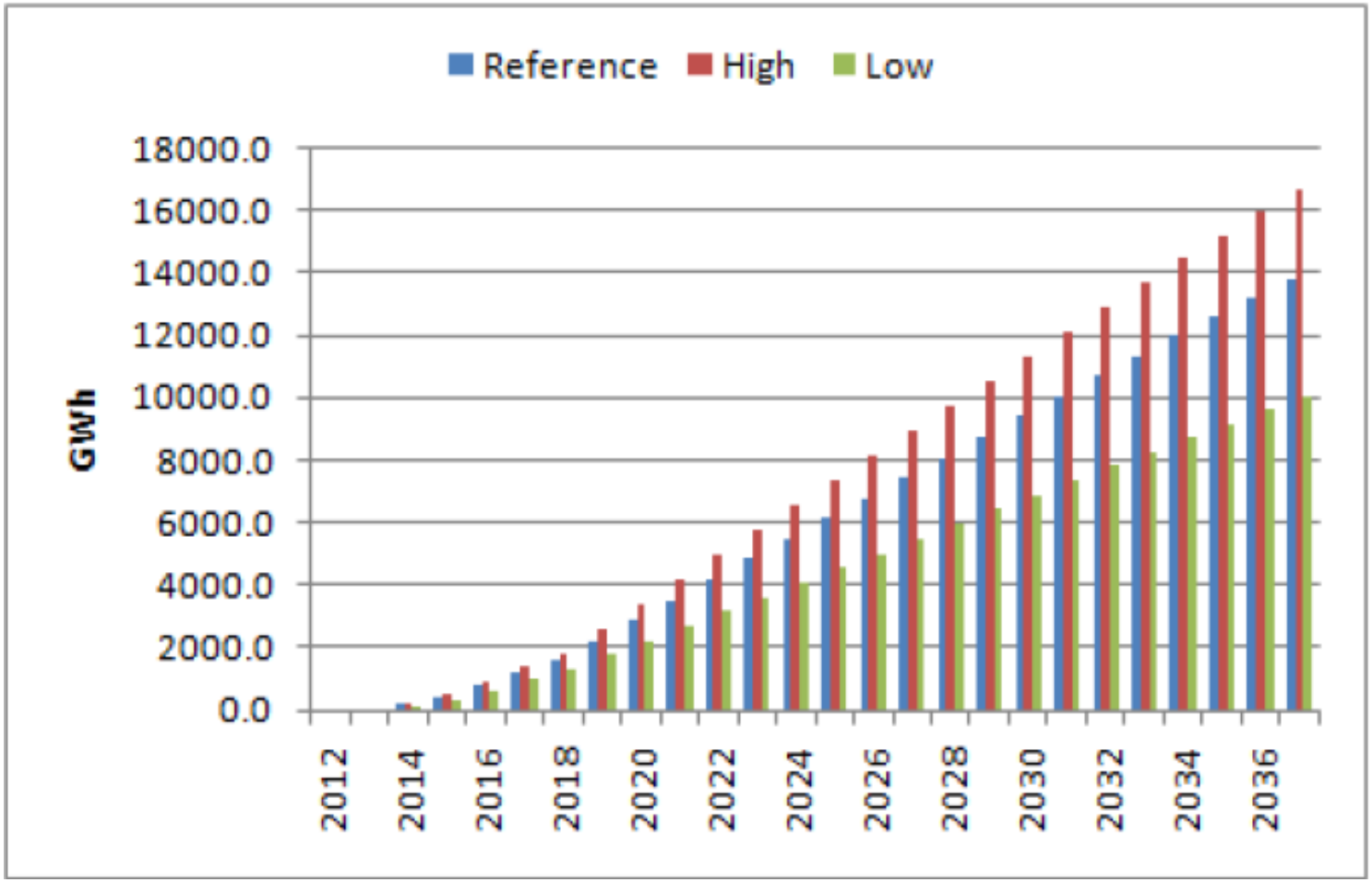
- Demand requirements distributed first 5 years (85% probability) thereafter up to the study period end (70% probability)
- Energy requirements calculated assuming average 5 hours operation per day 9 months of year
- For High and Low cases irrigable assumed higher (100% and 85%) and lower (70% and 50% probabilities)

Ethiopia Electricity Demand Forecast-Results

year	Sales (GWh)	Gen. (GWh)	Peak (MW)
2015	490	623	197
2020	2967	3438	1123
2025	6231	7178	2342
2030	9494	10913	3556
2035	12684	14580	4756
2037	13917	15996	5219

Total Agricultural Sales

Ethiopia Electricity Demand Forecast



Ethiopia Electricity Demand Forecast

3. New Industrial Development in Ethiopia- Sources

- Programme driven by government establish industrial zones-
  - Industrial parks during Growth and Transformation Plan period planned at 1,125MW
  - After the GTP period Industrial park development planned at 1,200MW

GTP-1

No.	Industry Zone	Expected Demand (MW)
1	Kilento	73
2	Bole	103
3	Melka Jebedu	315
4	Kombolcha	334
5	Awassa	300
Total		1125

GTP-2

No.	Industry Zone	Expected Demand (MW)
1	Bahar Dar	300
2	Gondar	300
3	Mekele	300
4	Jimma	300
Total		1200

Ethiopia Electricity Demand Forecast

3. New Industrial Development in Ethiopia- Sources

- Applications for new industrial developments received- EEP:

• Cement Factories	700 MW
• Steel & Metals	800 MW
• General industry	600 MW
• Mining	100MW
Total	2100MW

New Industrial Demand Forecast- Assumptions

Expected new industrial demand:

- Scheduled to develop across 10 year period from 2012 to 2022
- Load factor of 75% assumed to determine energy
- Uncertainty associated probabilities of 85% (for GTP-1 projects) and 70% (for GTP2 projects) assumed for base case
- Average annual electricity sales growth of 30% from 2012 to 2022
- Uncertainty associated probabilities of 70% and 50% assumed for low case
- Uncertainty associated probabilities of 100% and 85% assumed for High case

New Industrial Demand - Results

year	Sales (GWh)	Gen. (GWh)	Peak (MW)
2015	4303	5474	753
2020	16461	19074	2614
2022	20324	23496	3219

Industrial Demand Forecast- Assumptions

- Growth beyond 2022 econometric model used derived from historical industrial sales and sectoral GDP data correlation

Item	High Voltage	Low Voltage
Equation	Sales Growth=(1+Industrial GDP Growth)^b	Sales Growth=(1+Industrial GDP Growth)^b
Elasticity (b)	0.928	0.881

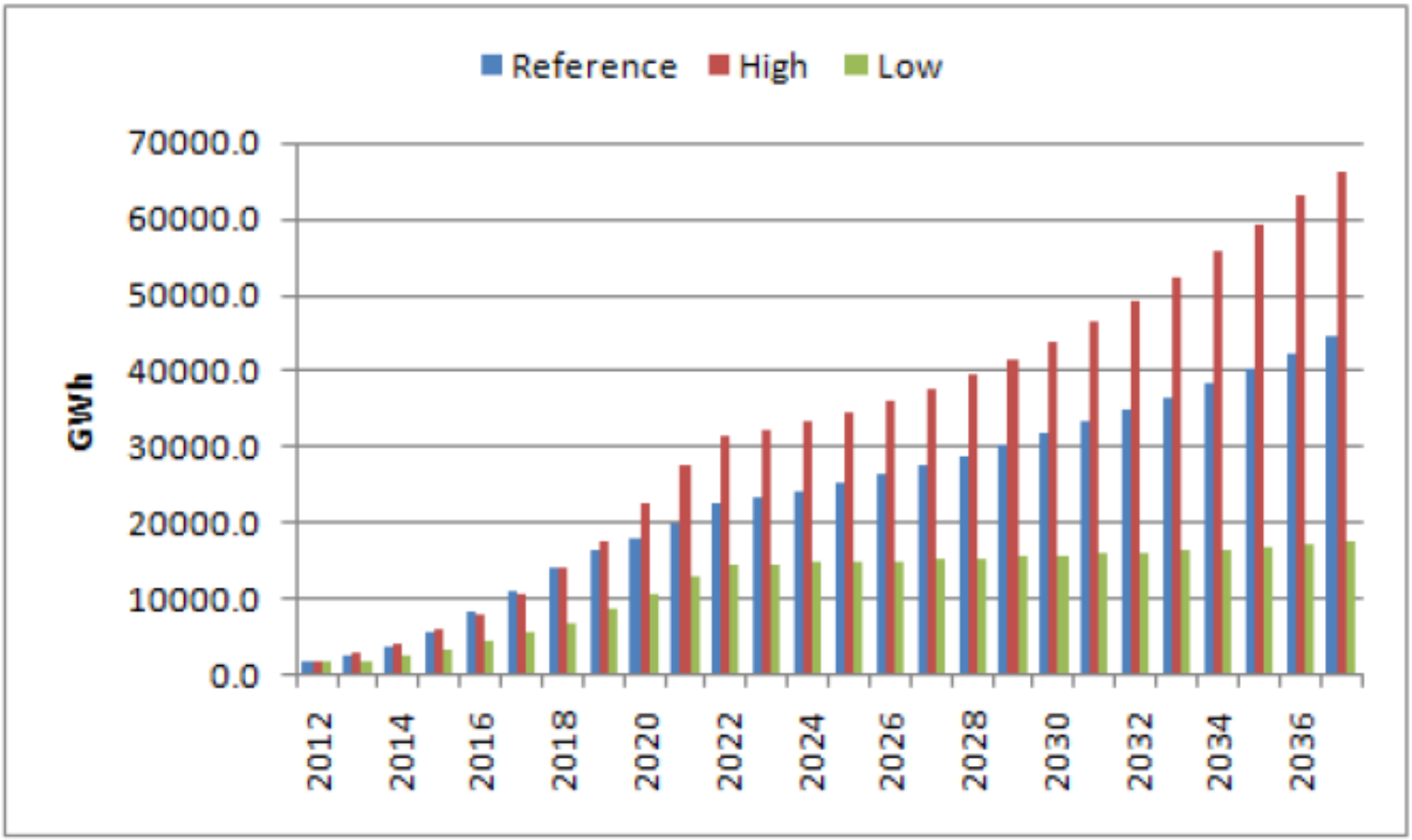
Industrial GDP Growth Rate Assumptions

Sector	2012-2015	2016-2020	2021-2025	2026-2030
Industrial	20%	15.60%	13.90%	10.70%

Total Industrial Demand Forecast- Results

year	Sales (GWh)	Gen. (GWh)	Peak (MW)
2013	2491	3244	447
2015	5758	7326	1007
2020	17916	20761	2845
2025	25319	29169	3994
2030	31695	36431	4986
2037	44505	51155	7002

Industrial Demand Forecast- Results



Commercial Demand Forecast- Assumptions

- Econometric analysis conducted on commercial demand and indicative independent Variables
- Number of connections in Commercial sector found to have correlation with GDP/capita
- Specific consumption correlates with number of households growth

Item	Commercial Number of Customers	Commercial Specific Consumption
Equation	Number of Customers=(1+ GDP/capita Growth)^b	Specific Consumption=(1+Number of HH Growth)^b
Elacticity (b)	1.403	0.448

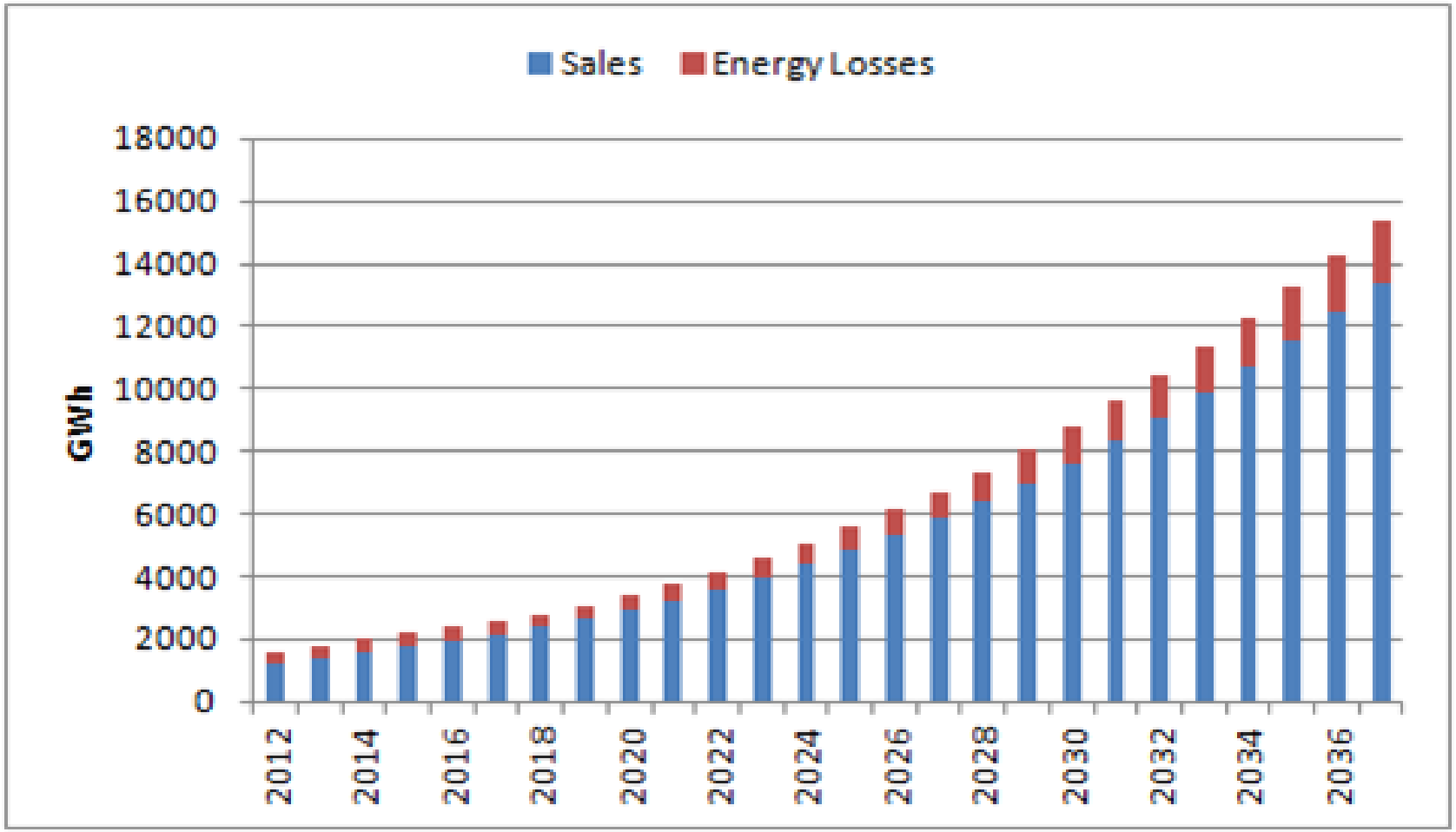
Number of HH and GDP/Capita Growth Assumptions

Sector	2012-2015	2016-2020	2021-2025	2026-2030	2031-2035
GDP/Capita	8.50%	6.80%	6.20%	5.50%	4.70%
Number of HH	2.6%	2.60%	2.60%	2.60%	2.60%

Service Sector Demand Forecast-Result

year	Sales (GWh)	Gen. (GWh)	Peak (MW)
2013	1350	1758	304
2015	1736	2209	381
2020	2937	3403	582
2025	4833	5568	950
2030	7642	8784	1498
2037	13391	15392	2624

Ethiopia Electricity Demand Forecast

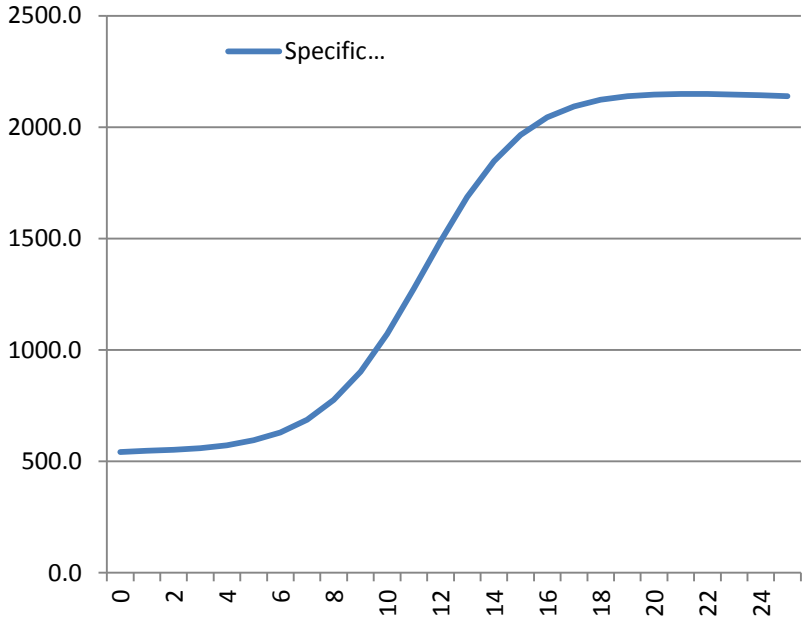


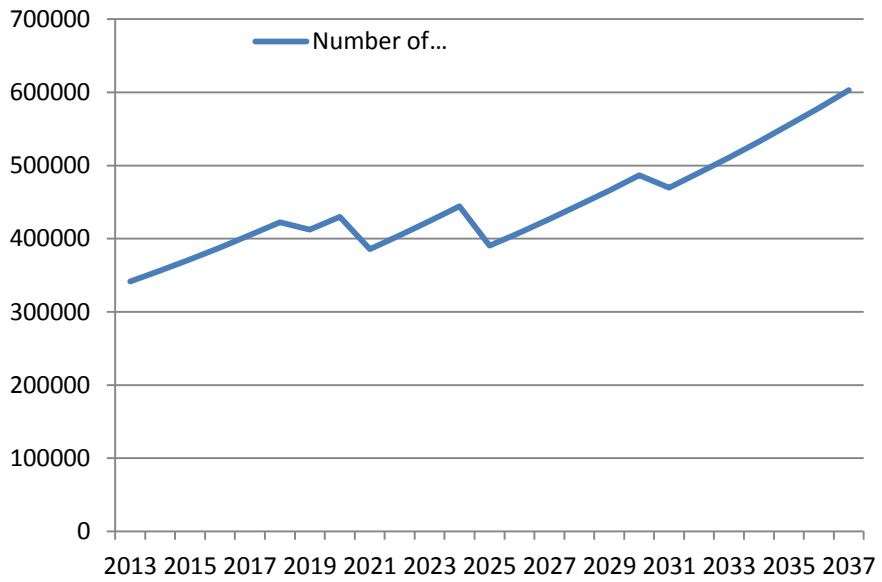
Ethiopia Electricity Demand Forecast

- Domestic forecast done in two categories
- Forecast based on Number of Connections and specific consumption
- Number of consumers forecasted to achieve 95% electrification ratio by 2037

Connection Rate	%	Year
Current Total Household Connection Rate	23%	2012
Target Household Connection Rate 1	45%	2018
Target Household Connection Rate 2	65%	2024
Target Household Connection Rate 3	80%	2030
Target Household Connection Rate	95%	2037

Domestic Demand Forecast (New Customers) - assumptions



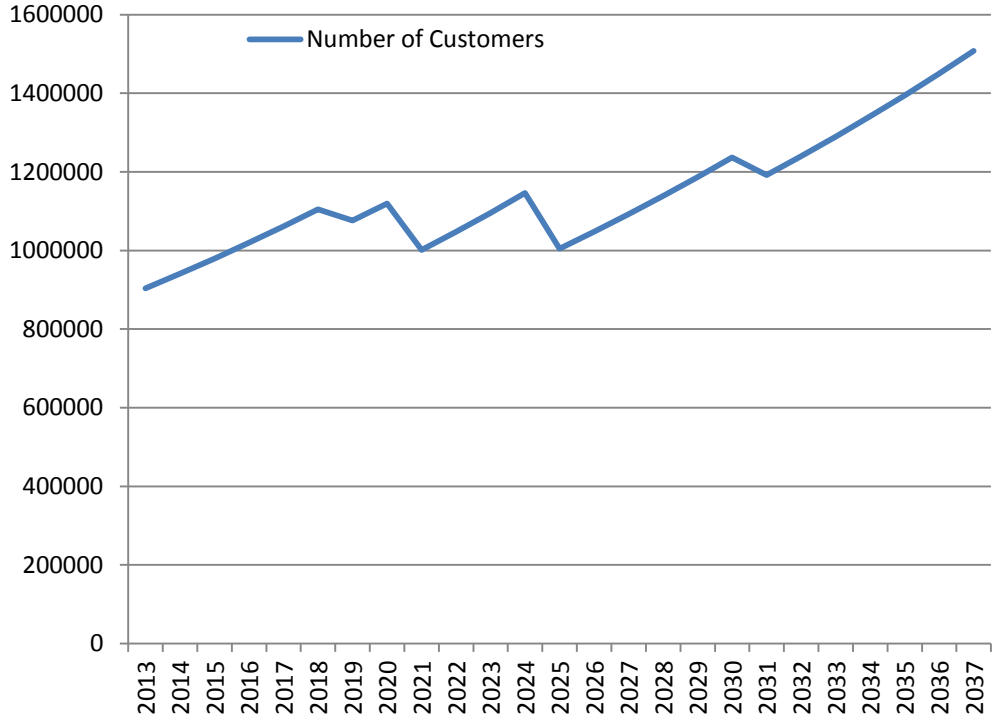


- Considers increased electric usage (more utensils) within a household.

- Considers Expansion of the Grid to rural areas (UEAP) and also the housing projects within the big towns.

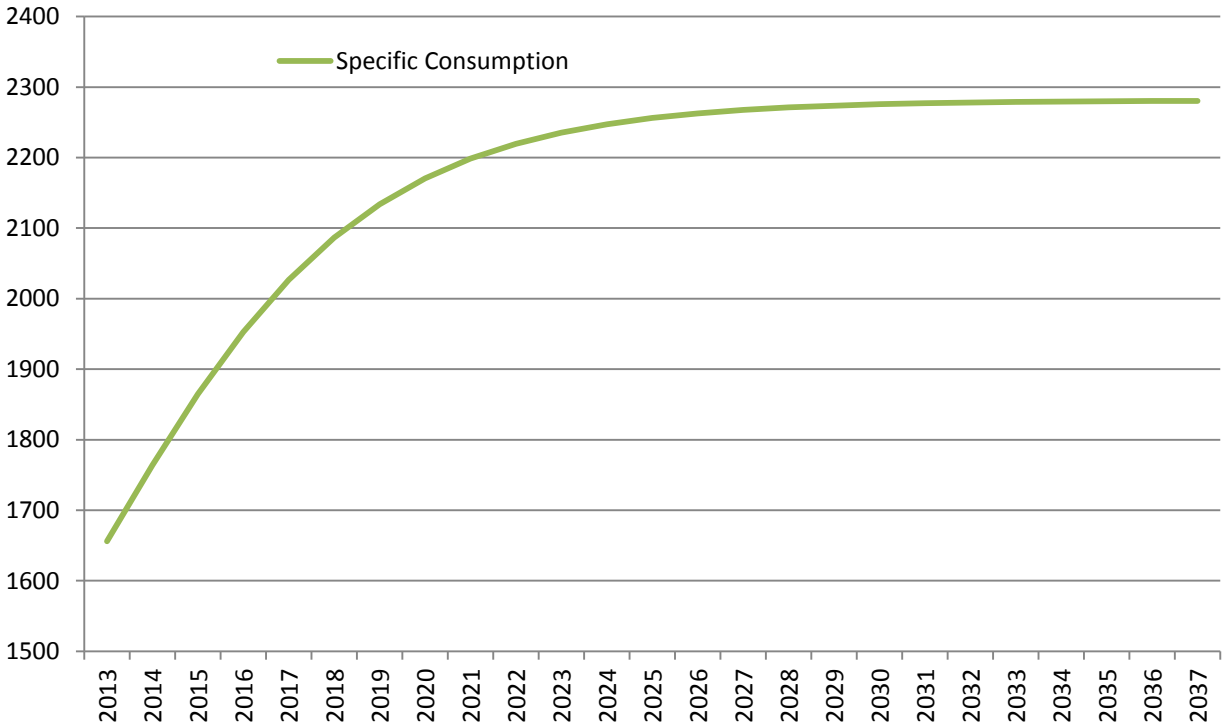
Domestic Demand Forecast (New Customers) - assumptions

– Avoiding Initial connection Barriers could increase the customer number significantly



Domestic Demand Forecast (Existing Customers) - assumptions

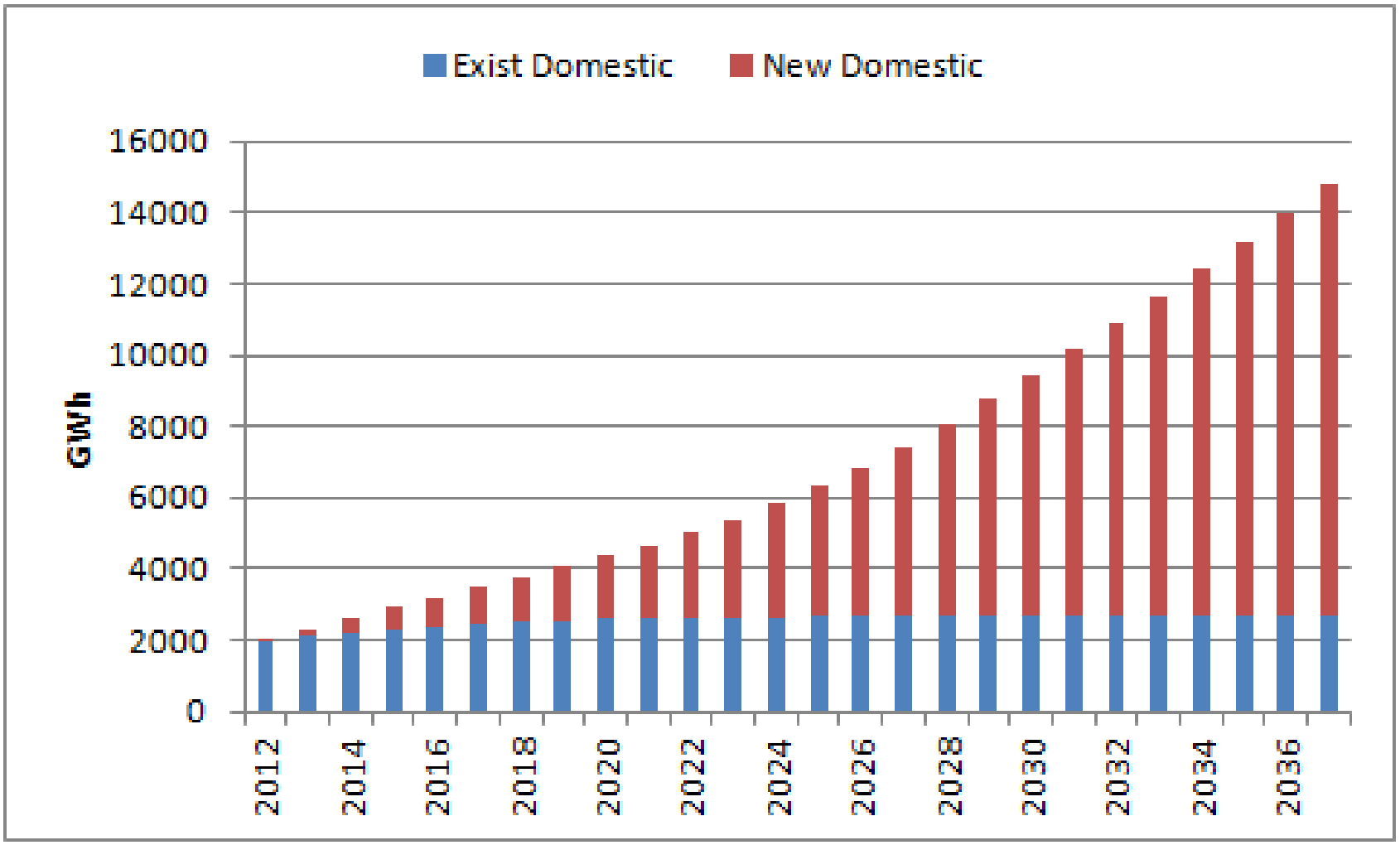
- EEU has an Existing Domestic customers base of 2.1 Million



Domestic Demand Forecast - Results

Year	Sales (GWh)			Gen. (GWh)	Peak (MW)
	Existing	UEAP	Total		
2013	2192	206	2398	3122	753
2015	2512	605	3118	3966	975
2020	2982	1845	4827	5593	1410
2025	3114	4039	7153	8241	2150
2030	3144	8029	11173	12842	3453
2035	3150	12772	15922	18302	5006
2037	3151	14485	17636	20271	5566

Domestic Demand Forecast composition

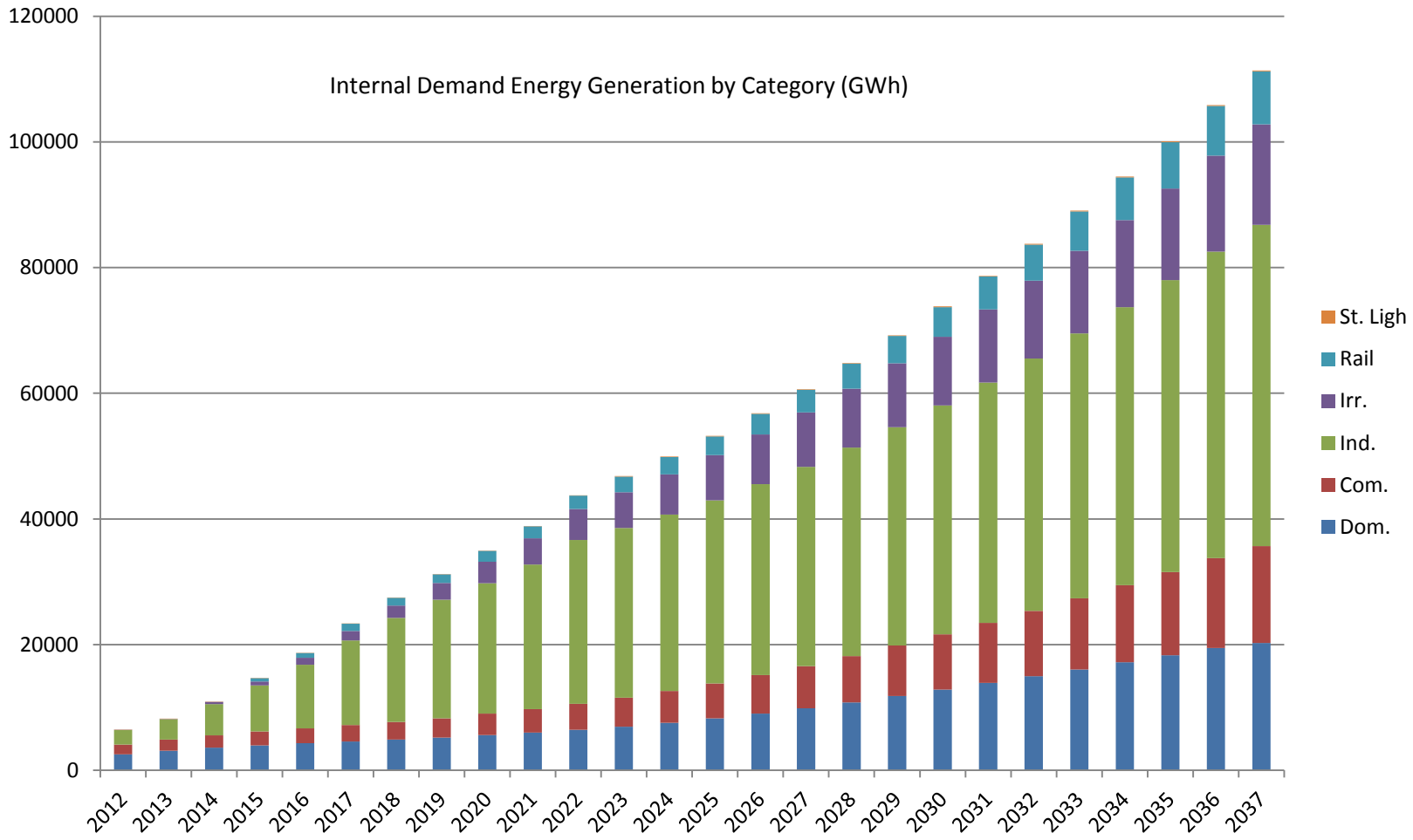


Ethiopia Electricity Demand Forecast

- Total energy sales forecasted grow 4,925GWh in 2012 to 97,326GWh by 2037 in Base case
- Presents an average annual compound growth rate of 12.7%
- Biggest growth occurs in industrial, in 2012 it 34% of totals sales and grows to 46% by 2037
- Total energy sales forecasted grow 5,204GWh in 2012 to 142,884GWh by 2037 in High case
- Presents an average annual compound growth rate of 14.2%
- Total energy sales forecasted grow 4,633GWh in 2012 to 54,019GWh by 2037 in Low case
- Presents an average annual compound growth rate of 10.1%

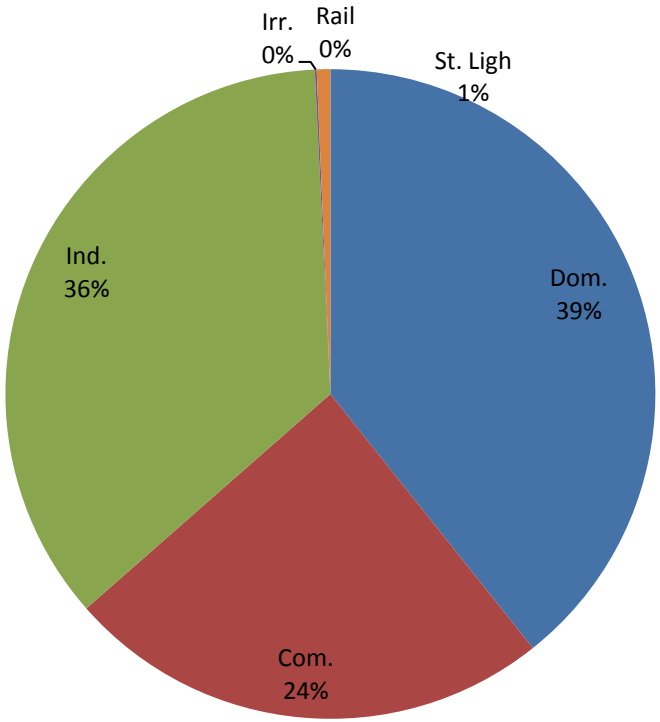
Total Base Case Electricity Sales

Ethiopia Electricity Demand Forecast

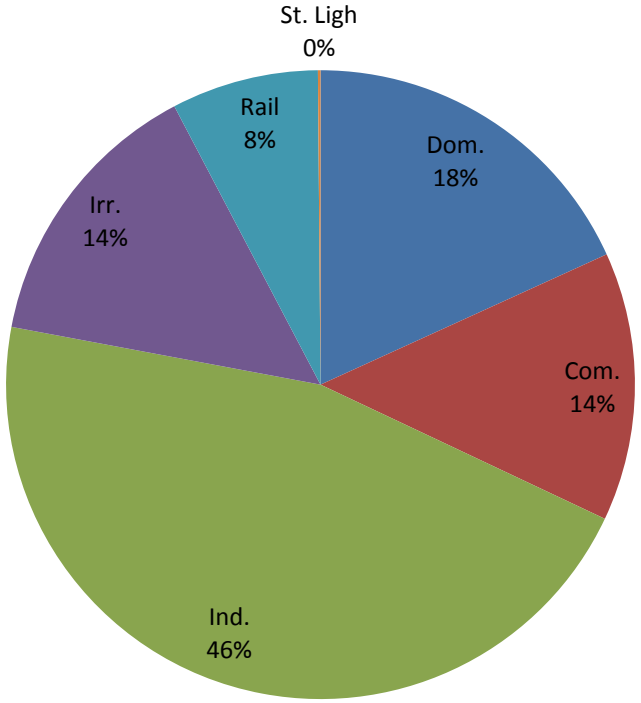


Ethiopia Electricity Demand Forecast

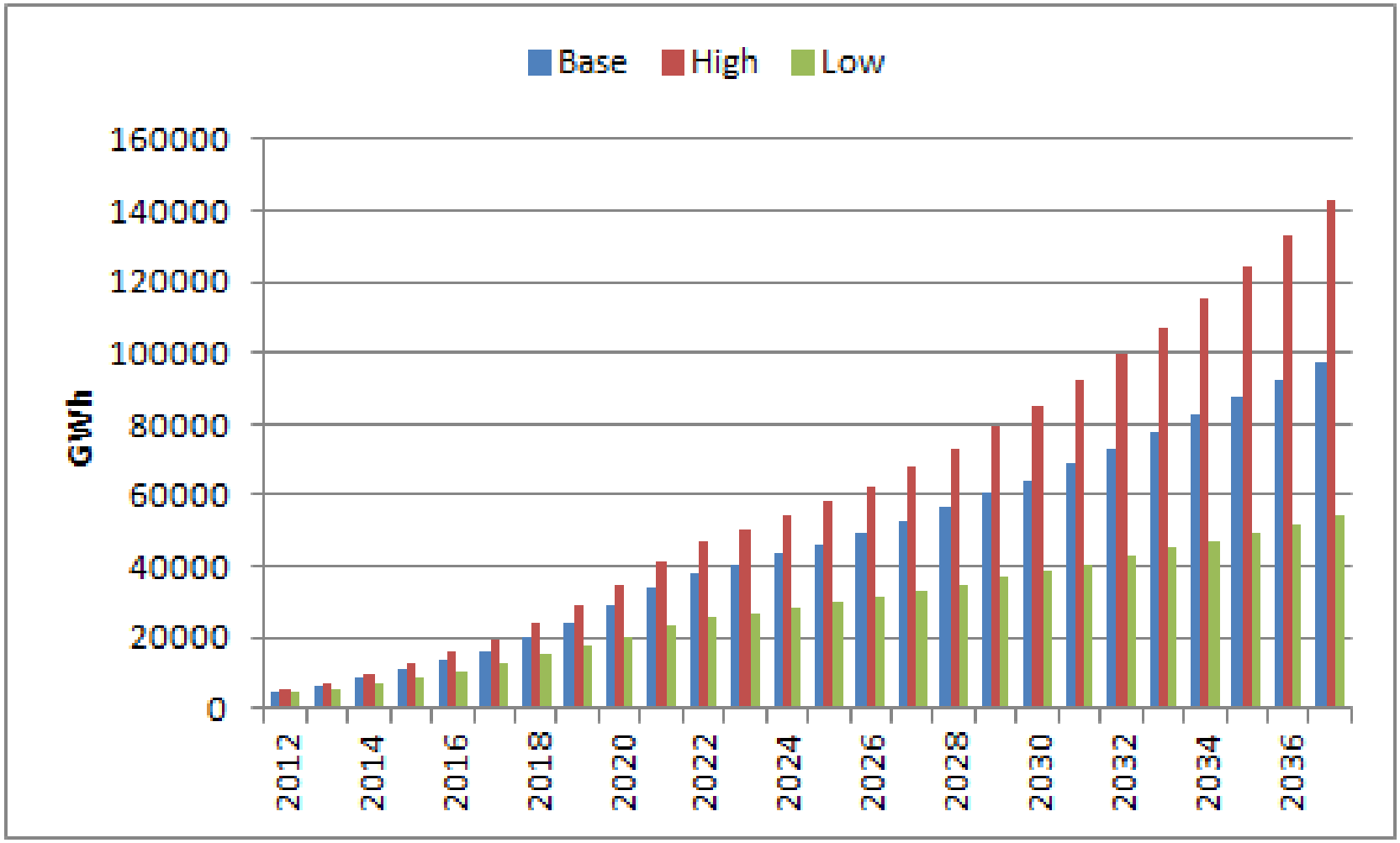
2012 Internal Demand Composition



2037 Internal Demand Composition



Ethiopia Electricity Demand Forecast



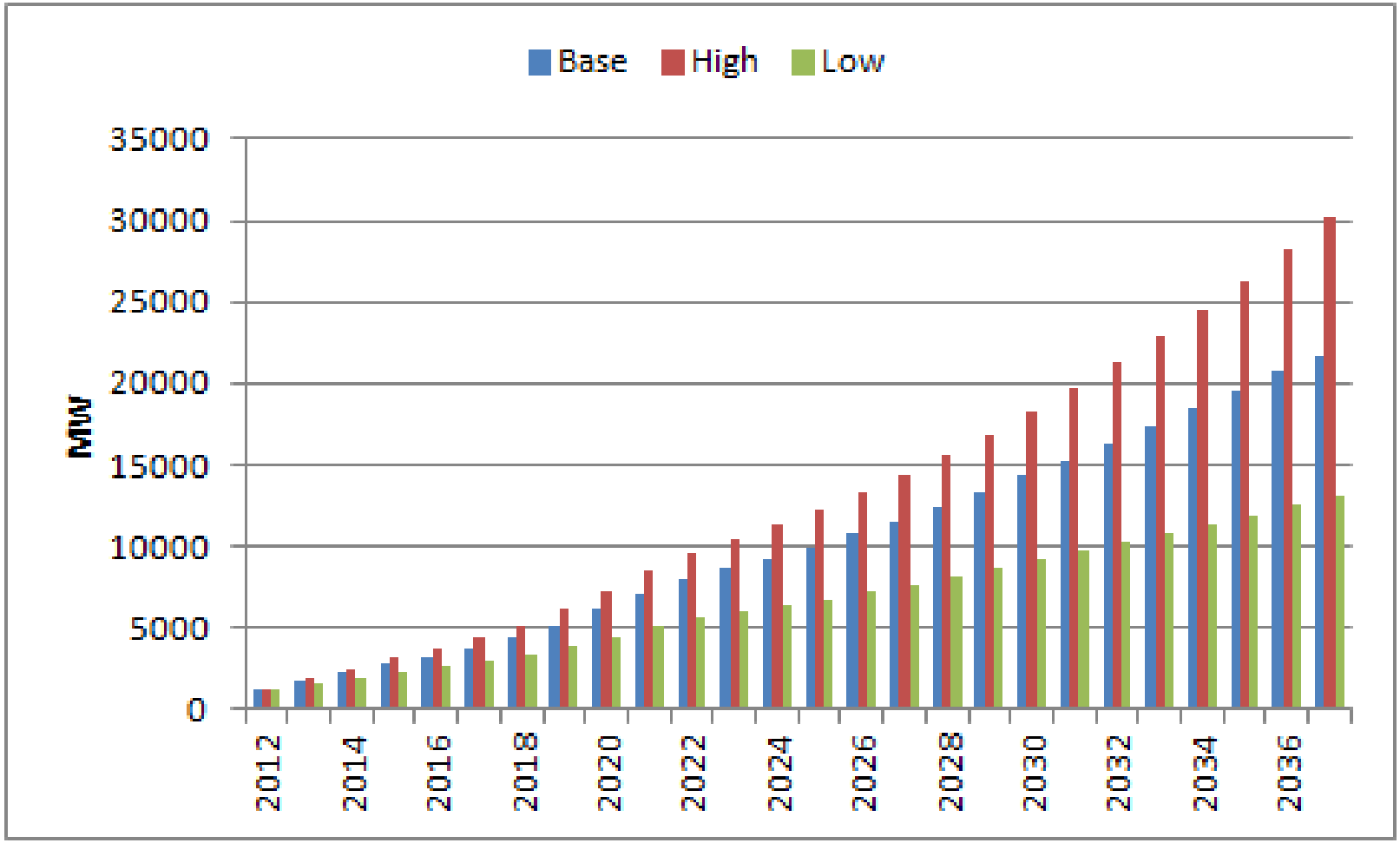
Ethiopia Electricity Demand Forecast

- Energy losses forecasted to reduce to 14%
- Total energy sent out forecasted grow 6,443GWh in 2012 to 111,388GWh by 2037 in Base case
- Presents an average annual compound growth rate of 12%
- Energy sent-out is forecast grow from 6,443GWh in 2012 to 179,064GWh by 2037 in High case
- Presents an average annual compound growth rate of 14%
- Energy sent-out is forecast grow from 6,443GWh in 2012 to 69,867GWh by 2037 in Low case
- Presents an average annual compound growth rate of 10%

Ethiopia Electricity Demand Forecast

- Peak demand forecast grow 1,237MW in 2012 to 21,731MW by 2037 in base case
- Represents average annual compound growth rate of 12.3%.
- Peak demand forecast grow 1,237MW in 2012 to 32,486MW by 2037 in high case
- Represents average annual compound growth rate of 13.5%.
- Peak demand forecast grow 1,237MW in 2012 to 14,356MW by 2037
- Represents average annual compound growth rate of 10.3%

Ethiopia Electricity Demand Forecast



Ethiopia Electricity Demand Forecast

4. Electricity export consumers

Assumptions/strategy estimating exports for study:

- Current export agreements Sudan (100MW) Djibouti (100MW) retained throughout study period;
- Exports Egypt via Sudan, exports Sudan and Egypt grouped;
- 1200 MW (Sudan) and 2000 MW (Egypt) scheme, 3,200MW assumed exports, Eastern Nile trade program study;
- Exports Kenya and Tanzania extracted draft Kenyan Updated Least Cost Development Plan February 2013.

Total Export Demand

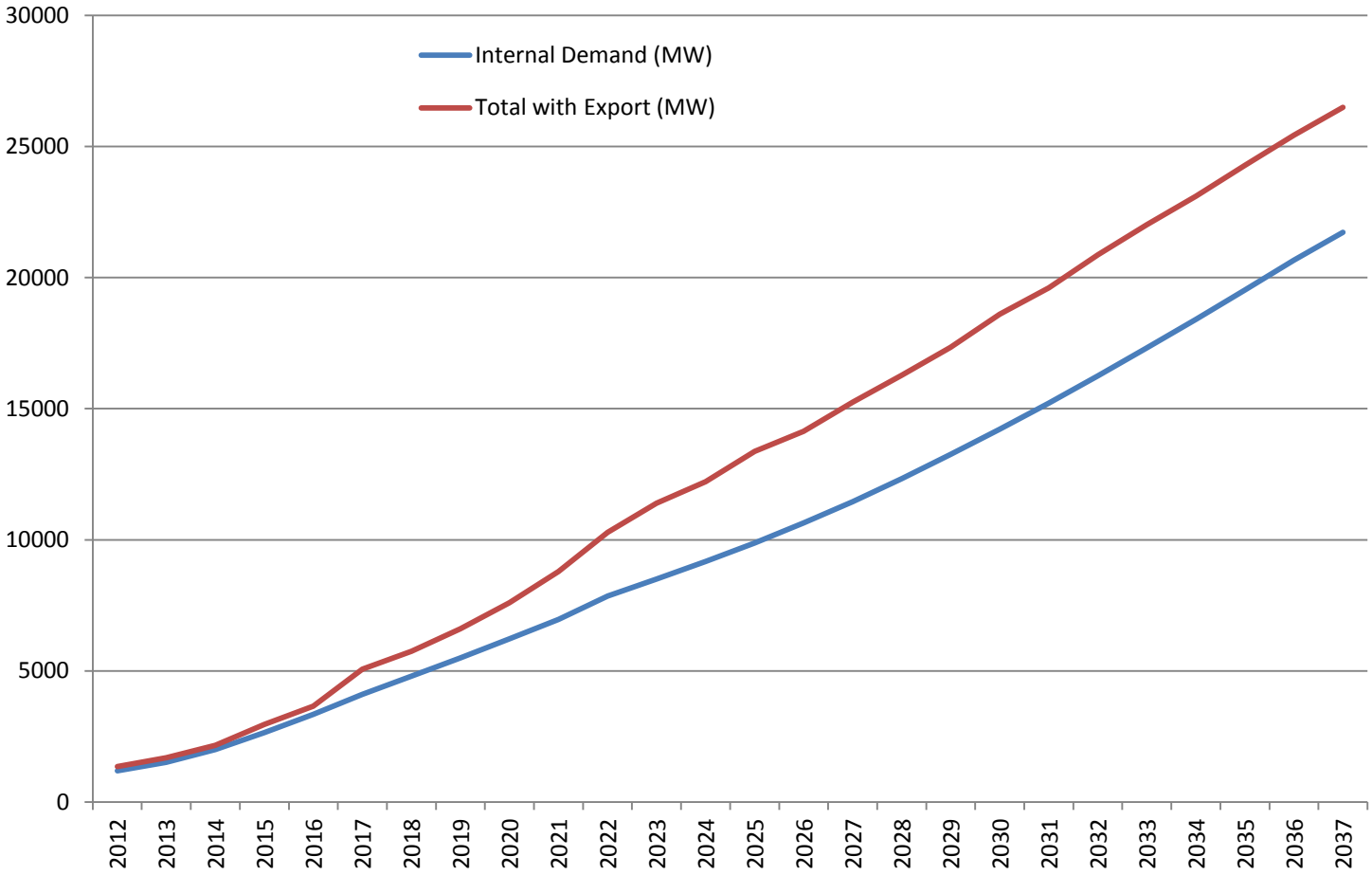
Ethiopia Electricity Demand Forecast

	Non-Coincident Max Demand (MW)						Energy (GWh)						Coincident Max Demand (MW)					
	Djibouti	Sudan	Sudan or Egypt	Kenya	Tanzania	Total	Djibouti	Sudan	Sudan or Egypt	Kenya	Tanzania	Total	Djibouti	Sudan	Sudan or Egypt	Kenya	Tanzania	Total
2012	100	100	0	0	0	200	569	876	0	0	0	1445	65	100	0	0	0	165
2013	100	100	0	0	0	200	569	876	0	0	0	1445	65	100	0	0	0	165
2014	100	100	0	0	0	200	569	876	0	0	0	1445	65	100	0	0	0	165
2015	100	100	200	0	0	400	569	876	1314	0	0	2759	65	100	150	0	0	315
2016	100	100	200	0	0	400	569	876	1314	0	0	2759	65	100	150	0	0	315
2017	100	100	600	400	0	1200	569	876	3942	2978	0	8366	65	100	450	340	0	955
2018	100	100	600	400	0	1200	569	876	3942	2978	0	8366	65	100	450	340	0	955
2019	100	100	800	400	0	1400	569	876	5256	2978	0	9680	65	100	600	340	0	1105
2020	100	100	800	400	200	1600	569	876	5256	2978	1314	10994	65	100	600	340	150	1255
2021	100	100	1200	600	200	2200	569	876	7884	4292	1314	14936	65	100	900	490	150	1705
2022	100	100	1200	600	200	2200	569	876	7884	4292	1314	14936	65	100	900	490	150	1705
2023	100	100	1600	600	400	2800	569	876	10512	4292	2628	18878	65	100	1200	490	300	2155
2024	100	100	1600	800	400	3000	569	876	10512	5606	2628	20192	65	100	1200	640	300	2305
2025	100	100	2000	1000	400	3600	569	876	13140	6920	2628	24134	65	100	1500	790	300	2755
2026	100	100	2000	1000	400	3600	569	876	13140	6920	2628	24134	65	100	1500	790	300	2755
2027	100	100	2200	1200	400	4000	569	876	14454	8234	2628	26762	65	100	1650	940	300	3055
2028	100	100	2200	1400	400	4200	569	876	14454	9548	2628	28076	65	100	1650	1090	300	3205
2029	100	100	2200	1600	400	4400	569	876	14454	10862	2628	29390	65	100	1650	1240	300	3355
2030	100	100	2600	1600	400	4800	569	876	17082	10862	2628	32018	65	100	1950	1240	300	3655
2031	100	100	2600	1600	400	4800	569	876	17082	10862	2628	32018	65	100	1950	1240	300	3655
2032	100	100	2900	1600	400	5100	569	876	19053	10862	2628	33989	65	100	2175	1240	300	3880
2033	100	100	3000	1600	400	5200	569	876	19710	10862	2628	34646	65	100	2250	1240	300	3955
2034	100	100	3000	1600	400	5200	569	876	19710	10862	2628	34646	65	100	2250	1240	300	3955
2035	100	100	3100	1600	400	5300	569	876	20367	10862	2628	35303	65	100	2325	1240	300	4030
2036	100	100	3100	1600	400	5300	569	876	20367	10862	2628	35303	65	100	2325	1240	300	4030
2037	100	100	3100	1600	400	5300	569	876	20367	10862	2628	35303	65	100	2325	1240	300	4030

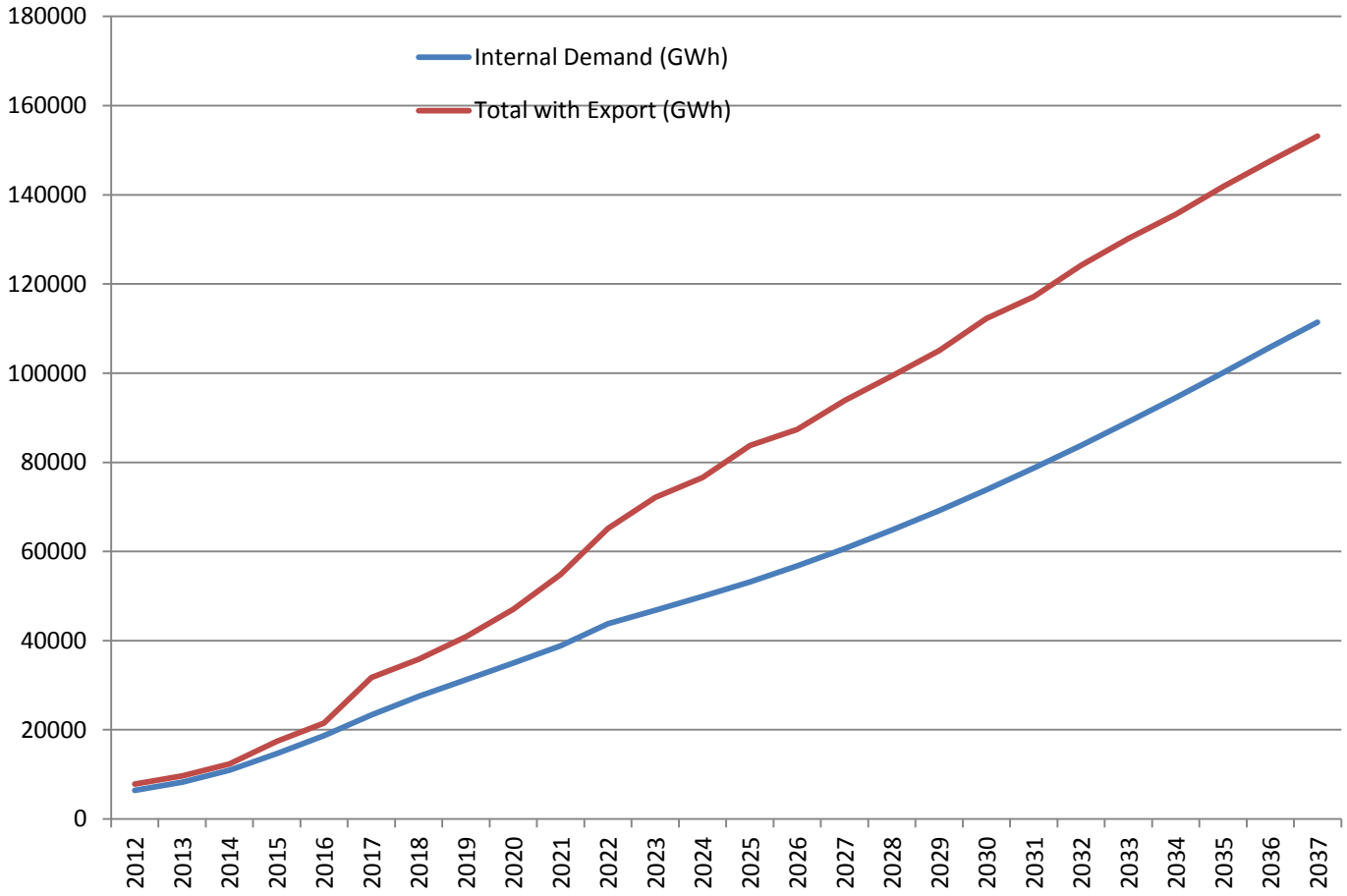
Ethiopia Electricity Demand Forecast-Increased export Scenario

	Non-Coincident Max Demand (MW)							Energy (GWh)							Coincident Max Demand (MW)						
	Djibouti	Sudan	Sudan or Egypt	Kenya	Tanzania	Other exports	Total	Djibouti	Sudan	Sudan or Egypt	Kenya	Tanzania	Other exports	Total	Djibouti	Sudan	Sudan or Egypt	Kenya	Tanzania	Other exports	Total
2012	100	100	0	0	0		200	569	876	0	0	0		1445	65	100	0	0	0		165
2013	100	100	0	0	0		200	569	876	0	0	0		1445	65	100	0	0	0		165
2014	100	100	0	0	0		200	569	876	0	0	0		1445	65	100	0	0	0		165
2015	100	100	200	0	0		400	569	876	1314	0	0		2759	65	100	150	0	0		315
2016	100	100	200	0	0		400	569	876	1314	0	0		2759	65	100	150	0	0		315
2017	100	100	600	400	0		1200	569	876	3942	2978	0		8366	65	100	450	340	0		955
2018	100	100	600	400	0		1200	569	876	3942	2978	0		8366	65	100	450	340	0		955
2019	100	100	800	400	0		1400	569	876	5256	2978	0		9680	65	100	600	340	0		1105
2020	100	100	800	400	200	165	1765	569	876	5256	2978	1314	1081	12075	65	100	600	340	150	123	1378
2021	100	100	1200	600	200	165	2365	569	876	7884	4292	1314	1081	16017	65	100	900	490	150	123	1828
2022	100	100	1200	600	200	982	3182	569	876	7884	4292	1314	6451	21387	65	100	900	490	150	736	2441
2023	100	100	1600	600	400	982	3782	569	876	10512	4292	2628	6451	25329	65	100	1200	490	300	736	2891
2024	100	100	1600	800	400	982	3982	569	876	10512	5606	2628	6451	26643	65	100	1200	640	300	736	3041
2025	100	100	2000	1000	400	982	4582	569	876	13140	6920	2628	6451	30585	65	100	1500	790	300	736	3491
2026	100	100	2000	1000	400	982	4582	569	876	13140	6920	2628	6451	30585	65	100	1500	790	300	736	3491
2027	100	100	2200	1200	400	982	4982	569	876	14454	8234	2628	6451	33213	65	100	1650	940	300	736	3791
2028	100	100	2200	1400	400	982	5182	569	876	14454	9548	2628	6451	34527	65	100	1650	1090	300	736	3941
2029	100	100	2200	1600	400	982	5382	569	876	14454	10862	2628	6451	35841	65	100	1650	1240	300	736	4091
2030	100	100	2600	1600	400	982	5782	569	876	17082	10862	2628	6451	38469	65	100	1950	1240	300	736	4391
2031	100	100	2600	1600	400	982	5782	569	876	17082	10862	2628	6451	38469	65	100	1950	1240	300	736	4391
2032	100	100	2900	1600	400	982	6082	569	876	19053	10862	2628	6451	40440	65	100	2175	1240	300	736	4616
2033	100	100	3000	1600	400	982	6182	569	876	19710	10862	2628	6451	41097	65	100	2250	1240	300	736	4691
2034	100	100	3000	1600	400	982	6182	569	876	19710	10862	2628	6451	41097	65	100	2250	1240	300	736	4691
2035	100	100	3100	1600	400	982	6282	569	876	20367	10862	2628	6451	41754	65	100	2325	1240	300	736	4766
2036	100	100	3100	1600	400	982	6282	569	876	20367	10862	2628	6451	41754	65	100	2325	1240	300	736	4766
2037	100	100	3100	1600	400	982	6282	569	876	20367	10862	2628	6451	41754	65	100	2325	1240	300	736	4766

Load Forecast

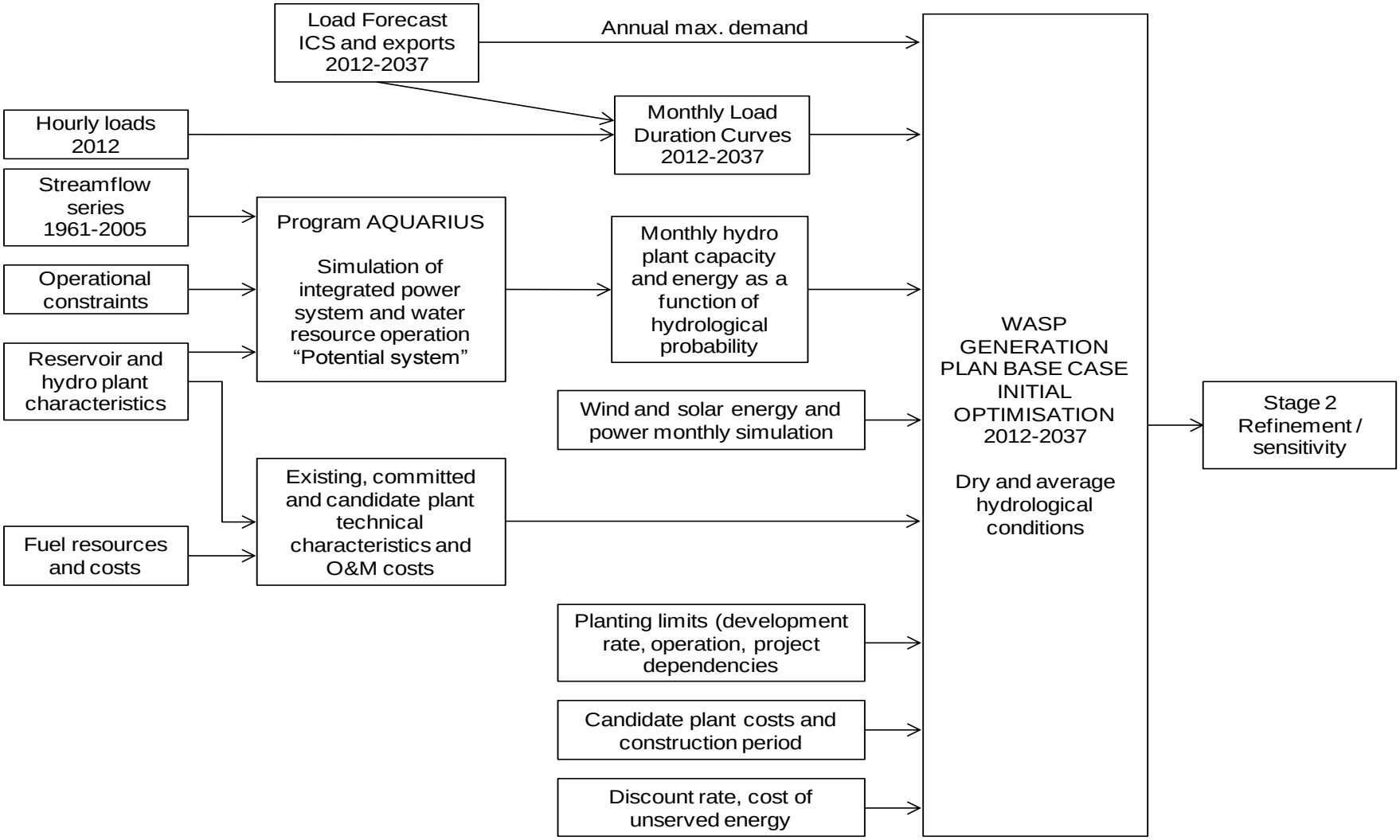


Load Forecast

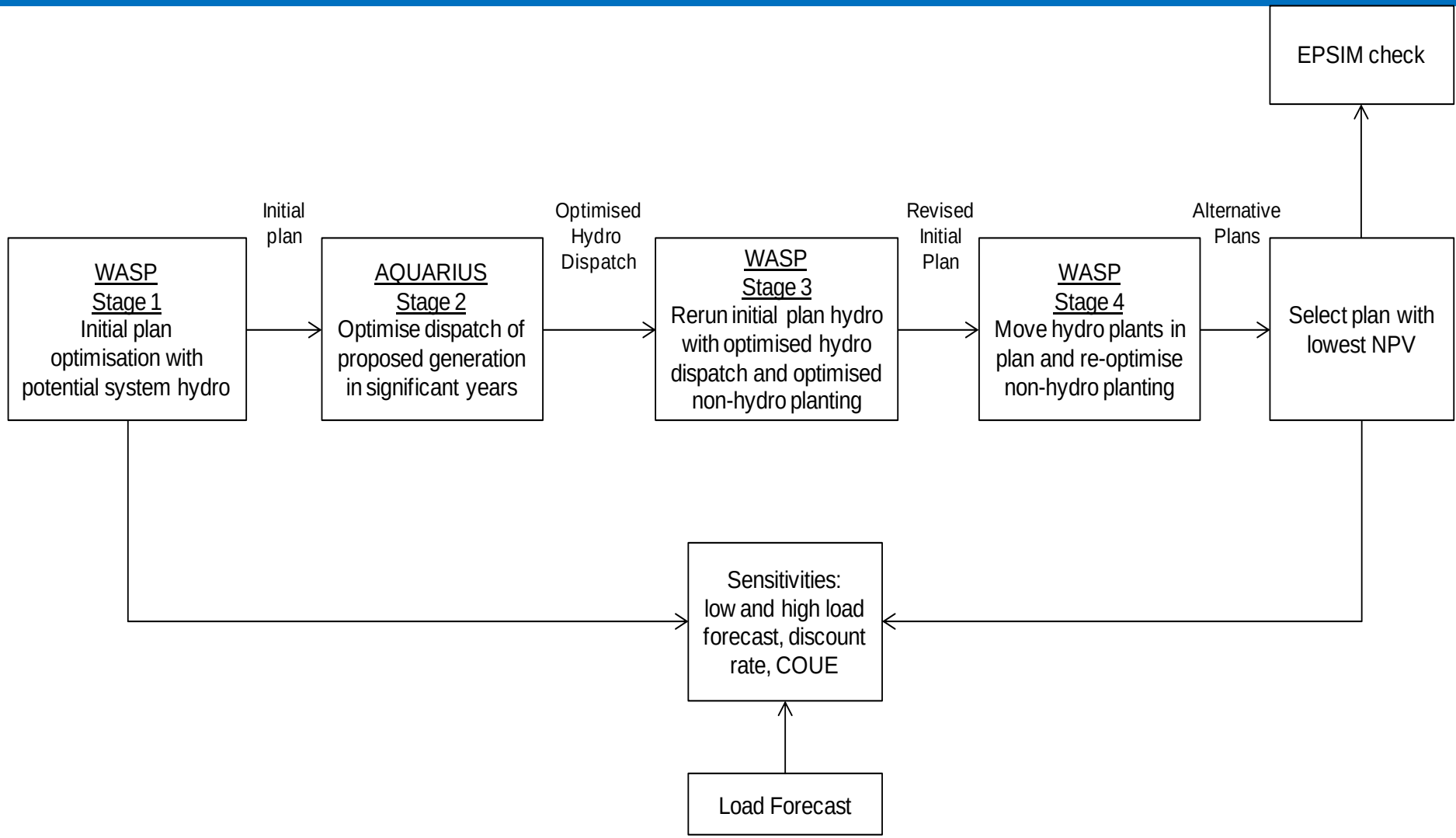


Generation Planning

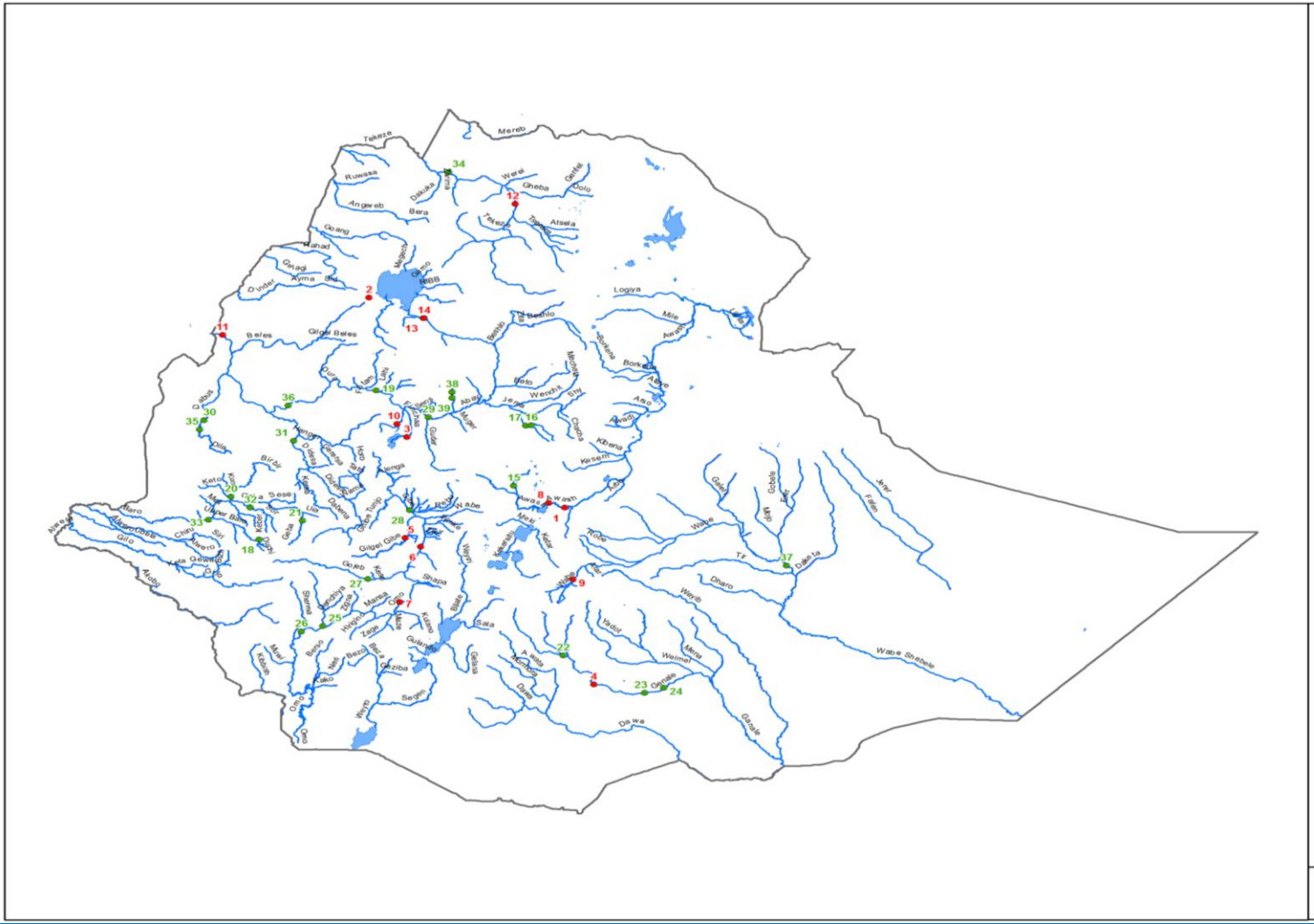
Generation Planning



Generation Planning

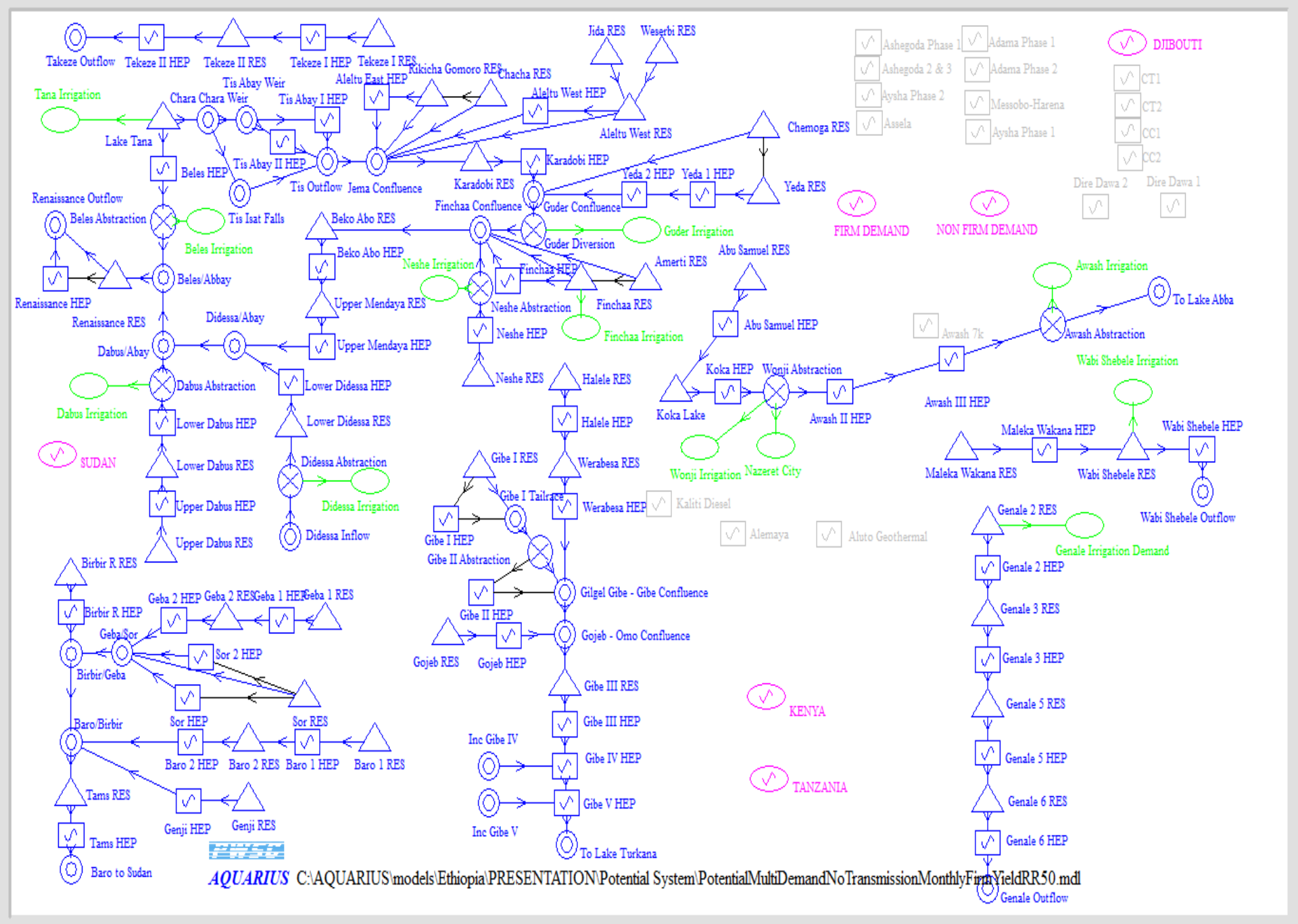


Generation Planning -Hydro System Modelling



Generation Planning -Hydro System Modelling

- For the Master Plan Study, *AQUARIUS* models have been constructed of :
  - The potential system, made up of
    - 41 Reservoirs
    - 45 Hydro plants
    - 26 Flow Points
    - 117 River Reaches
    - 12 Water Demand areas
    - 6 Electricity Demand areas i.e. domestic and export markets
    - 42 Inflow series
  - The seven major Ethiopian river basins
  - Individual projects viz. Grand Renaissance


Takeze Outflow
Tekeze II HEP
Tekeze II RES
Tekeze I HEP
Tekeze I RES
Jida RES
Weserbi RES
Aleltu East HEP
Kikicha Gomoro RES
Chacha RES
Aleltu West HEP
Aleltu West RES
Tana Irrigation
Chara Chara Weir
Tis Abay Weir
Tis Abay I HEP
Lake Tana
Beles HEP
Tis Abay II HEP
Tis Outflow
Jema Confluence
Karadobi RES
Karadobi HEP
Chemoga RES
Yeda 2 HEP
Yeda 1 HEP
Yeda RES
Finchaa Confluence
Guder Confluence
Renaissance Outflow
Beles Abstraction
Tis Isat Falls
Beles Irrigation
Guder Irrigation
Guder Diversion
Beko Abo RES
Beko Abo HEP
Neshe Irrigation
Finchaa HEP
Amerti RES
Abu Samuel RES
Beles/Abbay
Renaissance HEP
Renaissance RES
Didessa/Abay
Upper Mendaya RES
Upper Mendaya HEP
Neshe Abstraction
Finchaa RES
Finchaa Irrigation
Neshe HEP
Neshe RES
Abu Samuel HEP
Awash Irrigation
To Lake Abba
Awash 7k
Awash Abstraction
Dabus/Abay
Dabus Abstraction
Lower Didessa HEP
Lower Didessa RES
Dabus Irrigation
Lower Dabus HEP
Lower Dabus RES
Didessa Abstraction
Didessa Irrigation
Upper Dabus HEP
Upper Dabus RES
Didessa Inflow
Halele RES
Halele HEP
Werabesa RES
Werabesa HEP
Koka HEP
Wonji Abstraction
Koka Lake
Awash II HEP
Awash III HEP
Wonji Irrigation
Nazeret City
Wabi Shebele Irrigation
Maleka Wakana HEP
Wabi Shebele HEP
Maleka Wakana RES
Wabi Shebele RES
Wabi Shebele Outflow
Gibe I RES
Gibe I Tailrace
Gibe I HEP
Gibe II Abstraction
Gilgel Gibe - Gibe Confluence
Gibe II HEP
Gojeb - Omo Confluence
Gojeb RES
Gojeb HEP
Gibe III RES
Gibe III HEP
Inc Gibe IV
Gibe IV HEP
Gibe V HEP
Inc Gibe V
To Lake Turkana
Kaliti Diesel
Alemaya
Aluto Geothermal
Genale 2 RES
Genale Irrigation Demand
Genale 2 HEP
Genale 3 RES
Genale 3 HEP
Genale 5 RES
Genale 5 HEP
Genale 6 RES
Genale 6 HEP
Genale Outflow
Birbir R RES
Birbir R HEP
Geba 2 HEP
Geba 2 RES
Geba 1 HEP
Geba 1 RES
Geba/Sor
Sor 2 HEP
Birbir/Geba
Sor HEP
Sor RES
Baro/Birbir
Baro 2 HEP
Baro 2 RES
Baro 1 HEP
Baro 1 RES
Tams RES
Genji HEP
Genji RES
Tams HEP
Baro to Sudan
Ashegoda Phase 1
Ashegoda 2 & 3
Aysha Phase 2
Assela
Adama Phase 1
Adama Phase 2
Messobo-Harena
Aysha Phase 1
DJIBOUTI
CT1
CT2
CC1
CC2
Dire Dawa 2
Dire Dawa 1
FIRM DEMAND
NON FIRM DEMAND
SUDAN
KENYA
TANZANIA
AQUARIUS C:\AQUARIUS\models\Ethiopia\PRESENTATION\Potential System\PotentialMultiDemandNoTransmissionMonthlyFirmYieldRR50.mdl

Generation Planning

Objective :To estimate existing and candidate hydro plant capabilities for input to the expansion planning process, taking adequate account of:

- **Project interdependencies**
- **Cumulative regulation effects from reservoirs in cascade**
- **Benefits from coordinated operation**
- **Reductions in generation capacity during critical droughts**
- **Evaporation losses**
- **Water demands and compensation releases**

Generation Planning

Results obtained :

- Extension of (monthly) inflow series from 1961 to 2005
- Determination of system 'Firm' energies for Potential and River Basin systems
- Identification of multi-year 'critical' period from 1984 to 1987
- Hydro plant capacity and energy capabilities for up to five hydrological conditions, input to WASP

Generation Planning

Wien Automatic System Planning (WASP) program:

- Developed from Tennessee Valley Authority model for thermal systems – dynamic programming and probabilistic dispatch
- Adopted by International Atomic Energy Agency (IAEA) to *Generation Planning t*o promote nuclear power
- Further developed by Hydro Quebec for application to hydrothermal systems (cumulate methodology - WASP III and IV)
- Favored by World Bank, ADB and other international lending agencies
- Widely used by power utilities in over 60 countries

Generation Planning

For each year (up to 30) WASP calculates cost of each plant configuration meeting one or more of following annual planning constraints:

- Reserve Margin (upper and lower limits)
- Loss of Load Probability (LOLP)
- Cost of Unserved Energy (COUE)
- No of new units permitted (‘tunnel width’)

Generation Planning

Costs include:

- Capital
- Salvage
- Fuel
- Operations and Maintenance (O&M)
- Energy not Served

Generation Planning

In optimized planning, up to 5000 different sequences of annual generation planting can be examined

- For each sequence (plan) WASP calculates the OBJECTIVE FUNCTION
- The OBJECTIVE FUNCTION is the Present Value (PV) of all the discounted year-by year costs
- The plan with the minimum PV should be the optimum plan
- Sensitivity Analysis needed to confirm

Generation Planning

Existing and committed plant MW	Inst	Site	Dry Year	Comm	2012	2013	2014	2015	2016	2017	2018	2019
Hydro - Under Construction - MW							**427**	**1730**	**1730**	**6274**	**6274**	**6274**
Gilgel Gibe III (enters 2014)	748	748	427	2014			427	427	427	427	427	427
Gilgel Gibe III (enters 2015)	1122	1122	640	2015				640	640	640	640	640
Genale Dawa III	254	254	250	2015				250	250	250	250	250
Grand Renaissance (enters 2015)	500	500	413	2015				413	413	413	413	413
Grand Renaissance (enters 2017)	5500	5500	4544	2017						4544	4544	4544

Existing and committed plant MW	Inst	Comm	2012	2013	2014	2015	2016	2017	2018	2019
Wind - Existing			**81**	**81**	**171**	**171**	**171**	**171**	**171**	**171**
Adama	51	2012	51	51	51	51	51	51	51	51
Ashegoda (enters 2012)	30	2012	30	30	30	30	30	30	30	30
Ashegoda (enters 2014)	90	2014			90	90	90	90	90	90
Wind - Committed						**153**	**153**	**153**	**153**	**153**
Adama II	153	2015				153	153	153	153	153

Generation Planning

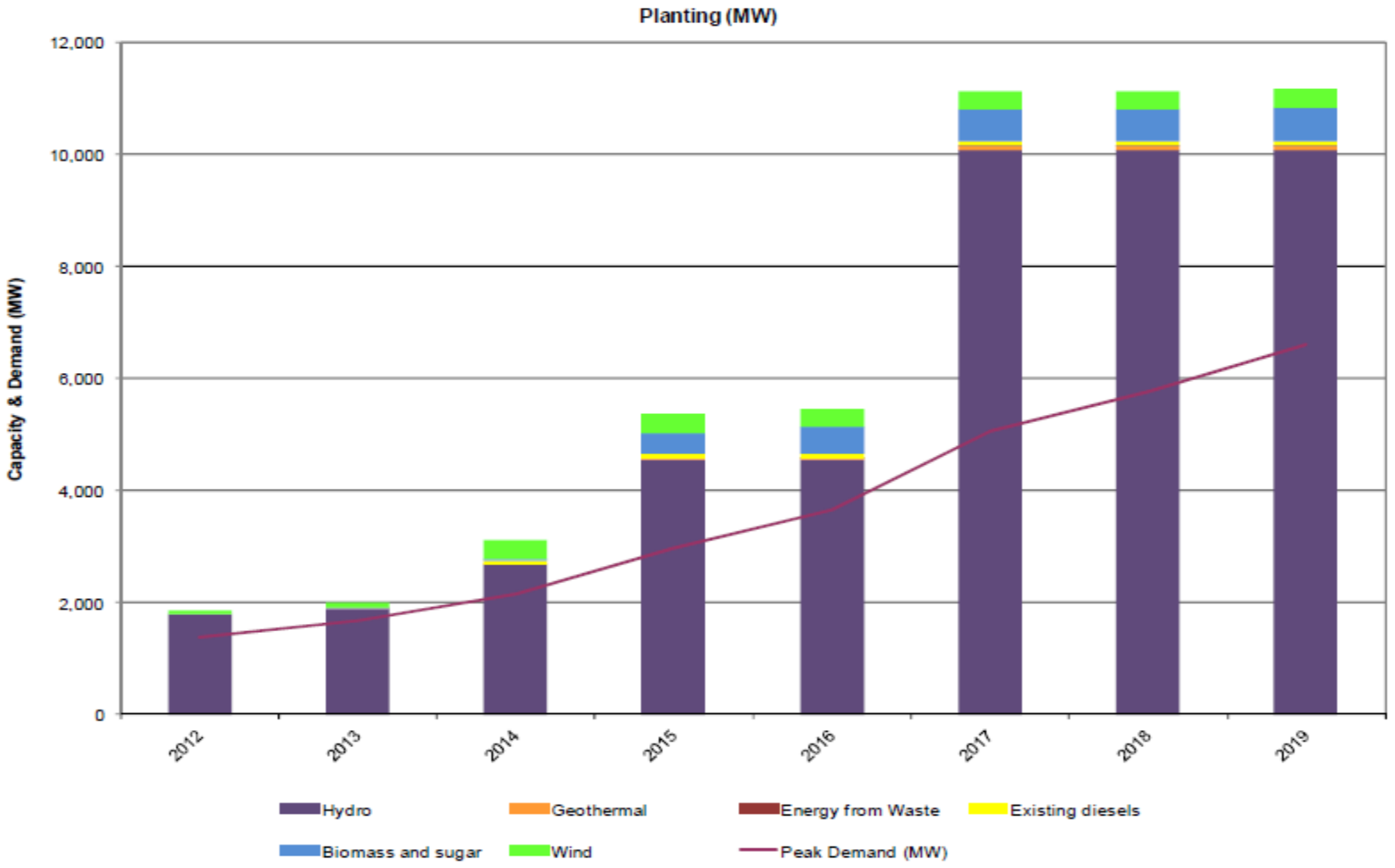
Existing and committed plant MW	Inst	Comm	2012	2013	2014	2015	2016	2017	2018	2019
Geothermal - Existing			5	5	5	5	5	5	5	5
Aluto Langano	7	2007	5	5	5	5	5	5	5	5
Geothermal - Committed									75	75
Aluto Langano II	75	2018							75	75

Energy From Waste - Committed						25	25	25	25	25
Addis Ababa EFW	25	2015				25	25	25	25	25

Generation Planning

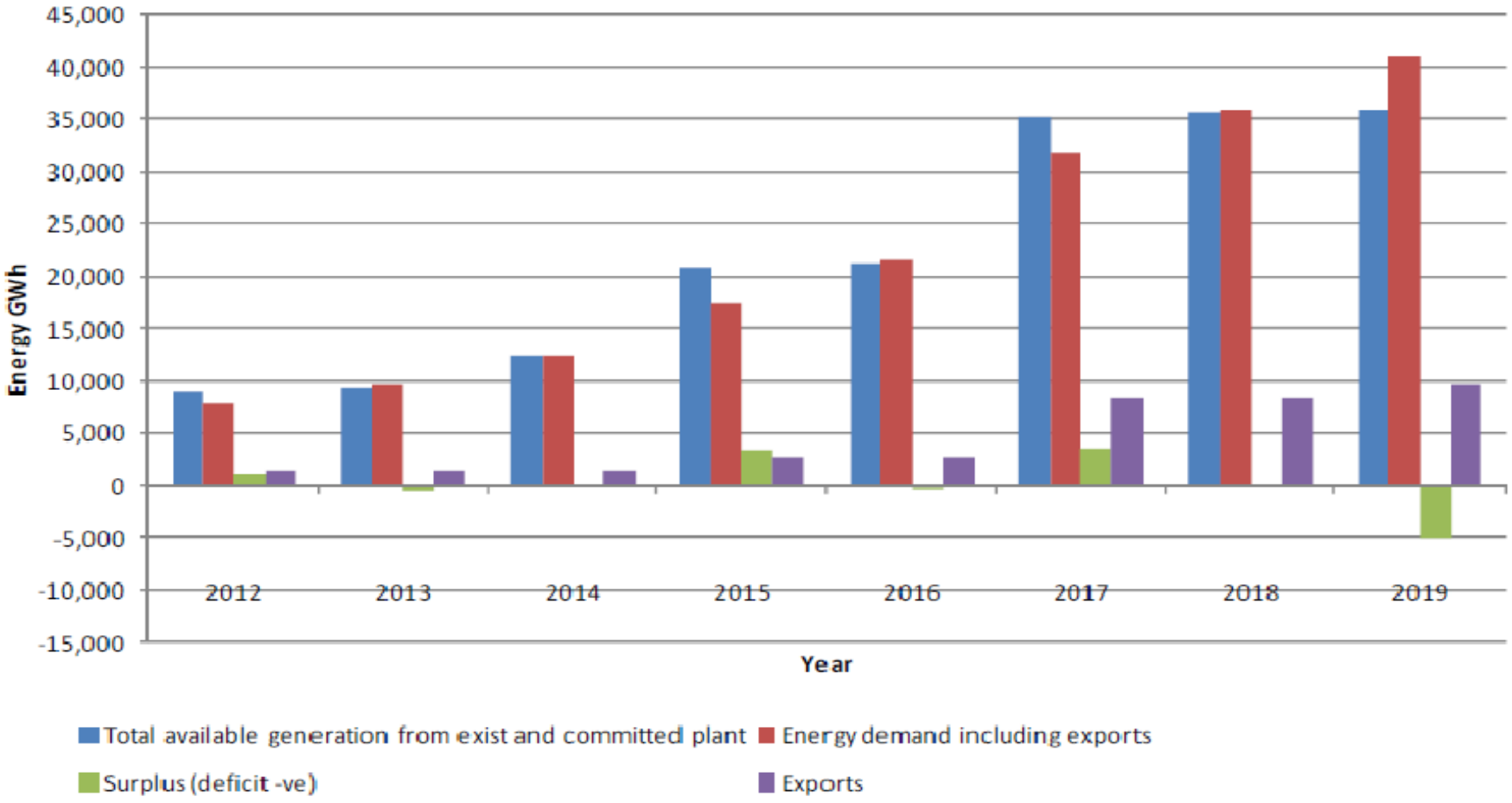
Existing and committed plant MW	Inst	Comm	2012	2013	2014	2015	2016	2017	2018	2019
Sugar Factories - Exist., U/C & Co	**Inst**			**26**	**26**	**254**	**354**	**434**	**434**	**474**
Tendaue / Ende	120	2015				70	70	70	70	70
Wenji	30	2013		16	16	16	16	16	16	16
Finchaa	31	2013		10	10	10	10	10	10	10
Beles 1	30	2015				20	20	20	20	20
Beles 2	30	2015				20	20	20	20	20
Beles 3	30	2016					20	20	20	20
Wolkayit	133	2015				82	82	82	82	82
Omo Kuraz 1	60	2015				20	20	20	20	20
Omo Kuraz 2	60	2016					40	40	40	40
Omo Kuraz 3	60	2016					40	40	40	40
Omo Kuraz 4	60	2017						40	40	40
Omo Kuraz 5	60	2017						40	40	40
Omo Kuraz 6	60	2019								40
Kessem	26	2015				16	16	16	16	16
Biomass - Committed						**120**	**120**	**120**	**120**	**120**
Bio - committed - "120MW"		2015				60	60	60	60	60
Bio - committed - "137.5MW"		2015				60	60	60	60	60

Generation Planning



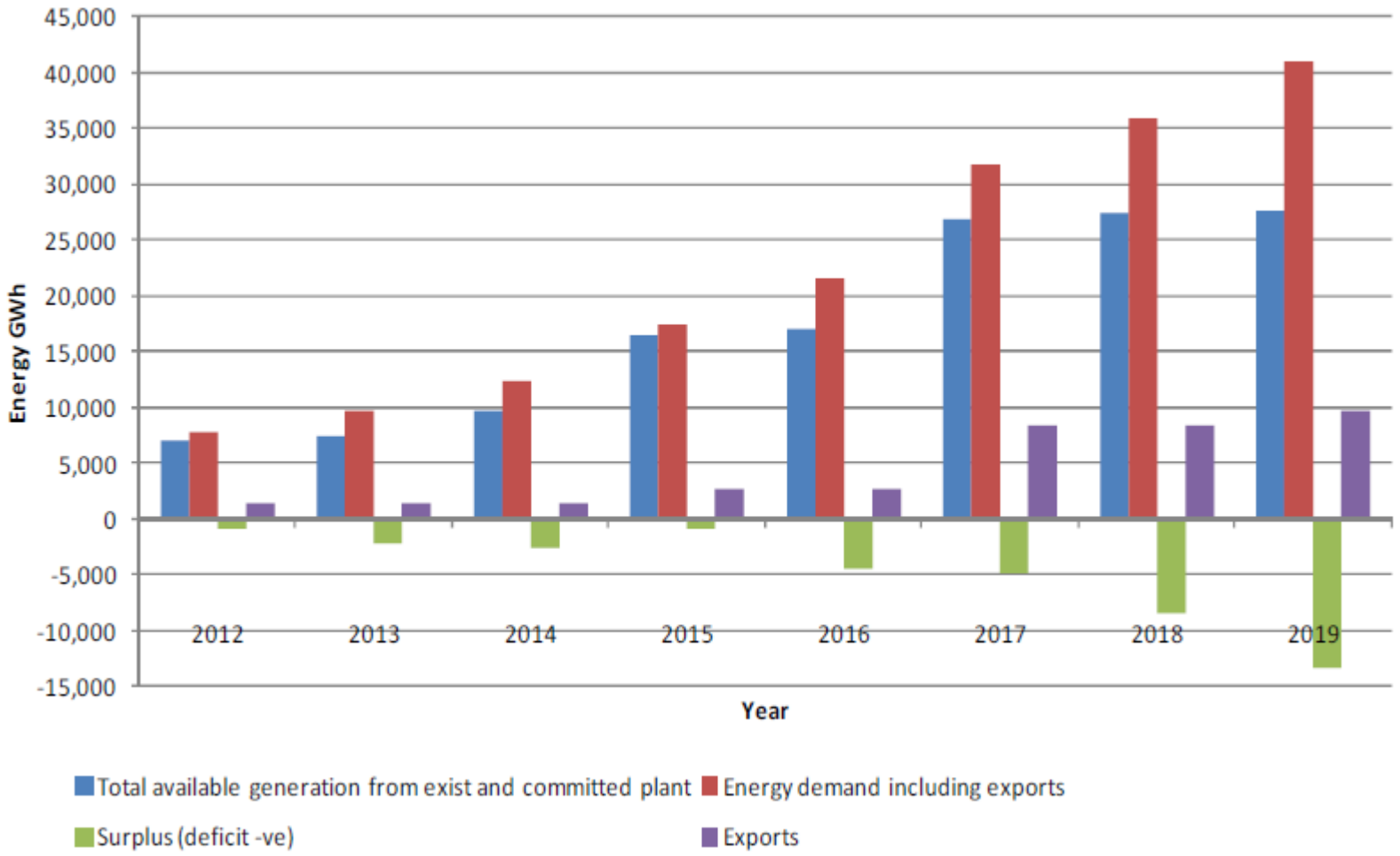
Existing and Committed Plants- Energy Balance (Average Hydrologic Year)

Generation Planning



Existing and Committed Plants- Energy Balance (Dry Hydrologic Year)

Generation Planning



Generation Planning- Pricing and other Information Source

Scheme	Pricing Year	Pricing Source
Beko-Abo	2010	Pre-feasibility Nov 2012 - Vol 3 Annex 3J Table 2-2 and Alternatives to Mandaya Cascade Options Memo July 2011 Table 3.1
Karadobi	2005	Pre-feasibility September 2006 Table 11-12 and Alternatives to Mandaya Cascade Options Memo July 2011 Table 3.1
Lower Didessa	2001	Reconnaissance study August 2001 Volume 2 Appendix 5
Lower Dabus	2002	Reconnaissance study June 2002 - Table 5.6
Lower Dabus Weir 1	2002	Reconnaissance study June 2002 - Table 5.7
Genale GD-6	2009	Feasibility study May 2009 - Annex 3G
Gibe V	2008	Reconnaissance study June 2008 - Gibe V Economic analysis CH 2.1
Gibe IV	2008	Reconnaissance study June 2008 - Gibe IV Economic analysis CH 2.1
Mandaya	2007	Inception report, 5th November 2010, Table 3.11 and Alternatives to Mandaya Cascade Options Memo July 2011 Table 3.1
Chemoga-Yeda Stg 1	2006	Feasibility study May 2006 - Table 13.2
Chemoga-Yeda Stg 2	2006	Feasibility study May 2006 - Table 11.2
Gojeb	1996	Design report May 1998 - Volume 3, Table 31A
Halele-Werabesa Stg II	2005	Feasibility study July 2005 Table 13.2
Geba 1	2005	Feasibility study February 2005 Volume 2 Table 15-11
Geba 2	2005	Feasibility study February 2005 Volume 2 Table 15-12
Aleltu West	1992	Aleltu Pre-feasibility Study Jan 1994 - Table 8.1
Aleltu East Stage 1	1993	Aleltu East Stage 1 feasibility study Feb 1995 - Table 10.1
Aba Samuel	2012	Preliminary design report August 2012
Halele-Werabesa Stg I	2000	Feasibility report Aug 2000. Table 15.1
Birbir R	2001	Reconnaissance study August 2001. Appendix 5
Wabi Shebele WS18	2004	Wabi Shebele Basin Development Masterplan Study. May 2004. Table 14
Sor Phase II	~1990	II Phase Sor hydroelectric feasibility study Table 7.5.I
Genale Dawa 5 (GD-5)	2004	Genale Dawa river basin integrated master plan study July 2007. Section 6.15.2.7
Tams	1996	Baro-Akobo river basin integrated development master plan study annex 1 pt 4 table 1J-9.2. May 1997

Generation Planning

Information from EEPCO and MWE for 28 schemes

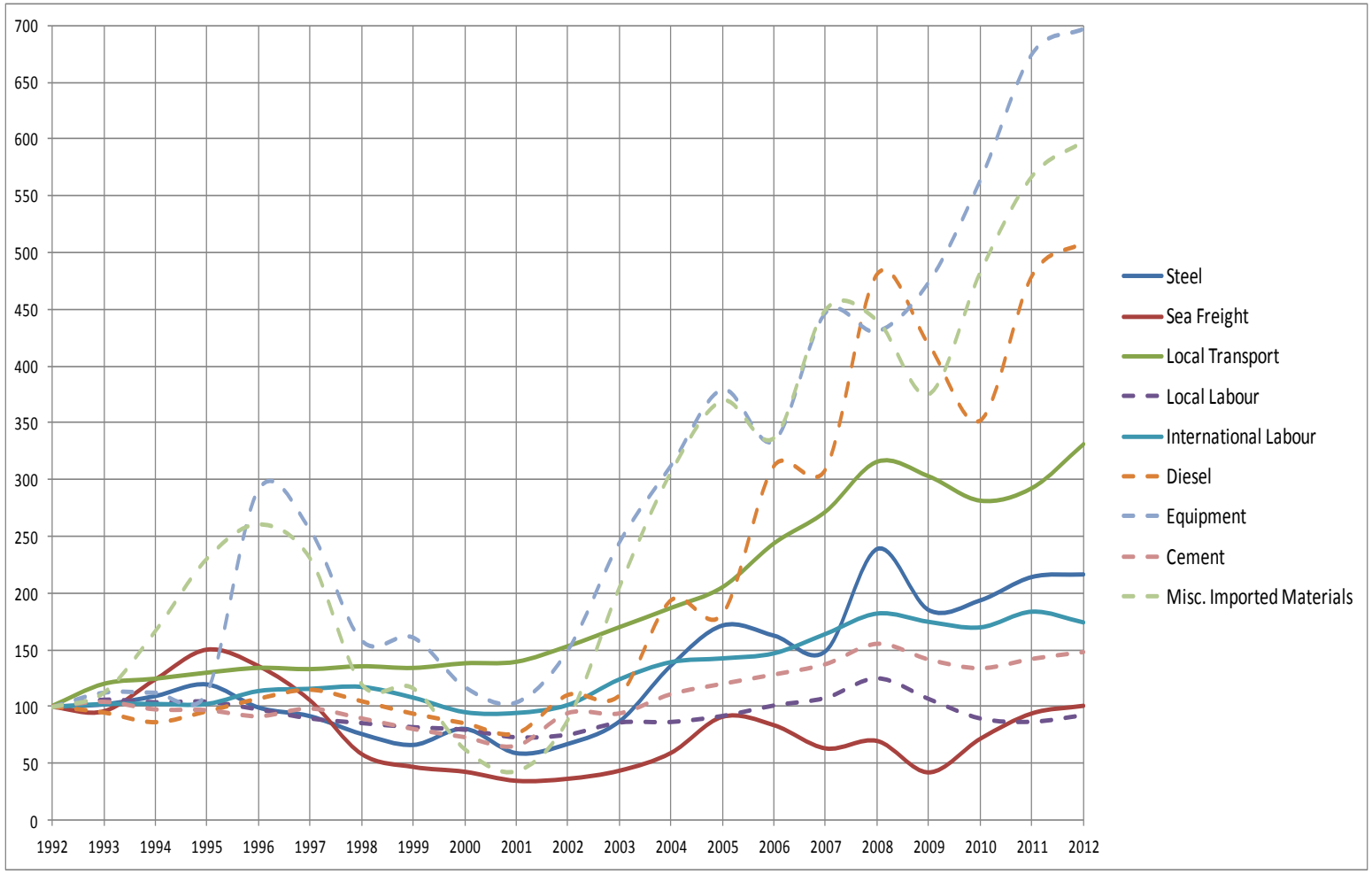
- Inception, Reconnaissance, Pre-Feasibility Feasibility studies
- Varying Dates
- Costs broken down into Civil, Electromechanical and
- Environmental

• Further broken down and the updated to 2012 prices using inflation indices
• Then add to get an EPC (engineer, procure, construct) price:
• 8% Engineering and construction
• 3% Owner's costs
• 20% Contractor's overheads and margins
• 0.90 Standard Conversion Factor (SCF) for local costs

Generation Planning

Category		Index	Factor
Civil works	Foreign Portion	Expat Labour	24%
		Steel	19%
		Equipment	15%
		Marine Transport	8%
		Misc. Imp. Material	14%
		Non-Adjusted Portion	20%
	Local Portion	Local Labour	23%
		Cement	25%
		Diesel	23%
		Local Transport	9%
		Non-Adjusted Portion	20%
Electromechanical works	Foreign Portion	Expat Labour	28%
		Steel	42%
		Marine Transport	10%
		Non-Adjusted Portion	20%
	Local Portion	Local Labour	50%
		Local Transport	30%
		Non-Adjusted Portion	20%
Environmental works	Foreign Portion	Expat Labour	100%
	Local Portion	Local Labour	100%

Generation Planning



Generation Planning

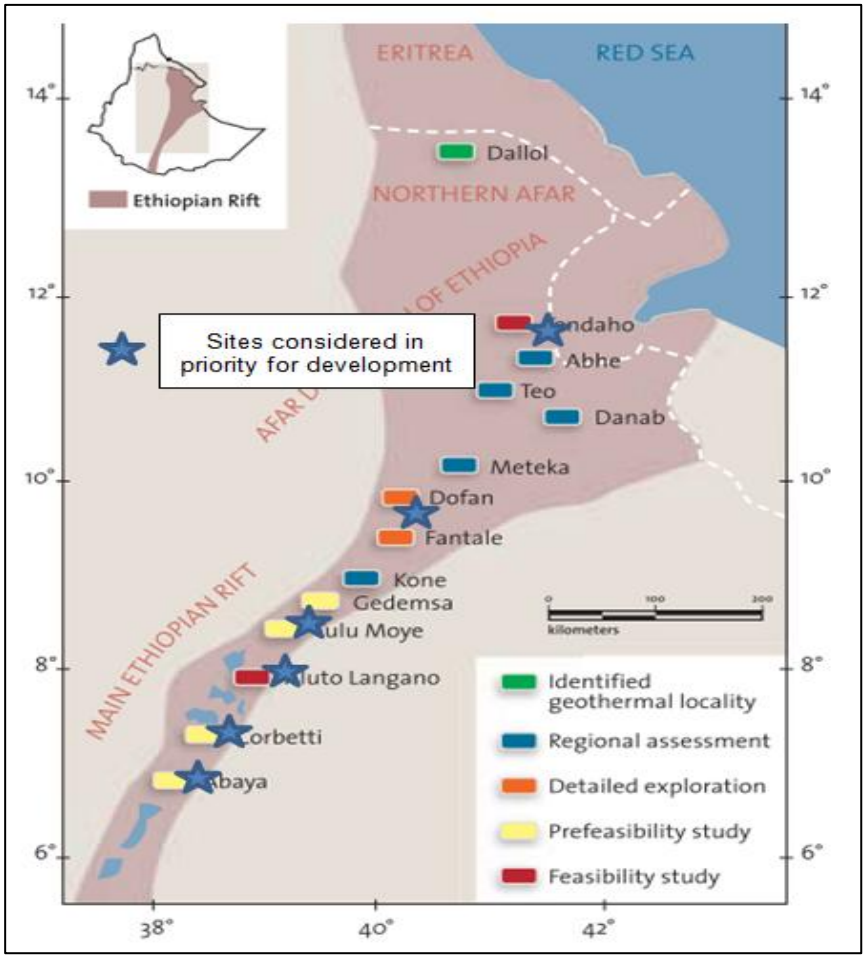
	Installed Capacity (MW)	Average Energy (GWh/year)	Average Plant Factor	Construction Cost (million $)	IDC Cost (million $)	Total Cost (million $)	Average Levelised Cost ($/kWh)	First available year
Beko Abo	935	6632	0.81	1260.8	441.3	1702.1	0.026	2022
Genji	214	910	0.49	197.6	69.1	266.7	0.029	2020
Upper Mendaya	1700	8582	0.58	2436.4	852.7	3289.1	0.038	2023
Karadobi	1600	7857	0.56	2576.0	901.6	3477.5	0.0443	2021
Geba 1 + Geba 2	372	1709	0.53	572.0	200.2	772.1	0.0452	2020
Genale 6	246	1532	0.71	587.9	205.8	793.7	0.052	2020
Gibe IV	1472	6146	0.48	2588.3	776.5	3364.8	0.055	2020
Sor 2	5	39	0.88	18.6	3.7	22.3	0.058	2017
Upper Dabus	326	1460	0.51	628.2	219.9	848.1	0.058	2020
Birbir R	467	2724	0.67	1231.1	369.3	1600.4	0.059	2020
Werabesa + Halele	436	1973	0.52	886.0	310.1	1196.1	0.061	2020
Yeda 1 + Yeda 2	280	1089	0.44	540.2	189.1	729.2	0.067	2020
Genale 5	100	575	0.66	297.7	89.3	387.1	0.067	2020
Gibe V	660	1905	0.33	1036.9	311.1	1348.0	0.071	2020
Lower Didessa	550	976	0.20	619.2	185.8	804.9	0.083	2020
Baro 1 + Baro 2	645	2614	0.46	1595.9	558.6	2154.4	0.082	2020
Tekeze II	450	2721	0.69	1690.4	591.6	2282.0	0.084	2020
Gojeb	150	562	0.43	526.8	184.4	711.2	0.127	2020
Aleltu East	189	804	0.49	760.6	266.2	1026.9	0.128	2020
Tams	1000	6057	0.69	5814.9	2035.2	7850.1	0.130	2020
Abu Samuel	6	16	0.30	18.5	2.8	21.2	0.135	2020
Aleltu West	265	1067	0.46	1180.5	413.2	1593.6	0.149	2020
Wabi Shebele	88	691	0.90	887.8	221.9	1109.7	0.161	2020
Lower Dabus	250	637	0.29	866.3	259.9	1126.2	0.177	2020

Generation Planning

Type and generic size

- Geothermal – 100 MW
- Wind – 300 MW
- Solar – 300 MW
- Gas turbines on light fuel oil (LFO) – 140 MW
- Diesels on heavy fuel oil (HFO) – converted to gas when available – 70 MW
- Gas turbines on gas – 140 MW
- Combined cycle gas turbines on gas 420 MW
- Nuclear 300 MW/ 1200 MW

Generation Planning



Typical Time line

Years	1	2	3	4	5	6
Exploration and field appraisal						
Drilling (production & reinjection)						
Financial closure - start of EPC						
Steamfield						
Power Plant						
COD (Commercial Operation date)						
Commercial Operation - Generation						
Costs spread % of investment	2	5	15	42	36	

Cost

Plant capacity MW Net	**100**
Well productivity	**5 MW/well**
Exploration and field appraisal	**30**
Drilling (production & reinjection)	**210**
Steamfield	**40**
Power Plant US$ million	**150**
Power Plant US$ / kW net	**1,500**
sub-total Capex US$ million	**430**
Owner's costs 10%	**43**
Total Capex US$ million	**473**
Total Capex US$/kW Net	**4,730**
Total Capex (local: 35%) US$/kW Net	1,656
Total Capex (foreign: 65%) US$/kW Net	3,075

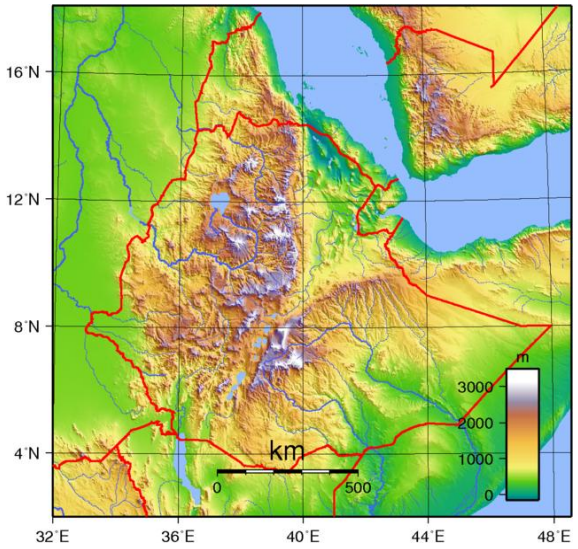
Generation Planning

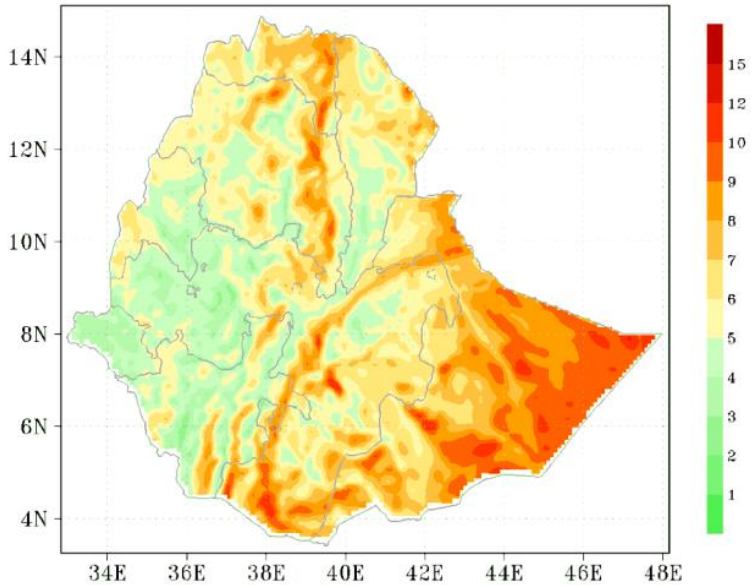
- Masterplan Report of Wind and Solar Energy – July 2012 – HYDROCHINA Corporation
  - •Considered 51 wind power sites using ave annual wind-speed data
  - •Recommended solar power at Debre Birhan, Metehara, Awash, and Dera with demonstration base in Addis Ababa
- Solar and Wind Energy Utilization and project Development Scenarios – SWERA 2007

Generation Planning

Good sites with av. speed >7m/s

- >15 m/s is too windy
- Central N-S axis, East central region
- Ogaden remote from transmission & security issues



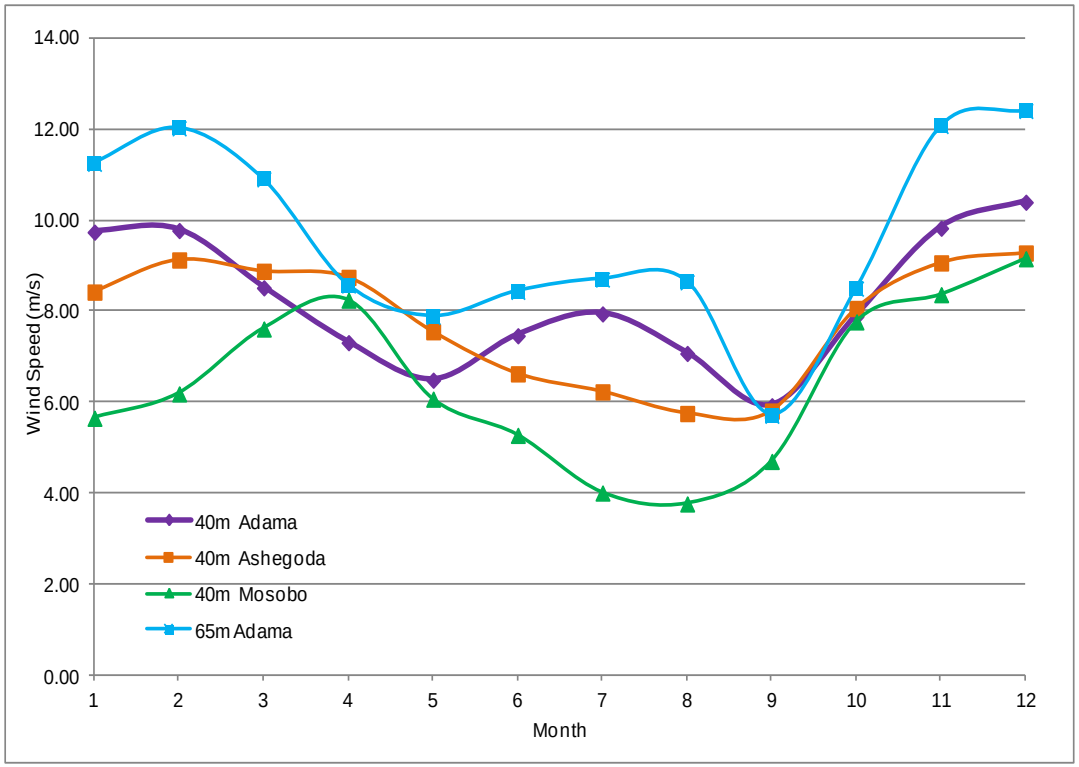


Lower altitude sites with greater air density hence greater power extracted from the air – i.e. Aysha area

- Complex topography causes turbulent flows and makes it difficult to use approximations for wind speed data

Generation Planning

- Detailed wind data from 4 data loggers at Ashegoda, Adama x2 and Mosobo No data for the Aysha region
- High wind speeds Nov to Feb, lower wind speeds May to Sept.
- Complimentary to hydro wet season June – Sept.
- Monthly Modelling in Aquarius, WASP and EPSIM



Generation Planning

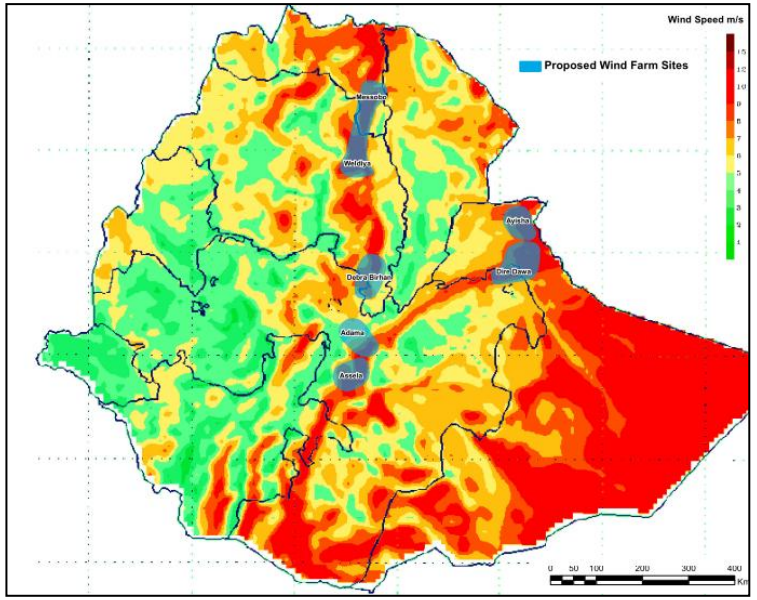
Wind capacity limited to max of 20% of demand (agreed with
EEPCO)

- Grid stability
- Ease of operation
- Minimize additional transmission costs associated with variable nature of wind generation
- Energy contribution would be 10% of total annual generation

Costs

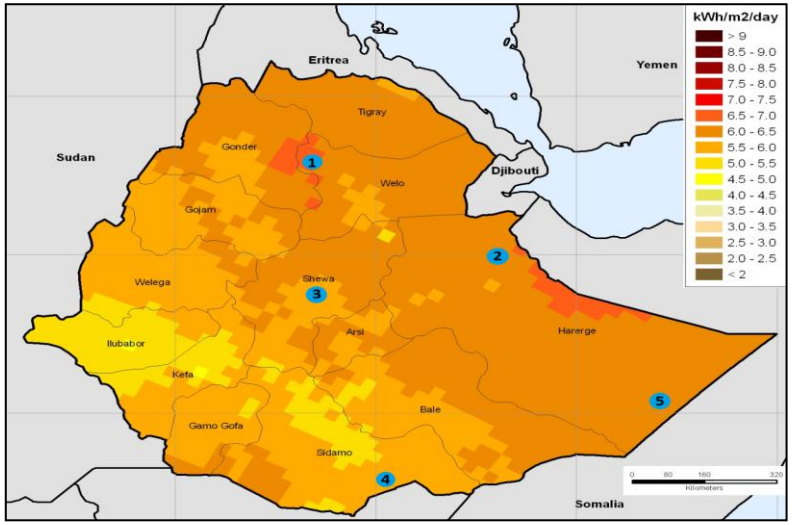
Technology	Capital	Operating	
		Fixed	Variable
Wind Farm	$1,900/kW	$25/kW/year	$0.01/kWh

Location



Generation Planning

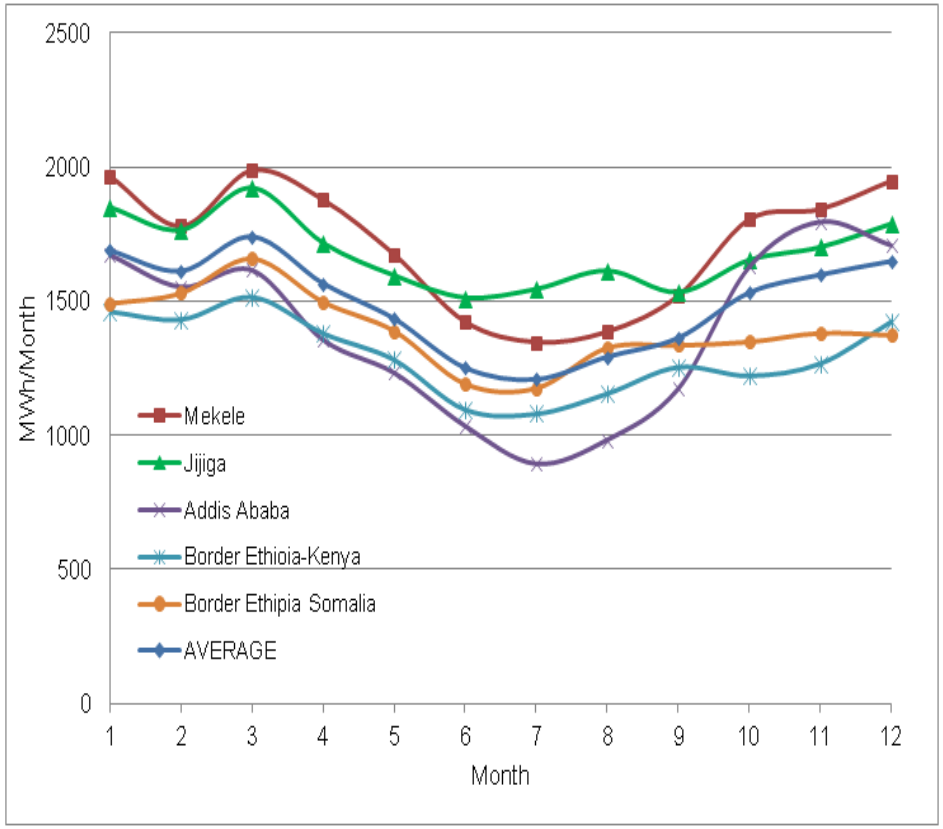
In Ethiopia the solar radiation resource is highest in the north highland, the mid south, and the east Somali regions

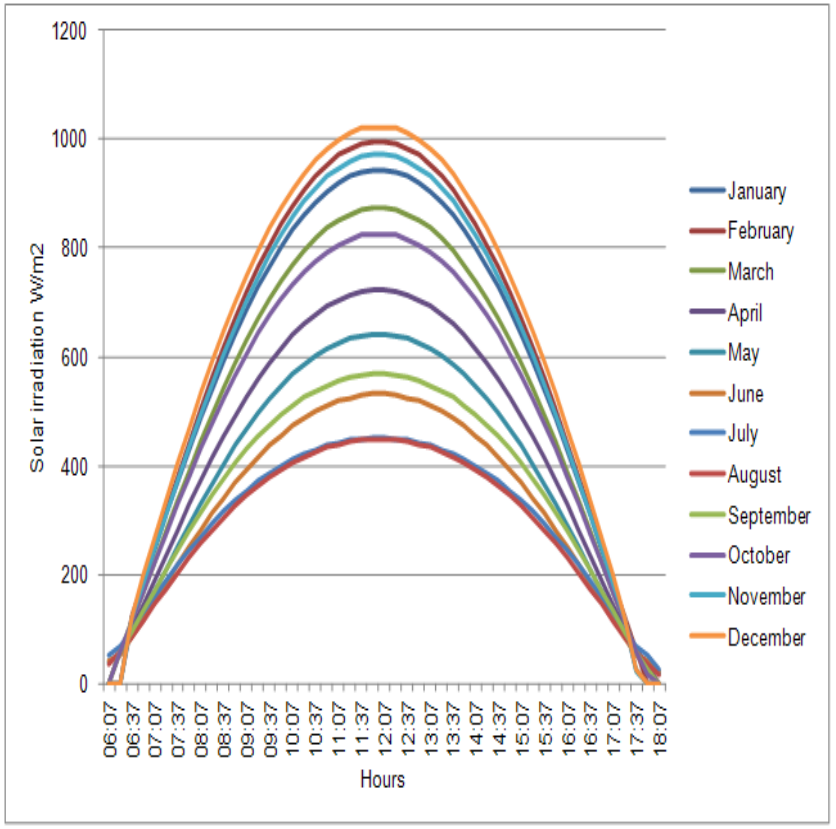


Station	Lat Degrees (North)	Long Degrees (East)	GHI kWh/m^2	Panel Tilt Degrees	Yield kWh/kWp /year	Energy Output MWh/year	CF %	Solar Plant Size MW
1) Mekele	13.5	39.5	2391.2	20	20,542	205,420	23.40%	100
2) Jijiga	9.3	42.8	2379.7	15	20,184	201,840	23.00%	100
3) Addis Ababa	9	38.7	1934.5	20	16,639	166,390	19.00%	100
4) Border Ethiopia-Kenya	4.1	40.2	1903.6	10	15,561	155,610	17.80%	100
5) Border Ethiopia- Somalia	7.2	45.7	2086	15	16,697	166,697	19.10%	100

- Candidate Non-Hydro Plants- Solar Potential

Generation Planning





Generation Planning

Limits on capacity

Reasonable limit - Installed solar to be 10% of demand

- Grid stability
- Ease of operation
- Extra transmission costs

Overall contribution 6% of total energy generation

Price of modules fallen 75% since 2008. Grid parity may soon reached

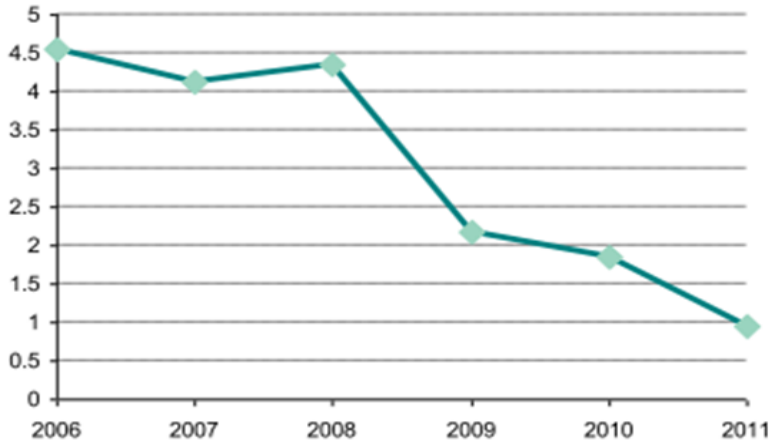
METEC PV assembly line in Addis

Used in planning:

Capex: 1800 $/kW

Opex: 25$/kWyear

Chinese c-Si PV module prices (US$/W)



Generation Planning

Sources:

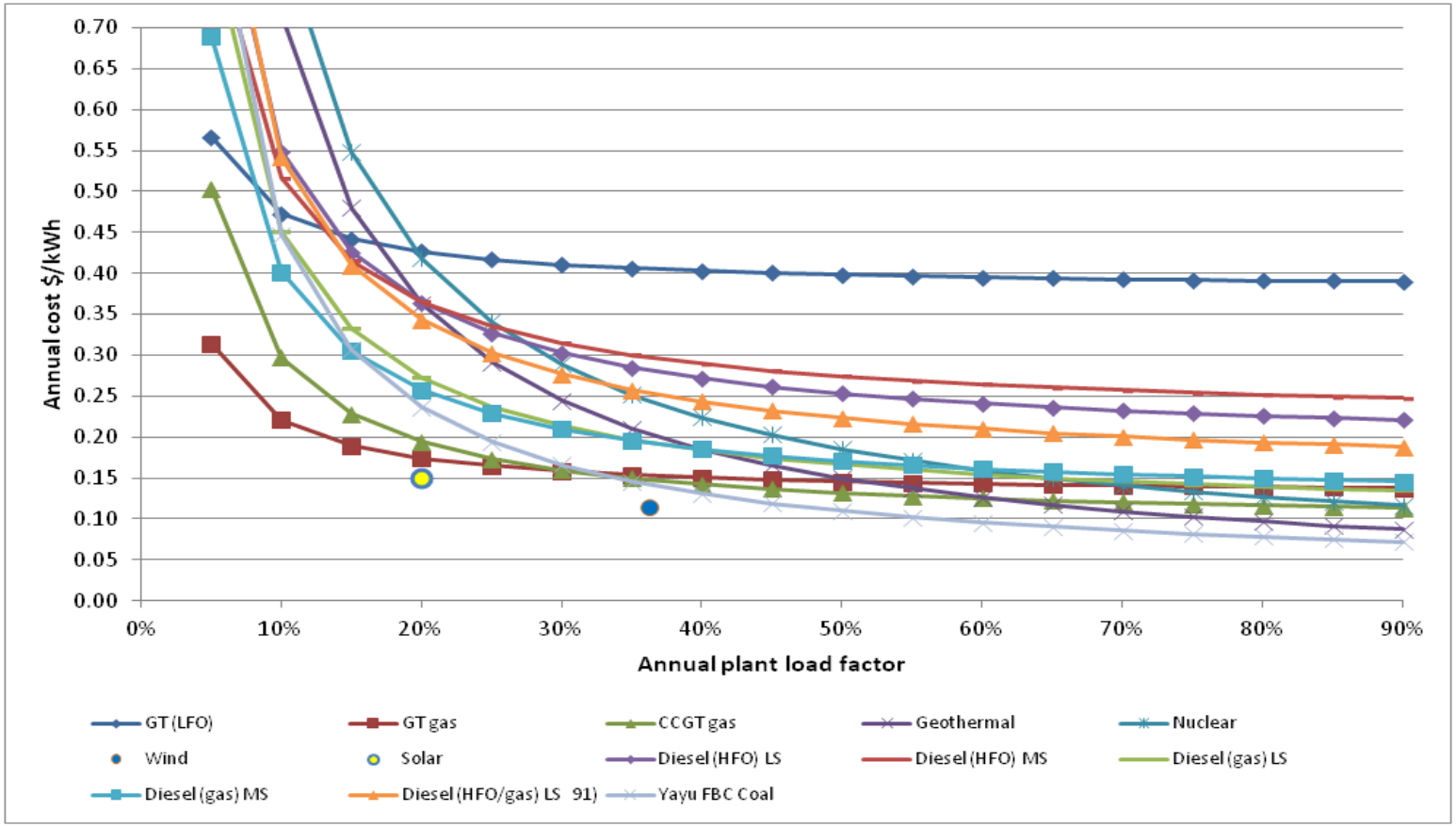
Ethiopia e.g. Calub and Hilala fields (4TCF = 113 billion cu m – BCM)

Import LNG at Djibouti, re-gassify and pipe to Dire Dawa /Awash

- Assumed available from 2025
- Sensitivity in Reference and High Case for gas in 2020
- Gas price of 11.5$/GJ assumed , based on import

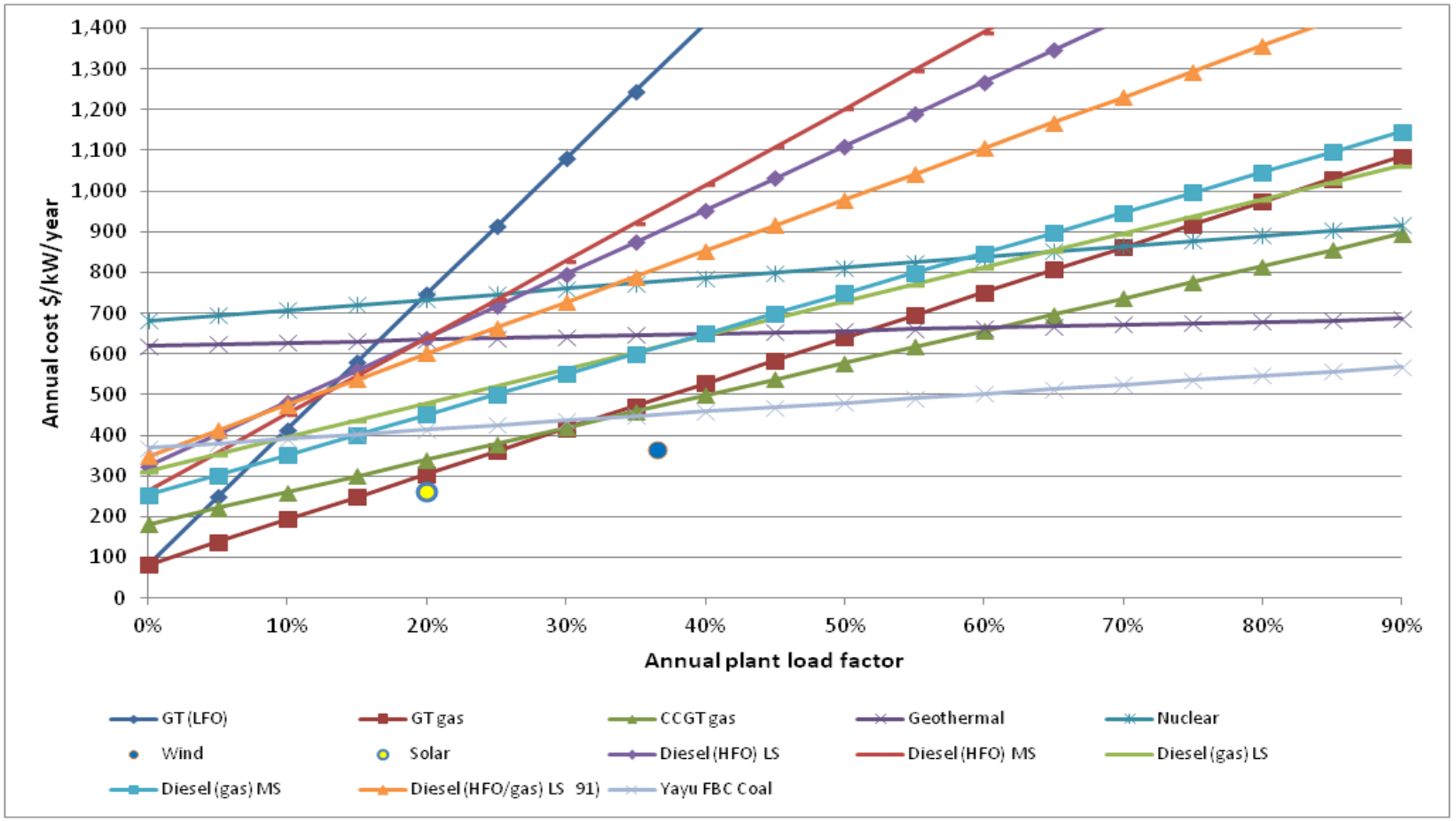
- Candidate Non-Hydro Plants- Screening $/kWh

Generation Planning



- Candidate Non-Hydro Plants- Screening $/kW

Generation Planning



Generation Planning

			Maximum number that can be installed																										
	Capacity MW	First year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Geothermal (1)	100	2018	-	-	-	-	-	-	2	3	5	7	9	11	13	15	17	19	21	23	25	28	31	34	38	42	46	50
Wind	300	2016	-	-	-	-	1	2	3	3	4	5	5	6	7	7	8	9	10	11	12	13	13	14	15	16	17	17
Solar	300	2016	-	-	-	-	1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	8	8	8	9
GT on diesel	140	2016	-	-	-	-	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
GT on gas	140	2025	-	-	-	-	-	-	-	-	-	-	-	-	-	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
CCGT on gas	420	2025	-	-	-	-	-	-	-	-	-	-	-	-	-	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
Nuclear	300	2021	-	-	-	-	-	-	-	-	-	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
Diesels	70	2016	-	-	-	-	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV	AV
Wind and solar limits		Limit																										
Ref. Forecast	**MW**		1378	1681	2157	2956	3650	5062	5750	6601	7474	8667	9553	10659	11481	12636	13399	14510	15540	16611	17868	18870	20134	21277	22365	23556	24699	25761
Max wind	MW	20%					730	1012	1150	1320	1495	1733	1911	2132	2296	2527	2680	2902	3108	3322	3574	3774	4027	4255	4473	4711	4940	5152
Existing	MW		81	81	171	171	171	171	171	171	171	171	171	171	171	171	171	90	90									
Committed	MW		0	0	0	153	153	153	153	153	153	153	153	153	153	153	153	153	153	153								
Max load supplied by candidates	MW						406	688	826	996	1171	1409	1587	1808	1972	2203	2356	2659	2865	3169	3574	3774	4027	4255	4473	4711	4940	5152
Max wind	Units						1	2	3	3	4	5	5	6	7	7	8	9	10	11	12	13	13	14	15	16	17	17
Max load supplied by solar	MW	0.1					365	506	575	660	747	867	955	1066	1148	1264	1340	1451	1554	1661	1787	1887	2013	2128	2237	2356	2470	2576
Max Solar	Units						1	2	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	8	8	8	9
AV	Available		(1) Maximum 5000MW																									

Generation Planning

Year	Costs in US$ million discounted to 2012 (all costs in money of 2012)							Cumulative Additional Plant (from Candidates)														
	Construction Cost	Salvage Cost	Operating Cost	Energy Not Served Cost	Total Discounted Cost	Cumulative Discounted Cost	Annual LOLP %	Geothermal 100 MW	Wind 300 MW	Solar PV 300 MW	GT (diesel) 140 MW	GT (gas) 140 MW	CCGT (gas) 420 MW	Nuclear 300 MW	Low Speed Diesel 70 MW	Hydro Group 1	Hydro Group 2	Hydro Planting				
2012			36		36	36																
2013			36	1,886.1	1,922	1,958	75.2%															
2014			130	940.0	1,070	3,028	43.7%															
2015			135	248.7	384	3,412	14.4%															
2016	891		145	11.1	1,048	4,460	1.1%		1+	1+												
2017	449	-2	222	27.2	696	5,155	2.5%		2+	1						1		Sor 2				
2018	940	-34	226	1.1	1,133	6,288	0.1%	2+	3+	1						1						
2019	778	-29	467	44.5	1,261	7,549	4.0%	3+	3+	-1					6	1						
2020	3,146	-527	310	2.7	2,932	10,481	0.2%	5+	3	1					-6	1	4	Geba 1 and 2	Genale 6	Gibe 4	Upper Dabus	
2021	1,884	-338	254		1,800	12,281		7+	3	1					6	2	4	Karadobi				
2022	842	-168	282	0.5	957	13,238	0.1%	8	3	-1					-6	3	4	Beko Abo				
2023	2,133	-509	214	0.7	1,838	15,076	0.1%	8	3	1					6	4	6	Upper Mendaya	Birbir R	Werabesa and Halele		
2024	1,557	-409	194		1,342	16,418		8	3	1					6	4	11	Genale 5	Yeda 1 and Yeda 2	Gibe V	Baro 1 and Baro2	Genji
2025	581	-125	243	3.3	702	17,120	0.3%	12	3	-1		1			-6	4	11					
2026	508	-127	241	5.6	628	17,749	0.4%	16	3	1		1			6	4	11					
2027			214	1.8	216	17,964	0.2%	16	3	1		1			-6	4	11					
2028	542	-174	235	2.6	605	18,569	0.2%	21+	3	-1		2			6	4	11					
2029	427	-156	281	0.1	552	19,121	0.0%	23+	3	1		2	2		-6	4	11					
2030	421	-159	328	2.3	592	19,713	0.4%	25+	4	1		3	3		6	4	11					
2031	334	-155	340	0.2	520	20,233	0.0%	28+	4	-1		3	4		6	4	11					
2032	408	-203	366	1.7	573	20,806	0.2%	31+	5	1		3	5		-6	4	11					
2033	287	-167	383	0.6	504	21,310	0.1%	34+	5	1		4	6		6	4	11					
2034	557	-375	329		512	21,821		37	5	-1		4	6		6	4	13	Tekeze 2	Lower Didessa			
2035	278	-202	329	3.1	408	22,229	0.6%	42+	5	1		5	6		-6	4	13					
2036	257	-208	328	0.6	378	22,607	0.1%	46+	5	1		5	7		6	4	13					
2037	233	-210	325	0.3	349	22,957	0.1%	50+	5	1		5	8		6	4	13					
Totals	17,453	-4,275	6,593	3,185	22,957																	
	57.4%		28.7%	13.9%	100.0%																	

Case **IHpL76FO**

Generation Planning

Comparison of NPVs for Stage 1 optimisation cases

Case	Description	NPV - $million
IHL_1DBWD	No diesels – Potential System hydro characteristics	29,780
IHL_1DBD	With diesels - Potential System hydro characteristics	26,046

Comparison of NPVs for Stage 3 and 4 optimisation cases

Case	Description	NPV - $million
IHL_800Aq	No diesels – Refined hydro characteristics	28,191
IHpL76FO	*With diesels – Refined hydro characteristics*	*22,957*
IHL_76F3	With diesels – Refined hydro characteristics -Upper Dabus moved back two years	23,005
IHL_78F5	With diesels – Refined hydro characteristics - Werabesa and Halele and Genji each moved back one year	22,961
IHL_84F4	**With diesels – Refined hydro characteristics – Werabesa and Halele, Genale 5 and Gibe 5 each moved back one year**	**22,932**
IHL_84F3	With diesels – Refined hydro characteristics –Werabesa and Halele, Genale 5, Gibe 5 and Genji each moved back one year	22,950

Generation Planning

Year	Costs in US$ million discounted to 2012 (all costs in money of 2012)							Cumulative Additional Plant (from Candidates)												
	Construction Cost	Salvage Cost	Operating Cost	Energy Not Served Cost	Total Discounted Cost	Cumulative Discounted Cost	Annual LOLP %	Geothermal 100 MW	Wind 300 MW	Solar PV 300 MW	GT (diesel) 140 MW	GT (gas) 140 MW	CCGT (gas) 420 MW	Nuclear 300 MW	Low Speed Diesel 70 MW	Hydro Group 1	Hydro Group 2	Hydro Planting			
2012			36		36	36															
2013			36	1,886.1	1,922	1,958	75.2%														
2014			130	940.0	1,070	3,028	43.7%														
2015			135	248.7	384	3,412	14.4%														
2016	891		145	11.1	1,048	4,460	1.1%		1+	1+											
2017	449	-2	222	27.2	696	5,155	2.5%		2+	1						1		Sor 2			
2018	940	-34	226	1.1	1,133	6,288	0.1%	2+	3+	1						1					
2019	778	-29	467	44.5	1,261	7,549	4.0%	3+	3+	-1					6	1					
2020	3,146	-527	310	2.7	2,932	10,481	0.2%	5+	3	1					6	1	4	Geba 1 and 2	Genale 6	Gibe 4	Upper Dabus
2021	1,884	-338	254		1,800	12,281		7+	3	1					6	2	4	Karadobi			
2022	1,028	-194	254		1,088	13,369		9+	3	-1					6	3	4	Beko Abo			
2023	1,714	-409	230	6.9	1,541	14,911	0.5%	9	3	1					6	4	5	Upper Mendaya	Birbir R		
2024	1,386	-364	213	0.0	1,235	16,146	0.0%	9	3	1					6	4	9	Werabesa and Halele	Yeda 1 and Yeda 2	Baro 1 and Baro2	Genji
2025	944	-240	243	3.3	950	17,096	0.3%	12	3	-1		1			6	4	11	Genale 5	Gibe V		
2026	508	-127	241	5.6	628	17,724	0.4%	16	3	1		1			6	4	11				
2027			214	1.8	216	17,940	0.2%	16	3	1		1			6	4	11				
2028	542	-174	235	2.6	605	18,544	0.2%	21+	3	-1		2			6	4	11				
2029	427	-156	281	0.1	552	19,096	0.0%	23+	3	1		2	2		6	4	11				
2030	421	-159	328	2.3	592	19,688	0.4%	25+	4	1		3	3		6	4	11				
2031	334	-155	340	0.2	520	20,208	0.0%	28+	4	-1		3	4		6	4	11				
2032	408	-203	366	1.7	573	20,781	0.2%	31+	5	1		3	5		-6	4	11				
2033	287	-167	383	0.6	504	21,285	0.1%	34	5	1		4	6		6	4	11				
2034	557	-375	329		512	21,797		37	5	-1		4	6		6	4	13	Tekeze 2	Lower Didessa		
2035	278	-202	329	3.1	408	22,205	0.6%	42+	5	1		5	6		6	4	13				
2036	257	-208	328	0.6	378	22,583	0.1%	46	5	1		5	7		6	4	13				
2037	233	-210	325	0.3	349	22,932	0.1%	50+	5	1		5	8		6	4	13				
Totals	17,411	-4,270	6,601	3,190	22,932																
	57.3%		28.8%	13.9%	100.0%																

Case **IHL_84F4**

Results for Reference Case-with no gas and Geothermal limit is increased

Generation Planning

Year	Costs in US$ million discounted to 2012 (all costs in money of 2012)							Cumulative Additional Plant (from Candidates)													
	Construction Cost	Salvage Cost	Operating Cost	Energy Not Served Cost	Total Discounted Cost	Cumulative Discounted Cost	Annual LOLP %	Geothermal 100 MW	Wind 300 MW	Solar PV 300 MW	GT (diesel) 140 MW	GT (gas) 140 MW	CCGT (gas) 420 MW	Nuclear 300 MW	Low Speed Diesel 70 MW	Hydro Group 1	Hydro Group 2	Hydro Planting			
2012			36		36	36															
2013			36	1,886.1	1,922	1,958	75.2%														
2014			130	940.0	1,070	3,028	43.7%														
2015			135	248.7	384	3,412	14.4%														
2016	891		145	11.1	1,048	4,460	1.1%		1+	1+											
2017	449	-2	222	27.2	696	5,155	2.5%		2+	1						1		Sor 2			
2018	940	-34	226	1.1	1,133	6,288	0.1%	2+	3+	1						1					
2019	731	-28	467	44.5	1,215	7,504	4.0%	3+	3+	-1					6	1					
2020	3,146	-527	310	2.7	2,932	10,436	0.2%	5+	3	1					6	1	4	Geba 1 and 2	Genale 6	Gibe 4	Upper Dabus
2021	1,884	-338	254		1,800	12,235		7	3	-1					6	2	4	Karadobi			
2022	1,028	-194	254		1,088	13,324		9	3	-1					6	3	4	Beko Abo			
2023	1,714	-409	230	6.9	1,541	14,865	0.5%	9	-3	1					6	4	5	Upper Mendaya	Birbir R		
2024	1,386	-364	213	0.0	1,235	16,100	0.0%	9	3	-1					6	4	9	Werabesa and Halele	Yeda 1 and Yeda 2	Baro 1 and Baro2	Genji
2025	1,341	-328	230	0.8	1,244	17,344	0.1%	15	-3	1					-6	4	11	Genale 5	Gibe V		
2026	508	-127	230	2.9	614	17,959	0.3%	19	3	-1					6	4	11				
2027			197	0.6	197	18,156	0.1%	19	-3	1					6	4	11				
2028	630	-204	206	2.2	634	18,790	0.2%	25	3	-1					-6	4	11				
2029	764	-279	203	2.6	691	19,481	0.2%	33	-3	1					6	4	11				
2030	781	-322	207	4.0	670	20,151	0.3%	42	3	-1					6	4	11				
2031	473	-219	203	5.5	462	20,613	0.4%	48	-3	1					-6	4	11				
2032	645	-336	202	7.0	519	21,132	0.5%	57	3	1					6	4	11				
2033	456	-266	200	9.1	400	21,532	0.6%	64	3	-1					6	4	11				
2034	438	-297	182	12.5	335	21,867	0.8%	65	-3	1					-6	4	13	Tekeze 2	Lower Didessa		
2035	377	-274	180	13.9	298	22,165	0.8%	72	3	-1					6	4	13				
2036	343	-277	175	14.1	255	22,419	0.8%	79	-3	1					6	4	13				
2037	356	-321	168	13.7	218	22,637	0.8%	87	3	1					6	4	13				
Totals	19,283	-5,145	5,242	3,257	22,637																
	62.5%		23.2%	14.4%	100.0%																

Case **IL84Fgen**

Results for Reference Case-with no diesel considered

Generation Planning

Year	Costs in US$ million discounted to 2012 (all costs in money of 2012)							Cumulative Additional Plant (from Candidates)																			
	Construction Cost	Salvage Cost	Operating Cost	Energy Not Served Cost	Total Discounted Cost	Cumulative Discounted Cost	Annual LOLP %	Geothermal 100 MW	Wind 300 MW	Solar PV 300 MW	GT (diesel) 140 MW	GT (gas) 140 MW	CCGT (gas) 420 MW	Hydro Group 1	Hydro Group 2	Hydro Planting											
2012			36		36	36																					
2013			36	1,886.4	1,922	1,959	75.2%																				
2014			130	940.7	1,070	3,029	44.8%																				
2015			140	226.5	366	3,395	14.0%																				
2016	891		146	8.6	1,046	4,441	1.0%		1+	1+																	
2017	824	-2	211	0.3	1,034	5,474	0.0%		2+	2+				1		Sor 2											
2018	940	-34	297	274.8	1,478	6,952	23.8%	2+	3+	2+				1													
2019	248	-19	298	2,102.9	2,629	9,581	61.5%	3+	3+	2+				1													
2020	6,281	-1,126	205		5,360	14,941		3	3	2				1	11	Geba 1 and 2	Genale 6	Gibe 4	Upper Dabus	Birbir R	Werabesa and Halele	Genale 5	Yeda 1 and Yeda	Gibe V	Baro 1 and Baro2	Genji	
2021	1,475	-291	210	18.0	1,412	16,354	2.3%	3	3	2				2	11	Karadobi											
2022	656	-142	186		700	17,054		3	3	2				3	11	Beko Abo											
2023	1,998	-412	204	14.4	1,804	18,858	1.9%	8	3	2				4	11	Upper Mendaya											
2024	769	-145	207	44.9	876	19,733	3.4%	13+	3	2				4	11												
2025	390	-83	298	0.1	606	20,340	0.0%	13	3	2		2	2	4	11												
2026	528	-131	296		693	21,033		17+	3	2		3	2	4	11												
2027	392	-111	374	1.5	657	21,690	0.3%	19+	3	2		4	3	4	11												
2028	357	-114	429	0.4	672	22,362	0.0%	21+	3	2		5	4	4	11												
2029	324	-118	483	2.1	692	23,054	0.2%	23+	3	2		6	5	4	11												
2030	389	-160	535	0.7	764	23,817	0.1%	25+	3	2		6	7	4	11												
2031	334	-155	531	0.1	711	24,528	0.0%	28+	3	2		6	8	4	11												
2032	315	-164	552	0.4	705	25,233	0.1%	31+	3	2		7	9	4	11												
2033	276	-161	552	1.2	669	25,901	0.1%	34+	3	2		7	10	4	11												
2034	311	-202	534	0.0	642	26,543	0.0%	38+	3	2		7	11	4	11												
2035	462	-329	501		634	27,177		42+	5	2		7	11	4	12	Tekeze 2											
2036	435	-356	463	0.1	542	27,719	0.0%	46+	5	2		8	11	4	13	Lower Didessa											
2037	233	-210	449	0.1	472	28,191	0.0%	50+	5	2		8	12	4	13												
Totals	18,830	-4,465	8,302	5,524	28,191																						
	51.0%		29.4%	19.6%	100.0%																						

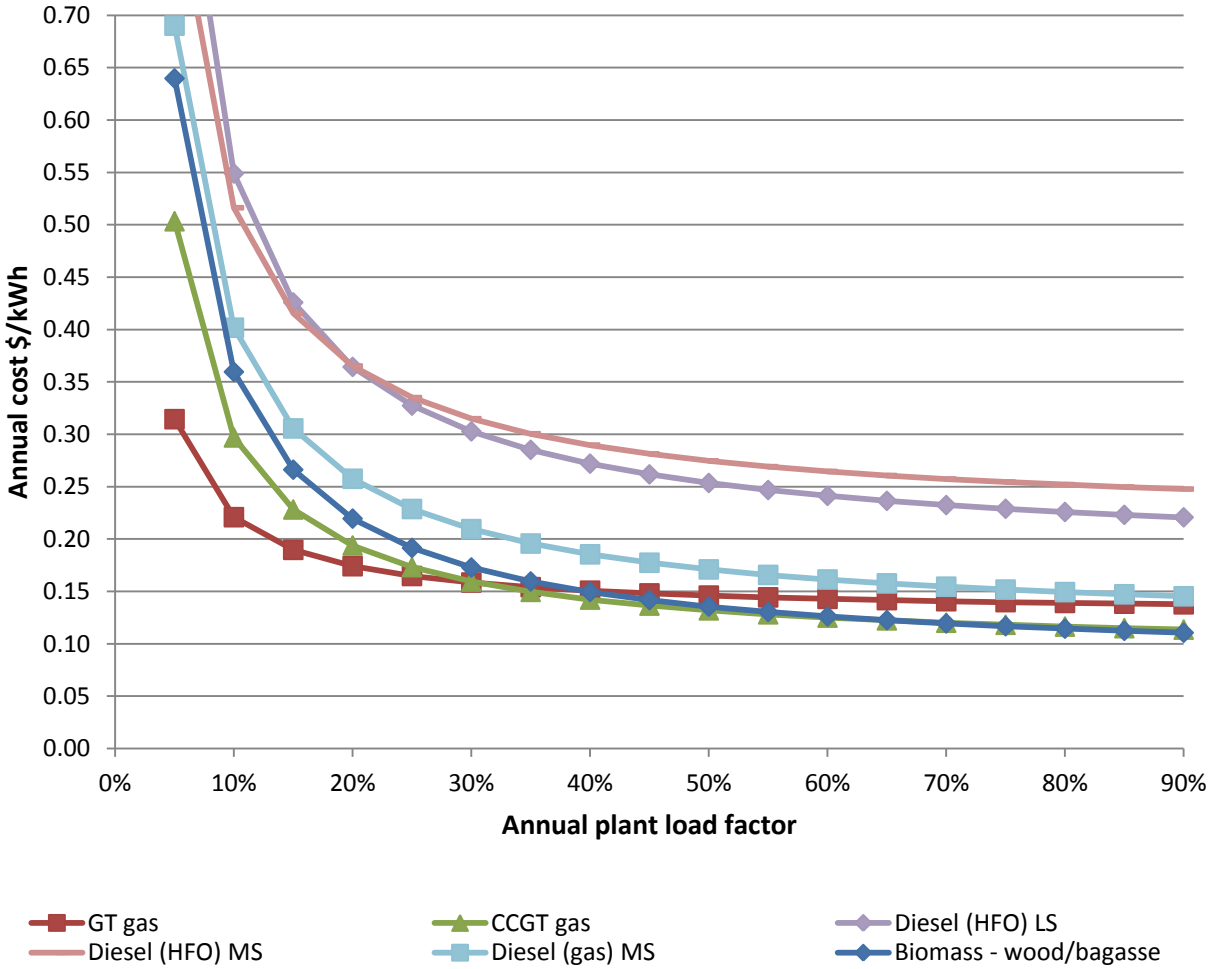
Case **IL_80OAq**

Generation Planning

Alternatives considered for replacing the imported fuel based diesel plants:

		Diesel (HFO) LS	Diesel (HFO) MS	Diesel (gas) LS	Diesel (gas) MS	GT gas	CCGT gas	Biomass - wood/bagasse	Yayu FBC Coal
Capital Cost	US$/kW	2060	1600	2060	1600	500	1250	1356	2440
Construction period	years	2	2	2	2	2	3	3	4
Discount Rate (real)	% p.a.	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
IDC (1)	%	10.00%	10.00%	10.00%	10.00%	10.00%	15.00%	15.00%	20.00%
IDC	US$/kW	206	160	206	160	50	187.5	203.4	488
IDC % Cap + IDC	%	9.09%	9.09%	9.09%	9.09%	9.09%	13.04%	13.04%	16.67%
Capital + IDC	US$/kW	2266	1760	2266	1760	550	1438	1559	2928
% Foreign		90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	81.0%
Foreign	US$/kW	2039.4	1584.0	2039.4	1584.0	495.0	1293.8	1403.5	2372
Local	US$/kW	226.6	176.0	226.6	176.0	55.0	143.8	155.9	556.3
Standard Conversion factor		0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Local with SCF	US$/kW	203.9	158.4	203.9	158.4	49.5	129.4	140.3	500.7
Capital +IDC with SCF	US$/kW	2243.3	1742.4	2243.3	1742.4	544.5	1423.1	1543.8	2872.4
Life	Years	20	20	20	20	20	25	25	25
Annual capital cost	US$/kW/year	263.5	204.7	263.5	204.7	64.0	156.8	170.1	316.4
Fixed O and M cost	US$/kW/month	5.00	5.00	4.00	4.00	1.50	2.00	6.278	4.4
Fixed O and M cost	US$/kW/year	60.0	60.0	48.0	48.0	18.0	24.0	75.3	53.2
Total Annual LRMC cost	US$/kW/year	323.5	264.7	311.5	252.7	82.0	180.8	245.4	369.6
Fuel		HFO	LFO	gas	gas	gas	gas	Wood/bagasse	Lignite
Fuel cost	US$/GJ	22.0	22.0	11.5	11.5	11.5	11.5	4.52	1.240
Fuel cost	US$/kWhth	0.079	0.079	0.041	0.041	0.041	0.041	0.0163	0.0045
"Efficiency"		46.4%	38.6%	46.4%	38.6%	33.0%	47.0%	22.5%	33.5%
Fuel cost per kWh	US$/kWh	0.171	0.205	0.089	0.107	0.125	0.088	0.072	0.0133
Variable O and M	US$/kWh	0.0090	0.0090	0.0060	0.0060	0.0018	0.0025	0.0070	0.0119
Fuel + Var Oand M	**US$/kWh**	**0.180**	**0.214**	**0.095**	**0.113**	**0.127**	**0.091**	**0.079**	**0.0252**

Generation Planning



- Comparison:
  - Above the 40% P.F CCGT and the Woody Biomass plants are comparable
  - Below 25% P.F the Gas Turbine plant is preferable.
  - Since during the early years the plant can be utilized at higher plant factors the woody Biomass and CCGT plants are preferable
  - Because of lack of definitive resource assessment on the woody biomass the Natural gas based CCGT is preferred

Generation Planning

- Preliminary discussions made with the Ministry of Mines personnel indicate that the Calub and Hilala sites are under the concession agreement with a company named Poly GCL
- The company intends to export the gas after transporting it to the Djibouti port with a gas pipe and liquefying it.
- The amount of gas required for the 420 MW is much less than the potential in the region and the company could agree to sell the gas to EEP with a price less than the international price.
- It is good that the generating station be located at Calub with minor additional transmission line works.
- EEP needs to get a Government agreement to use the gas for power generation.
- If EEP gets the government agreement, discussions with ministry of Mines and with the company (Poly GCL) needs to be started.

Generation Planning

- Review of the new Tams prefeasibility study:
  - Installed Capacity = 1700 MW
  - Average Energy = 5760 GWh/year
  - Cost = 3,241.6 MUSD
- The Unit generation Cost is 7.3 USD cents/kWh with the following assumptions:
  - Discount rate = 10%
  - Construction Period= 6 year
  - Life time = 70 years

Results for Reference Case- Option to avail additional export energy

Generation Planning

Plant	Installed Capacity (MW)	Average Energy (GWh/year)	Project Cost (million $)	IDC Cost (million $)	Total Cost (million $)	Cost /kW inst ($/kW)	Annualised Cost (million $)	Average Levelised Cost ($/kWh)	Rank
Beko Abo	935	6632.2	1260.8	441.3	1,702	1,820.5	170.348	0.0257	1
Genji	214	910.2	197.6	69.1	267	1,246.3	26.692	0.0293	2
Upper Mendaya	1700	8582.3	2436.4	852.7	3,289	1,934.8	329.173	0.0384	3
Karadobi	1600	7857.2	2576.0	901.6	3,478	2,173.5	348.027	0.0443	4
Geba 1 + Geba 2	372	1709.4	572.0	200.2	772	2,078.4	77.275	0.0452	5
Genale 6	246	1532.4	587.9	205.8	794	3,226.3	79.428	0.0518	6
Sor 2	5	38.5	18.6	3.7	22	4,461.6	2.233	0.0580	7
Upper Dabus	326	1460.3	628.2	219.9	848	2,601.6	84.880	0.0581	8
Gibe IV + V	2132	8051.3	3625.2	1087.6	4,713	2,210.5	471.651	0.0586	9
Birbir R	467	2724.1	1231.1	369.3	1,600	3,427.1	160.170	0.0588	10
Werabesa + Halele	436	1972.8	886.0	310.1	1,196	2,743.4	119.708	0.0607	11
Yeda 1 + Yeda 2	280	1089.4	540.2	189.1	729	2,604.5	72.982	0.0670	12
Genale 5	100	574.6	297.7	89.3	387	3,870.6	38.737	0.0674	13
Tams	1700	5760.0	3241.5	972.3	4,214	2,478.7	421.715	0.0732	15
Baro 1 + Baro 2	645	2614.3	1595.9	558.6	2,154	3,340.2	215.614	0.0825	16
Lower Didessa	550	975.6	619.2	185.8	805	1,463.5	80.557	0.0826	17
Tekeze II	450	2720.7	1690.4	591.6	2,282	5,071.2	228.382	0.0839	18
Gojeb	150	561.7	526.8	184.4	711	4,741.4	71.177	0.1267	19
Aleltu East	189	804.1	760.6	266.2	1,027	5,433.2	102.768	0.1278	20
Abu Samuel	6	15.7	18.5	2.8	21	3,536.8	2.124	0.1351	21
Aleltu West	265	1067.3	1180.5	413.2	1,594	6,022.7	159.487	0.1494	22
Wabi Shebele	88	691.0	887.8	221.9	1,110	12,637.6	111.058	0.1607	23
Lower Dabus	250	637.0	866.3	259.9	1,126	4,504.7	112.707	0.1769	24

Generation Planning

- According to the ranking TAMS stand as the 15th plant and is to be considered after the Baro 1, 2 and Genji project which has a unit cost of 6.9 US cents per kWh.

- The prefeasibility study document indicates that the project is a multi-purpose project having additional benefits such as:
  - downstream Irrigation projects
  - Flood control
  - Drinking water supply
  - And others

- But in the prefeasibility study no portion of the dam cost is ascribed for the irrigation and the other side benefits.

Generation Planning

- Finchaa Amerti Neshe project study documents were also Investigated in order to identify possible cost allocation of the dam structure among the multiporpose applications.
  - Presented Project irrigation costs were rather downstream costs such as: irrigation diversion weirs, intakes, pumping stations, canals, irrigation tertiary network and systems.
  - No irrigation cost is associated with the dam

- Even though the studies indicate the benefits of the upstream dams to the downstream irrigation activities, it was not possible to identify costs that can be deducted from the project cost in order to bring the project forward in the project ranking.

Generation Planning

- The consultant in prioritizing projects used a cost minimization objectives. Based on this criteria the following hydro plants were prioritized.

Year	Hydro Planting			
2017	Sor 2			
2018				
2019				
2020	Geba 1 and 2	Genale 6	Gibe 4	Upper Dabus
2021	Karadobi			
2022	Beko Abo			
2023	Upper Mendaya	Birbir R		
2024	Warebesa and Halele	Yeda 1 and 2	Baro 1 and Baro2	Genji
2025	Genale 5	Gibe V		
2034	Tekeze 2	Lower Didessa		

Results for Reference Case- additional prioritizing criterions

Generation Planning

- Other prioritization criterions include:
  - Multipurpose use
  - Basin Distribution
  - Project readiness
- On the basis of availing additional power for export ,Multipurpose use and basin distribution TAMS and Wabishebeli projects are advanced forward to be implemented by year 2021
- On the basis of project readiness and also availing additional power Chemoga Yeda is advanced forward to year 2020.
- This will allow to increase export generation capability by around 1000 MW and 6500 GWh possibly to Yemen corridor and South Sudan starting from year 2021.
- The advancement of the plants will result into increased costs to the system and this shall be compensated with the revenue to be generated from the export. This will be further investigated with WASP analysis .

Generation Planning

- Reference Forecast - COUE 0.50$/kWh
  Un-served energy doubles – slight decrease in non-hydro plant
- Reference Forecast - Discount Rate 8%
  A few hydro plants brought forward
- Reference Forecast - Discount Rate 12%
  Tekeze 2 delayed, Lower Didessa not built
- High Forecast – Gas in 2025
  Hydros brought forward, large number of diesels, 6% increase in NPV

Generation Planning

- Ethiopian system will move from a hydro system to a mixed hydro- renewable – thermal system
- Renewables will comprise geothermal plus some wind & solar
- Mixed system with dispatchable plant (thermal and geothermal) will need sophisticated modelling to optimise operation
- If load growth is lower than reference case or exports reduced,
- diesels may not be required in short-term
- Monitor rate of load growth to decide on planting in short-term
- Some hydros can be late without big penalty in cost – insurance
- Gas needed from 2025
- Geothermal potential shall be investigated immediately and if it is proofed to be greater than 8500 MW Gas utilization can be safely avoided
- More expensive hydros (after Tekeze 2) not selected
- Ability to reduce exports in dry years could delay new plant
- .

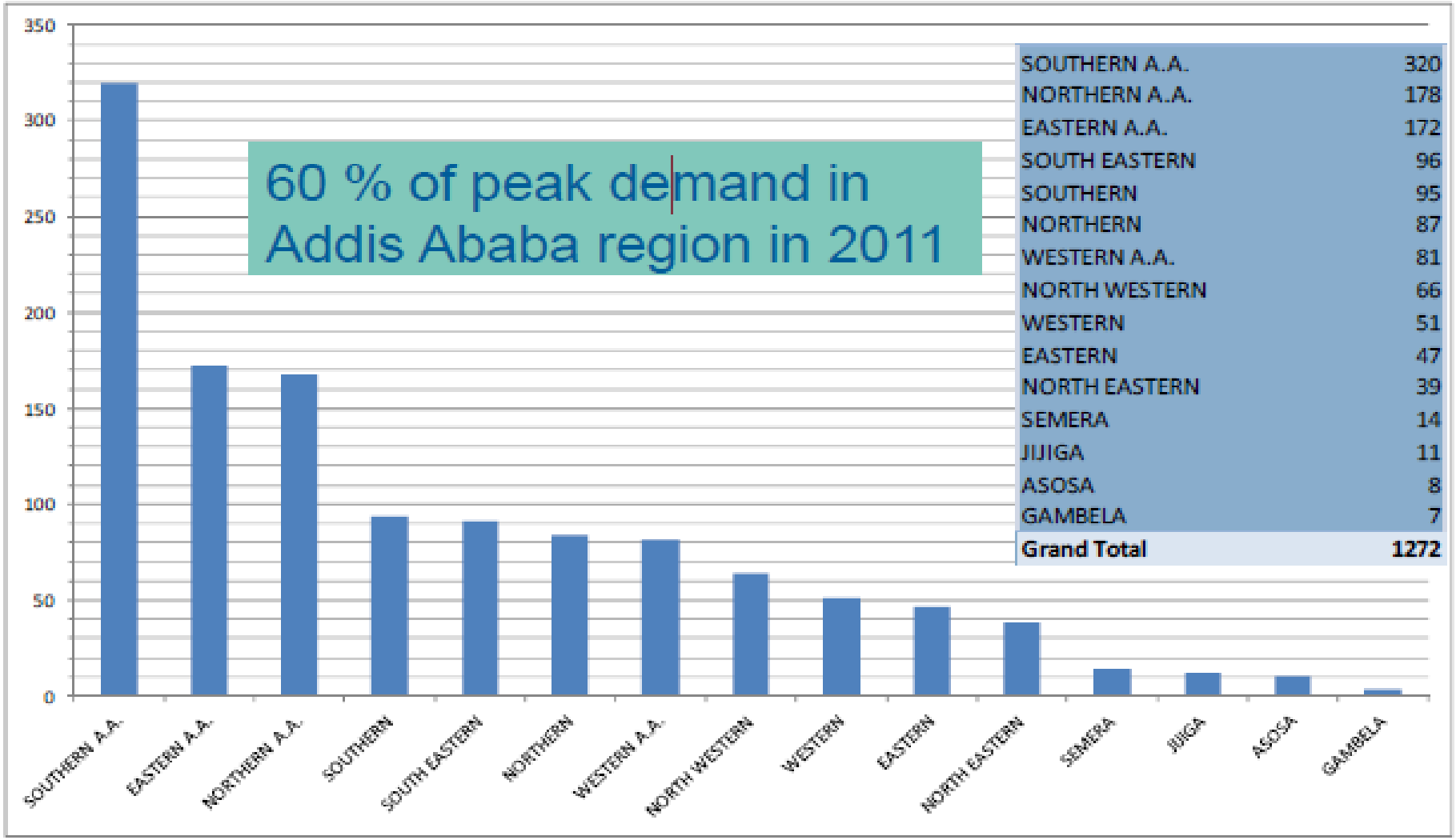
Transmission Planning

Transmission Planning

The transmission expansion plan must identify the required transmission infrastructure at a number of key stages for:

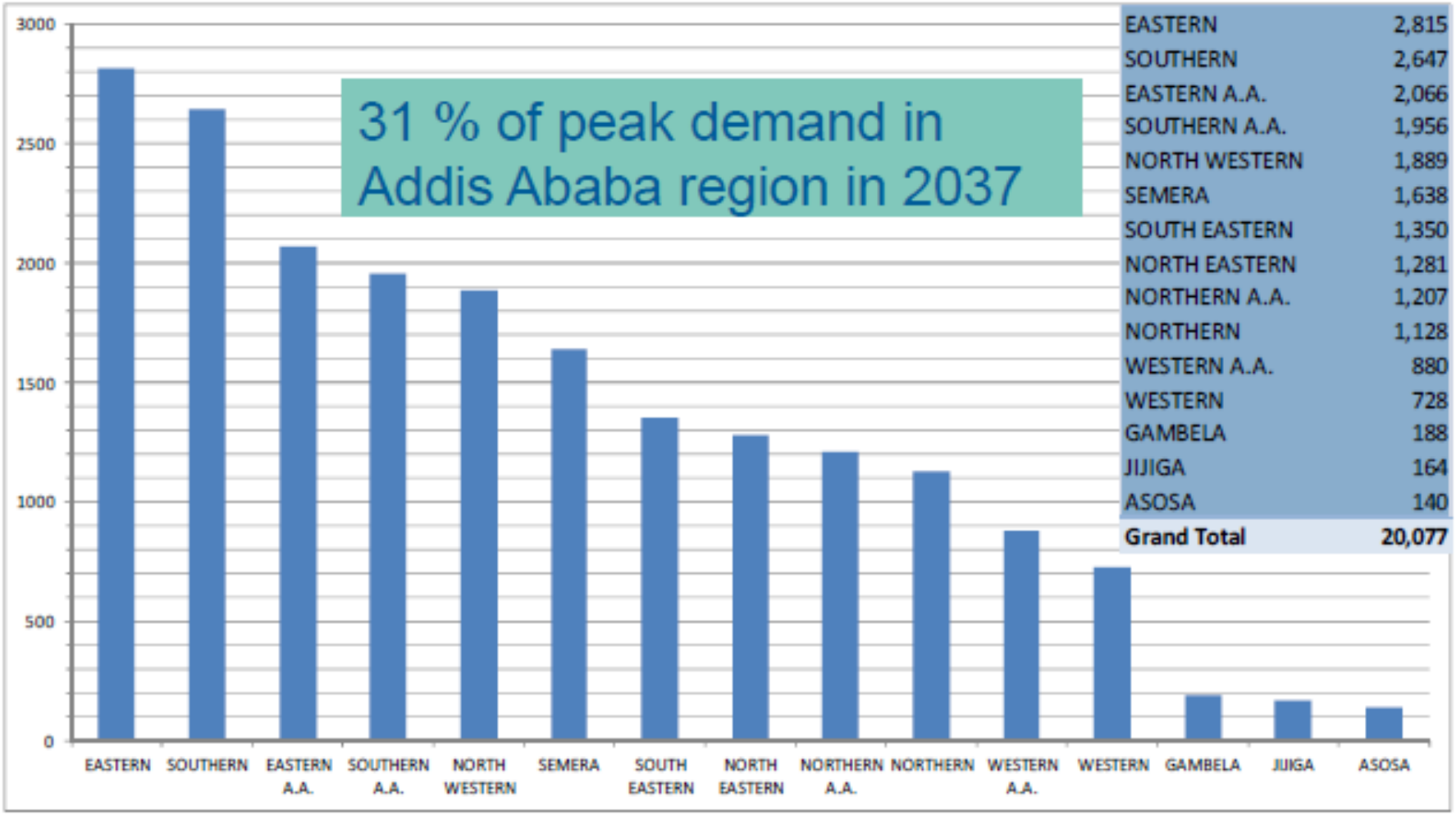
- Interconnection of all generating plant identified in the generation expansion plan.
- Reinforcement and expansion of the grid to meet the forecast demand at all existing and planned transmission substations.
- Compliance with the transmission planning criteria at all stages of development

Transmission Planning



SOUTHERN A.A.	320
NORTHERN A.A.	178
EASTERN A.A.	172
SOUTH EASTERN	96
SOUTHERN	95
NORTHERN	87
WESTERN A.A.	81
NORTH WESTERN	66
WESTERN	51
EASTERN	47
NORTH EASTERN	39
SEMERA	14
JIJIGA	11
ASOSA	8
GAMBELA	7
Grand Total	**1272**

Transmission Planning

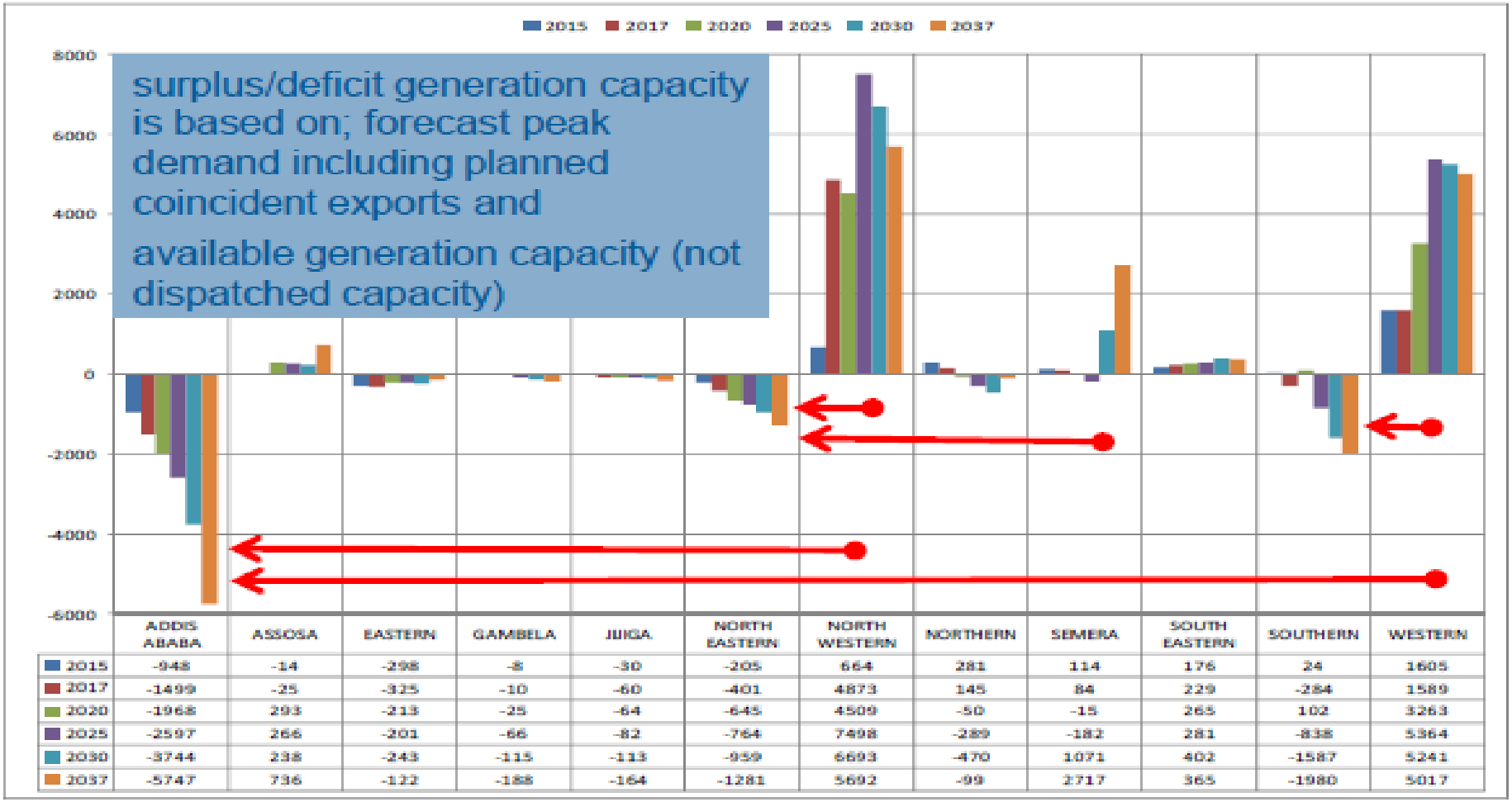


EASTERN	2,815
SOUTHERN	2,647
EASTERN A.A.	2,066
SOUTHERN A.A.	1,956
NORTH WESTERN	1,889
SEMERA	1,638
SOUTH EASTERN	1,350
NORTH EASTERN	1,281
NORTHERN A.A.	1,207
NORTHERN	1,128
WESTERN A.A.	880
WESTERN	728
GAMBELA	188
JIJIGA	164
ASOSA	140
Grand Total	**20,077**

Transmission Planning

- Prior to developing the detailed expansion plan a regional assessment of supply and demand was conducted, based on the location of existing and planned power plants and the disaggregated demand forecast.

Transmission Planning



	ADDIS ABABA	ASSOSA	EASTERN	GAMBELA	JIJIGA	NORTH EASTERN	NORTH WESTERN	NORTHERN	SEMERA	SOUTH EASTERN	SOUTHERN	WESTERN
2015	-948	-14	-298	-8	-30	-205	664	281	114	176	24	1605
2017	-1499	-25	-325	-10	-60	-401	4873	145	84	229	-284	1589
2020	-1968	293	-213	-25	-64	-645	4509	-50	-15	265	102	3263
2025	-2597	266	-201	-66	-82	-764	7498	-289	-182	281	-838	5364
2030	-3744	238	-243	-115	-113	-959	6693	-470	1071	402	-1587	5241
2037	-5747	736	-122	-188	-164	-1281	5692	-99	2717	365	-1980	5017

Transmission Planning

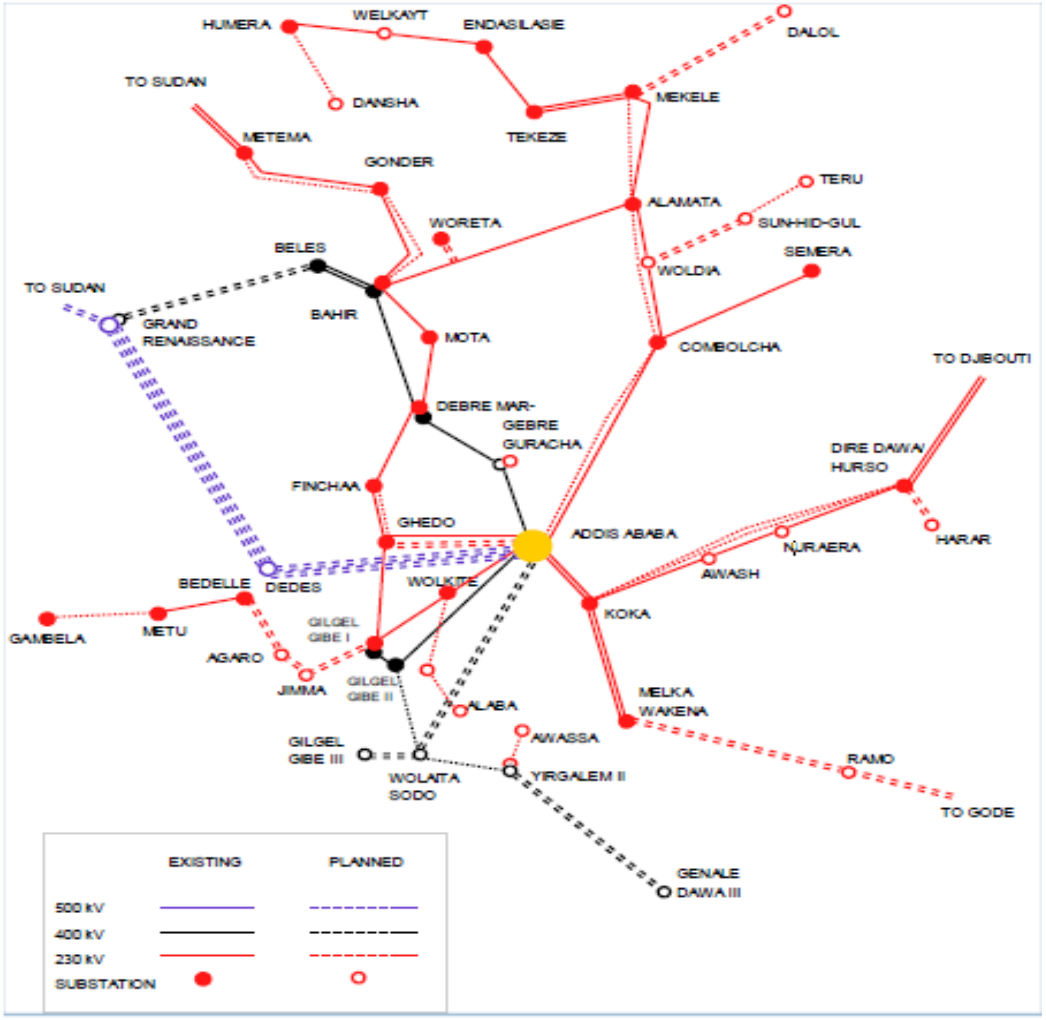
The short-term plan includes:

- 114 new transmission substations,
- 63 substation reinforcements and
- 13,540 km of new 500 kV to 66 kV transmission lines

required at various stages up to 2020.

Year	New Substations	Substation Reinforcemnets	Transmission Lines
2013	11	9	2343
2014	9	3	1167
2015	45	30	4071
2016	27	5	2352
2017	22	16	3627
Total	114	63	13560

Transmission Planning



Peak substation demand 2524 MW (excluding exports) – approximately double the 2012 peak.

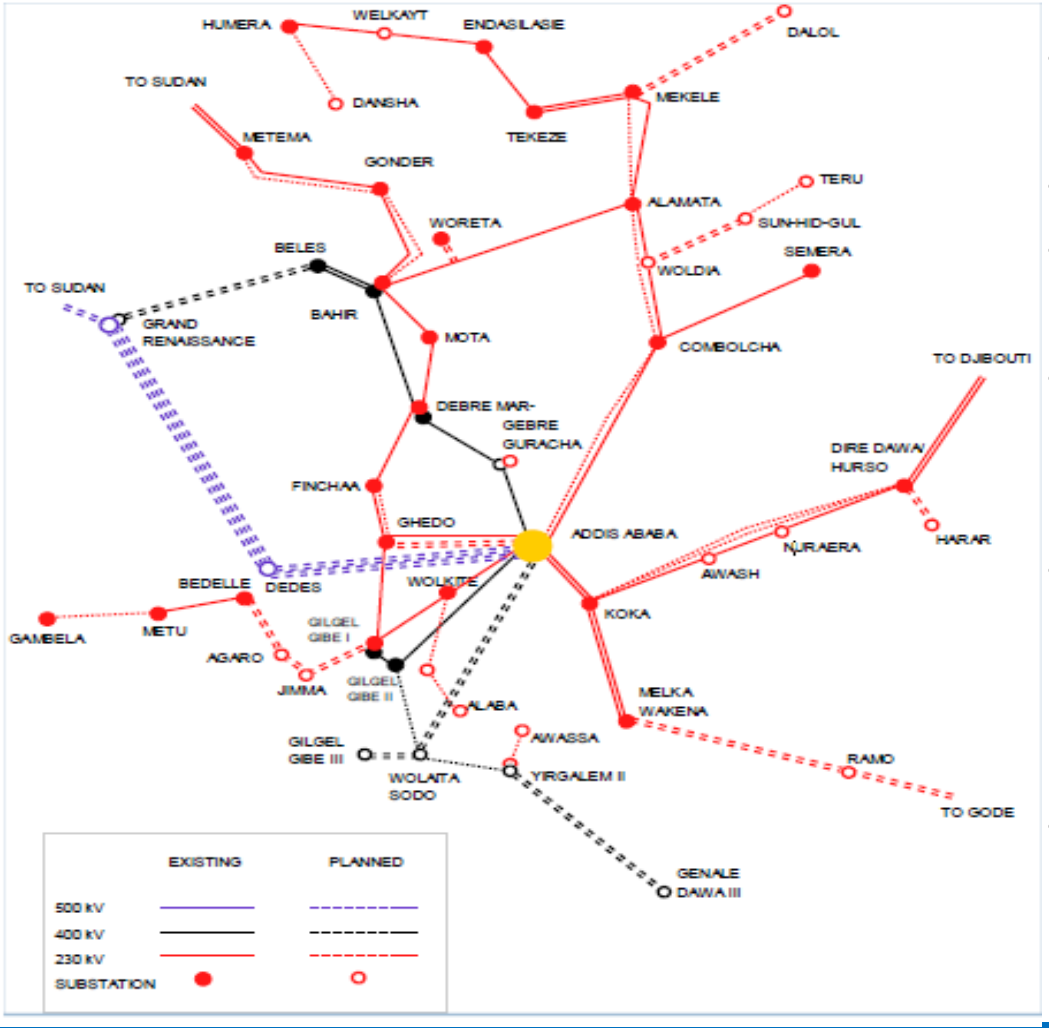
- Many projects either already under construction or at design/feasibility Stage.

Generation

- GR (2015, 400MW)
- GD III (2015, 250MW)
- Gibe III (2015, 1000MW)
- 65 new transmission substations and 42 substation reinforcements

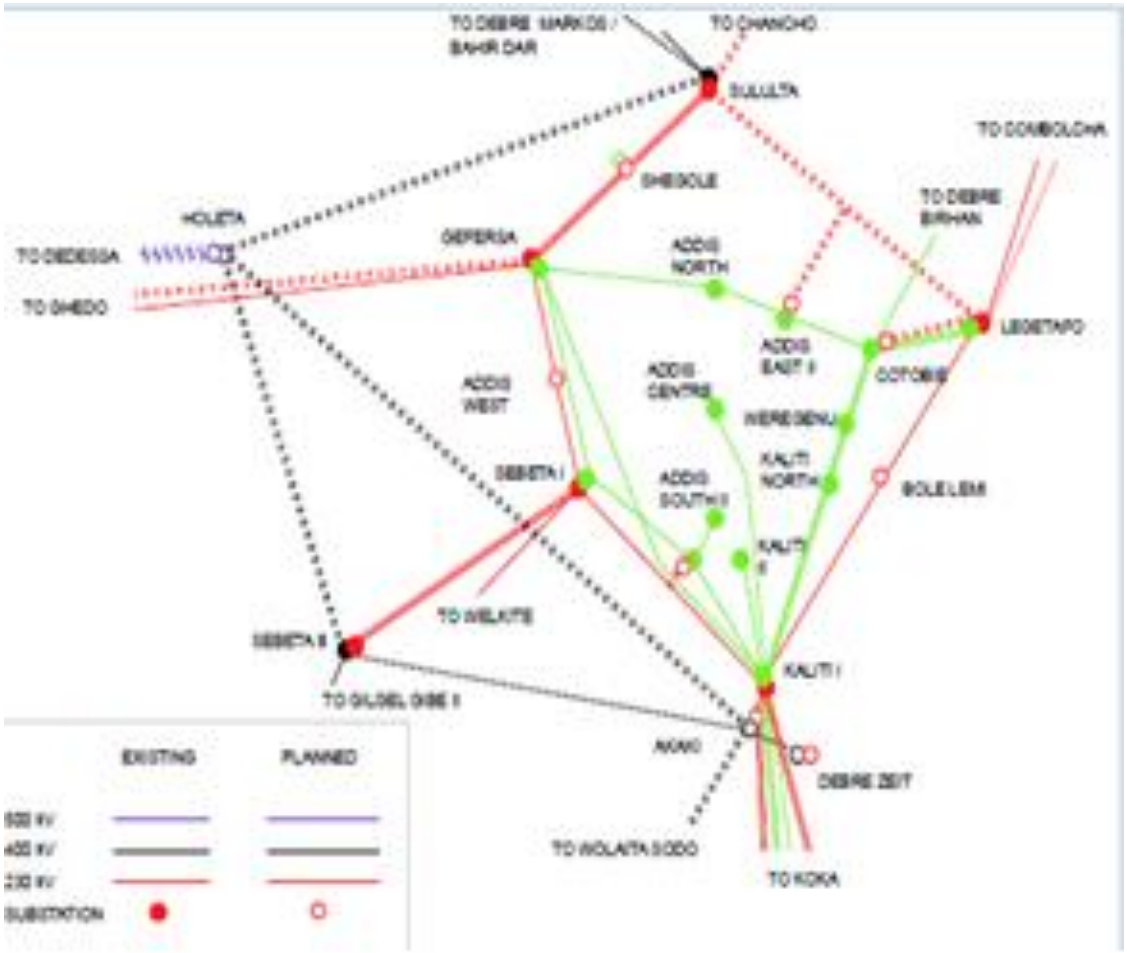
+ 7000 km of new transmission lines.

Transmission Planning



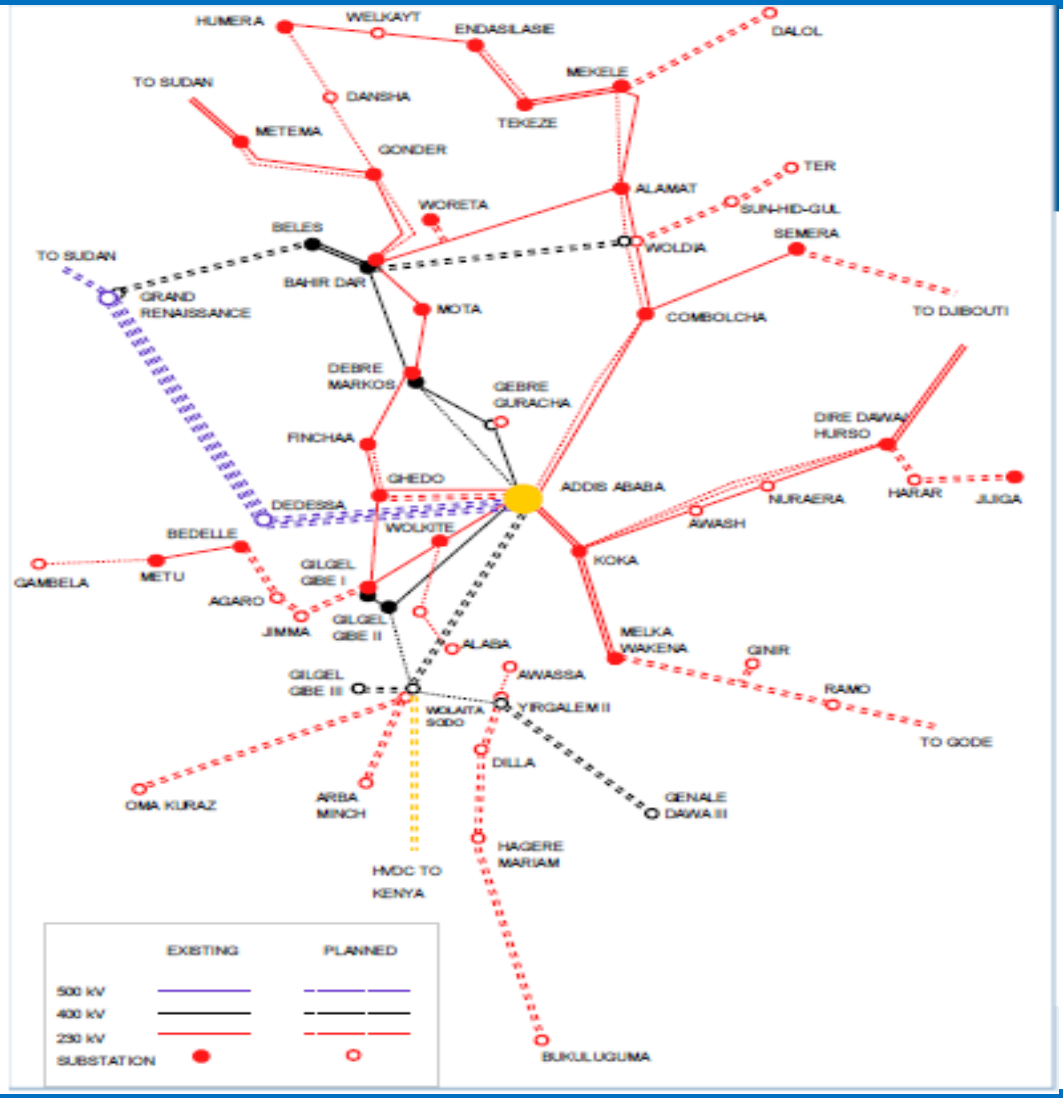
- 500 kV GERD-Dedessa- Holeta.
- 500 kV GERD-Rabak (Sudan interconnector)
- 400 kV GERD-Beles
- 400 kV developments around Addis (next slide)
- 400 kV developments associated with Gilgel Gibe III and Genale Dawa
- Numerous 230 kV projects including reinforcement of the Djibouti and Sudan export routes.
- Numerous 132 kV projects.

Transmission Planning



- New 400 kV substations at Holeta, Akaki and Debre Zeit.
- Completion of 230 kV ring around Addis.
- New bulk supply points at Addis West, Bole Lemi and Shegole.

Transmission Planning



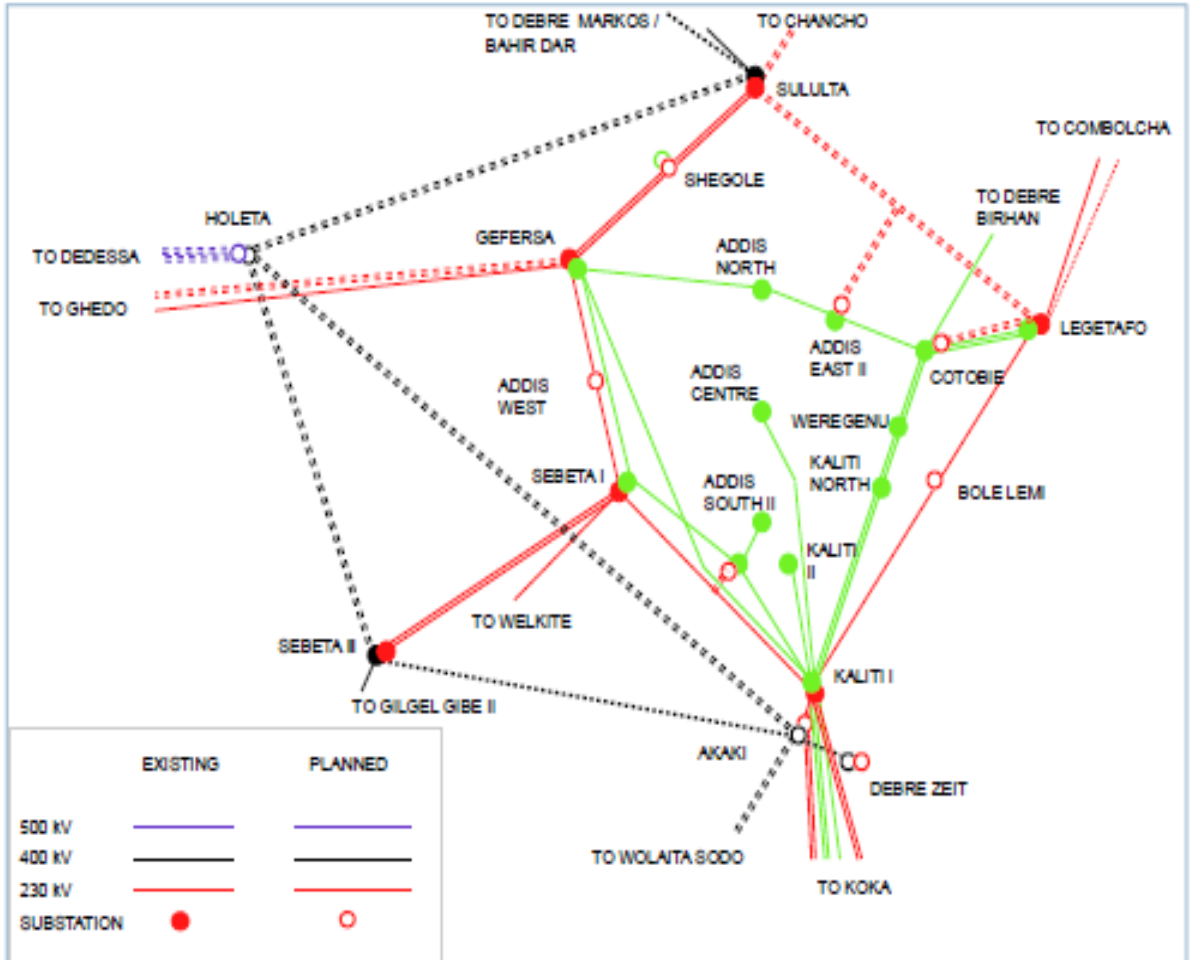
- Peak substation demand 3935 MW (excluding exports) - 56% increase on 2015 peak.

Generation includes

- GR (2017, 6000MW)
- Aysha (2016, 300MW)
- Assela (2017, 300MW)

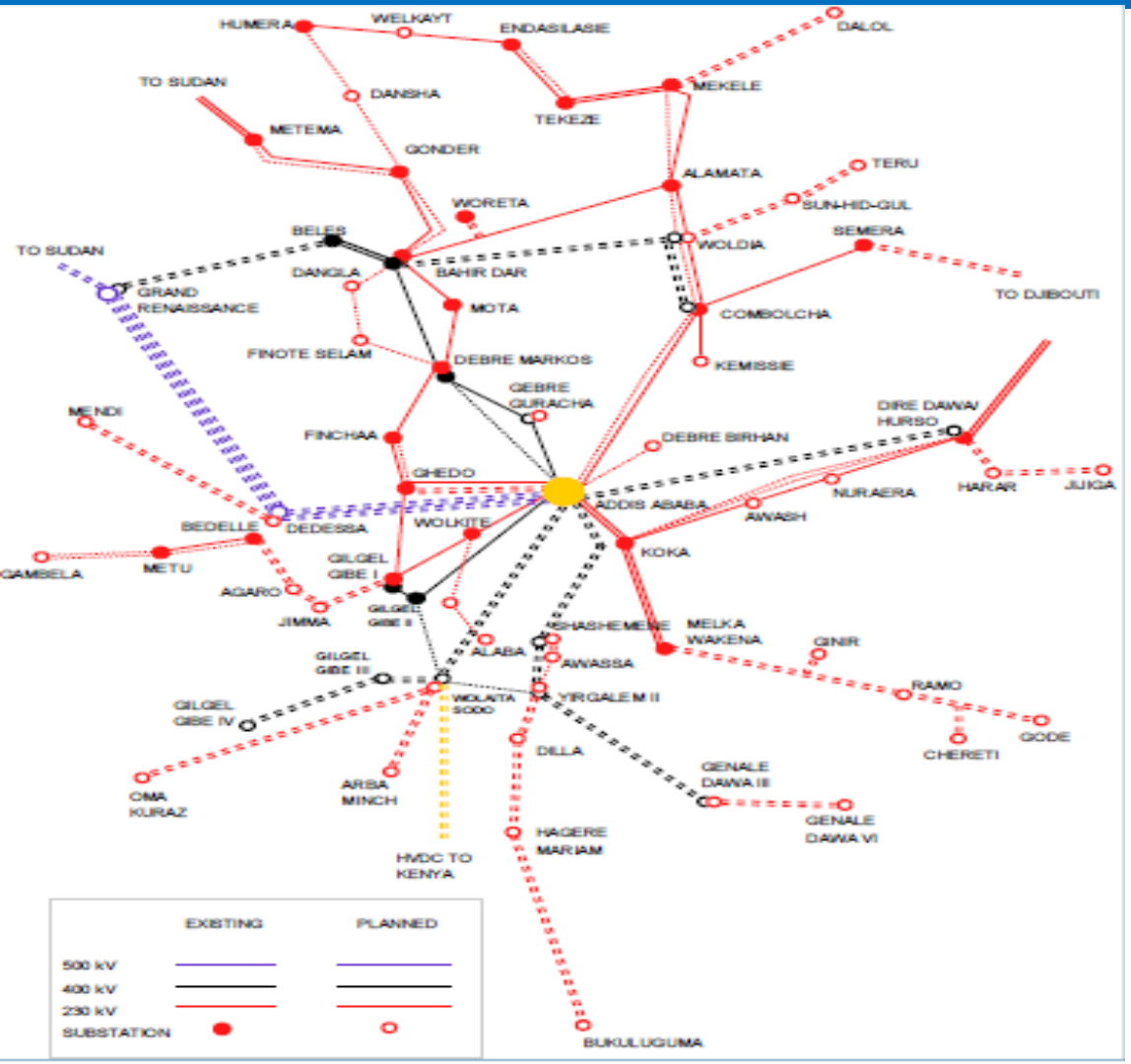
- Required projects (in addition to the 2015 projects) include 27 new transmission substations, 5 substation reinforcements and 2300 km of new transmission lines.
- HVDC link to Kenya
- Additional 400 kV circuit from Debre Markos-Suluta.
- 400 kV Bahir Dar-Woldia
- Numerous 230 kV and 132 kV

Transmission Planning



New 230 kV substations – Cotobie I, Addis East II, H. Tannery

Transmission Planning

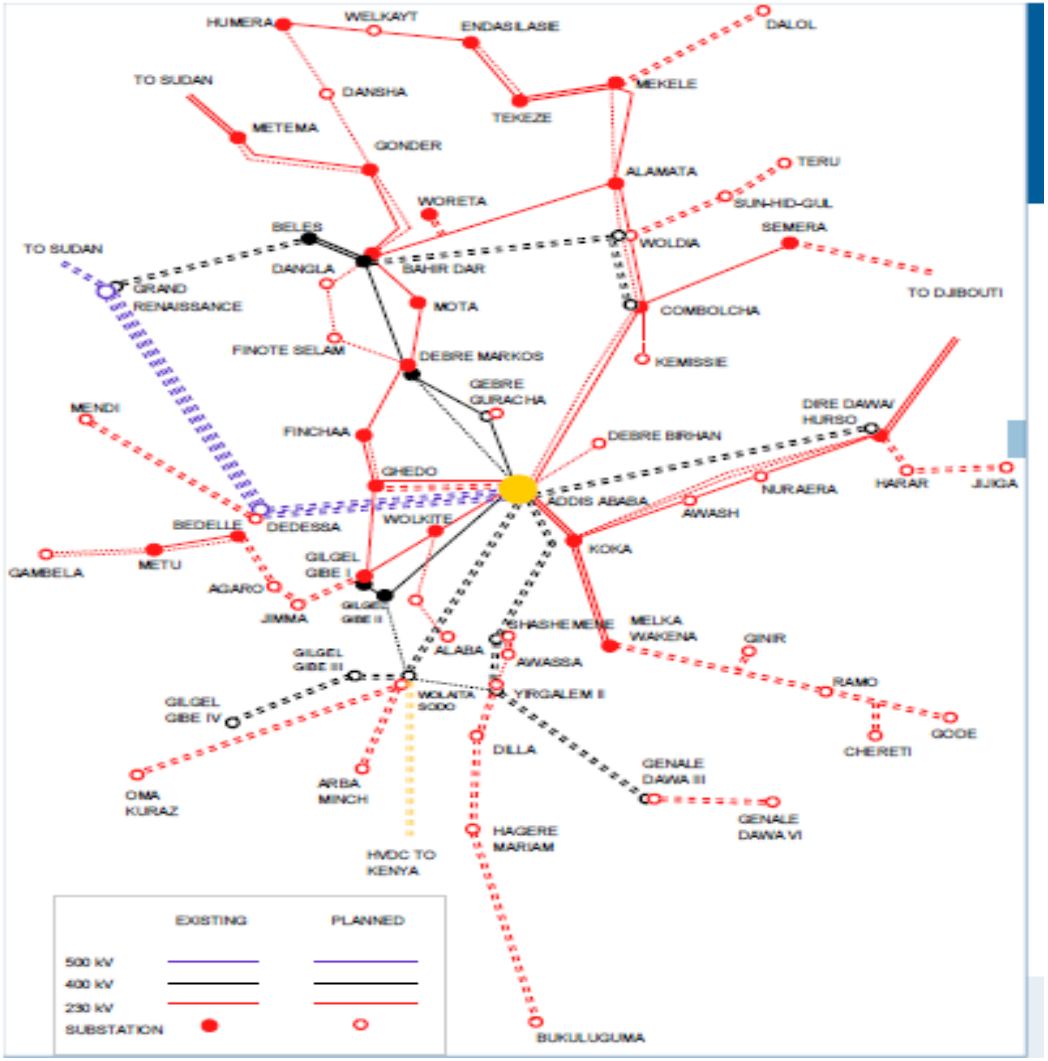


Peak substation demand 5918 MW (excluding exports) - 50% increase on 2017 peak.

Generation:

- Upper Dabus (2020, 326MW)
- Aluto Lan II (2018, 75MW)
- Corbetti (2018, 200 to 500MW)
- Dire Dawa die (2018, 70 – 420MW)
- Genale 6 (2020, 237MW)
- Geba 1 & 2 (2020, 344MW)
- Gibe IV (2020, 1410MW

Transmission Planning



Required projects (in addition to the 2017 projects) - 22 new transmission substations, 16 substation reinforcements and 3600 km of new transmission lines.

- 400 kV developments including generation connections;

Debre Zeit- Hurso in Eastern region.

Hurso – Shi Kulun

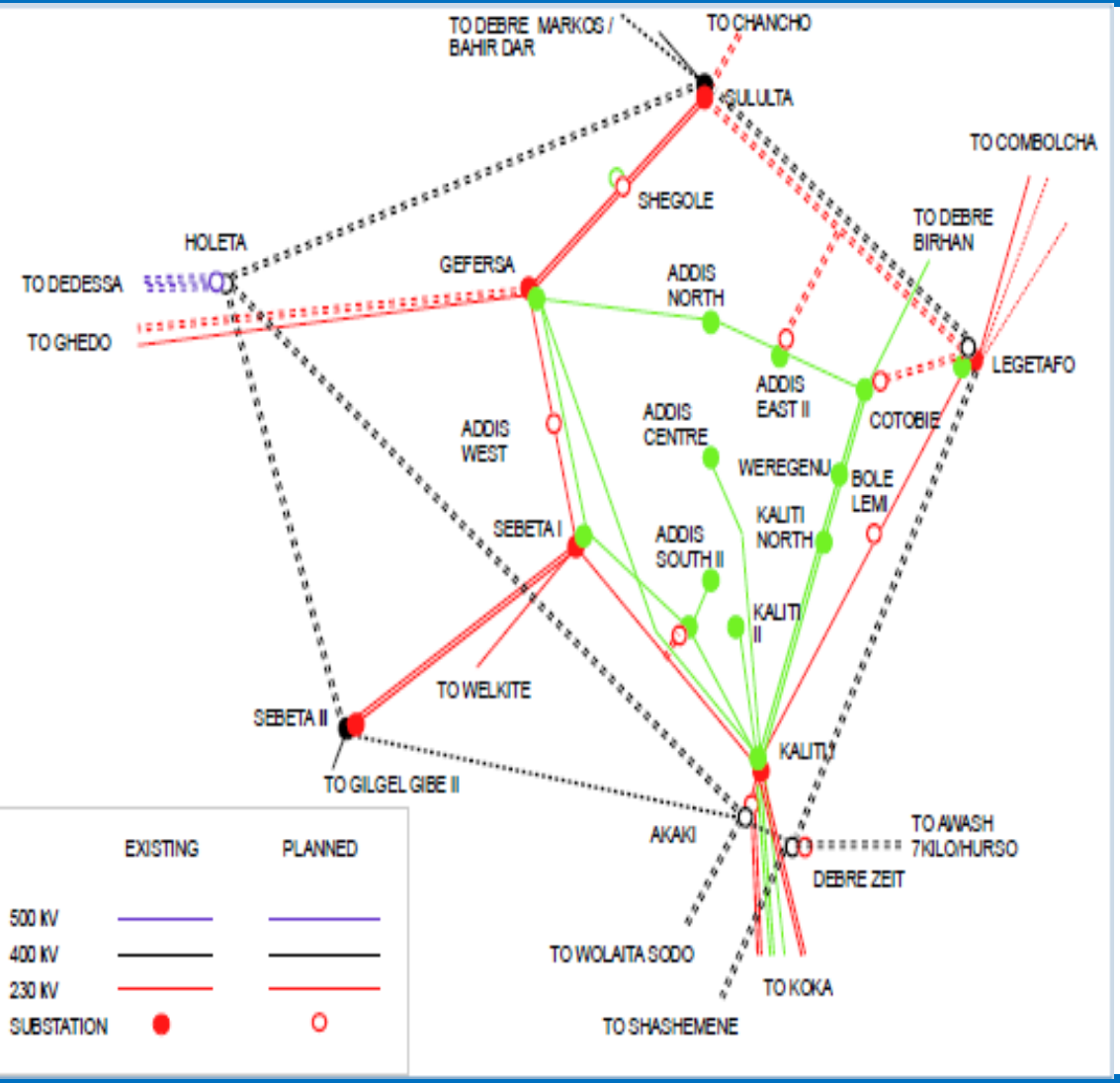
Woldia-Combolcha.

Debre Zeit-Shashemene-Yirgalem

Gilgel Gibe III-Gilgel Gibe IV.

Numerous 230 kV and 132 kV projects

Transmission Planning



Completion of a 400 kV ring around Addis Ababa by constructing a 400/230 kV substation at Cotobie II (Legetafo) and interconnecting it with Sululta and Debre Zeit

Transmission Planning

There is less detail in the long-term plan due to uncertainty in the developments. The plan includes (indicative based on modelling);

- Approximately 130 new and upgraded substations
- Approximately 9,000 km of new 400 kV to 132 kV transmission lines required at various stages up to 2037

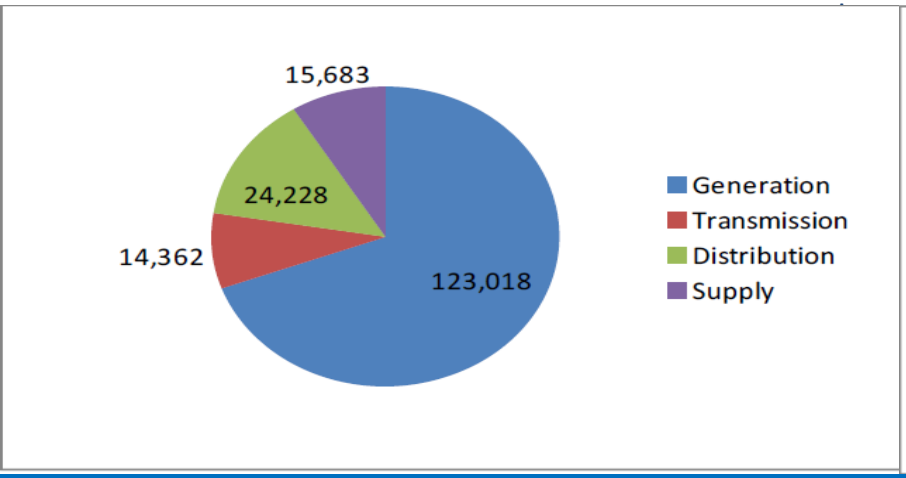
Year	Substation Reinforcemnets	Transmission Lines
2025	33	2769
2030	38	3098
2037	59	3186
Total	130	9054

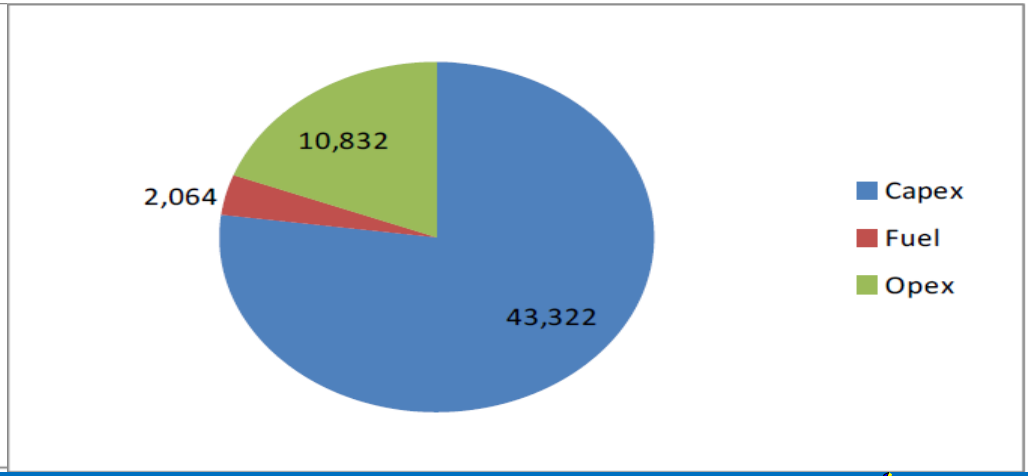
FINANCE

FINANCIAL ANALYSIS AND TARIFFS

•The resultant total cost of the expansion plan over the 25 year period is estimated at US$177bn, equivalent to US$56bn in 2012 values)

Cost allocation: MUS$






THANK YOU