Nuclear energy and Bio Energy Carbon Capture and Storage, keys for obtaining 1.5 ° C mean surface temperature limit

GISOC

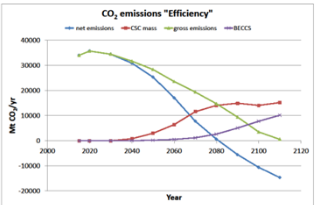
Berger, A., Blees, T., Bréon, F-M., Brook, B.W., Deffrennes, M, Durand, B., Hansen, P., Huffer.E., Grover, R.B., Guet, C., Liu, W., Livet F., Nifenecker, H., Petit, M., Pierre, G., Prévot, H., Richet, S., Safa, H., Salvatores, M., Schneeberger, M. and Zhou, S. (2017)
Collaboration GISOC « Global Initiative to Save Our Climate » and « Save The Climate »

Reference: "Int. J. Global Energy Issues, Vol. 40, Nos. 3/4, 2017.

From 2° to 1,5°

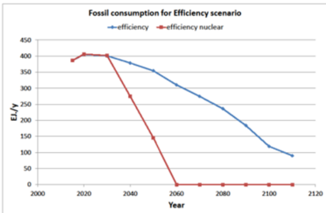
To limit the increase of Global Mean Surface Temperature (GMST) with respect to the pre-industrial period to 1.5 ° C, as evaluated by the IPCC following the Paris COP21 conference, the CO_2 budget is limited to 600 Gt CO_2 . To determine if such an objective is realistic, we use, as a reference, the scenario MESSAGE Efficiency of the GEA (2012) (Global Energy Assessment) which respects the RCP 2.6 as defined by the IPCC for limiting the increase of the GMST to 2 ° C. We increase considerably the contribution of nuclear energy in the energy mix. This leads to a limitation of the CO_2 budget to 800 Gt CO_2. At the end of the century we propose to use BECCS to limit the increase of CO_2 in the atmosphere to 600 Gt. We call this new scenario EFFICIENCY-N

CO_2 EMISSIONS in EFFICIENCY



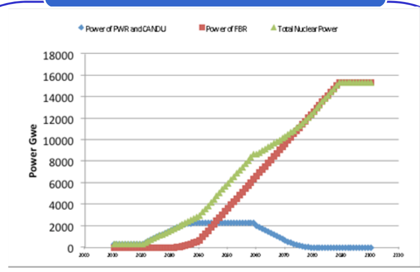
CO_2 Emissions (Gross and Net) and CCS mass (total and Biomass Energy) for scenario EFFICIENCY.

Fossil Consumptions



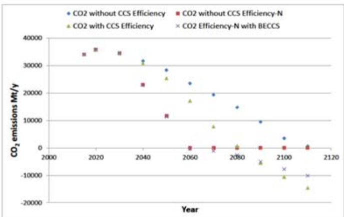
Fossil consumption for the EFFICIENCY and EFFICIENCY-N scenarios

NUCLEAR DEVELOPMENT



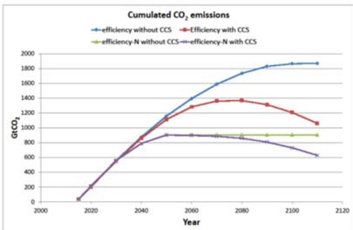
The scenarios MESSAGE-N assume a nuclear production of 100 000 TWh in 2100 corresponding to a nuclear power around 16 000 GWe. PWR reactors require 120 tons of Natural Uranium per GWe annually. Annual Uranium consumption would then be about 1.4 million tons. The Nuclear Energy Agency gives an estimate for "classical" reserves around 16 million tons. Thus, Fast Breeder Reactors (FBR) are needed. In 2100 the Plutonium inventory would amount to 65 000 tons. Building 16 000 GWe breeding power in 50 years implies a building rate of 320 Gwe/yr, requiring, annually, between 1 800 and 2 500 tons of plutonium, depending on the amount of plutonium in the cycle. PWR and FBR produce annually 0,25 and CANDU 6 tons of Plutonium per GW. The figure above shows how such a development of nuclear energy might take place. Thermal reactors (PWR and CANDU) start the program both for energy production and building up the plutonium inventory necessary for the FBR.

Comparison of CO_2 emissions



Annual CO_2 emissions for the original scenarios EFFICIENCY with and without CCS and for EFFICIENCY-N without and with BECSS.

Fossil consumption for the EFFICIENCY and EFFICIENCY-N.



Cumulated CO_2 emissions with and without CCS

- EFFICIENCY without CCS
- EFFICIENCY with CCS
- EFFICIENV-N with CCS
- EFFICIENCY-N without CCS

ENERGY MIX

	Efficiency	Efficiency-N	Efficiency-N	Efficiency
	2015	2060	2110	2100
Fossil EJ	386	0	0	90
Wind+solar EJ	0,717	96	283	283
Hydro EJ	10	21	23	23
Biomass EJ	42	98	221	221
Nuclear EJ	9	173	605 (173)	0
Primary energy EJ	448	388	1132 (700)	617
CO_2 /y net Gt	34	-0,5	-10,2	-14
CO_2/y stored	0	0,5	10,2	15,2
Cumulated CO_2 stored	0	8	276	801
Cumulated CO_2 Gt	34	896	627	1270

Table 1

Summary of the energy mix and CO_2 emissions for the EFFICIENCY and EFFICIENCY-N scenarios in 2015, 2060 and 2110.
Two options are made for Nuclear production.
Number in brackets correspond to a constant nuclear production after 2060

CONCLUSION

The substitution of fossil energy by nuclear energy in the MESSAGE-EFFICIENCY scenario allows the end of fossil use in 2060 rather than 2100.

With storage of 800 Gt of CO_2, the original EFFICIENCY scenario still leads to a cumulated mass of CO_2 injected into the atmosphere of 1100 Gt, while with a storage of only 275 Gt of CO_2, the scenario MESSAGE efficiency-N limits the CO_2 injected in the atmosphere to 600 Gt, compatible with the 1.5 ° C requirement.

The nuclear direct primary energy needed for obtaining this result reaches 93 EJ in 2060 (25 600 TWh) produced thanks to a nuclear power of 3200 GWe. Without negative consequences on the climate, it should be possible to pursue the nuclear development reaching a nuclear production of 600 EJ/y in 2110. This would allow an increase of primary energy supply (following the direct primary energy convention of the GEA) from 900 EJ/y in the original efficiency scenario to 1300 EJ/y in the efficiency-N scenario with continued nuclear production development.

Table 1 under "Energy Mix" summarizes the results we obtain for the scenario Efficiency-N and compares them to those of the original MESSAGE-Efficiency.