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IAEA Role, Tools & Activities on Non-Electric Applications and Cogeneration Using Nuclear Energy

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International Atomic Energy Agency

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Contents

- ❑ IAEA and its Role
- ❑ IAEA Meetings & Activities (2017-2018)
- ❑ Tools & Toolkits
- ❑ Recent & Upcoming Publications
- ❑ Questions & Discussion!

Activities of IAEA Project on Non-Electric Applications

IAEA Project on Non-Electric Applications

Events

- Technical Meetings
- Research Coordination Meetings
- Training Workshops
- Consultants Meetings
- Conferences

Tools & Toolkits

- HEEP
- DEEP
- DE-TOP
- WAMP
- Hydrogen Toolkit
- Desalination Toolkit

Publications

- Technical Documents
- Nuclear Energy Series Documents
- Meeting Reports
- Peer-Reviewed Journal Publications
- Conference Papers

International Atomic Energy Agency
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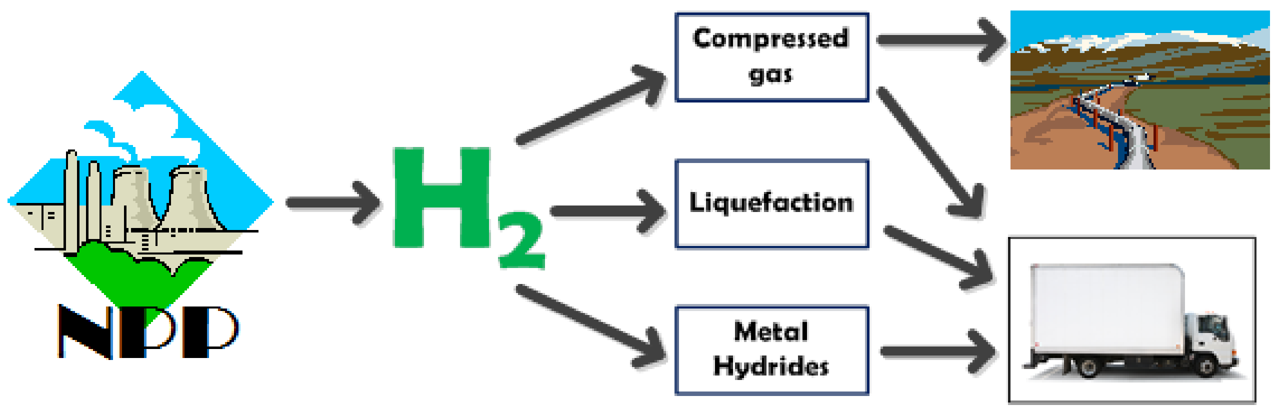
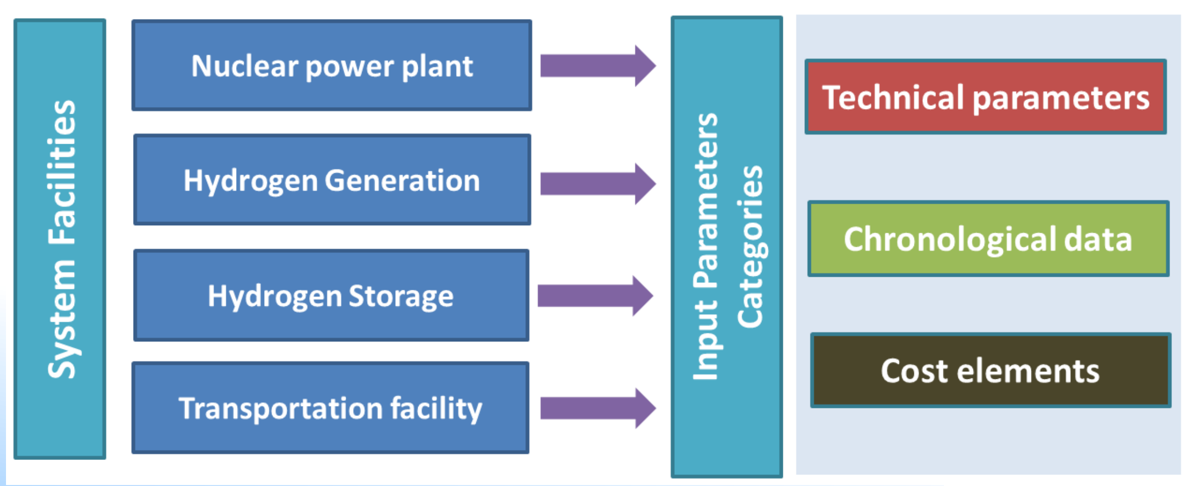
IAEA Tools & Toolkits

IAEA Tool on Nuclear Hydrogen Production

HEEP Hydrogen Economic Evaluation Programme

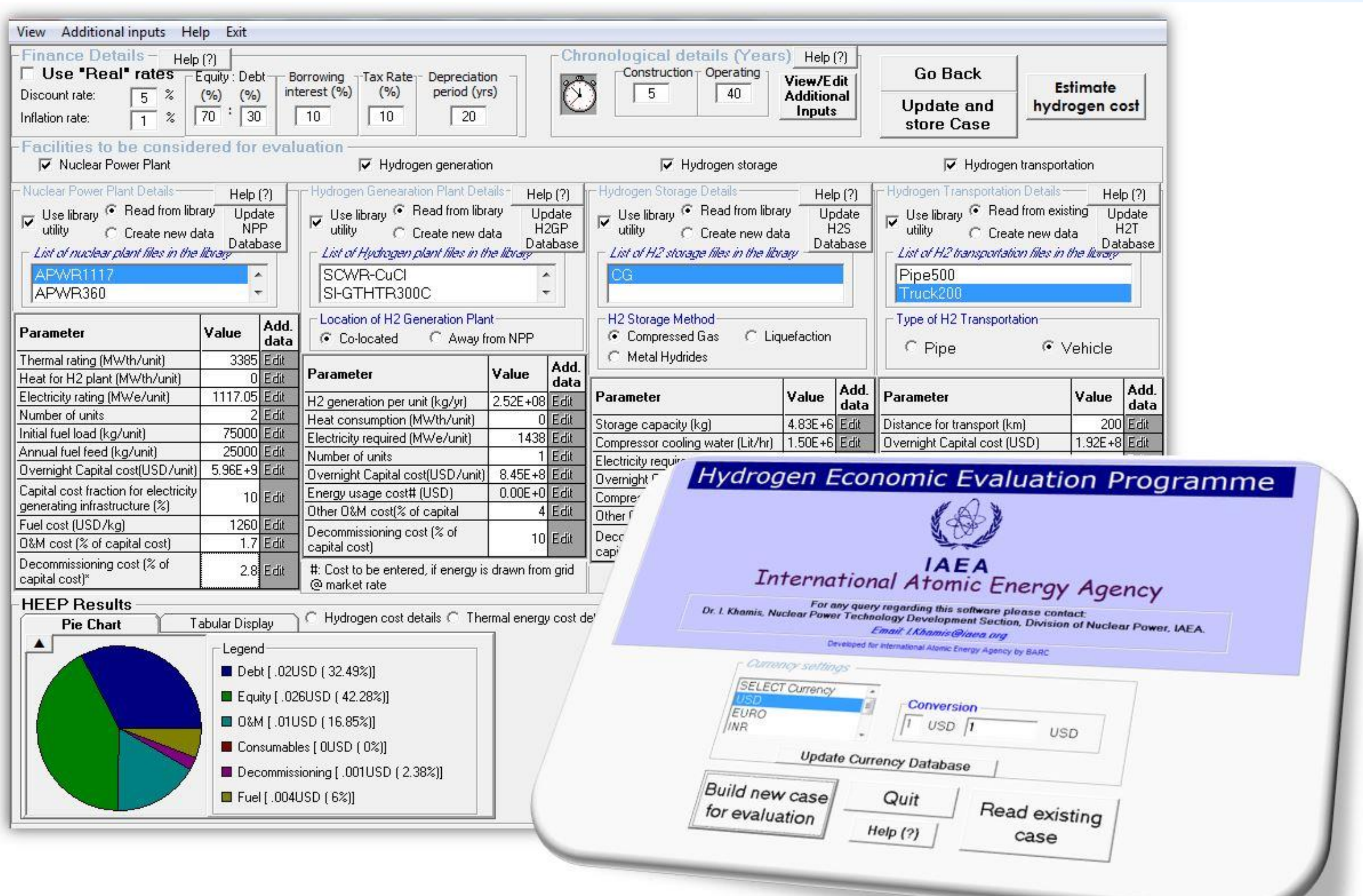




HEEP

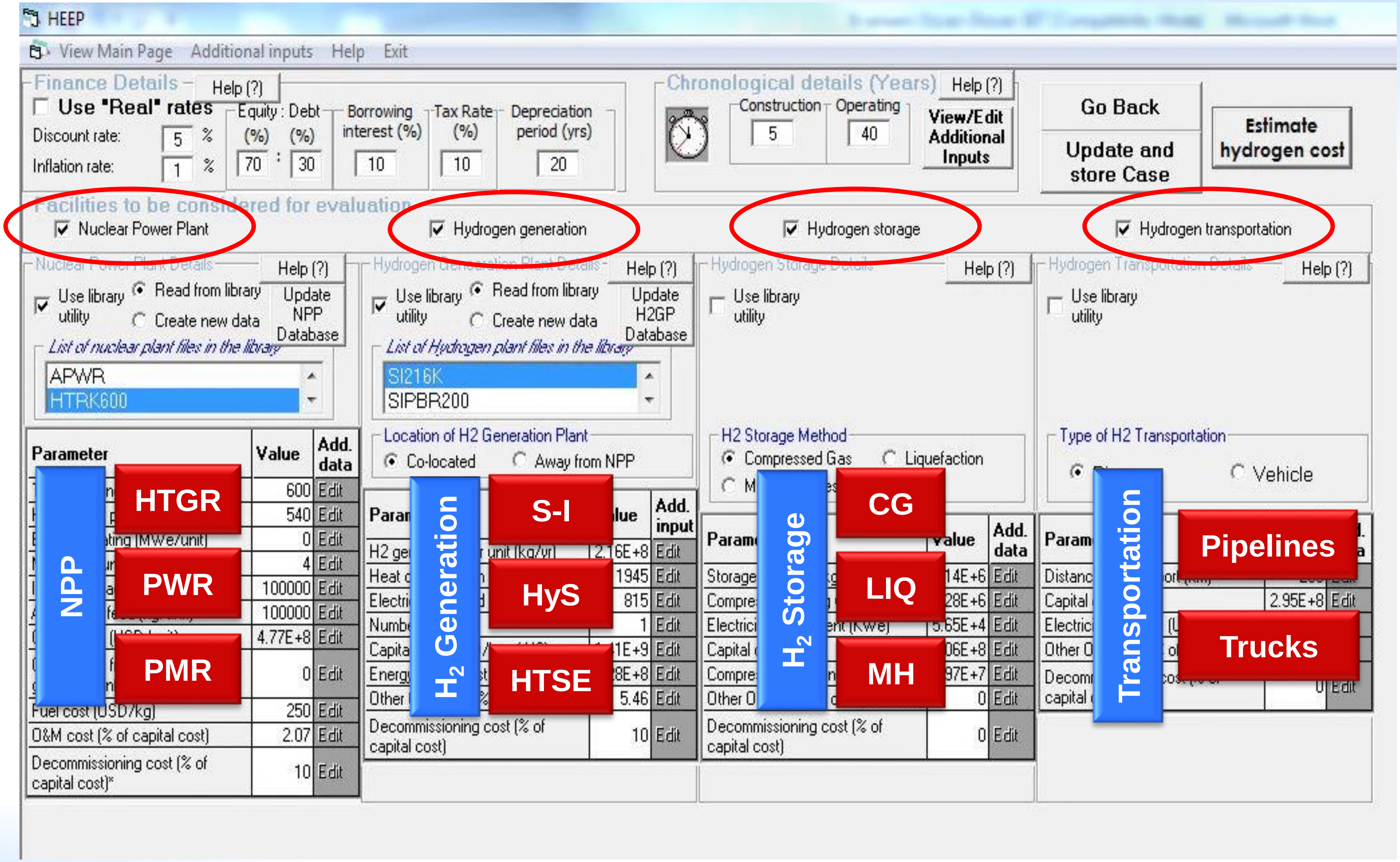
Evaluates the economics of the most promising processes for hydrogen production

IAEA



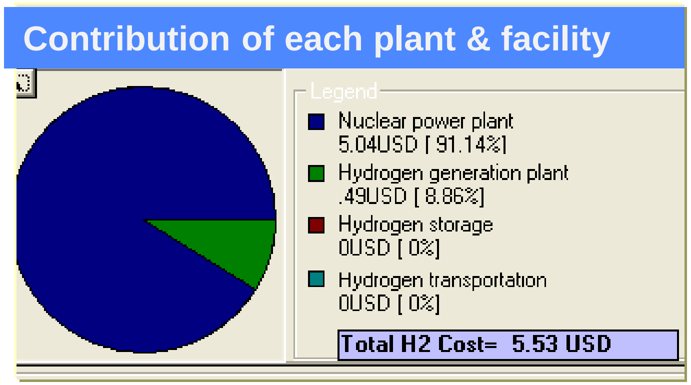
Hydrogen Economic Evaluation Programme

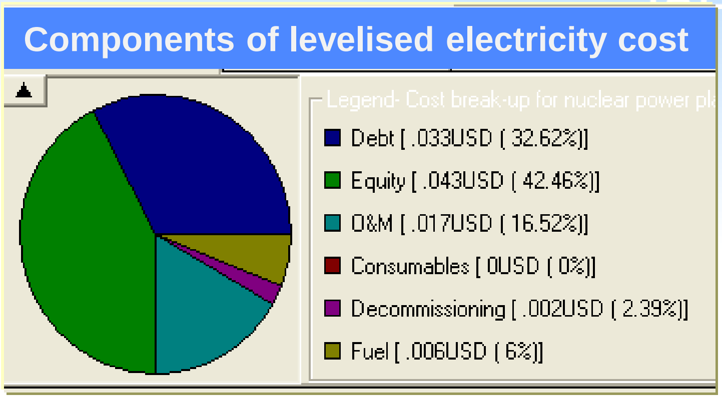
HEEP Features



A captured image from main page of HEEP software

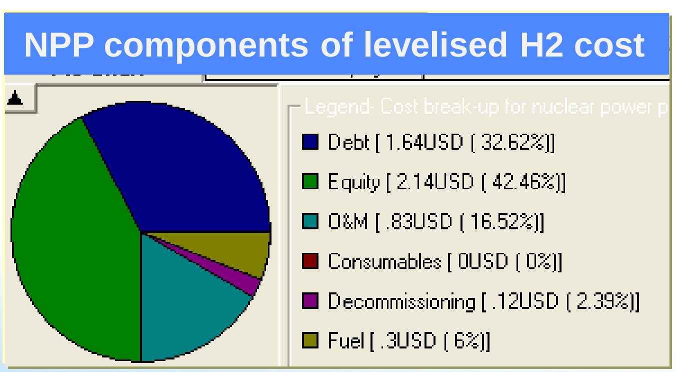
HEEP Results





Provides levelised cost of unit energy in the form of heat and/or electricity as an output.

Directly give contribution of each plant & facilities in total H2 cost.



Models the location of H2 generation plant with respect to the nuclear power plant and facilitate

Facilitates the study of effect of source of electricity/heat energy on the cost of hydrogen generation.

Hydrogen Economic Evaluation Programme

International Atomic Energy Agency

For any query regarding this software please contact:
Dr. I. Khamis, Nuclear Power Technology Development Section, Division of Nuclear Power, IAEA. (I.Khamis@iaea.org)

Developed for International Atomic Energy Agency by BARC

Table - 1: Finance details (using 'Nominal' rates)

Discount rate	5%
Inflation rate	1
Equity/Debt	70% : 30%
Borrowing interest	10%
Tax rate	10%

Table - 2: Time Period (years)

Construction	5
Operation	40

Table - 3: Nuclear Power Plant Details

Thermal rating (MWth/unit)	600
Heat for H2 plant (MWth/unit)	170
Electricity rating (MWe/unit)	203.99
Number of units	1
Initial fuel load (kg/unit)	7090
Annual fuel feed (kg/unit)	1773
Overnight Capital cost(USD/unit)	5.50E+8
Capital cost fraction for electricity generating infrastructure (%)	21
Fuel cost (USD/kg)	12962
O&M cost (% of capital cost)	3.98
Decommissioning cost (% of capital cost)*	0.52

Table - 4: Hydrogen Generation Plant Details

H2 generation per unit (kg/yr)	2.17E+07
Heat consumption (MWth/unit)	170
Electricity required (MWe/unit)	25.4
Number of units	1
Overnight Capital cost(USD/unit)	1.43E+8
Energy usage cost# (USD)	0.00E+0
Other O&M cost(% of capital cost)	4.26
Decommissioning cost (% of capital cost)	0

Table - 5: Hydrogen Storage Details

Storage capacity (kg)	4.16E+5
Compressor cooling water (Lit/hr)	5.18E+5
Electricity requirement (KWe)	5.67E+3
Overnight Capital cost (USD)	6.47E+7
Compressor operating cost (USD)	9.08E+3
Other O&M cost (% of capital cost)	0
Decommissioning cost (% of capital cost)	0

Table - 6: Hydrogen Transportation Details

Distance for transport (km)	500
Overnight Capital cost (USD)	2.39E+8
Electricity charges (USD)	0.00E+0
Other O&M cost (% of capital cost)	1
Decommissioning cost (% of capital cost)	1

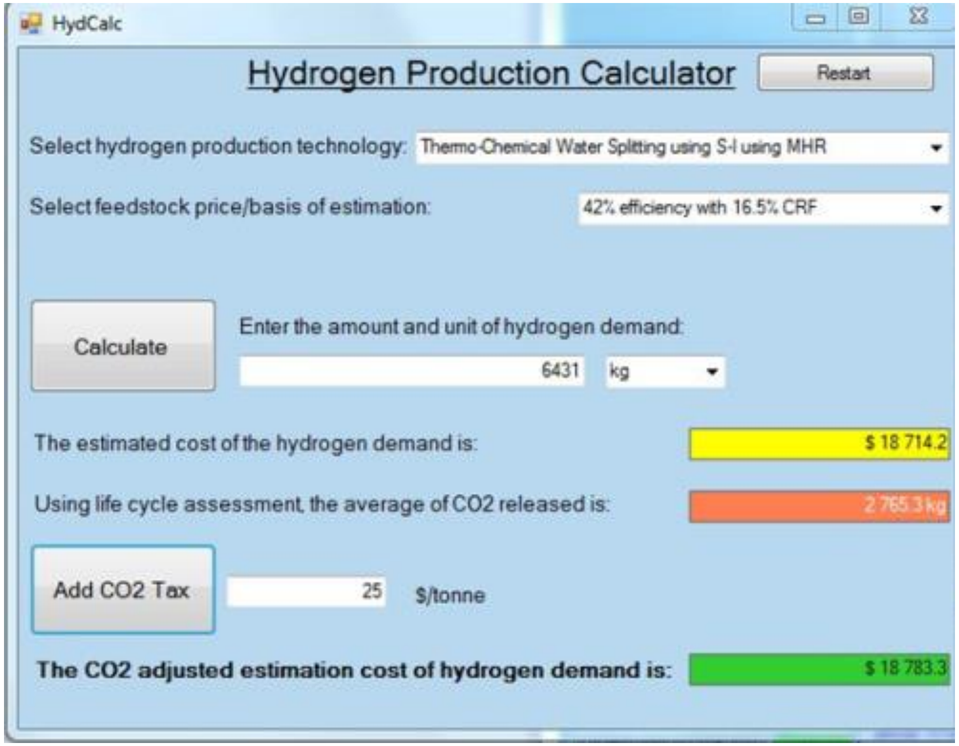
HYDCALC Hydrogen Calculator

HydCalc is a single window calculator to make rough estimate of the hydrogen production cost utilizing different technologies.

HydCalc provides cost value of hydrogen based on average estimated **CO_2** release.

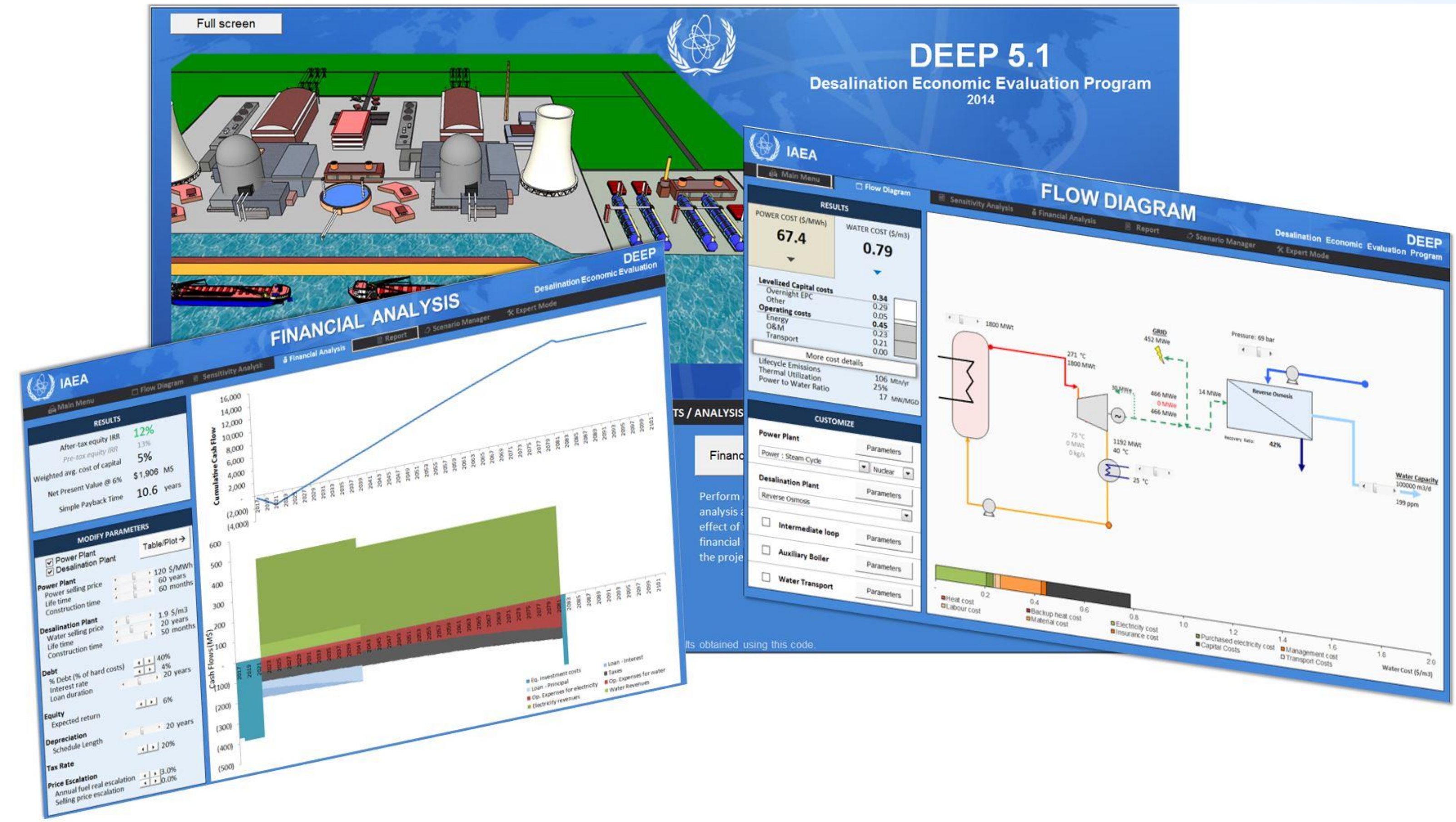
HydCalc also considers the effect of **CO_2 tax** on the production cost.

HydCalc uses current price estimate from publications and articles in open literature.



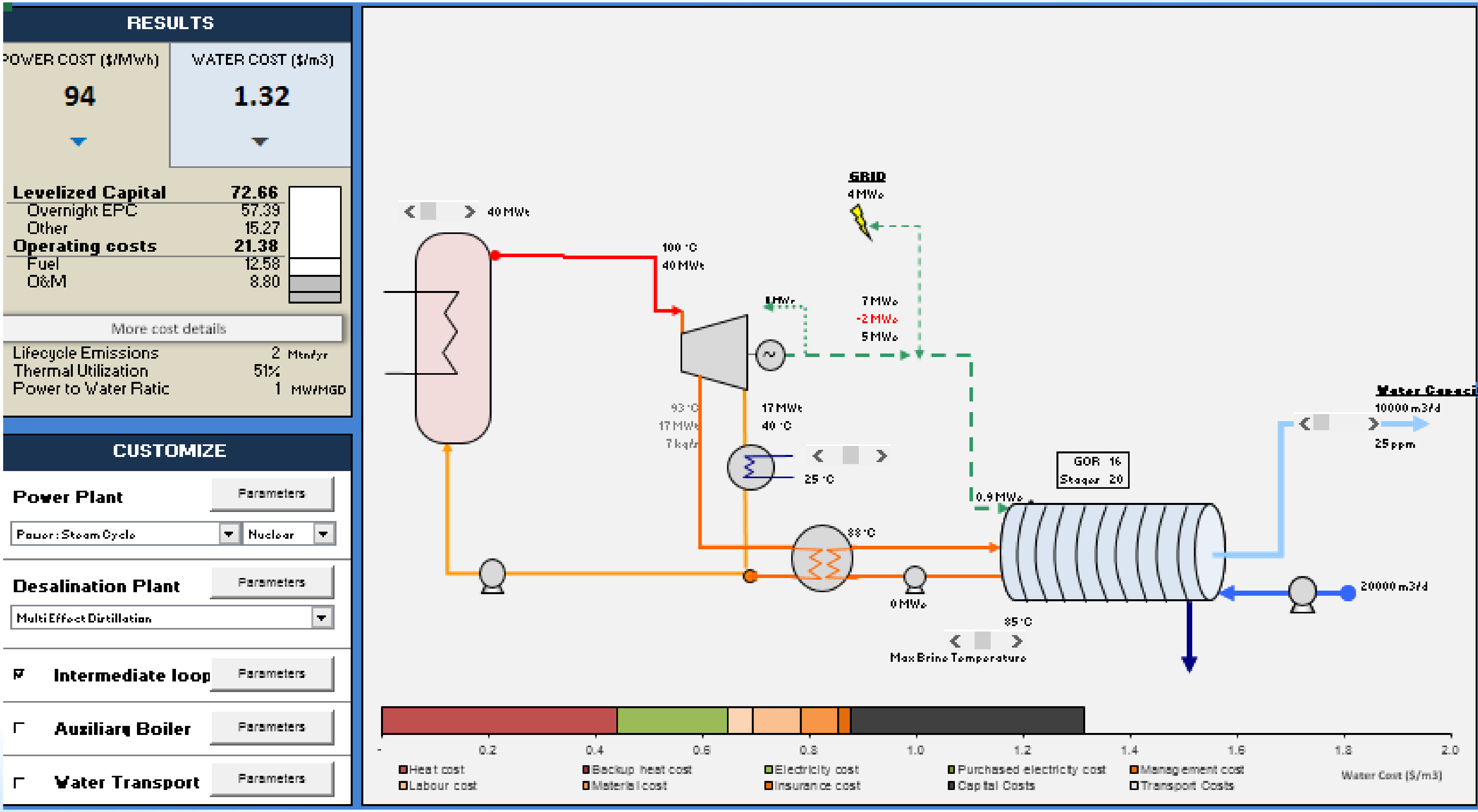
DEEP

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



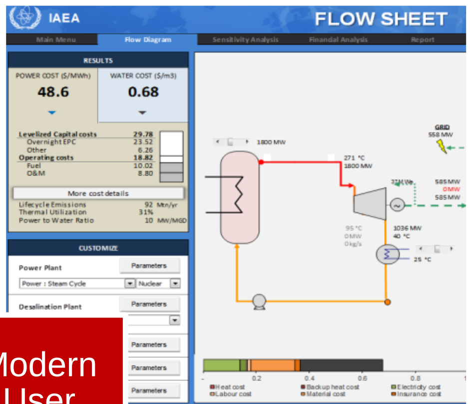
Desalination Economic Evaluation Programme

NPP with NF-MED steam at 92 C and 20 effects with GOR 16 using hot water transformer.

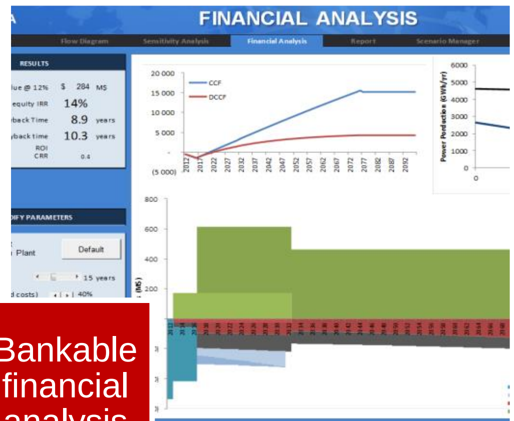


IAEA Tool on Nuclear Desalination

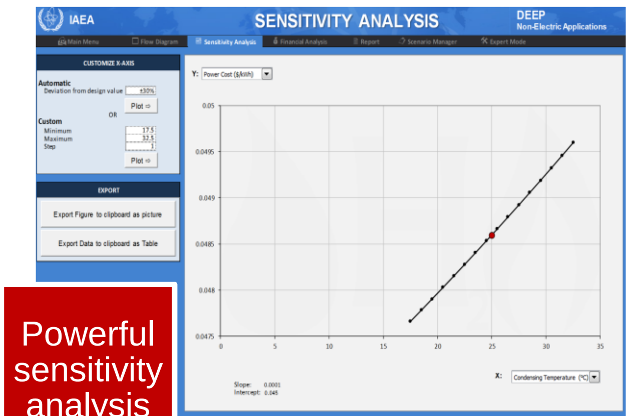
DEEP Desalination Economic Evaluation Programme



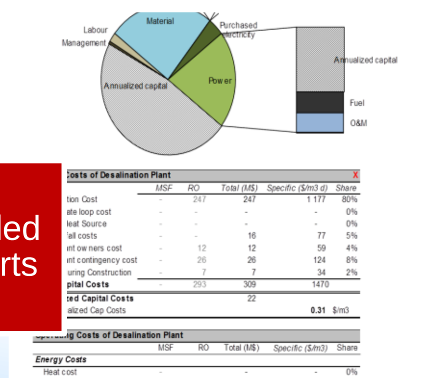
Modern User Interface



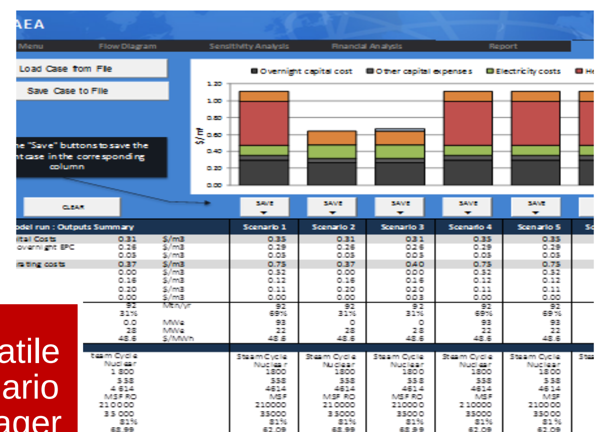
Bankable financial analysis



Powerful sensitivity analysis



Detailed Reports



Versatile scenario Manager

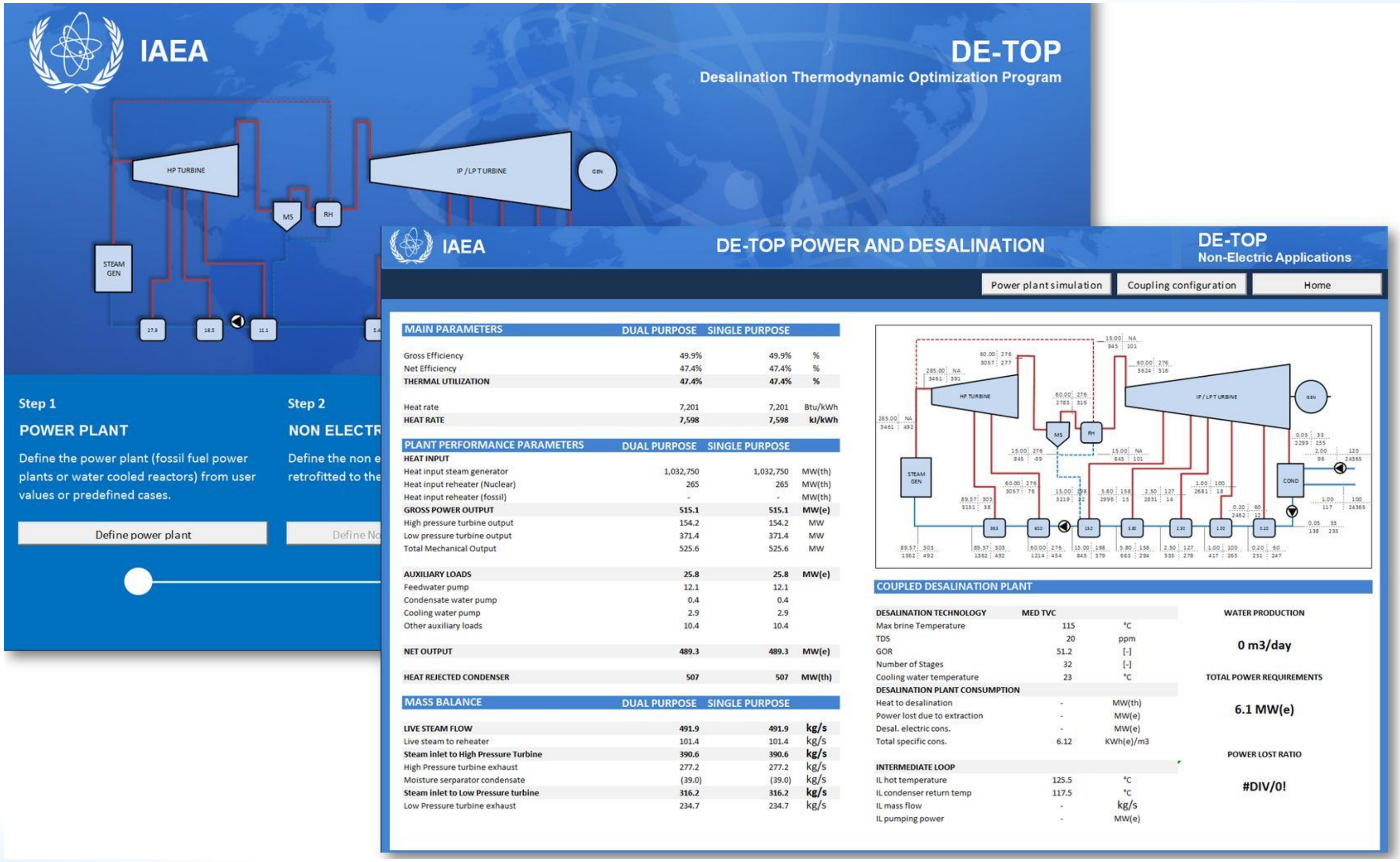
IAEA TOOLKIT

Nuclear Desalination

- Up-to-date information
- Link to IAEA tools
- Highlights of IAEA Publications
- News on IAEA Activities
- Summaries of the TWG-ND
- Newsletter on nuclear desalination

DE-TOP

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



Desalination Thermodynamic Optimization

DE-TOP Structure

POWER PLANT INPUT

HEAT SOURCE → POWER CYCLE

Supported Power plant types:

Nuclear power plants

(PWR, PWR, PHWR)

Fossil steam power cycles

COGENERATION INPUT

NON ELECTRIC APP SPECS → COUPLING

NON-ELECTRIC APPLICATION

Desalination, Process heat, District Heating, etc.

COUPLING CONFIGURATION

Energy requirements and coupling alternative

RESULTS

REPORT

COMPLETE REPORT

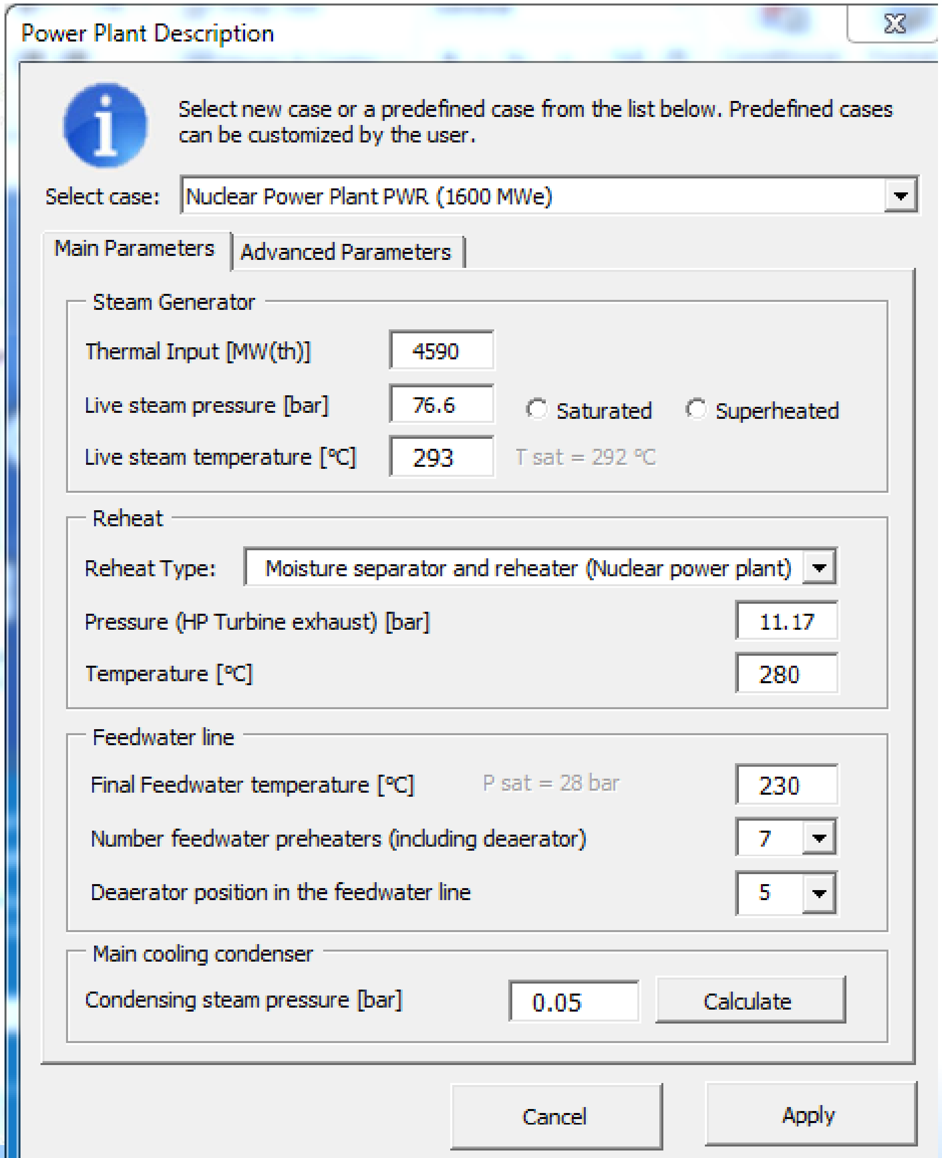
Power lost
Thermal utilization
Other significant parameters

CASE COMPARISON

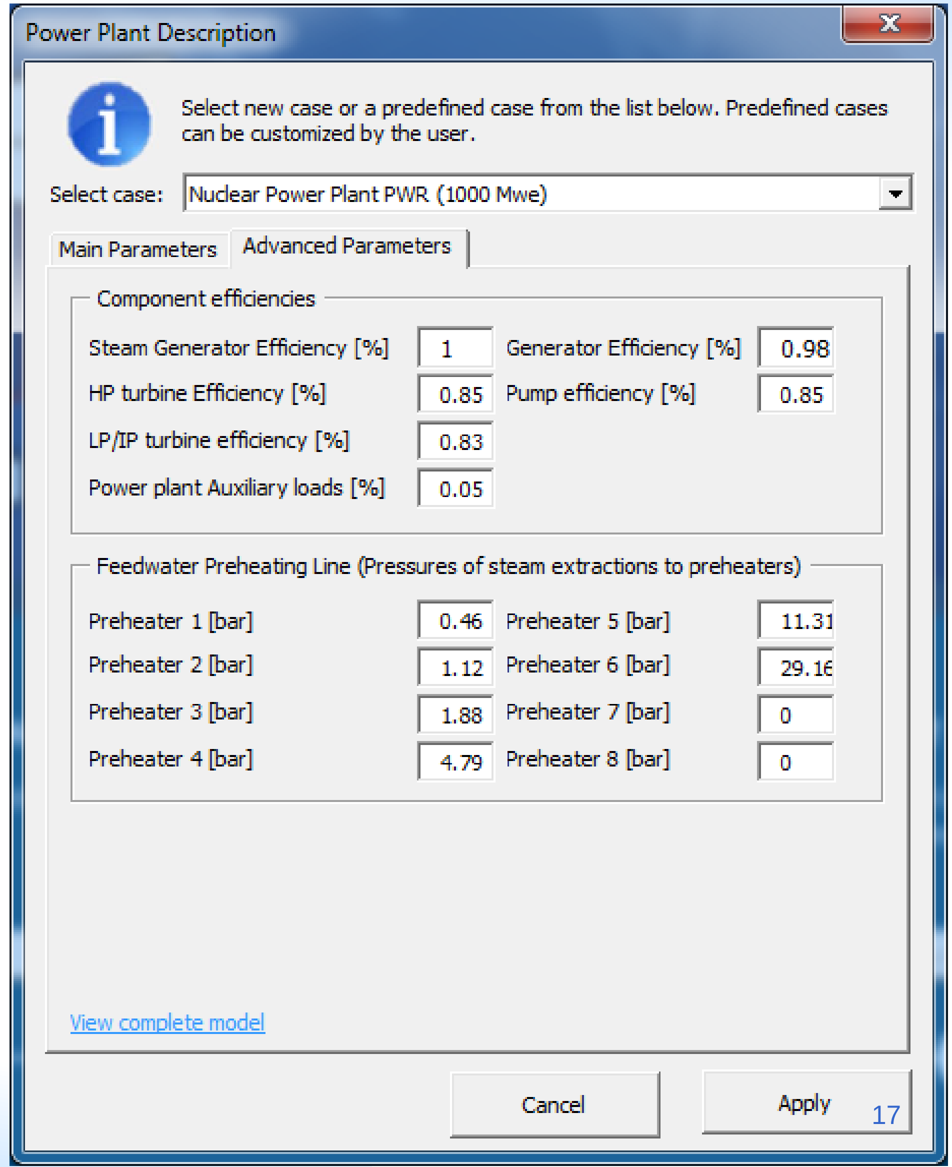
Between different configuration options

Inputs for the NPP

Main-Input Parameters



Advanced-Input Parameters

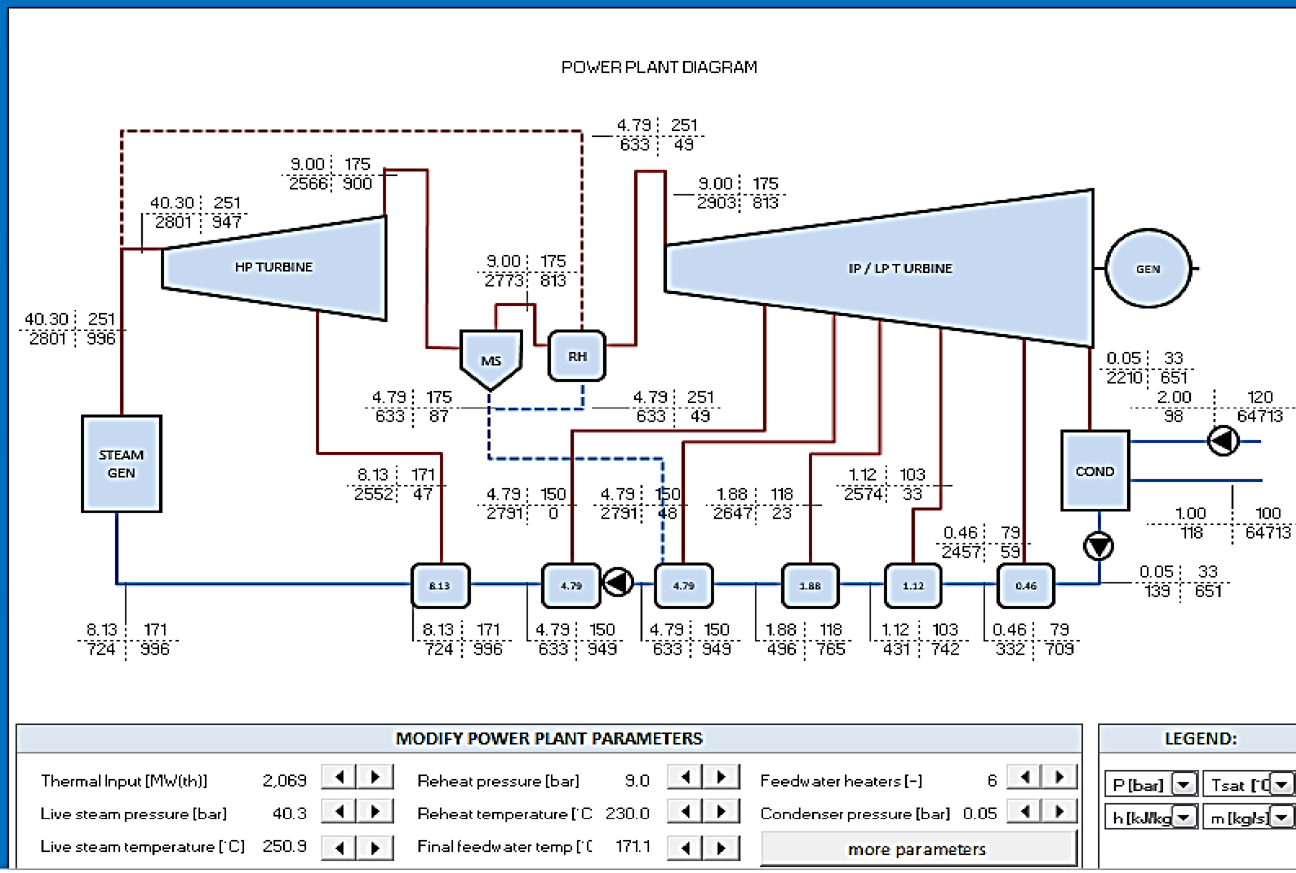


Plant Simulation Pickering CANDU-6 NPP

Next step

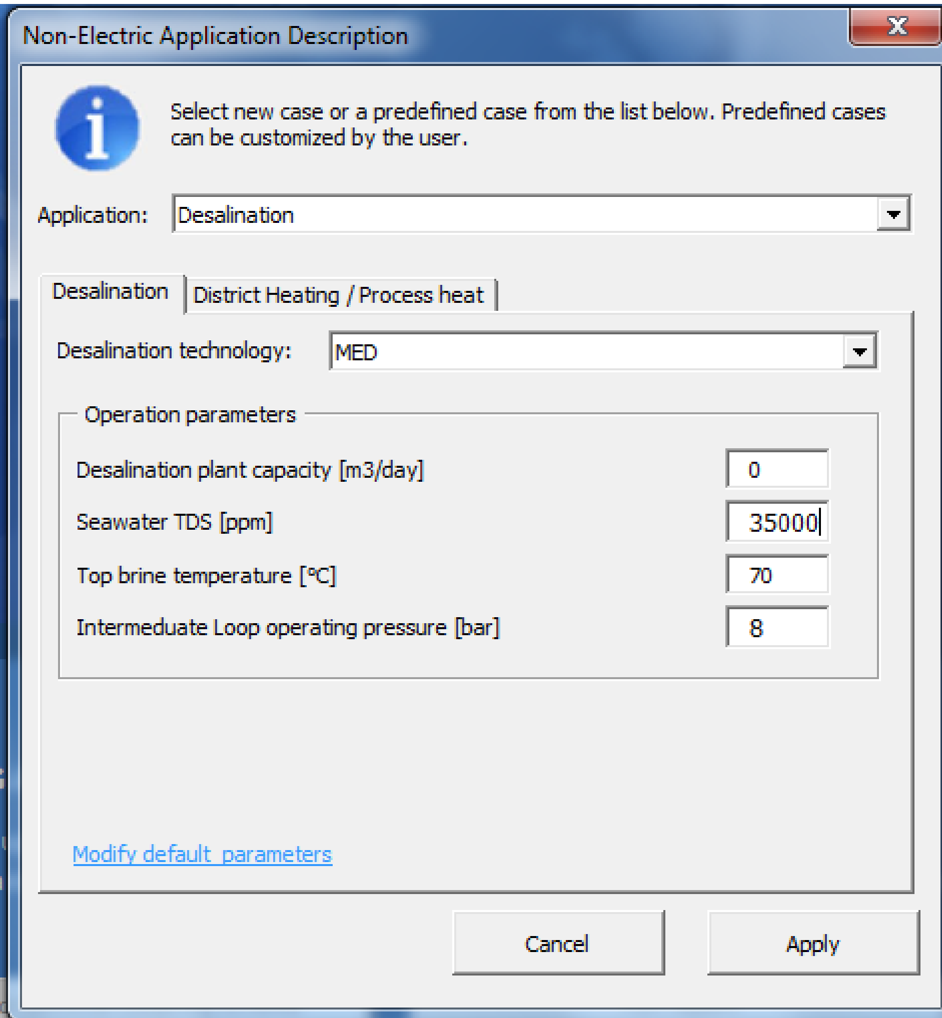
PLANT PERFORMANCE		
Gross efficiency	%	**34.2%**
Net efficiency	%	**32.5%**
Heat rate	kJ/kWh	**11,081**

PLANT PERFORMANCE		
Total heat input	MW(th)	**2,069.0**
Live steam	kg/s	996.1
HP turbine output	MW	223.1
IP/LP turbine output	MW	498.9
Mechanical output	MW	722.0
Gross output	MW(e)	**707.6**
Auxiliary loads	MW(e)	35.4
Net output	MW(e)	**672.2**
Heat to condenser	MW(th)	1,347.0
Cooling water	ton/s	**64.7**

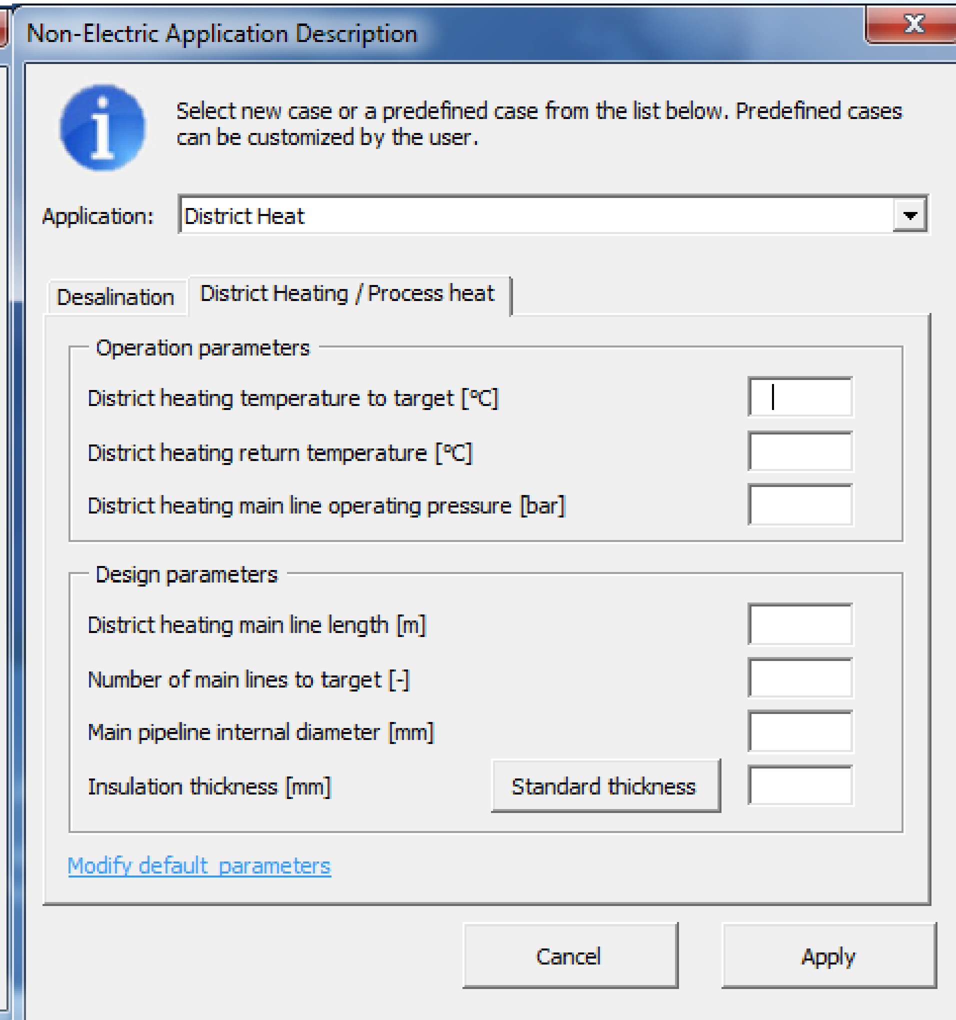


Inputs for Cogeneration Plant

Desalination



District Heating



Extraction Point for Cogeneration Application

COGENERATION PLANT

Net power output [MW(e)]	1,038
Reference plant net output	1,041
Var.	0%
Water production [m3/d]	8,800
Cogeneration plant eff.	34.8%
Reference plant efficiency	34.0%
Var.	2%

DESALINATION PLANT

Plant specifications

Desalination technology		MED
Max brine Temperature	[°C]	65
Number of effects	[-]	11
GOR	[-]	8.8

Energy use

Heat to desalination	[MW(th)]	27.1
Power lost due to extract	[MW(e)]	3.0
Desal. electric cons.	[MW(e)]	0.5
Int. Loop electric cons.	[MW(e)]	0.1
Equiv. specific cons.	[KWh(e)/m3]	9.71

COUPLING OPTIMIZATION

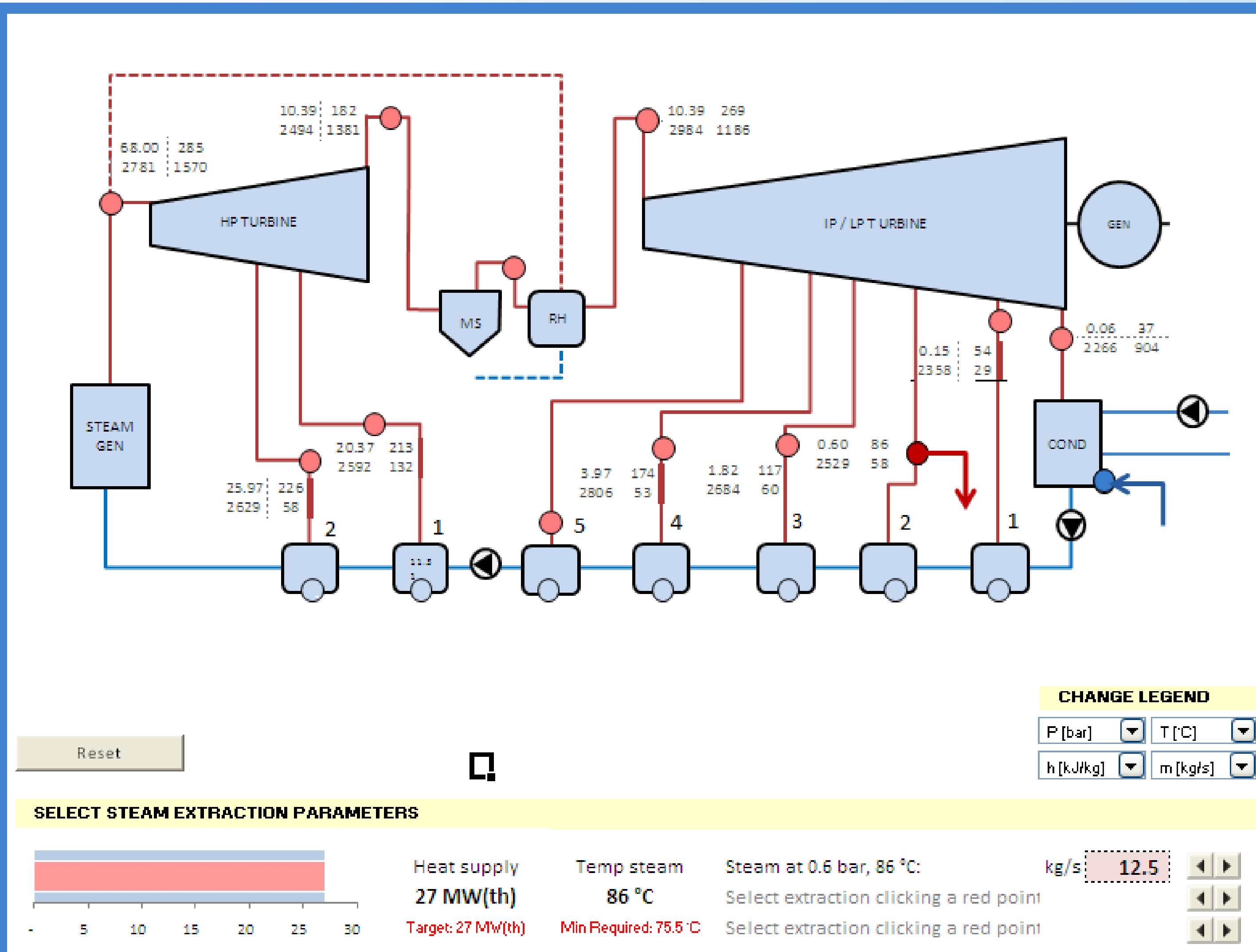
Power lost ratio	10.9%

Optimize steam extraction flows for:

Current size | Design size

Modify Desalination parameters

Parameters



Results Report

Project details

Project title	Standard PWR Case
Application	Thermal Desalination
Coupling configuration	Bleed from Low Pressure Turbine

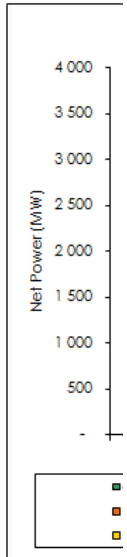
ENERGY BALANCE		REF	COGEN
Thermal input	**MW(th)**	**3 400**	**3 400**
Gross electrical output	**MW(e)**	**1 199**	**1 180**
Gross mechanical output	MW	1 223	1 205
HP Turbine output	MW	464	464
LP Turbine Output	MW	759	740
Net electrical output	**MW(e)**	**1 177**	**1 159**
Additional turbine	MW(e)	-	-
Auxiliary loads	MW(e)	22.2	21.1
Heat rejected through condenser	**MW(th)**	**2 179**	**1 948**
Heat to desalination plant	**MW(th)**	**-**	**250**
Total power lost	**MW(e)**	**-**	**-17.5**
Power lost due to extraction	MW(e)	-	-19.6
Possitive effect of ext steam red downstream	MW(e)	-	0.6
Positive effect of condensate upstream	MW(e)	-	0.5
Auxiliary loads decrease (pumps)	MW(e)	-	1.1

MASS BALANCE			
Feedwater to Steam Generator	**kg/s**	**1 833**	**1 833**
Steam to reheater	kg/s	156	156
Steam to the HP turbine	**kg/s**	**1 677**	**1 677**
HPT total preheating bleeds	kg/s	202	202
Exhaust from HP turbine	kg/s	1 475	1 475
Moisture separator condensate	kg/s	200	200
Steam to the LP turbine	**kg/s**	**1 276**	**1 276**
LPT total preheating bleeds	kg/s	249	242
Steam to desalnation	kg/s	-	116
Steam to condenser	kg/s	1 027	918
Relative steam to desalnation	[-]	0%	11%
Cooling Water	**ton/s**	**37**	**33**

Go to model calculations

SYSTEM EFFICIE
Gross efficienc
Net efficiency
Thermal utilisat

Plant perf



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Go to model calculations

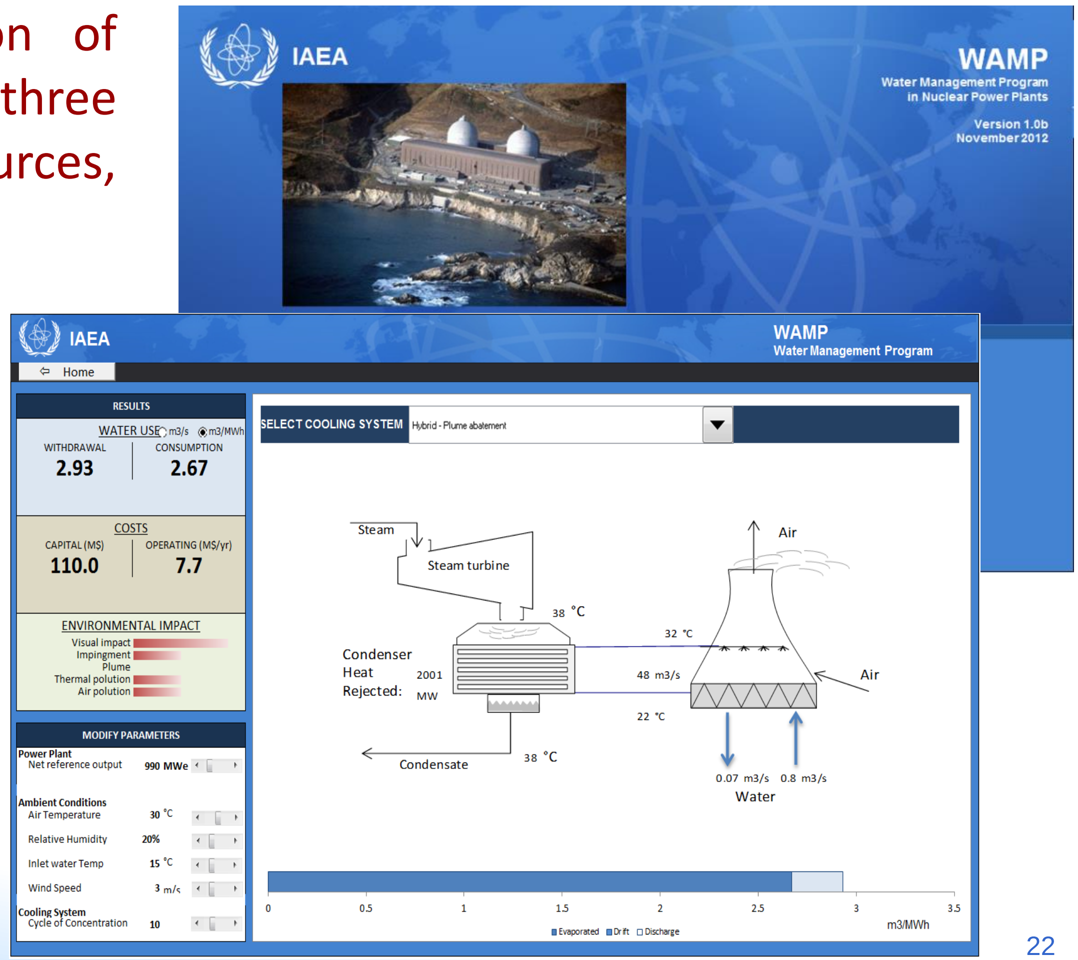
IAEA Tool on Nuclear Water Management

WAMP Water Management Program

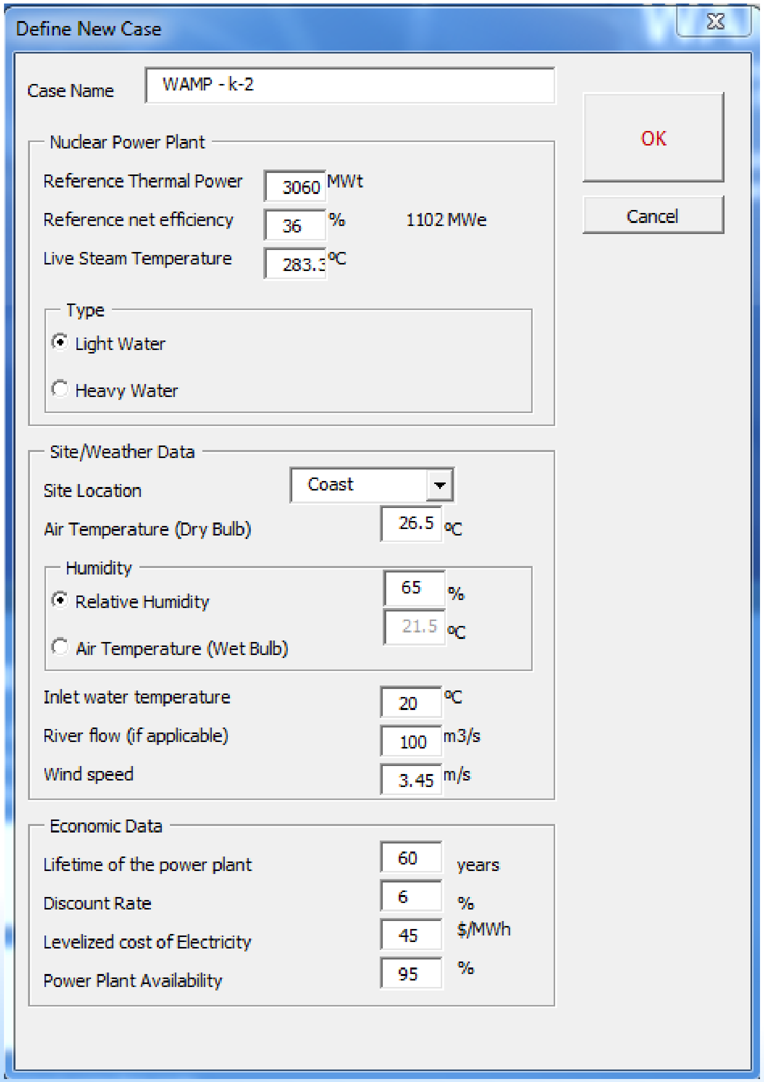
WAMP helps in the selection of cooling systems by evaluating three different criteria: Water resources, environmental, economical.

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

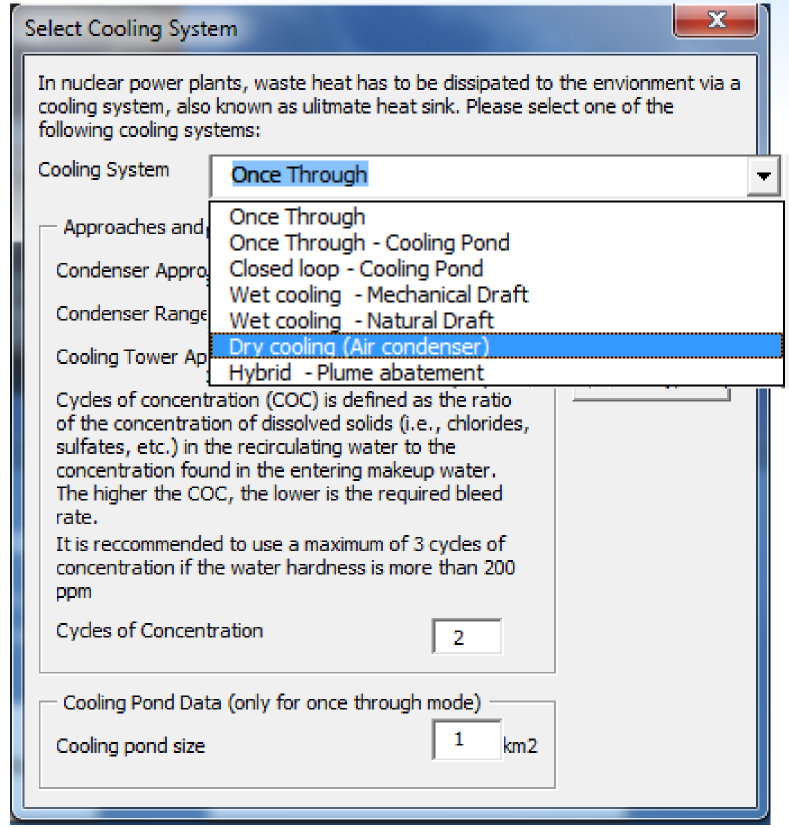
WAMP estimates both the needs for cooling water and other essential systems.



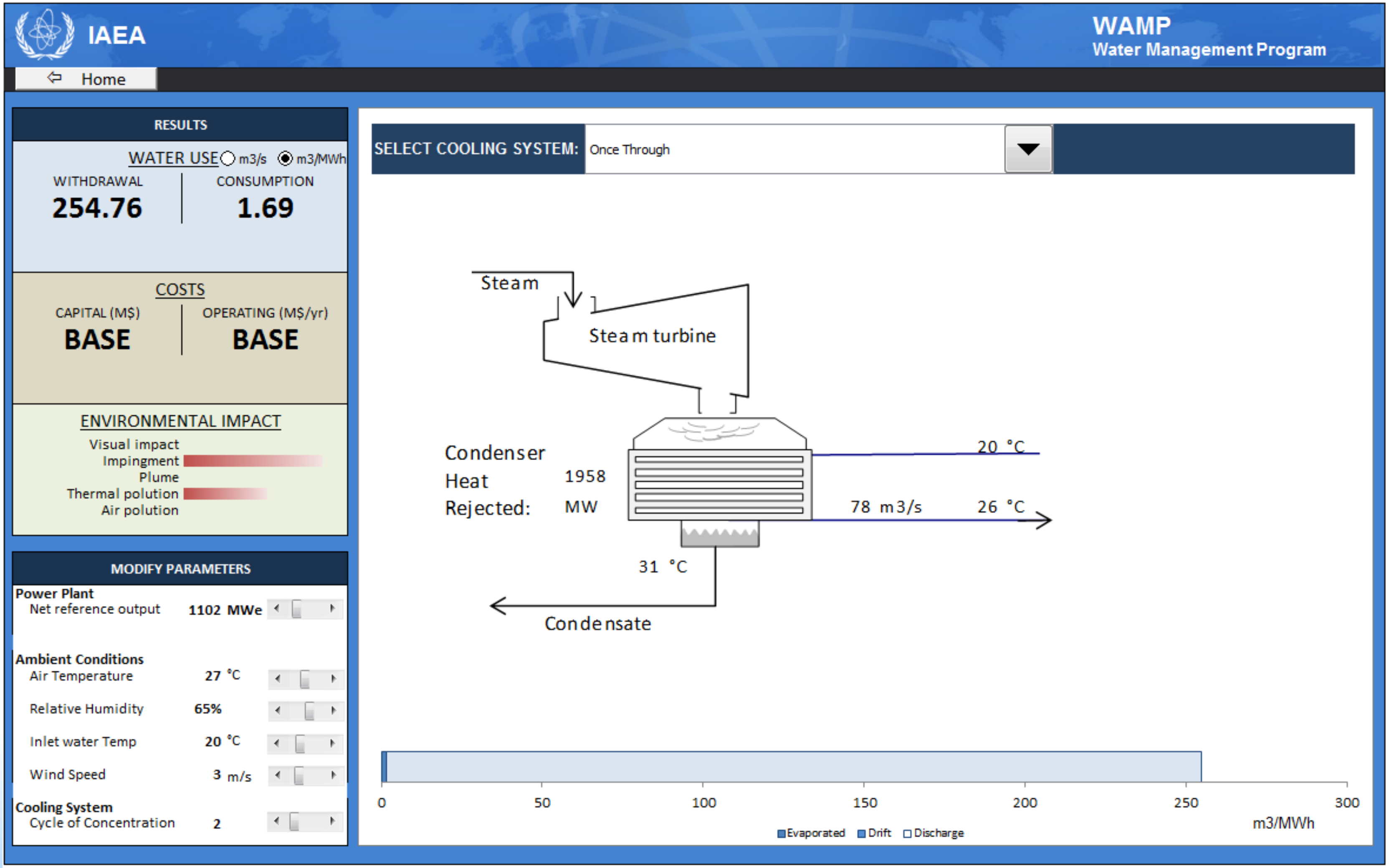
Define Power Plant Data



Select Cooling System



Summary Results



Report

Water Management Program
Summary of Results

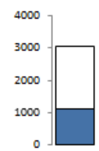
Case Study: WAMP - k-2

Home

Sav PI

Power Plant Specifications

Type	Light Water Reactor	
Reactor electric capacity	1102	MWe
Reactor thermal capacity	3060	MWth
Reference efficiency	36%	
Rejected heat	1958	MWth



Site conditions

Location	Coast	
Dry bulb temperature	26.5	°C
Wet bulb Temperature	21.5	°C
Relative Humidity	65%	
Surface water temperature	20	°C
River flow	100	m3/s
Average wind velocity	3	m/s

Summary of results

	Cooling system	Supporting systems
Recirculating cooling water	78.0 m3/s	1.20 m3/s
Evaporation losses	0.52 m3/s	0.02 m3/s
Blow-down losses	77.44 m3/s	0.01 m3/s
Make-up water	77.96 m3/s	0.03 m3/s

Total Water needed

During Construction	570 980	m^3
During commissioning	47 540	m^3
During operation		
Condenser cooling (withdrawal)	660 334	Million m^3/month
Other Supporting systems	10 298	m^3/month

Total Water inventory needed

Fresh Water	3 000	m^3
Demineralized water	9 550	m^3

Water Management Program
Cooling system analysis

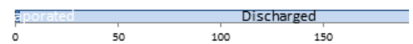
Case Stud

Design variables

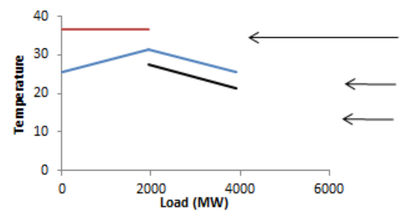
Cooling system type	Once Throu
Cycles of concentration	
Condenser Approach	
Condenser Range	
Cooling Tower Approach	

Results

Evaporation loss	0.
Drift loss	0.
Blowdown	77.
Cooling system makeup water	77.
Total consumption	0.



Temperature Profile



Total Annual Revenues / Profits

Investment Costs	BASE	M$
Annualized Investment Cost	BASE	M$
Total Operating Costs	BASE	M$
Total Cost	0.0	M$

Water Management Program
Supporting Systems cooling

Case Study: WAMP - k-2

Water needs during construction

Excavation	25 080	m^3	
Concrete mixing	95 100	m^3	
Supply for construction staff	450 800	m^3	(Peak: 6000 m3/d)

Water needs during comissioning

Flushing,cleaning etc	25 000	m^3	
Drinking water	22 540	m^3	(Peak: 300 m3/d)

Water needs during operation (except from condenser cooling)

Makeup for Secondary loop	4100	m^3/month	Demineralized
Makeup for primary loop	138	m^3/month	Demineralized
Waste Treatment	1736	m^3/month	Fresh Water
Condensate Polishing Plant	1188	m^3/month	Demineralized
Component cooling water make up	361	m^3/month	Demineralized
Fire protection	223	m^3/month	Fresh Water
Sanitary and potable	2551	m^3/month	Fresh Water

Water system inventories during operation

Condenser cooling water circuit	0	m^3	Fresh water
Service water circuit + 7 days storage	0	m^3	Fresh water
Fire water circuit - pipes	300	m^3	Demineralized
Fire water circuit - storage	3000	m^3	Fresh water
Nuclear systems& component cooling circuit	500	m^3	Demineralized
TG component cooling circuit	450	m^3	Demineralized
Feed water circuit	1800	m^3	Demineralized
Steam generator secondary side inventory	300	m^3	Demineralized
Reactor auxilary circuits	500	m^3	Demineralized
Spent fuel bay cooling circuit	1700	m^3	Demineralized
Emergency core cooling circuit (and dump inventc	1900	m^3	Demineralized
Emergency feed water pools and circuit	1700	m^3	Demineralized
Primary heat transport system	400	m^3	Demineralized
Moderator system	0	m^3	-

SAMG-D

IAEA

OVERVIEW OF THE SAMG-D TOOL

The Tool to enhance Severe Accident Management

The SAMG-D describes the elements necessary to develop a full package of Severe Accident Management Guidelines (SAMG), which serve to achieve the main goals of severe accident management at a Nuclear Power Plant (NPP). Severe accident managagement is a subset of accident management as follows:

Accident management is the taking of a set of actions during the evolution of a beyond design basis accident:
(a) To prevent the escalation of the event into a severe accident;
(b) To mitigate the consequences of a severe accident;
(c) To achieve a long term safe stable state.

The second aspect of accident management (to mitigate the consequences of a severe accident) is also termed **severe accident management**. It includes measures to: Read more →
(1) terminate the progress of core damage once it has started,
(2) maintain the integrity of the containment as long as possible and
(3) minimize releases of radioactive material.

See *Accident Management*, *Anticipated Operational Occurrence*, *Beyond Design Basis Accident*, *Design Basis Accident*, *Operational states*, *Severe Accident*, and *Severe Accident Management*.

Guidelines that have been developed for the operating staff for managing severe accidents are called Severe Accident Management Guidelines (SAMG).

The SAMG-D is also an education and training tool to help plant staff understand the context of severe accidents and the associated procedures and guidelines. The SAMG-D describes the elements that a full package of SAMG should encompass to achieve the goals of severe accident management. It is set up to help utilities to select proper SAMG products from the various vendors and implement those at their plants. The SAMG-D is designed for use with LWRs and PHWRs. **The SAMG-D is not designed to independently construct a full SAMG package.**

The IAEA Nuclear Power Technology Development Section (NPTDS) developed the SAMG-D also as a contribution to the IAEA Action Plan on Nuclear Safety.

Please, before starting the use of SAMG-D have a look at the *DISCLAIMER* and the information provided in About.