Towards Efficient Water Management in Nuclear Power Plants

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Overview

- Introduction
- Water needs for NPPs
- Strategies for Water Management in NPPs
- IAEA Support

The Water Crisis

844 M | 2.3 B | 2 min |

844 Million People living without access to safe water
(**1** in **9** people lack access to safe water)

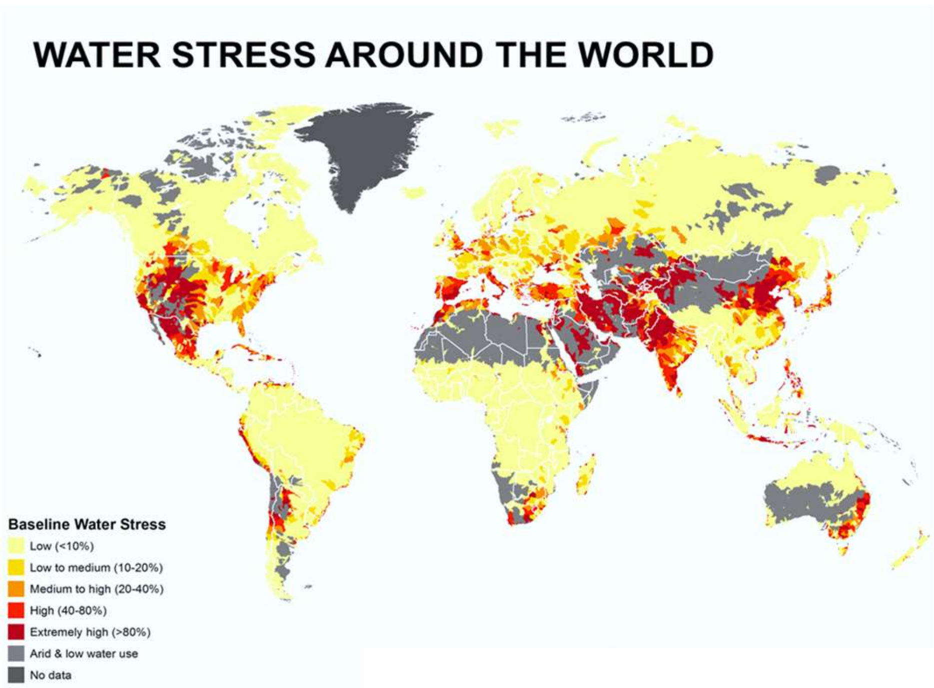
2.3 Billion People living without access to improved sanitation
(**1** in **3** people lack access to a toilet)

2 min: every 2 minutes a child dies from a water-related disease

water.org

The Water Crisis

Middle East, which is already the least water-secured region in the world, would face exceptional water-related challenges for the foreseeable future



Top Water-Stressed Countries by 2040

Name	Score
Bahrain	5.00
Kuwait	5.00
Qatar	5.00
San Marino	5.00
Singapore	5.00
UAE	5.00
Palestine	5.00
Israel	5.00
Saudi Arabia	4.99
Oman	4.97
Lebanon	4.97
Kyrgyzstan	4.93
Iran	4.91
Jordan	4.86
Libya	4.77
Yemen	4.74
Macedonia	4.70
Azerbaijan	4.69
Morocco	4.68
Kazakhstan	4.66
Iraq	4.66
Armenia	4.60
Pakistan	4.48
Chile	4.45
Syria	4.44
Turkmenistan	4.30
Turkey	4.27
Greece	4.23
Uzbekistan	4.19
Algeria	4.17
Afghanistan	4.12
Spain	4.07
Tunisia	4.06

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World Resources Institute, 2015

Countries already *operating*/*constructing*/ *considering* nuclear power plants (NPPs)

Singapore

Morocco

Turkey

UAE

Kazakhstan

Uzbekistan

Saudi Arabia

Armenia

Algeria

Iran

Pakistan

Jordan

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World Resources Institute, 2015

Water needs for NPPs

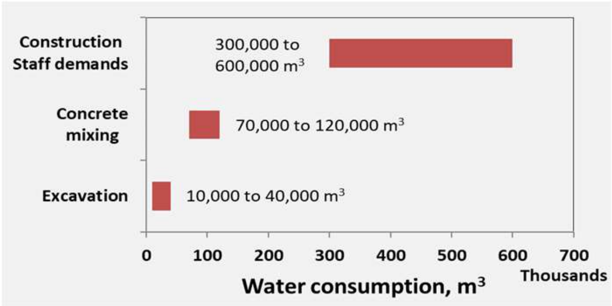
NPP with once-through cooling requires **water withdrawal** of **1.25 – 3.0** times that of a Fossil-based Power Plant*.

NPP with cooling tower or cooling pond **consumes** more than **Double** the water consumed by comparable fossil-based Power Plant*.

* of same capacity

Water needs for NPPs

Water consumption during 4- 5 years of NPP construction period



water consumption is mainly for cleaning and flushing and initial filling for the plants operating circuits. 20,000 to 30,000 m^3 used during commissioning, in addition an average of 300 m^3 per day for the staff use.

Reactor cooling is no longer required.

<u>water is required for:</u>

- **spent fuel cooling,**
- **decommissioning of other industrial facilities,**
- **dust control.**

Water needs for operating NPPs

WATER FLOW RATES IN CLOSED LOOP FOR A 1000 MW(e) NPP	Turbine condenser cooling (m^3/s)	Supporting systems cooling (m^3/s)
Recirculating cooling water	46	1.2
Evaporation losses	0.63	0.016
Blow-down losses	0.4	0.011
Make up water to compensate losses	1.03	0.027

More than 90 000 m^3/d

Cover the needs of 150,000 – 1,500,000 people

Approximate Flow Requirements for NPPs

For once-through cooling of typical 1000 MWe NPP:

- **30 m^3/sec or 476,500 gpm (for 30 ΔT)**
- **45 m^3/sec or 714,750 gpm (for 20 ΔT)**

  - flow, gpm = 14,295 x MWe /ΔT

Water needs for NPPs

Ultimate Heat Sink

- Range depends on design & Rated power: 4000 – 15000 m^3
- Provide all of the nuclear power reactor's cooling water and makeup water needs for the first 30 days of an accident as a minimum.

Strategies for Watering (NPPs)

Use of Desalination

Construction:

- (RO: potable water)

Operation:

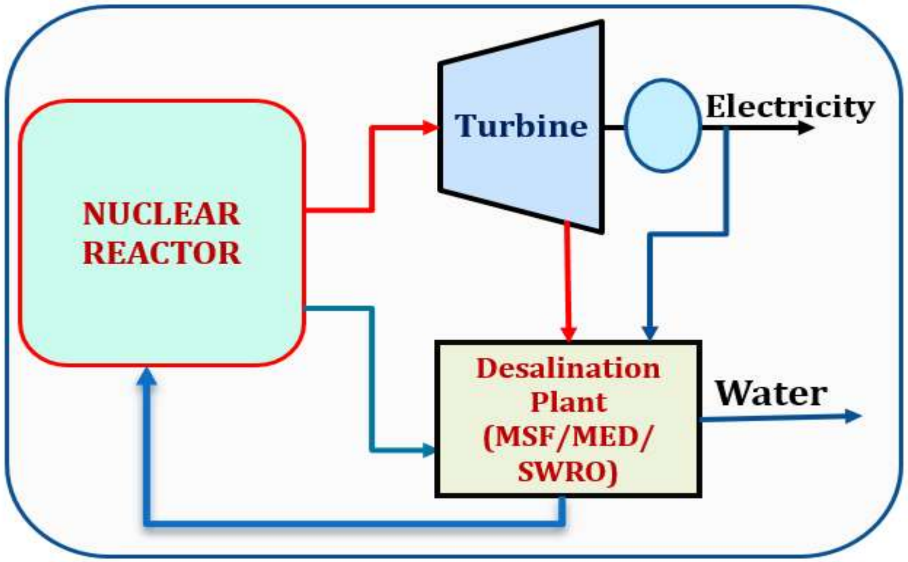
- (Hybrid: RO + MED/MSF:makeup)

Accident /Emergency:

- (RO: decontamination)

Shared Resources:

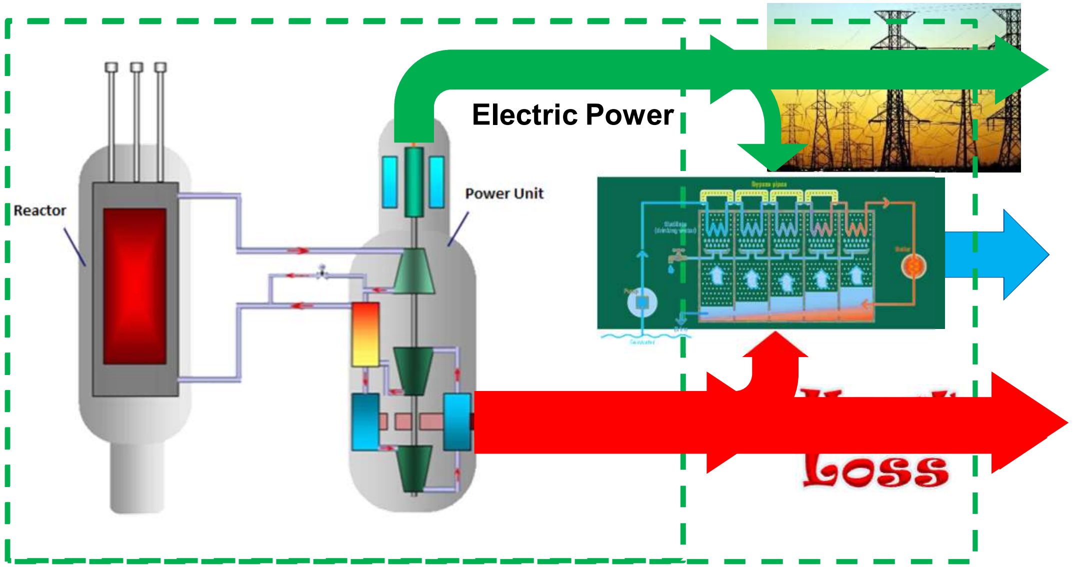
- (intake & outfall)



Strategies for Watering (NPPs)

Use of Waste Heat from NPP: for Desalination

Waste heat: **Heat extracted from NPP with no considerable penalty to the power production**

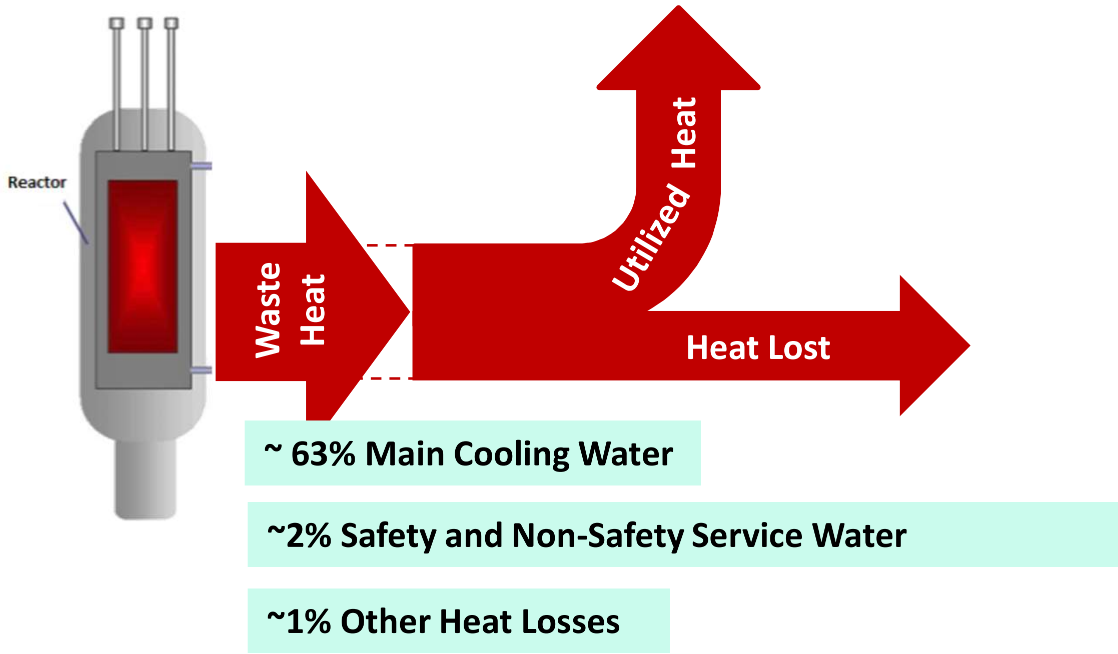


Strategies for Watering (NPPs)

Reduce Cooling Requirements: Harness the waste heat

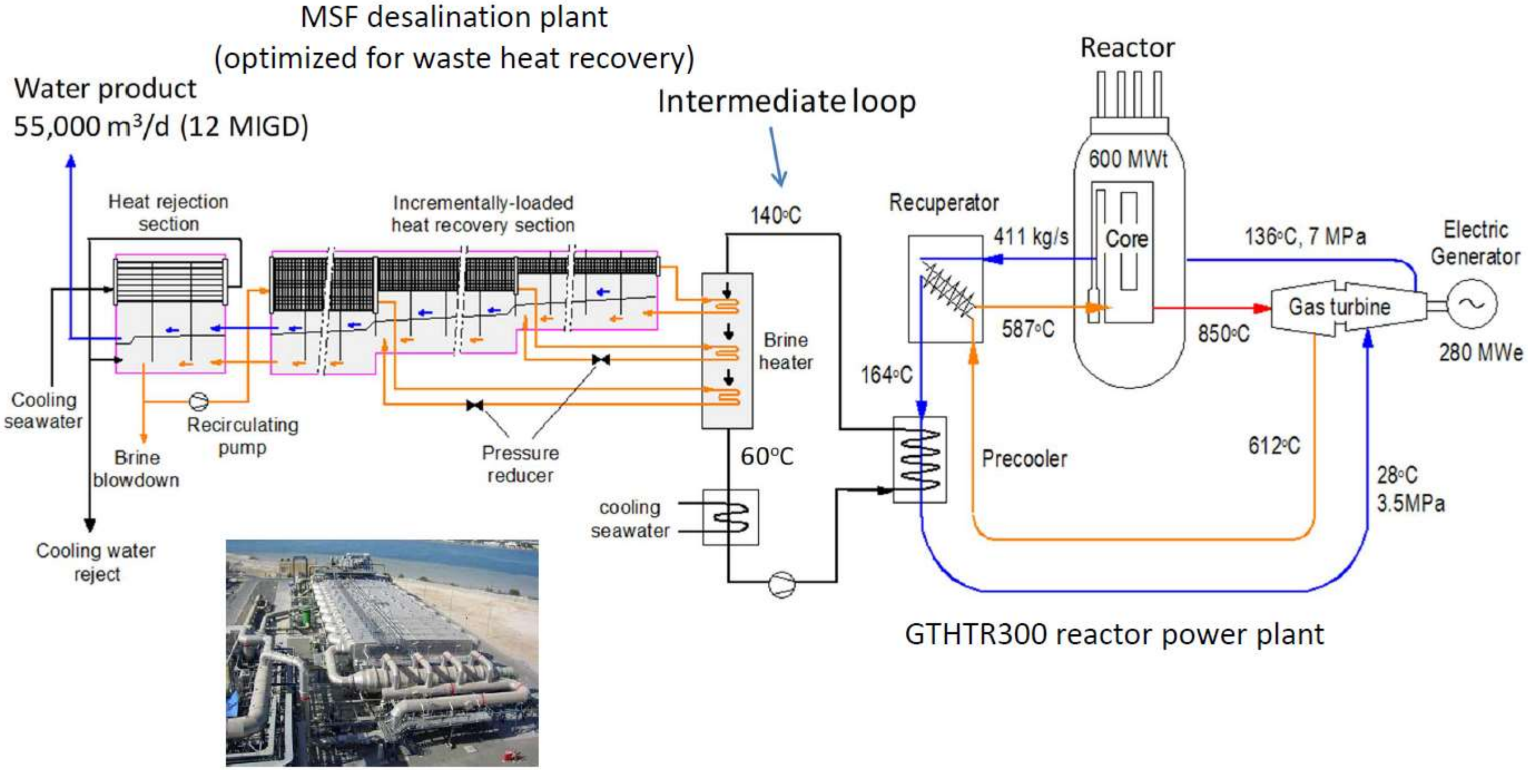
(Think of zero-brine discharge)

Cogeneration!



Strategies for Watering (NPPs)

Use advanced technologies: High Temperature Reactors !!!



Y. Xang, 2018

Strategies for Watering (NPPs)

Competitive cost for nuclear desalination using HTRs

Desalination costs between HTGR and fossil-fired CCGT

Plant ->	CCGT desalination plant		HTGR desalination plant
	Oil-fired**	Gas-fired**	
Capital (US$/m³)	0.29	0.29	0.39
Energy (US$/m³)			
Heat	1.65	0.67	0.04
Electricity	0.13	0.13	0.09
Operation (US$/m³)			
Consumables	0.02	0.02	0.02
O&M	0.03	0.03	0.03
Water cost (US$/m³)	**2.13**	**1.14**	**0.57**

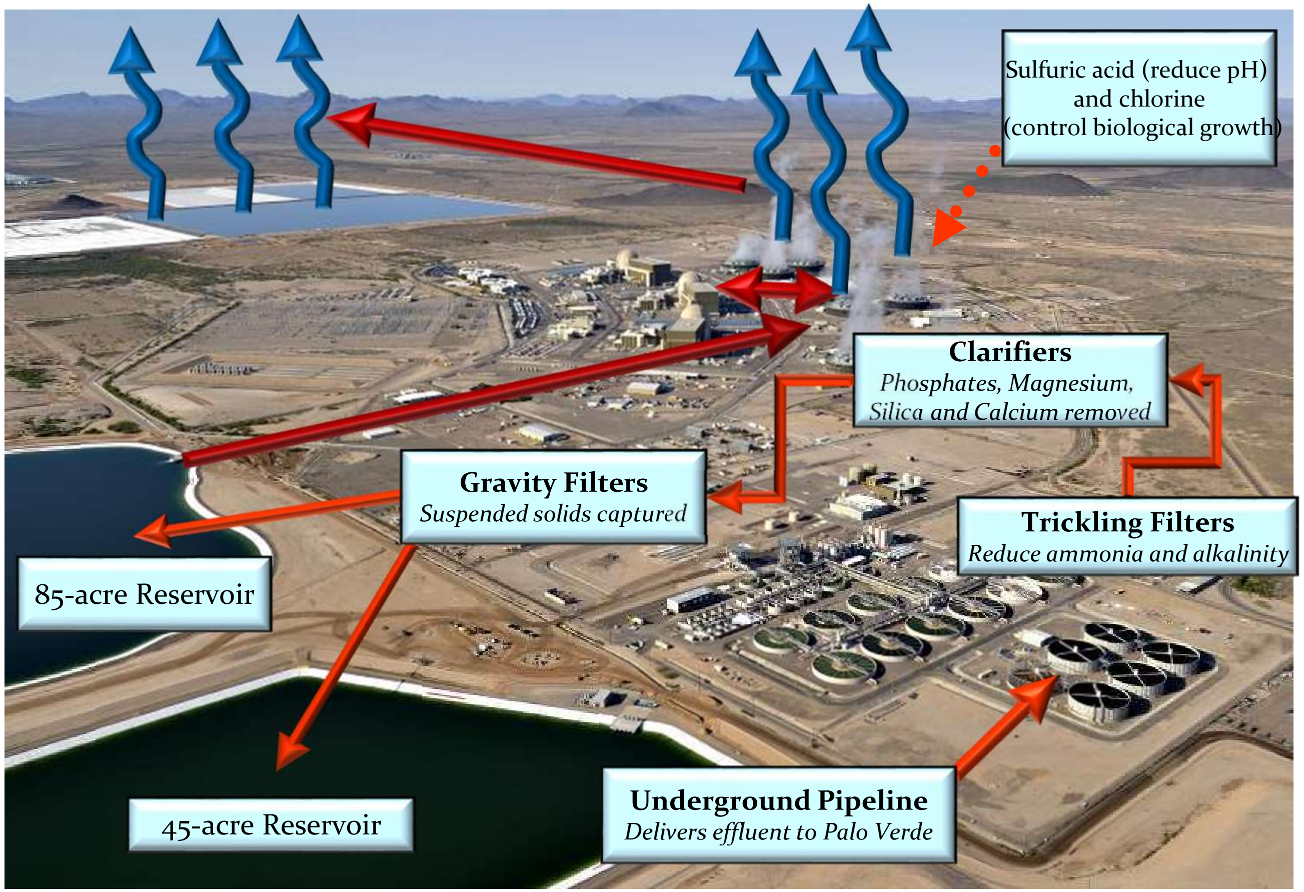
** Cost of fuel oil is 79.8 US$/bbl, the minimum of the average of Brent, Dubai and WTI benchmarks during 2004.7 to 2014.7 and natural gas 5.6 US$/MMBtu, the minimum of the average of US, Europe and Japan prices in the same period.

Y. Xang, 2018

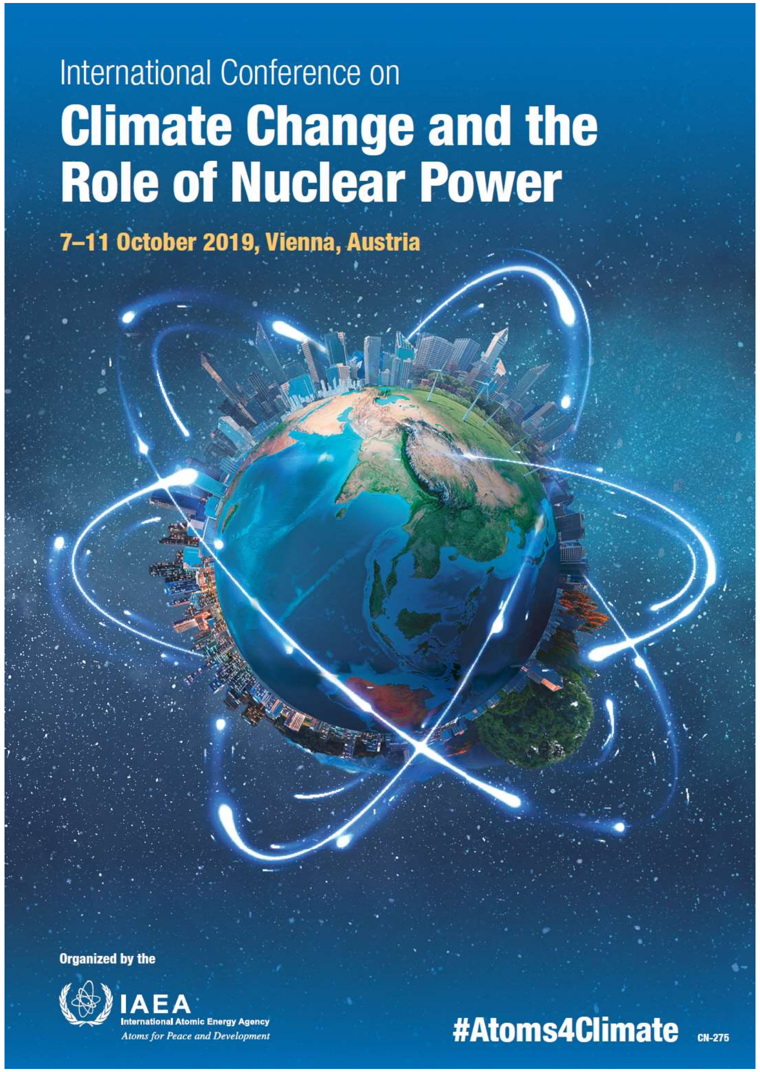
Strategies for Watering (NPPs)

Think of other Water Resources for NPPs!!!

WATER RECLIAMATION FACILITY at Palo Verde NPP (USA)



Upcoming IAEA Major event in 2019



iaea.org/Atoms4Climate

Atoms4Climate@iaea.org

iaea.org/atoms4climate

Purpose/ scope:

To provide a forum on:

- ✓ the role of nuclear power,
- ✓ the opportunities and challenges of safe, secure and safeguarded nuclear technology development in supporting the low-carbon energy transformation needed to achieve the climate change goals.

The conference themes include a description of the mitigation challenge, implications for the power sector, environmental perspectives, and potential roles of existing, evolutionary and innovative nuclear power systems, including the integration of nuclear/renewable energy systems.

Email:

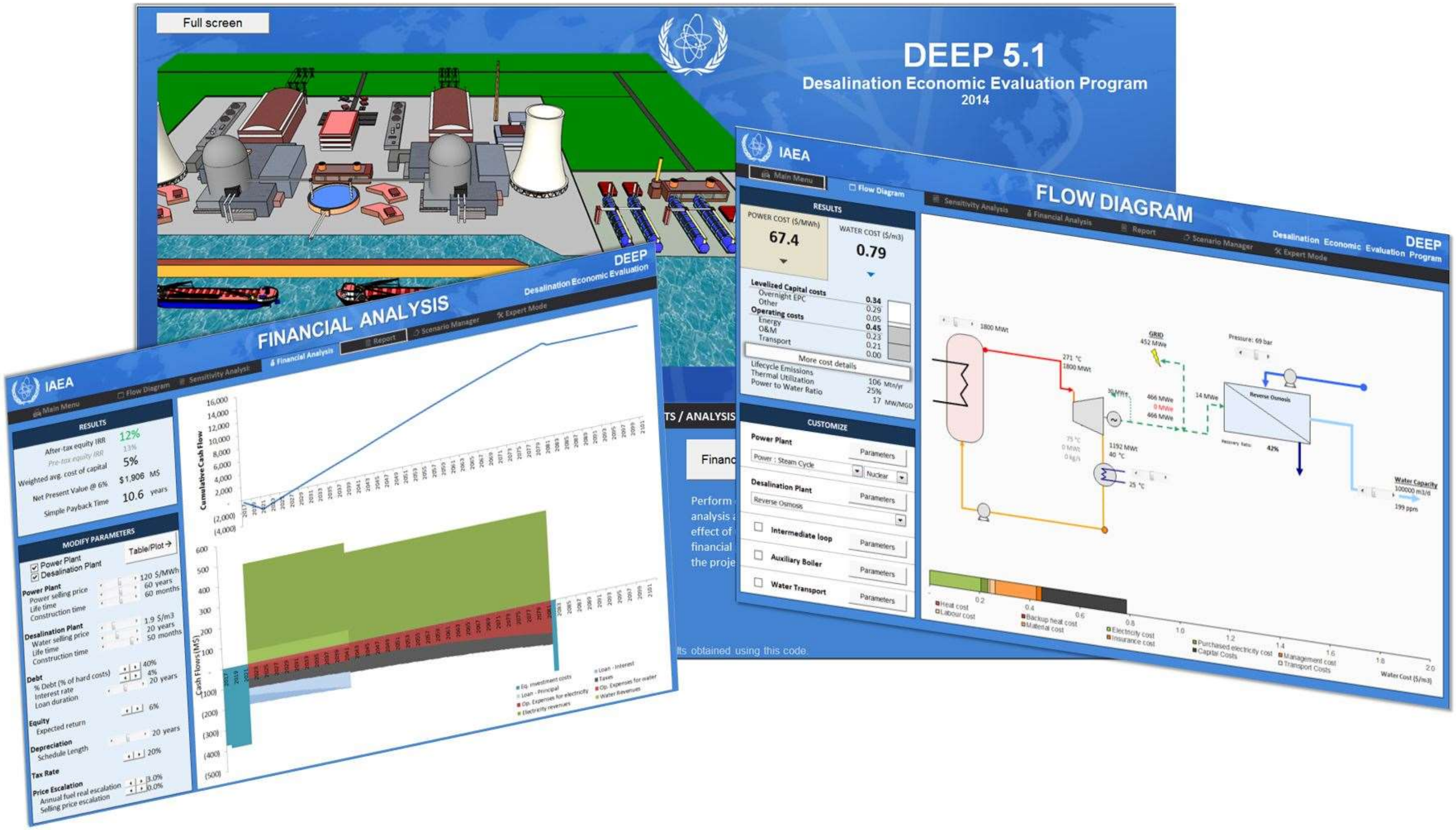
Atoms4Climate@iaea.org

Key deadlines:

- Submission of contributed papers, including Forms A and B, through official channels to the IAEA
  28 April 2019
- Submission of Grant Application Form (Form C) through official channels
  28 April 2019
- Deadline for exhibitor registration
  31 May 2019
- Notification of acceptance of paper
  26 June 2019

DEEP

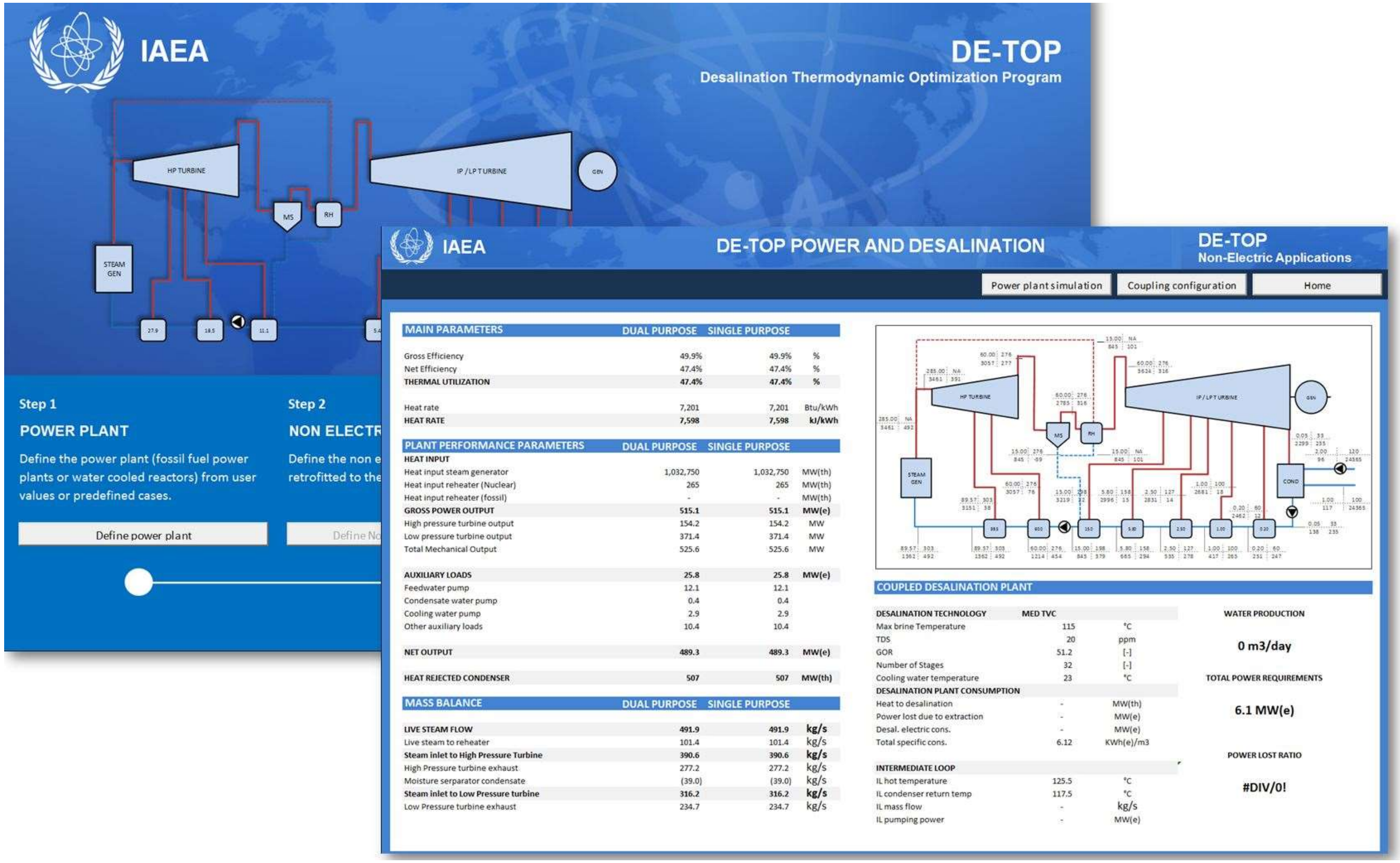
performance and cost evaluation of various power and seawater desalination cogeneration configurations.



Desalination Economic Evaluation Programme

DE-TOP

models the steam power cycle of different WCRs coupled with nonelectrical applications



Desalination Thermodynamic Optimization

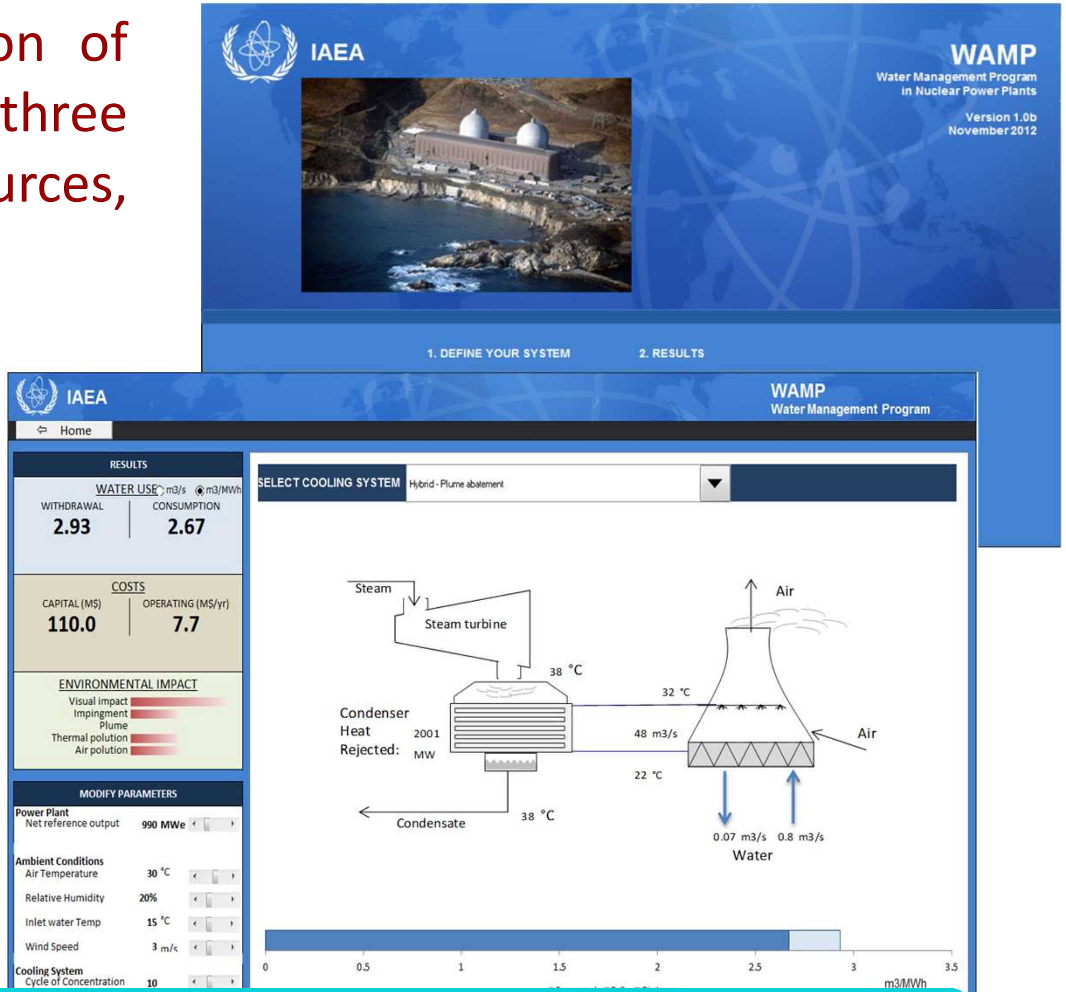
WAMP

Estimates water needs in NPPs especially for WCRs

WAMP helps in the selection of cooling systems by evaluating three different criteria: Water resources, environmental, economical.

WAMP estimates water needs in NPPs especially for water cooled nuclear power plants.

WAMP estimates both the needs for cooling water and other essential systems.



Water Management Program

IAEA Publications