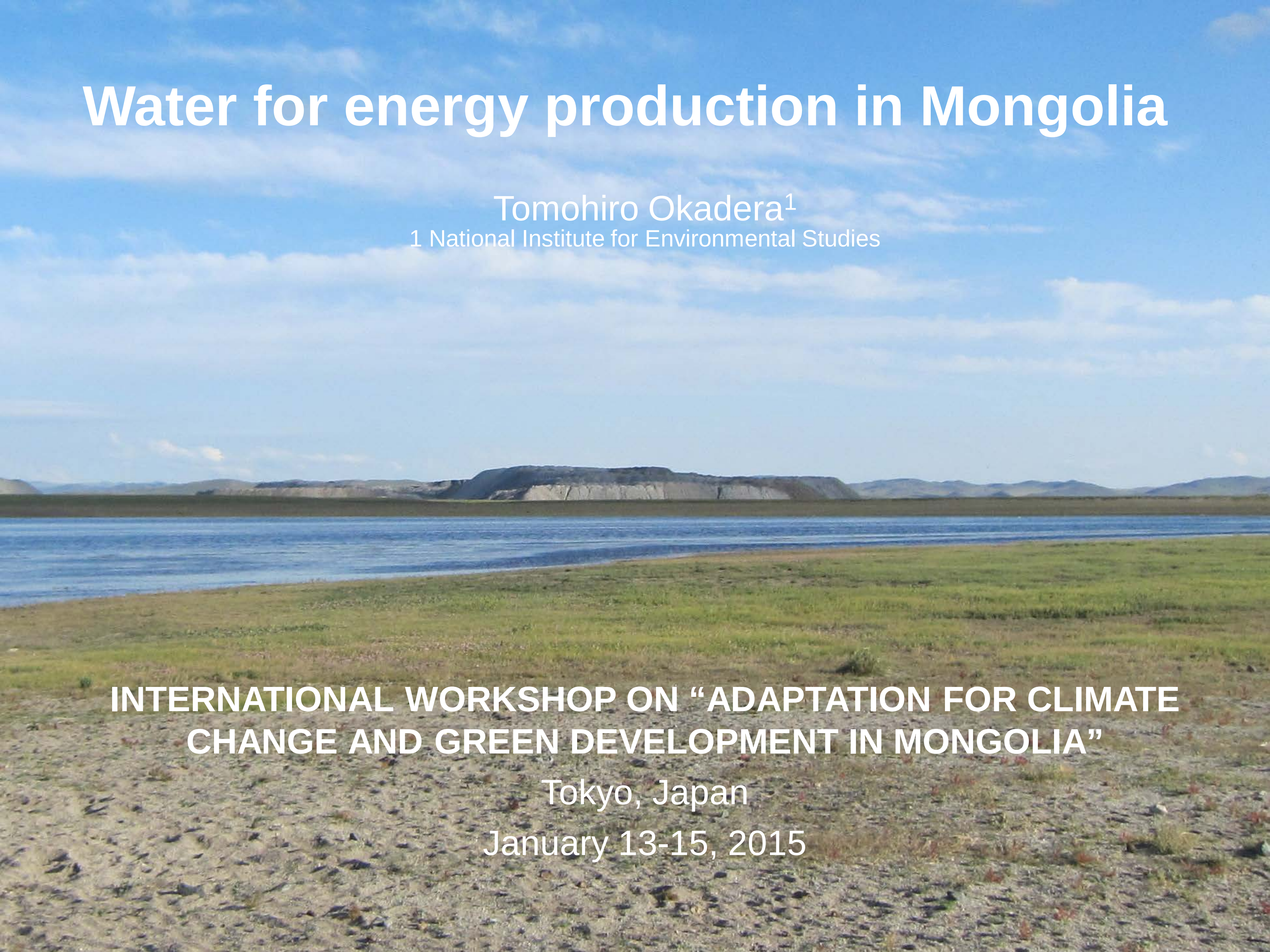

Water for energy production in Mongolia

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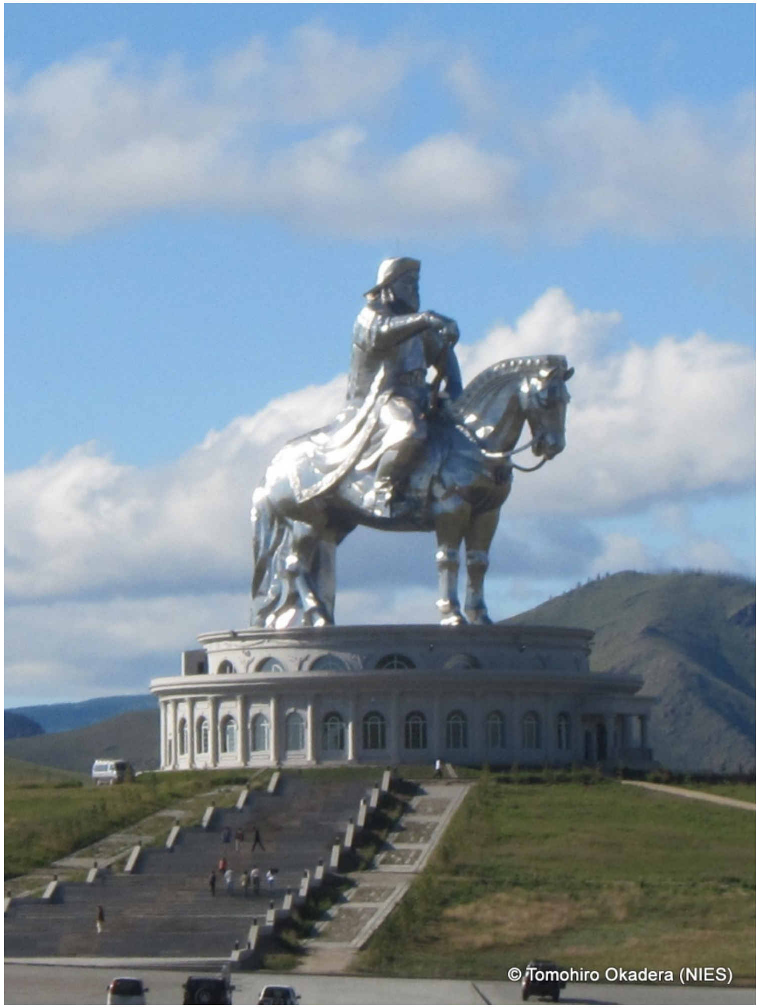
Outline

- Introduction
- Water for coal
- Water for electricity
- Impacts to water resources
- Conclusions
- Future tasks for adaptation and green development



Background

- **Vulnerable water resources**
  - Low precipitation:87-324 mm (2010)
  - Melting permafrost by climate change (Wu et al., 2012a; Wu et al., 2012b; Wu et al., 2013)
- **Rapid economic growth**
  - Annual GDP growth ration + 25% (2010)
- **Coal Production**
  - 22% of industrial gross output
  - Annual growth ratio: +115%
- **Power consumption**
  - Power generation +9%
  - Import +68%
- **Energy production requires much water (Gleick, 1994)**

Issues

- Sustainability of energy production under the limitation of water resources in Mongolia
  - How much water is required to produce coal and electricity?
  - Impacts to water resources in Mongolia

Water for coal

Water for coal production

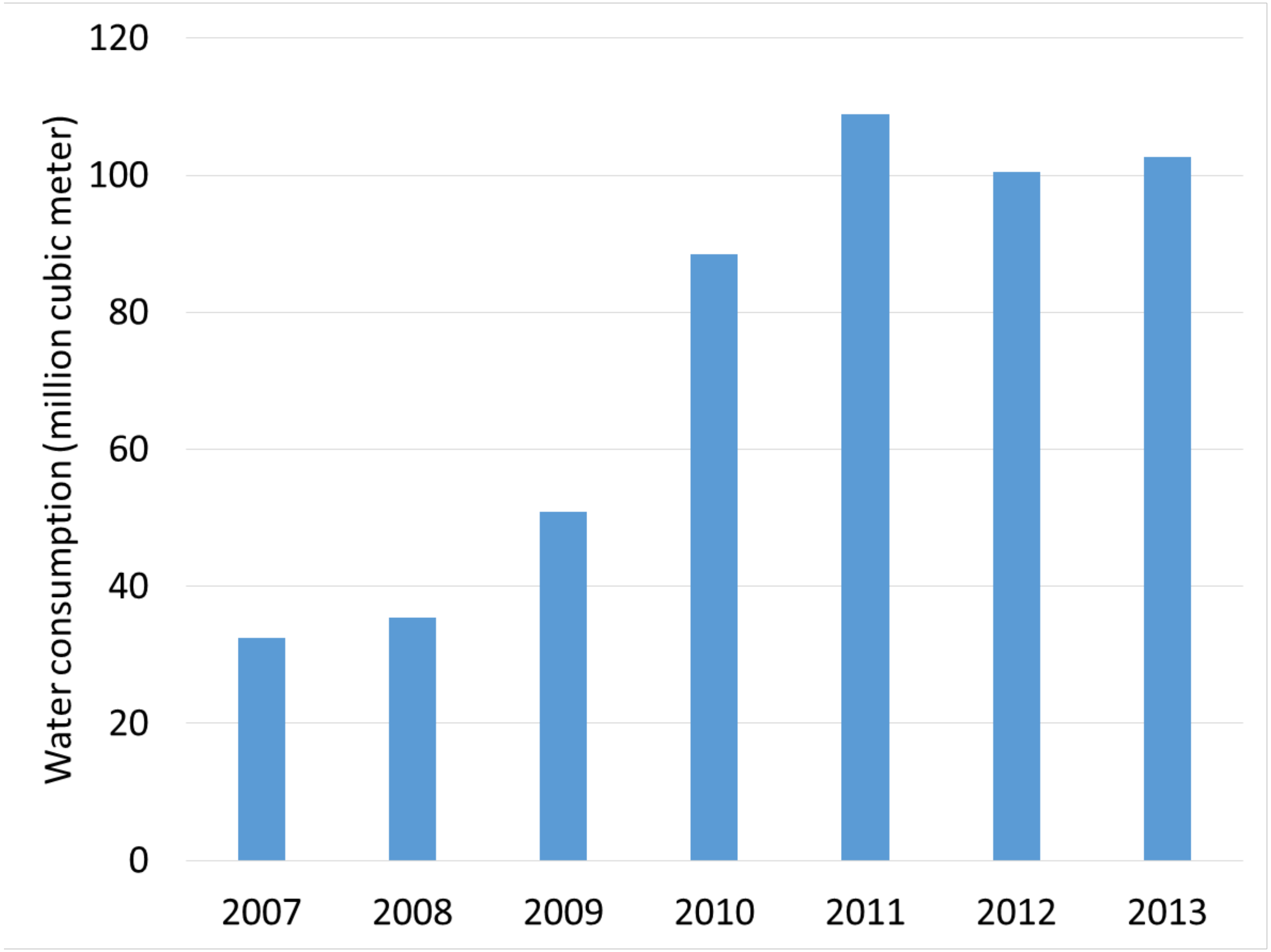
Production Process	Consumed water (m³/TJ)
Surface mining (No vegetation)	2
Surface mining (Revegetation)	5
Underground mining	3–20
Beneficiation	4
Slurry pipeline	40–85
Other plant operation	90
Total	**136–199**

(Gleick, 1994)

Calculation of water for coal production

- Bottom-up approach
  - Coal production
  - Water consumption per coal production
- Amount of coal production (GJ)
  - The balance of coal (NSOM, 2011; 2013)
- Water consumption per coal production
  - 0.17 m^3/GJ (Gleick, 1994; Okadera et al., 2014)

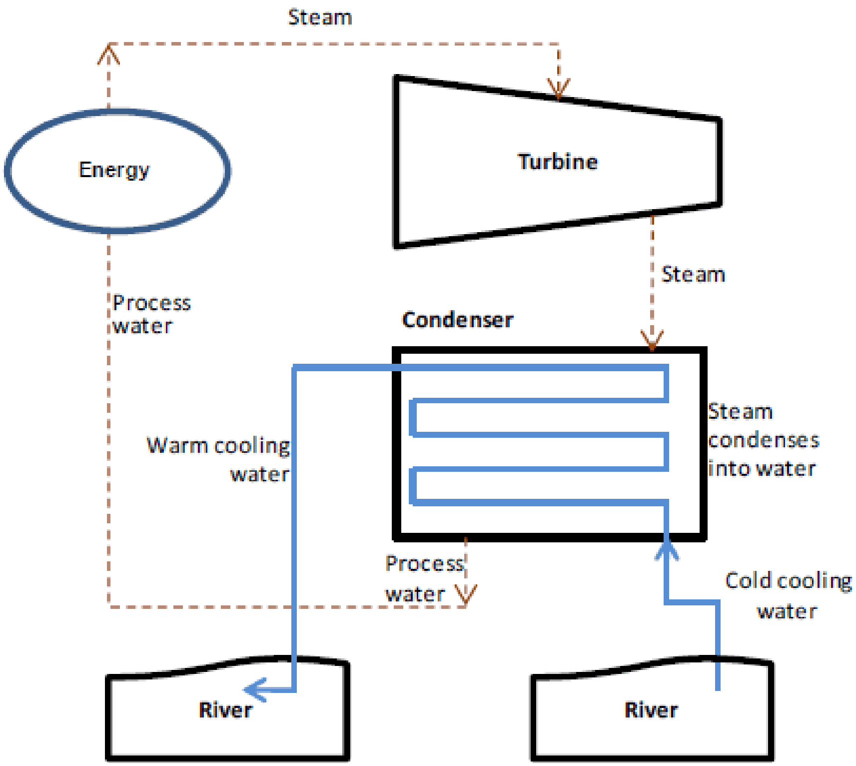
Water consumption to produce coal in Mongolia



Water for electricity

Water for power generation

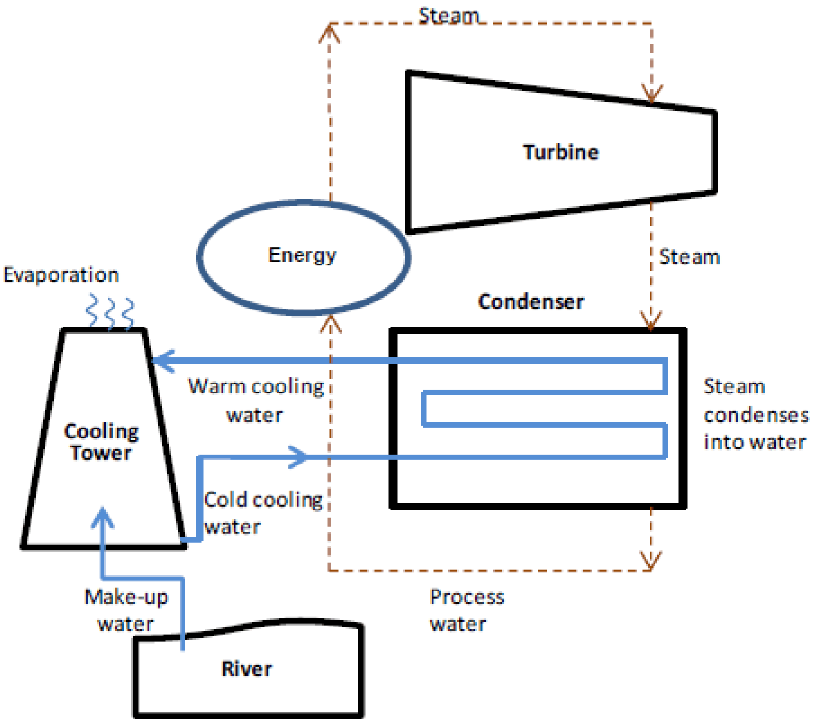
- Process water
  - Water drawn into hydropower plants
  - Steam of thermal plants (Dotted line)
- Cooling water
  - Water for cooling process water in thermal plants (blue line)



(Kohli and Frenken, 2011)

Methods of water for electricity

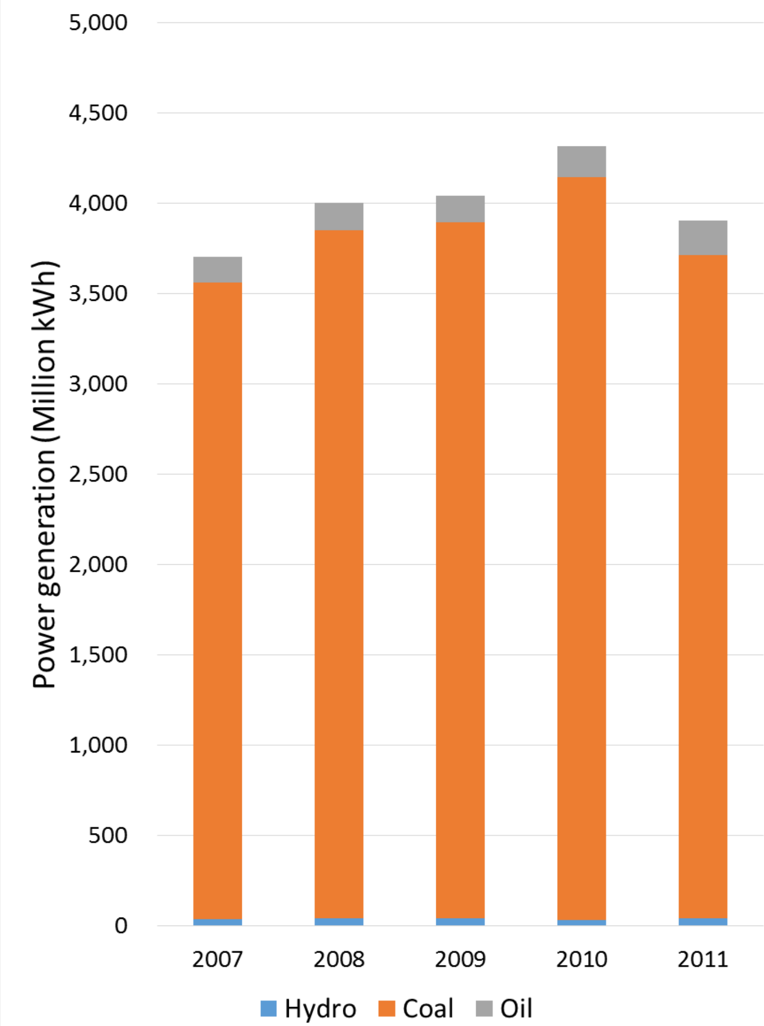
- Indicator
  - Water withdrawal
  - Water consumption
- Bottom-up approach
  - Power generation (kWh)
  - Water use parameters for power generation (i.e. m^3 / kWh)



(Kohli and Frenken, 2011)

Data

- Domestic power generation
  - Electricity balance sheet (NSOM, 2011)
- Power generation by fuel
  - IEA statistic (IEA, 2014)
    - Hydro
    - Coal
    - Oil
- Water use parameters
  - Averaged value by literature reviews (Rio Carrillo and Frei, 2009; Gleick, 1994; Sovacool and Sovacool, 2009)
    - Water consumption per power generation (35 samples)
    - Water withdrawal per power generation (19 samples)

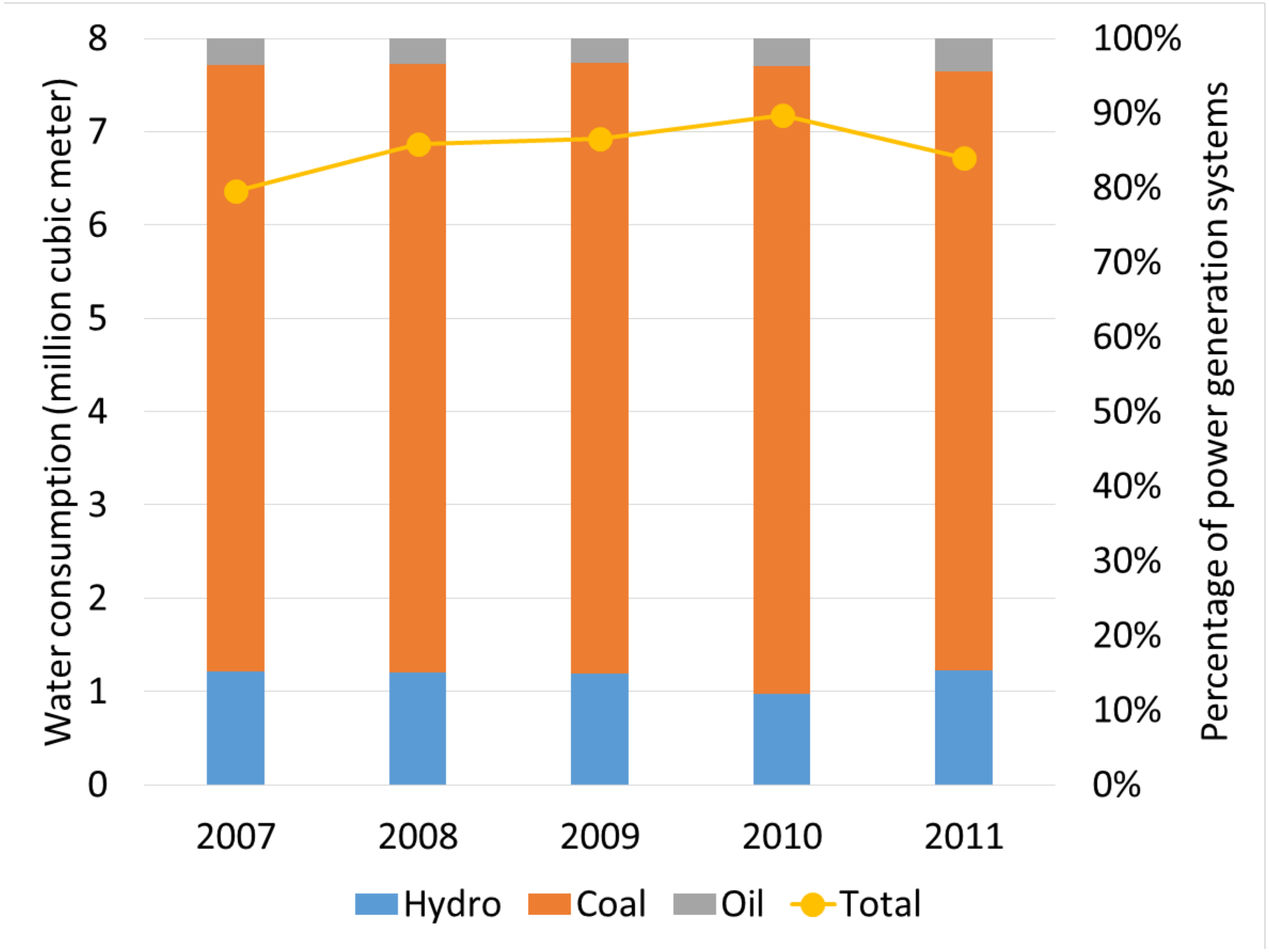


Water use parameter

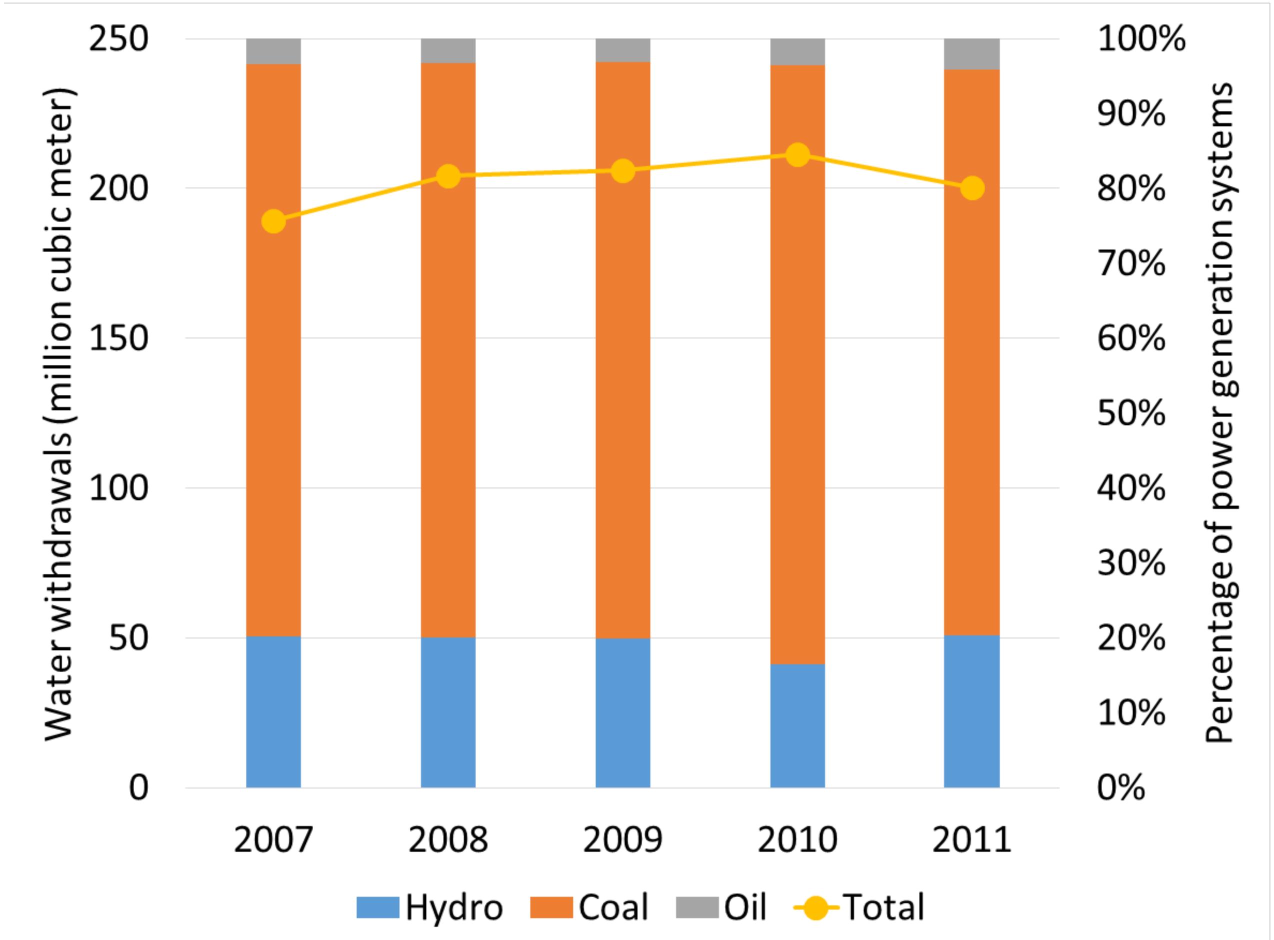
	Water consumption (m^3/MWh)	Water withdrawal (m^3/MWh)
Coal	1,469	41,088
Oil	1,557	44,310
Hydro	27,439	1,086,142

- Limitation
  - The differences of cooling systems is not taken into account .
  - Wind and photovoltaic is assumed as zero or negligible (Gleick, 1994; Rio Carrillo and Frei, 2009).

Water consumption of power generation in Mongolia



Water withdrawal of power generation

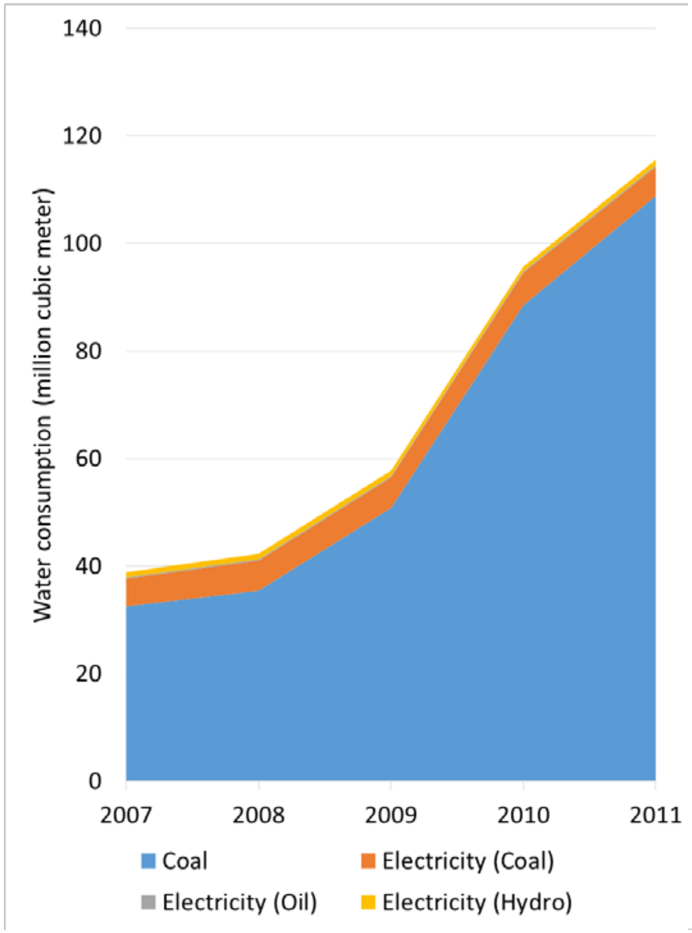


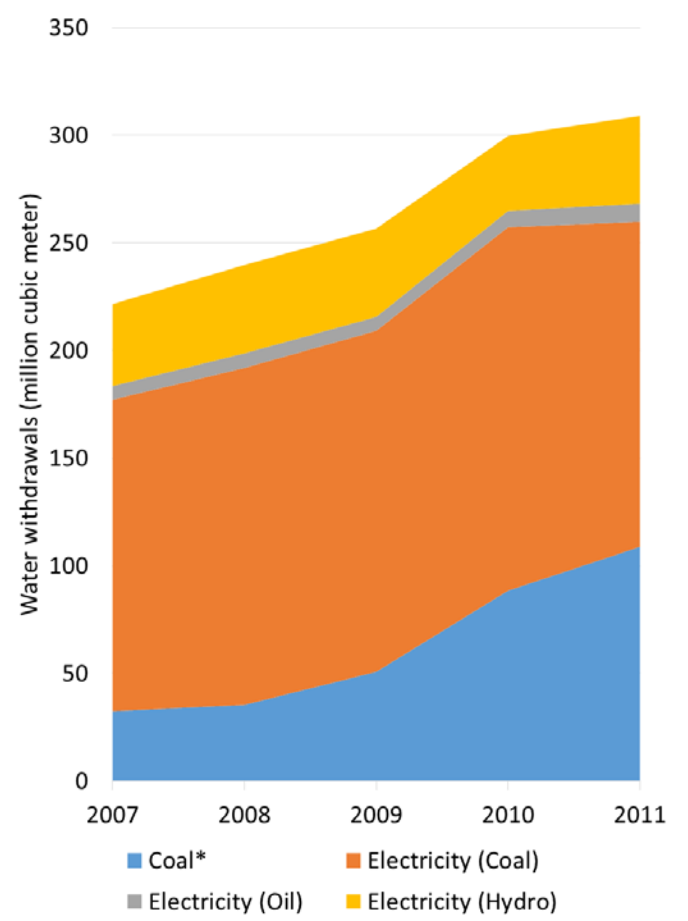
Industrial water withdrawal*
238 million m^3
(2009; FAO, 2014)

* It includes cooling water of thermoelectric plants, but it does not include hydropower.

- 69% of the industrial water is drawn by thermoelectric plants.
- Hydro additionally withdraws water corresponding to 17% of the industrial water.

Impact to water resource by energy production





* Water consumption.

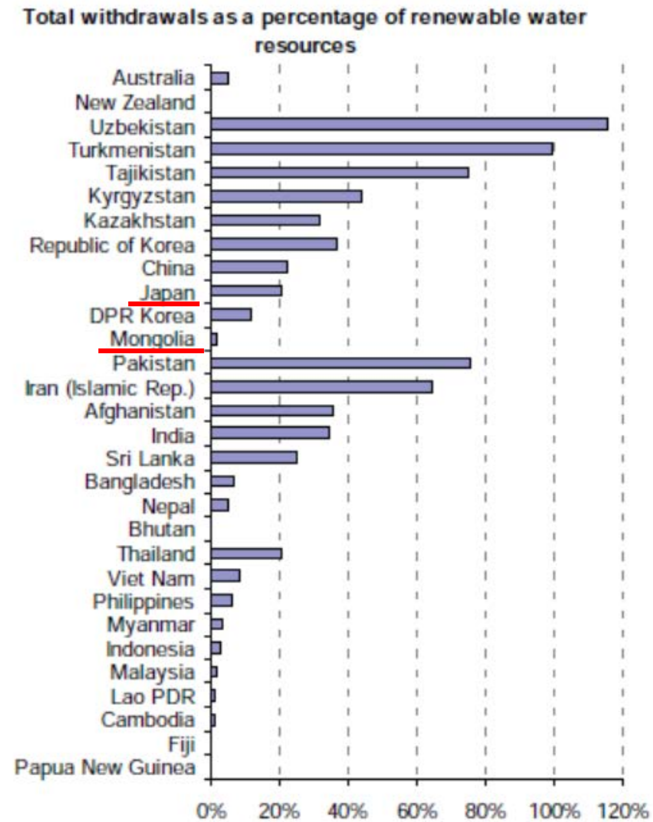
Renewable water resources
34,800 million m^3
(FAO, 2013)

6-9% of renewable water resources is withdrawn, while 1-3% of them is evaporated for energy production.

Conclusions

- Power generation has a great influence for industrial water withdrawals in Mongolia.
- Coal mining a main contributor to promote consumed water resources.
- The current impacts to water resources not so serious in the nation.
  - Low water exploitation

Water exploitation indices (WEI) in Asia-Pacific region



(Alexander and West, 2011)

Future tasks for adaptation and green development

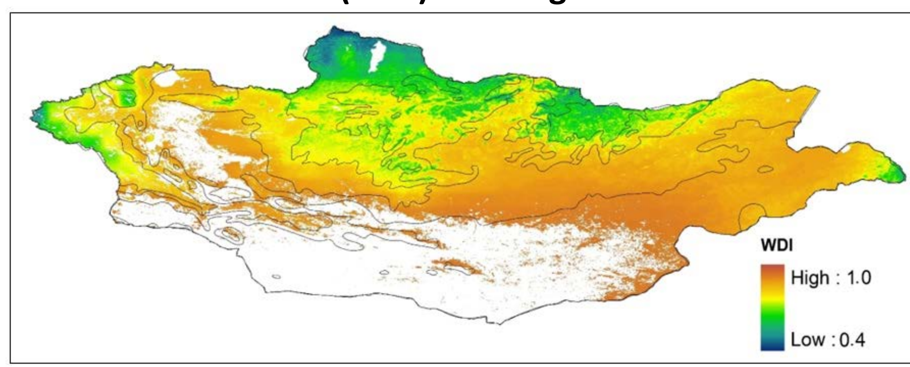
- **High potential to develop water resources**
  - Utilization of surface water
  - Advantage to sustainable energy supply (i.e. hydro power plants)
  - Increase energy demand
- **“Regional” water availability and requirement**
  - Regional water availability (i.e. WDI)
    - Controllable/usable water resources
  - Regional water requirements
    - 70% of power generation capacity is installed in Ulaanbaatar;
    - Coal is mainly produced in arid areas.
- **Multiple trade-offs (co-benefits)**
  - Water for energy production (i.e. power generation with saving water or without water)
  - Water for animal husbandry (food security) and grassland (CO_2 sequestration)
- **Regional scientific database**
  - Regional natural resources(i.e. renewable water resources, grassland)
  - Regional development level (i.e. infrastructures)
  - Verification (i.e. water use by power plants and coal mining)
- **Water-based performance index for adaptation and green developments**

Actual usage of renewable water resources in Mongolia

	Renewable water resources	Withdrawals		
Surface water	32,700	92		
Ground water	6,100	448		
Overlap	- 4,000			
Total	34,800	540		
		Agriculture	Industry	Municipal
		224	218	98

(FAO, 2014)

Water deficit index (WDI) in Mongolia



(Wang, 2014)

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Thank you for your attention.

Анхаарал тавьсан та бүхэнд баярлалаа

ご清聴ありがとうございました。

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