ParisTech's Chair Modeling for sustainable development

Towards a shared optimum for water and energy resources: a focus on the Middle East using the TIAM-FR model

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Policies dealt separetely but... interdependency

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

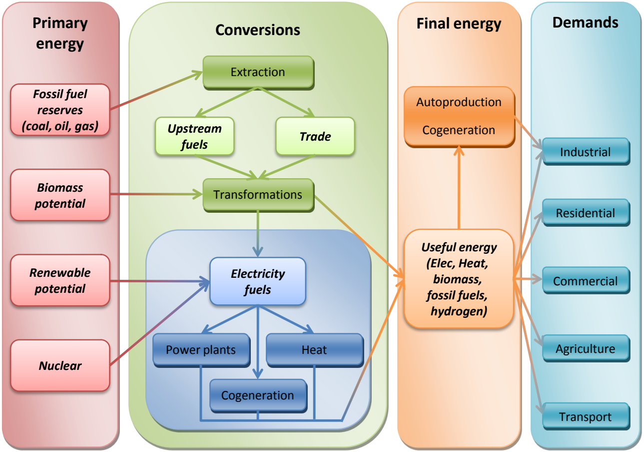
- Interdependency of the two resources
  - Energy for water: Pumping, transport, treatment etc
  - Water for energy: Cooling systems, hydropower, extraction etc

- Water models and energy system models usually uncorrelated
  - Computation of a shared optimum is unachievable
  - **Implementation of water allocation in the TIAM-FR energy system model**

TIAM-FR model: long term planning tool

- TIMES Integrated Assessment Model developed by ETSAP (Energy Technology System Analysis Program)
- Technology-rich representation of the energy systems: bottom-up model
- Global model: 15 regions
- Long-term development of the energy system (2005-2100)
- Technical optimum: minimizing the discounted global cost

Reference Energy System : RES



Two approaches to implement water in the TIAM-FR model:

1. Commodity approach
2. Process approach

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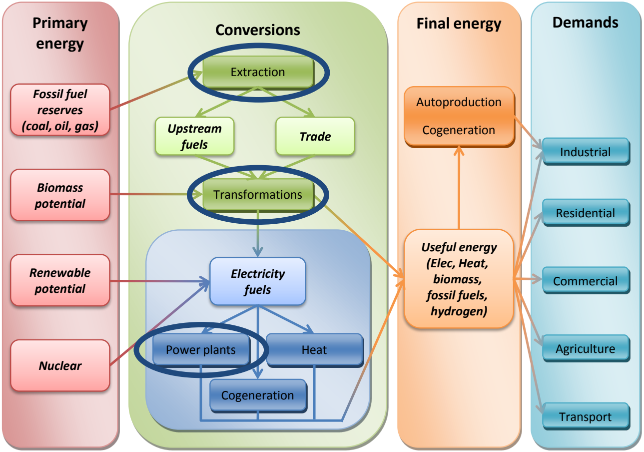

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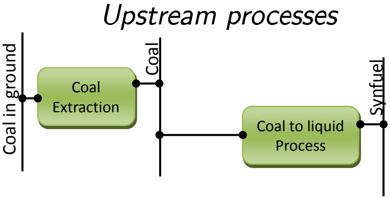
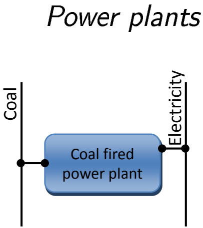
Commodity approach: for each technology





- WCU: Water consumption for upstream processes
- WWU: Water withdrawal for upstream processes
- WCE: Water consumption for electricity production
- WWE: Water withdrawal for electricity production

☞ Brackish water, fresh water, ground water, municipal water, saline water

Water factor:

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

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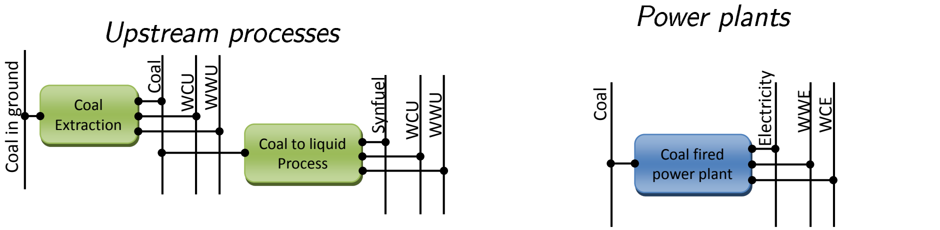

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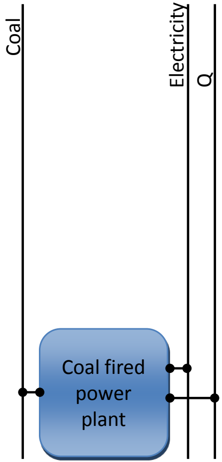

- Output of the power plant :
  - Heat to discharge(Q)
  - Water for gazeification, emission control processes
- New processes : cooling systems
- Electricity input for closed loop systems : giving lower efficiency to power plants

⇒ Allowing the model to be more flexible with water

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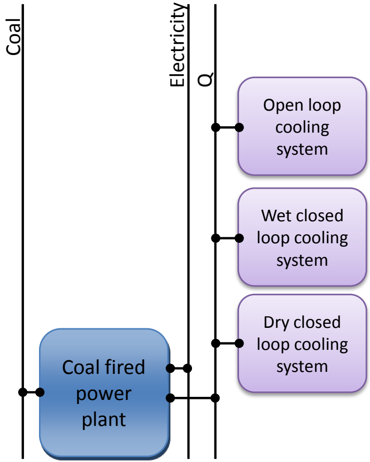

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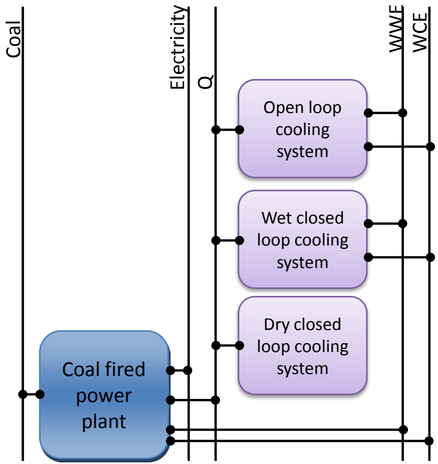

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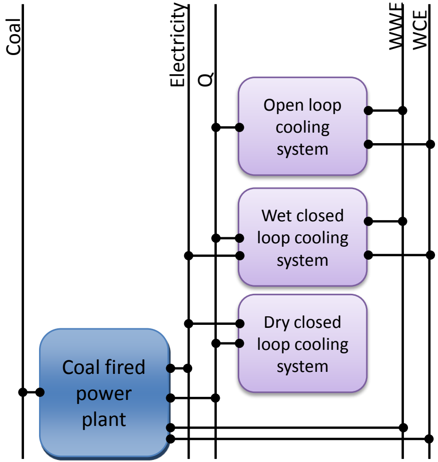

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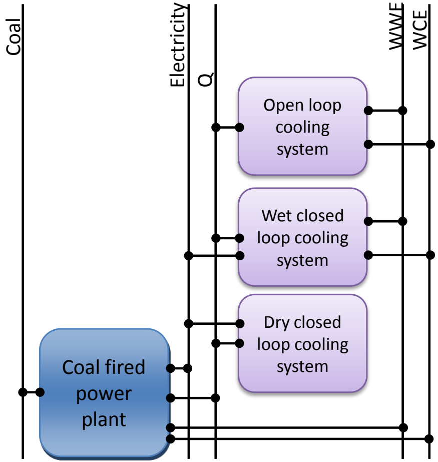

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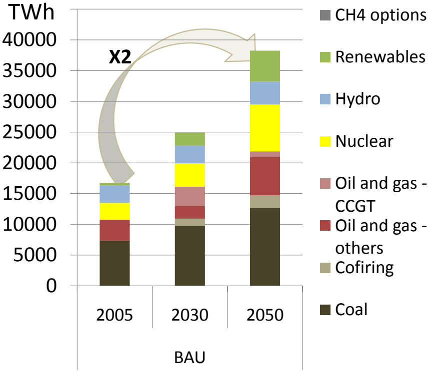
⇒ **Allowing the model to be more flexible with water**

A real need to take water into account

With a business as usual scenario: global electricity production may double from 2005 to 2050 but... freshwater consumptions may be multiplied by 6 in the same period.

Global electricity production



Global Fresh water consumptions

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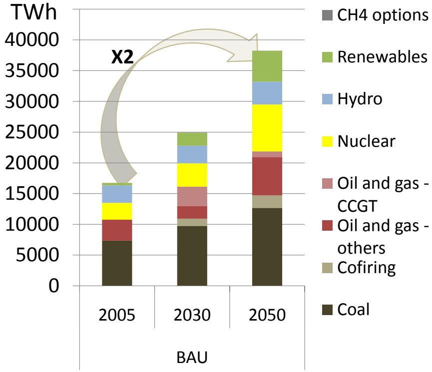

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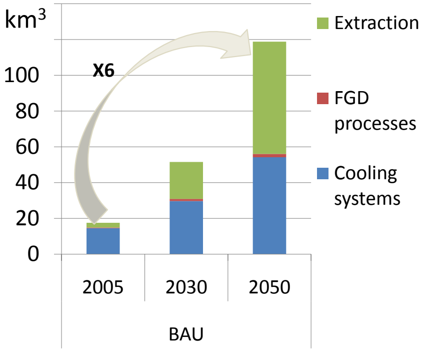


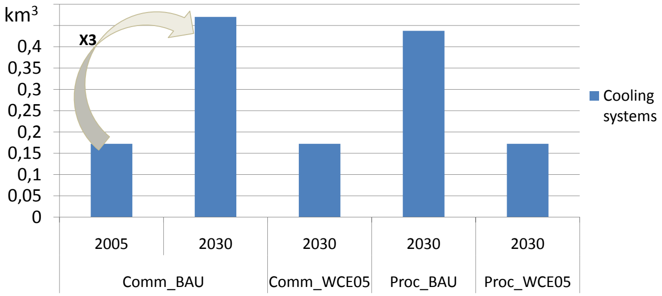
Focusing on the Middle East

☞ The Middle East is a region where water is already scarce.

- Scenarios to evaluate water scarcity in the Middle East region :
  - Scenarios *Comm_****:* Scenarios where water is implemented with the **commodity approach**
  - Scenarios *Proc_****:* Scenarios where water is implemented with the **process approach**
  - Scenarios *****_BAU*: Business as usual scenarios
  - Scenarios*****_WC**E**05*: Fresh water consumptions for **electricity production** in the Middle East until 2050 $\leqslant$ fresh water consumptions in 2005
  - Scenarios *****_WC**EU**05*: Fresh water consumptions for **electricity production and upstream processes** in the Middle East until 2050 $\leqslant$ fresh water consumptions in 2005

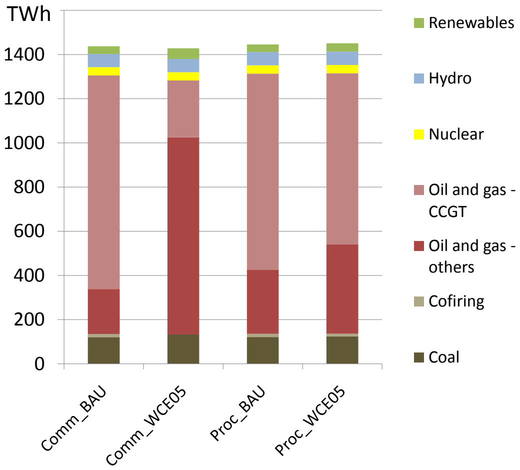
Representing water scarcity in the Middle East

Fresh water consumptions in the Middle East for electricity production



- Scenarios Comm_****: commodity approach
- Scenarios Proc_****: process approach
- Scenarios ****_BAU: Business as usual
- Scenarios ****_WCE05: Fresh water consumptions for electricity production constrained

MEA electricity production in 2030



Oil and gas power plants

- BAU scenario: less combined cycles power plants (CCGT) with a process approach (61%) than with a commodity approach (67%)
- Commodity approach: decrease of CCGT (18%)
- Water constrained scenario (WCE05): more CCGT with a process approach (53%) than with a commodity approach (18%)

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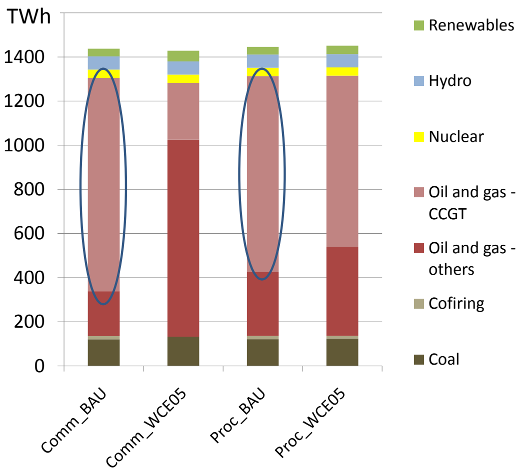

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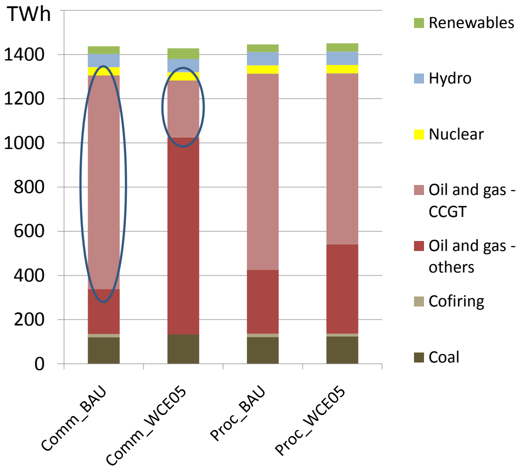

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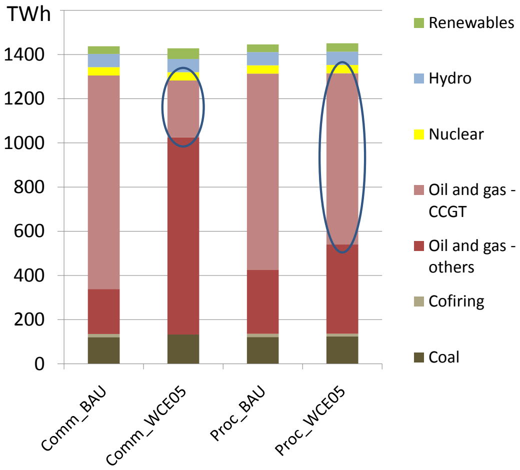

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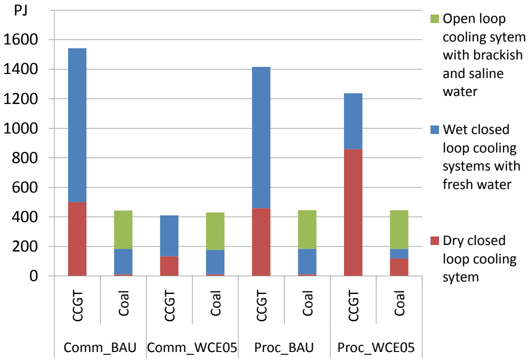
MEA cooling systems used in 2030



Oil and gas power plants

- BAU scenario: same ratios for cooling systems used for both approaches
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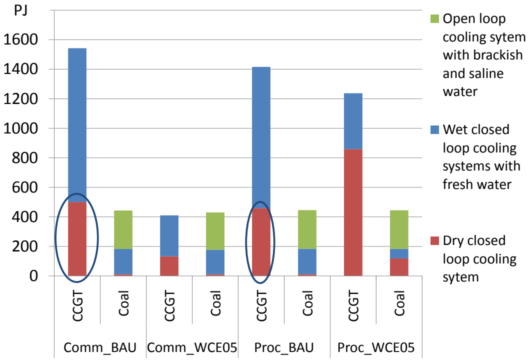

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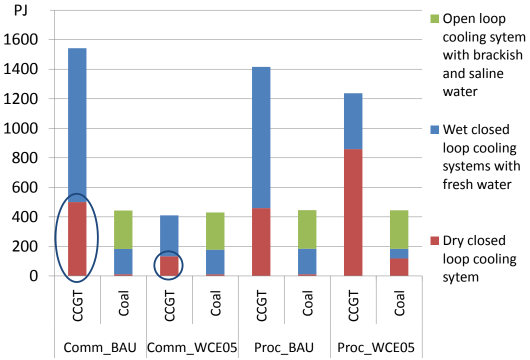

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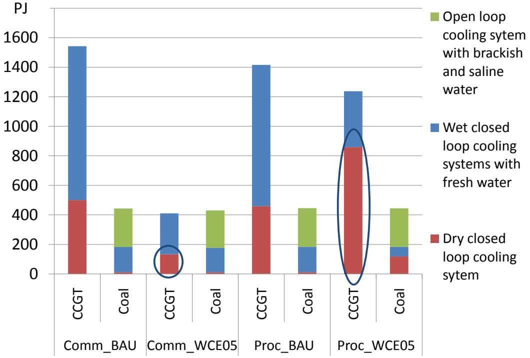

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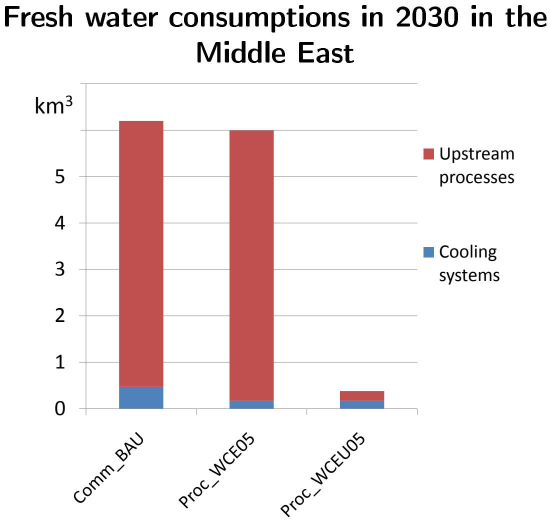
Constraining water for upstream processes



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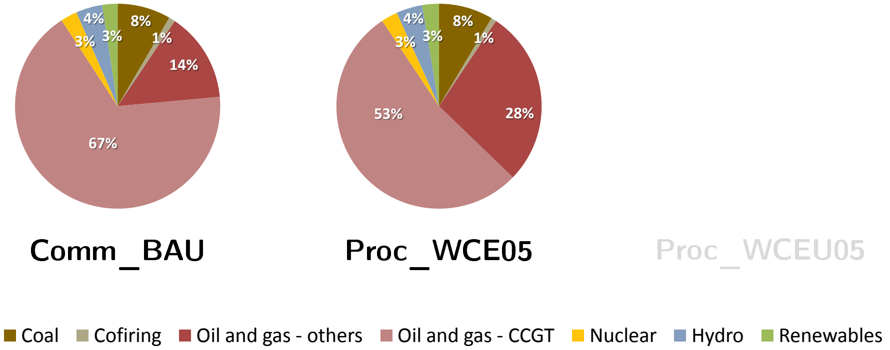

Oil and gas power plants

- Constraining also water for extraction decrease the ratio of combined cycle power plants in the energy mix

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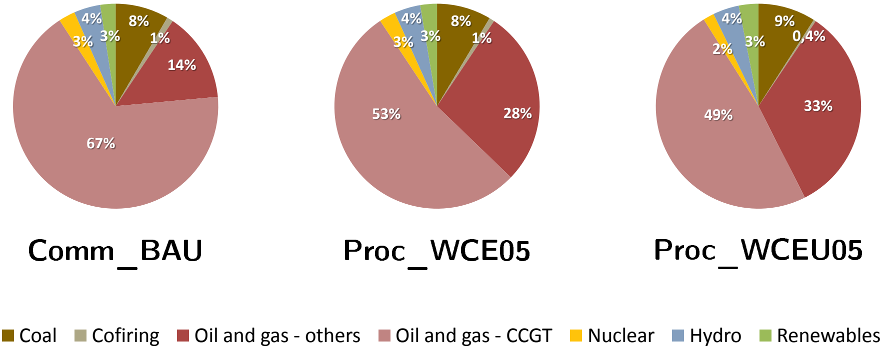

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Conclusion

Towards a shared optimum?

Water allocations for the energy system may increase significantly

- Electricity production: flexibility of cooling system choices with a process approach
- Upstream processes: fresh water consumptions constrained may have an impact on the energy mix

Future studies

- Taking into account other water uses (residential, agriculture etc)