

# Implementing water allocation in the TIAM-FR energy model

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## 1 Overview

## 2 Implementation in TIAM-FR

## 3 Results

## 4 Conclusion

# Policies dealt separately but... interdependency

## Growing issues for water and energy

- Energy sector: depletion of fossil resources, environmental impacts
- Water supply: availability and sustainability of water resources



# Policies dealt separately but... interdependency

## Growing issues for water and energy

- Energy sector: depletion of fossil resources, environmental impacts
- Water supply: availability and sustainability of water resources

### Water for energy

- Cooling systems
- Hydropower
- Extraction and mining
- Fuel production
- Emission controls



### Energy for water

- Pumping
- Transport
- Treatment
- Desalination

# Increase of water uses

## Basic knowledge

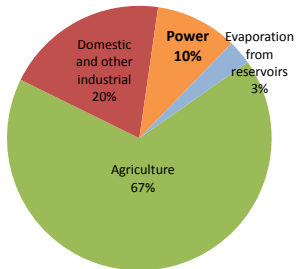
- **Withdrawal:** water removed from any sources, either permanently or temporarily
- **Consumption:** part of withdrawal which is no longer available for utilization

# Increase of water uses

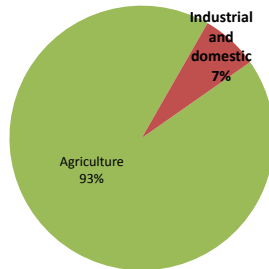
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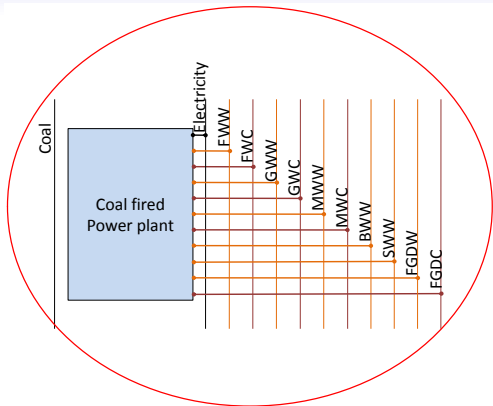
### World withdrawals



### World consumptions



# Water RES



1 Consumption : \*WC

2 Withdrawal : \*WW

- F: Fresh water
- B: Brackish water
- M: Municipal water
- G: Ground water
- S: Saline water
- FGD: Water for FGD process

## Water factor for each technology :

- **Upstream**: type of coal mine, ratio onshore/offshore etc.
- **Electricity**: cooling systems, efficiency, FGD etc.

# Review and analysis of factor of influence

Different scenarios have been considered to analyze the influence of :

- ① Cooling systems used
- ② FGD process in coal thermal power plant
- ③ Environmental policies and extraction costs
- ④ Water as a constraint

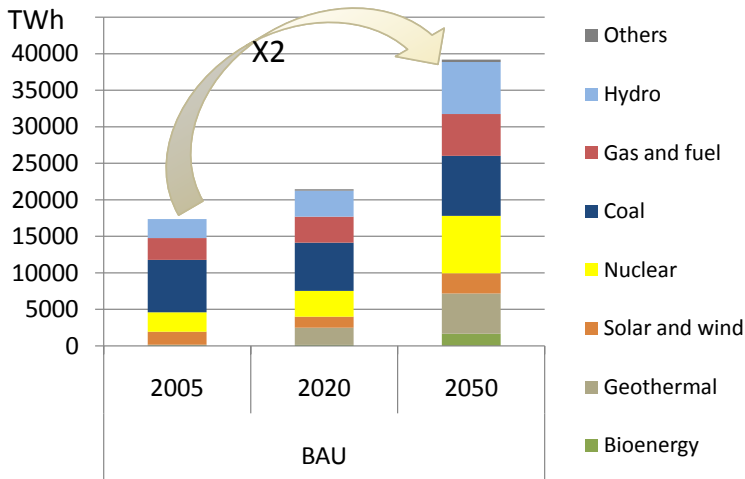
# 1. Cooling systems

Scenarios for new installations, no change of existing power plants water factors.

- BAU (Business as usual scenario): Water factors for new installations = water factors for existing installations
- CL: New installations use only closed loop systems (better efficiency enables to decrease the temperature difference)
- CL+NR: New installations use only closed loop systems and better efficiency allows decreasing the flow needed in the cooling system

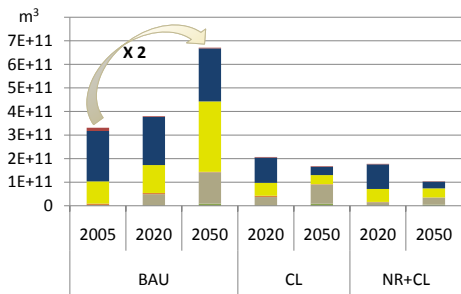
# 1. Cooling systems

## Worldwide electricity generation by source



# 1. Cooling systems

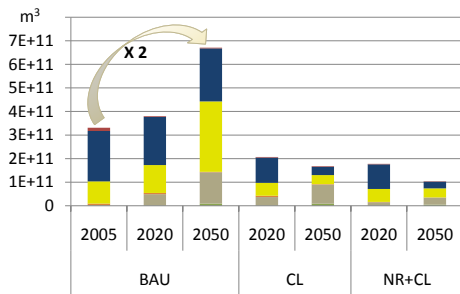
## Fresh water withdrawals



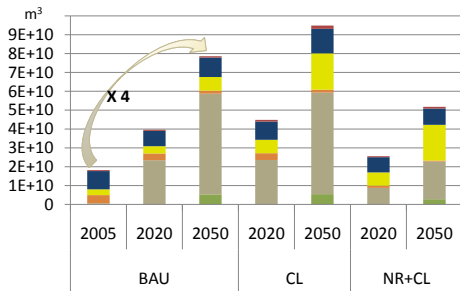
■ Bioenergy 
 ■ Geothermal 
 ■ Solar 
 ■ Nuclear 
 ■ Coal 
 ■ Gas and fuel

# 1. Cooling systems

## Fresh water withdrawals



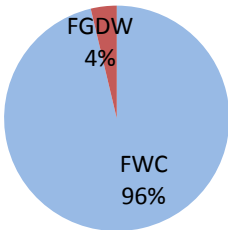
## Fresh water consumptions



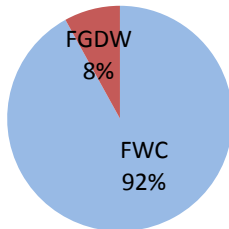
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## 2. Increase of water for FGD process in coal thermal power plant

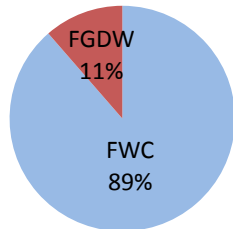
**BAU 2005**



**BAU 2020**

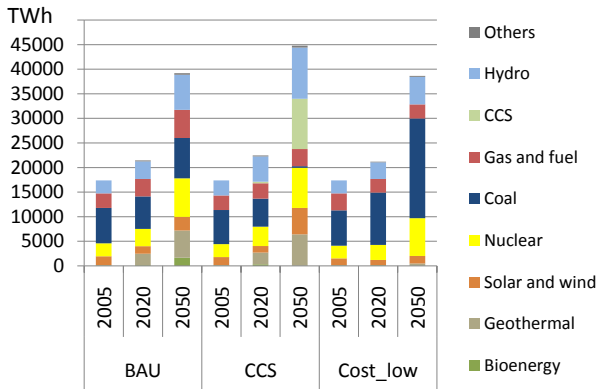


**BAU 2050**



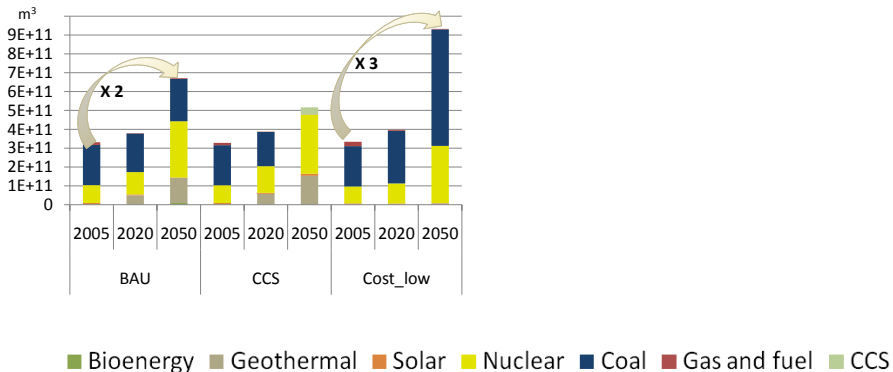
### 3. Environmental policies and decrease of extraction costs

- **CCS**: constraint the energy system to a maximum increase of temperature of 2°C in 2100
- **Cost\_low**: decrease of extraction cost of fossil energy



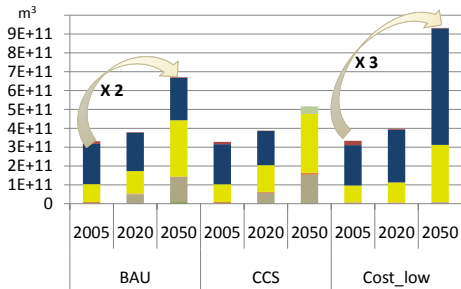
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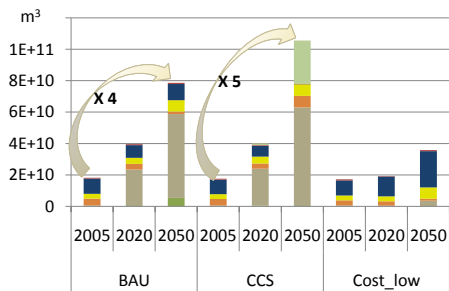


### 3. Environmental policies and decrease of extraction costs

#### Fresh water withdrawals



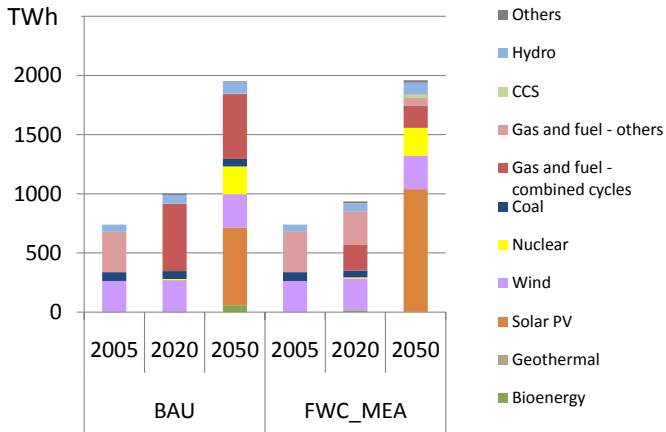
#### Fresh water consumptions



■ Bioenergy ■ Geothermal ■ Solar ■ Nuclear ■ Coal ■ Gas and fuel ■ CCS

## 4. Water as a constraint

- **FWC\_MEA**: fresh water consumptions in Middle East until 2100  $\leq$  consumptions in 2005



# Conclusion

## Strategic factors

- Some technologies water footprints may be important
- Cooling system
- Emission controls: FGD (+10%), CCS(+90%)

## Evolution of water in the model

- Water as an output commodity
- Water as a constraint

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**Towards a global optimum considering water and energy ?**

*Thank you for your attention!*

## Consommations d'eau dans le cycle pétrole

Procédé	[m <sup>3</sup> /TJ]
Extraction et production onshore de pétrole conventionnel	3-8
Injection d'eau (Récupération secondaire)	600
Injection de gaz immiscible (Récupération secondaire)	340
Injection de vapeur (EOR)	100-180
Injection de CO <sub>2</sub> miscible (EOR)	340
Combustion <i>in situ</i> (EOR)	50
Injection de polymères (EOR)	8900
Injection de solutions caustiques (EOR)	100
Schistes bitumineux	55-135
Sables bitumineux (mines)	70-180
Sables bitumineux ( <i>in situ</i> )	30-60
Raffinerie (classique)	25-65

# Consommations d'eau dans le secteur gazier

Procédé	[m <sup>3</sup> /TJ]
Extraction du gaz conventionnel	Négligeable
Extraction du <i>Shale Gas</i>	3-13
Process du gaz	6
Transport par pipeline	3

# Consommations d'eau dans la filière charbon

Procédé	[m <sup>3</sup> /TJ]
Carrière à ciel ouvert sans revégétation	2
Carrière à ciel ouvert avec revégétation	5
Mine souterraine	3-20 <sup>1</sup>
Lavage du charbon	4
Gazéification	40-95
Liquéfaction (Fischer-Tropsch)	150-215

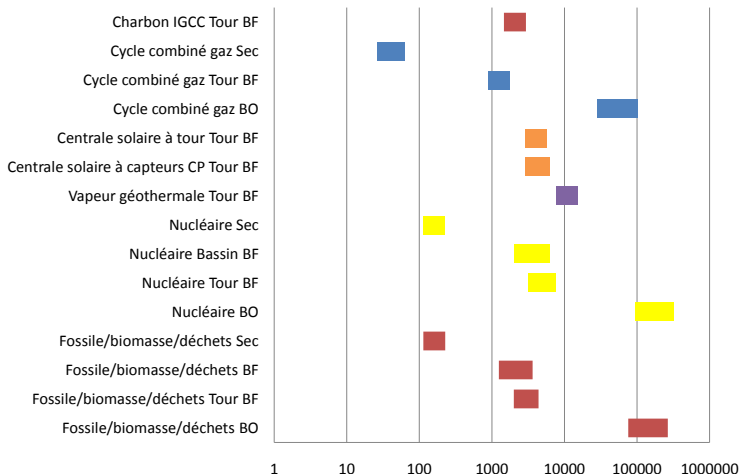
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<sup>1</sup>L'intervalle dépend du type de refroidissement utilisé, le plus élevé correspondant à un circuit ouvert

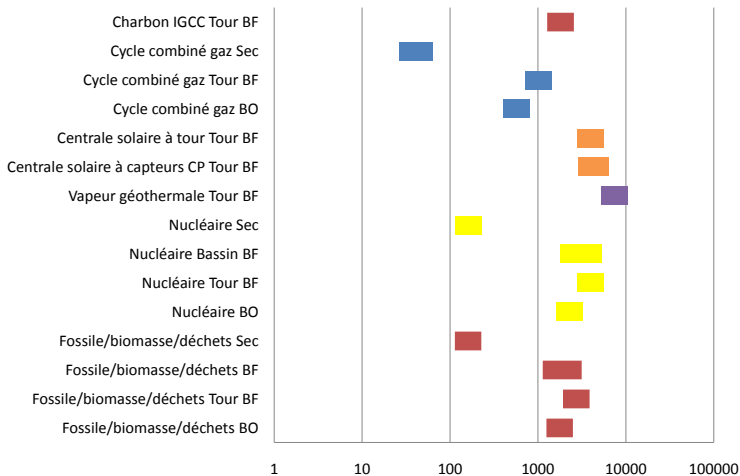
## Consommations d'eau dans la filière uranium

Procédé	[m <sup>3</sup> /TJ]
Carrière à ciel ouvert	20
Mine souterraine	0.2
Lessivage du minerai	8-10
Conversion de l'uranium en hexafluoride	4
Enrichissement de l'uranium : diffusion gazeuse	11-13
Enrichissement de l'uranium : centrifugation	2
Fabrication du combustible	1

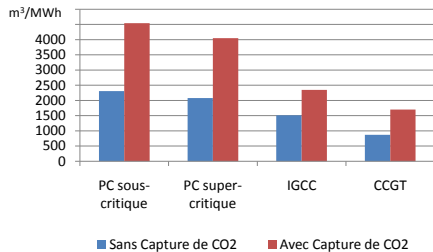
# Prélèvements d'eau dans la production d'électricité



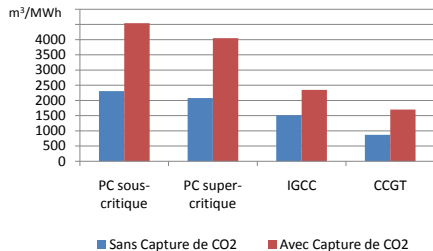
# Consommations d'eau dans la production d'électricité



## Prélèvements



## Prélèvements



## Consommations

