

The issue of regionalizing the electricity sector in Africa

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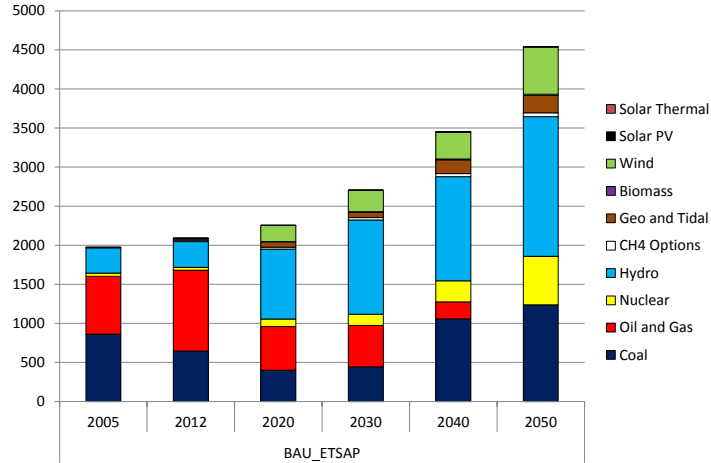


African energy context

- More than 60% of the African population have not access to commercial energy and use firewood
- So, the expected growth of the population and development in Africa will lead to **increased energy needs**
- **The natural resources are important**
 - Fossil fuels or renewables potential
 - Renewables, largely untapped, should be promote



African electricity mix: broadly similar to other continent



Electricity production in Africa (PJ)

But significantly different from one region to another

➤ Different economic and energy realities within Africa

- North Africa and South Africa: 75% of the energy consumed
- Sub-Saharan Africa: ¼ of the population

Heuraux 2010	Population (millions, 2009)	GDP per capita (US \$)	Conso. Elec. per capita (kWh)	Conso. Elec. (GWh)
AFRICA	1 030	1 380	474	446 150
North	169	2 665	1 039	138 325
Sub-Saharan	810	525	136	105 825
South	50	5 720	4 008	202 000

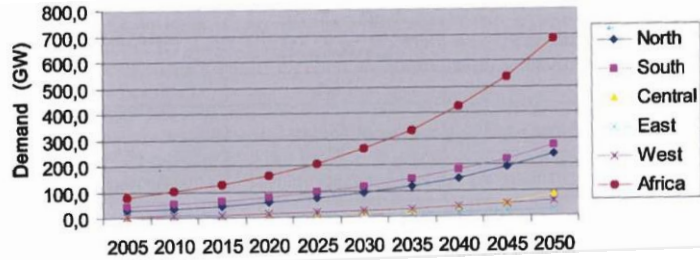
➤ Energy resources and potential: unequally distributed

- North Africa: abundant oil and gas and CSP potential
- Sub-saharan Africa: hydro potential
- South Africa: coal

Heuraux 2010	Installed capacities (GW)		Potential and reserves			
	TOTAL	Hydro	Hydro (GW)	Gas (Gm3)	Coal (Mt)	Oil (Mbl)
AFRICA	114	24	201,3	14 893	55 519	125 000
North	43	5	7,2	8 079	73	60 900
Sub-Saharan	30	17	192,6	6 795	1 446	64 100
South	41	2	1,5	19	54 000	-



Important expected increase of the electricity consumption : North and South Africa



Source: WEC, 2007 according 2004 data

- Different impacts on the electricity mix according to sub-regions

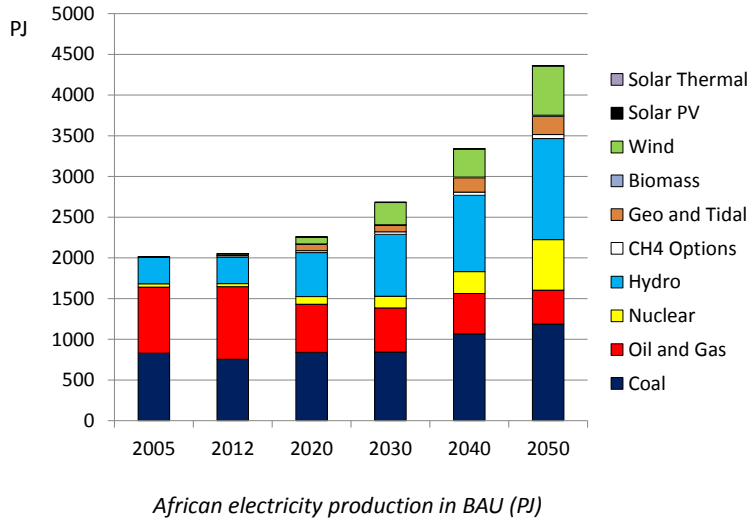


Modification in ETSAP-TIAM

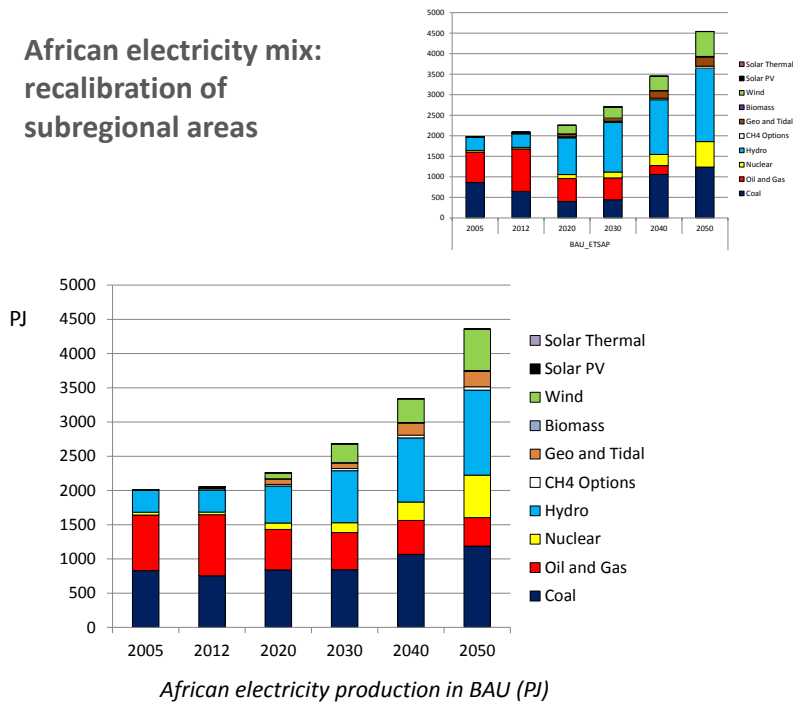
- Implementation of 3 power sub-sectors in Africa
 - North Africa **AFR1**
 - Sub-Saharan Africa **AFR2**
 - South Africa **AFR3**
- Calibration of the electricity sector
 - Base year source: IEA Statistics, 2011 Edition, Energy statistics of non-OECD countries
 - Scenarios of sub-regional distribution of African electricity on the time period: electricity production per capita
 - Potential by sub-region
- *Subsequent modifications in related files*

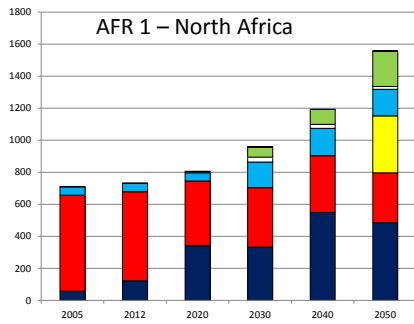


African electricity mix: recalibration of subregional areas



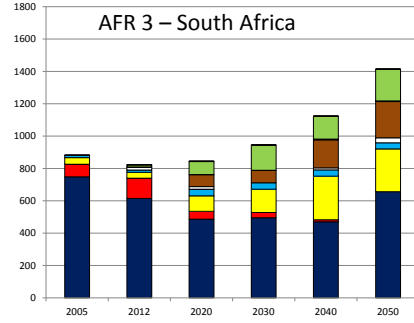
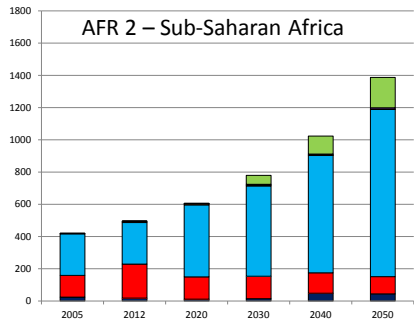
African electricity mix: recalibration of subregional areas



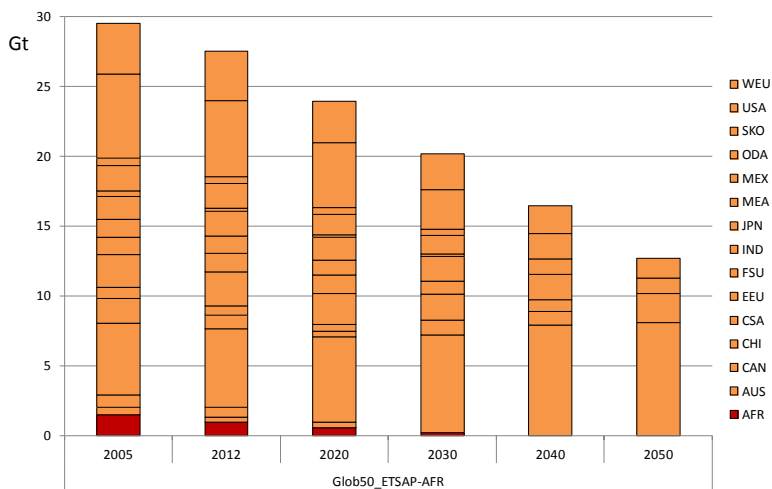


African electricity mix by sub-regions in BAU (PJ)

- Coal
- Oil and Gas
- Nuclear
- CH4 Options
- Biomass
- Wind
- Solar PV
- Solar Thermal
- Hydro
- Geo and Tidal

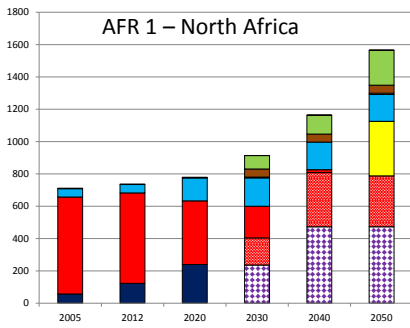


Climate constraint: 50% of reduction of CO₂ emissions by comparison with 2000

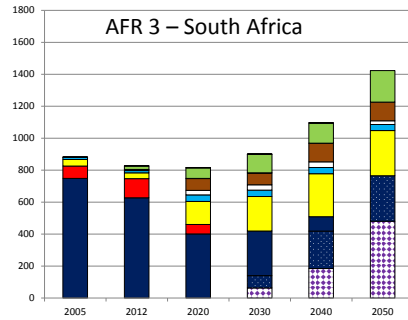
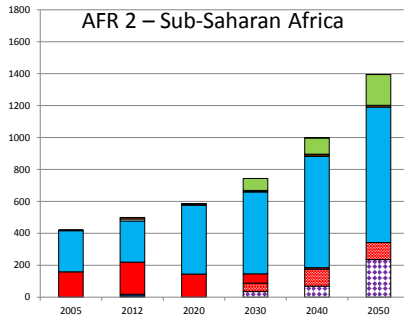


CO₂ emissions (Gt CO₂)

African electricity mix by sub-regions in climate context (PJ)



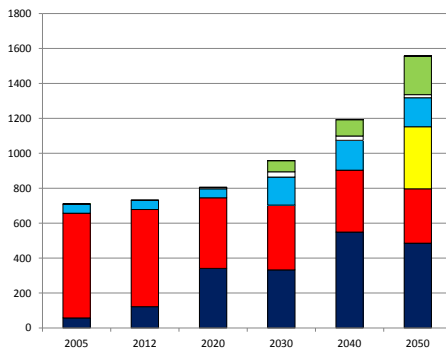
- CCS - BIO ■ CCS - COA ■ CCS - GAS
- Coal ■ Oil and Gas ■ Nuclear
- Hydro ■ CH4 Options ■ Geo and Tidal
- Biomass ■ Wind ■ Solar PV
- Solar Thermal



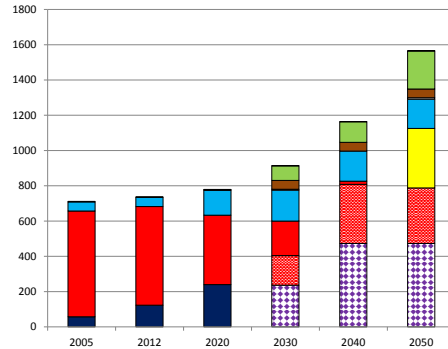
African electricity mix by sub-regions (PJ)

AFR 1 - North Africa

- CCS - BIO ■ CCS - COA ■ CCS - GAS
- Coal ■ Oil and Gas ■ Nuclear
- Hydro ■ CH4 Options ■ Geo and Tidal
- Biomass ■ Wind ■ Solar PV
- Solar Thermal



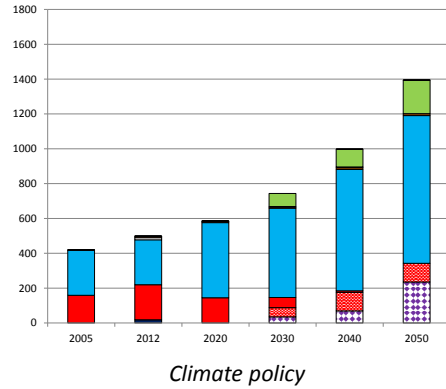
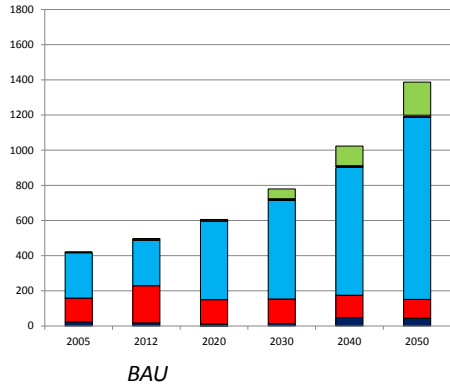
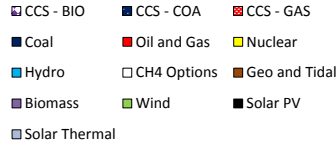
BAU



Climate policy

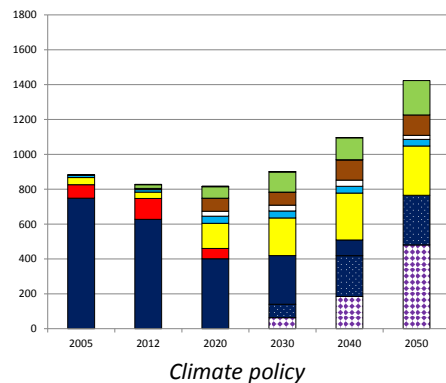
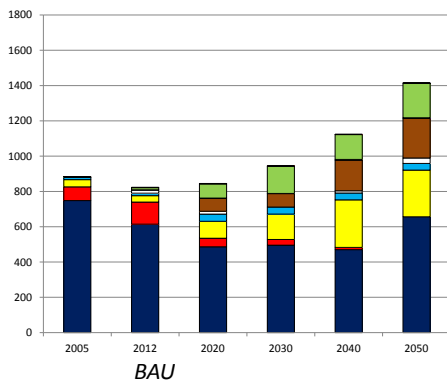
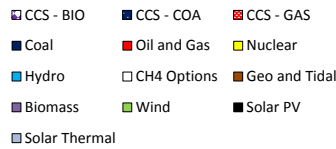
African electricity mix by sub-regions (PJ)

AFR 2 – Sub-Saharan Africa



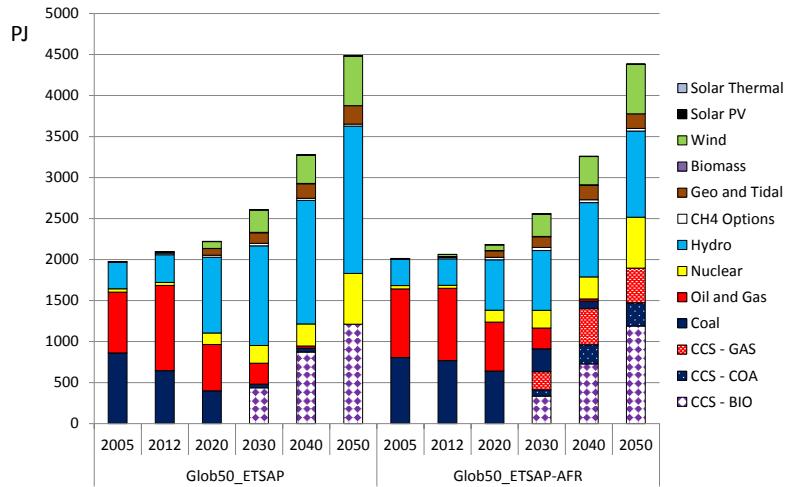
African electricity mix by sub-regions (PJ)

AFR 3 – South Africa





African energy mix in case of climate policy



African electricity production in case of carbon constraint (PJ)



To conclude

- More relevant representation of the electricity sector in African (in a global or regional perspective)
- In a climate context, possibility to analyse the decarbonation of the African power sector according to a regional potential
- Consideration of the power access of the African population



Thank you!



Annex: Structural changes



VT_AFR_ELC_V1p1

- Sub-regional distribution of the base year technologies
 - Source: IEA Statistics, 2011 Edition, Energy statistics of non-OECD countries
 - Efficiency and residual installed capacity

Fuel name	-IEAStats	MAINELEC	ELMAINE	MAINCHP	ELMAINC	HEMAINC	MAINHEAT	HEMAINH	ELOUTPUT	HEMAINH
GASWGW	GASWKSGS									
GASBFG	BLFURGS									
GASCOC	COKEOVGS									
GASQXY	OXYSTGS	1449.55	536.62						536.90	
GASNGA	NATGAS									
GASRFG	REFINGAS									
OILLPG	LPG									
ELCNGA	<i>V: Only GASNGA and GASQWG</i>	1449.55	536.62	0.00	0.00	0.00	0.00	0.00	536.90	0.00
OILCRD	CRUDEOIL	19.05								
OILDST	GASDIES	238.44	1.72						3.30	
OILGSL	MOTORGAS									
OILNAP	NAPHTHA									
OILNGL	NGL									
OILNCR	NONCRUDE				184.88					
OILNSP	ONONSPEC	5.53							207.58	
OILKER	OTHERKO	373.38	0.40						0.40	
OILHFO	RESFUEL									
ELCOIL	<i>V: Incl OILPTC and OILLPG,RFG</i>	636.39	187.00	0.00	0.00	0.00	0.00	0.00	211.26	0.00
BIOBLO	GBIOMASS,OBIOLO									
BIOBIN	INDWASTE									
BIOSMU	MUNWASTEN,MUNWASTER									
BIOSLS	SBIOMASS								2.30	
BIOREN	RENEWNS									
ELCBIO	V:ELCBIO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.30	0.00
COABCO	PEAT,BKB,BROWN,SUBCOAL,LIGNITE									
COABCO	E									
COAHCO	HARDCOAL,PATFUEL,ANTCOAL,BITCOAL	2347.29	861.93							
COAOAV	OVENCOKE								903.34	
OILPTC	PETCOKE									
ELCCOA	<i>V:GASBFG,COG,OXY incl. here. OILPTC in ELCOIL</i>	2347.29	861.93	0.00	0.00	0.00	0.00	0.00	903.34	0.00
ELCNUC	NUCLEAR	123.22	40.65						40.65	
ELCHYD	HYDRO	323.68	323.63						326.76	
ELCGEO	GEOTHERM	31.95	3.19						3.19	
ELCSOL	SOLARPV,SOLARTH	3.77	1.92						1.93	
ELCTDL	TIDE									
ELCWIN	WIND	3.01	3.00						3.00	
<i>V: Total produced</i>		4918.86	1957.94	0.00	0.00	0.00	0.00	0.00	2029.36	0.00
TOTAL		2961.24	1958.16						2030.08	



IEA Database – Africa 2005

- ELMAINC: Electricity output (GWh) - main activity producer CHP plants
- ELMAINE: Electricity output (GWh) - main activity producer electricity plants
- ELOUTPUT: Electricity output (GWh)
- HEMAINC: Heat output (TJ) - main activity producer CHP plants
- HEMAINH: Heat output (TJ) - main activity producer heat plants
- MAINCHP: Main activity producer CHP plants
- MAINELEC: Main activity producer electricity plants
- MAINHEAT: Main activity producer heat plants



VT_AFR_ELC_V1p1

- New commodities
 - ELCC1, ELCC2, ELCC3
- New processes
 - To aggregate sub-regional commodities
ELCCAGG: ELCC1+ELCC2+ELCC3=ELCC
 - Existing power production processes for each sub-region
Ex: E_Tech_01, E_Tech_02, E_Tech_03 instead of E_Tech_00;
Output = ELCC1, ELCC2, ELCC3

SysSetting

- Modified and added parameter
 - COM_IE
 - COM_PKRSV
 - PRC_PCG (EOILGEN00,EOILGEN01, EOILGEN02, EOILGEN03)



SubRes_B-NewTechs

- New commodities
 - ELCC1, ELCC2, ELCC3
 - ELCD1, ELCD2, ELCD3
 - ELCS1, ELCS2, ELCS3
- New processes (+ some modifications of existing processes)
 - To aggregate sub-regional commodities
ELCCAGG: ELCC1+ELCC2+ELCC3=ELCC
ELCDAGG: ELCD1+ELCD2+ELCD3=ELCD
ELCSAGG: ELCS1+ELCS2+ELCS3=ELCS
 - Future power production processes for each sub-region
Ex: E_Tech_115, E_Tech_125, E_Tech_135 / E_Tech_105;
Output = ELCC(D,S)1, ELCC(D,S)2, ELCC(D,S)3
- Modified parameter
 - For already selected processes based on RETD project
(sheet ELC_RETD: ELC_1_RETD, ELC_2_RETD, ELC_3_RETD)
AF, AFA, EFF, INVCOST, VAROM, FIXOM, NCAP_DRATE, BOUND(BD),
BOUND(BD)O, PEAK(CON), LIFE