Water consumption and availability

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Water consumption

Definition:

“Water consumption denotes the part of the freshwater which is not released back to the original watershed; primarily due to evaporation and product integration” (Pfister, 2011)

Differentiation needed between “withdrawal” and “consumption”
Water consumption

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Differentiation needed between “withdrawal” and “consumption”
‘The Nexus’

Water and energy systems are interdependent. Water is used in all phases of energy production. Energy is required to extract, pump and deliver water for use by humans, and to treat wastewater so it can be safely returned to the environment.
IPCC (2011) raised water consumption into the energy sector


- What is the potential for renewable sources to replace fossil-based fuels?

- The different technologies benchmarked with respect to various criteria, including ‘water needed to produced 1 MWh electricity (water consumption)’
Water consumption from electricity generation:

Source: IPCC SRREN, 2011

Wide range between minimum and maximum of estimates

- 209 m³/MWh
- ~0 m³/MWh
Water consumption from electricity generation:

**Source:** IPCC SRREN, 2011

Main source of water losses: evaporation from reservoir surfaces

- **209 m³/MWh**
- **~0 m³/MWh**

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Very few data points (n = 2) from 4 sources, i.e. Gleick, 1993; LeCornu, 1998; Torcellini et al., 2003 & Mielke et al., 2010.
IPCC SRREN (2011) states

• *Upper values for hydropower result from few studies measuring gross evaporation values, and may not be representative.*

• *Allocation schemes for determining water consumption from various reservoir uses in the case of multipurpose reservoirs can significantly influence reported water consumption values.*
The concern in the hydropower sector

- A fear that the high numbers can be taken as ‘typical water footprint of hydropower’
- Potentially a large reputational and business risk
- Might disqualify hydropower based on an unfair methodological basis
- The water footprint methodology seems to gain an increasing foothold (ISO Water Footprint 14046)
- Does not take into account the increased water availability introduced by reservoirs
On-going scientific debate

- “The methodology is immature”
- “Hydropower is a large water consumer”
- “High water consumption in water stressed regions, but reservoirs needed”
- “Reservoirs needed to mitigate climate change”
- “Water security”
Imbalance in time
Imbalance in space

- **55.9 MAF**
- **14.9 MAF**

Average Annual Runoff (70.8 MAF)

Majority of supply is in the North
Majority of demand is in the South
The engineering solution
The trade-offs – Case Egypt

Trade-off: Increased availability versus reduced annual volumes

Source: Strzepek et al., 2008
What reservoirs are used for

~25% of the reservoirs are multi-purpose

Many of the reservoirs used for a specific purpose also has another function

Source: ICOLD database, 2014
Hydropower has a limited role in multipurpose projects in parts of the world, which might mean:

- New projects complex
- Potential for retrofitting with HP

Source: ICOLD database, 2014
The role of reservoirs:

Case study Kizilirmak River Basin, Turkey
Concerns

How much water will be available for use in the future?

1. Climate change
2. Land use changes/irrigation practice
3. Effects of reservoirs on downstream use
Climate change

Temperature

Precipitation

Source: IPCC, 2013: Annex I
Plans for irrigation

Source: DSI, Turkey
WEAP - Model tool applied

- WEAP – Water evaluation and planning tool
- Supports long-term analysis of available water resources (e.g. climate change)
- Supports the effects of policy scenarios on the water resources (e.g. changes in priorities of water use, land management practice, etc.)
The art of modelling

1. Input data – what is available and not available?

2. Model parameters and representation

3. What we do not know
Effect of climate change, irrigation and reservoirs

![Annual average water flow - Kizilirmak outlet](chart)

- **Present**: No reservoir
  - Flow: 180 m$^3$/sec

- **Mid century**: No reservoir
  - Flow: 140 m$^3$/sec

- **End century**: No reservoir
  - Flow: 120 m$^3$/sec

- **With reservoir**:
  - Flow: 180 m$^3$/sec
The water use, Kizilirmak

Present

- With reservoir: 2.63
- No reservoir: 2.51

Mid-century

- With reservoir: 3.30
- No reservoir: 3.12

End-century

- With reservoir: 3.18
- No reservoir: 2.87
The water use, Kizilirmak

1. With reservoir: 0.25, 37.5, 1.99, 59.7, 9.01, 82.9, 4.28, 140.9
   Present: 2.63, 2.51
   No reservoir: 37.6, 3.90, 60.6, 22.7, 7.00, 175.5

2. With reservoir: 0.28, 32.6, 2.17, 49.8, 9.84, 52.6, 4.67, 95.9
   Mid-century: 3.30, 32.8
   No reservoir: 3.12, 28.7, 79.1, 10.06, 139.4

3. With reservoir: 0.28, 30.2, 2.21, 45.3, 10.0, 44.5, 4.74, 81.9
   End-century: 3.18, 4.86
   No reservoir: 30.8, 47.6, 72.0, 10.06, 126.4

Reservoir evaporation
Irrigation
Reflections on future hydropower development & planning

Multi-purpose projects the rule?
HP must demonstrate benefits in other sectors
Identify ‘win-win’ opportunities

Hydrological risk must be assessed:
- climate change
- other water users
- changes in water use/priority
- environmental flow
- reservoir establishment upstream
Planning the water resources:

A challenge with many and big uncertainties

Robust Methodologies & Tools needed

Owens Lake, California