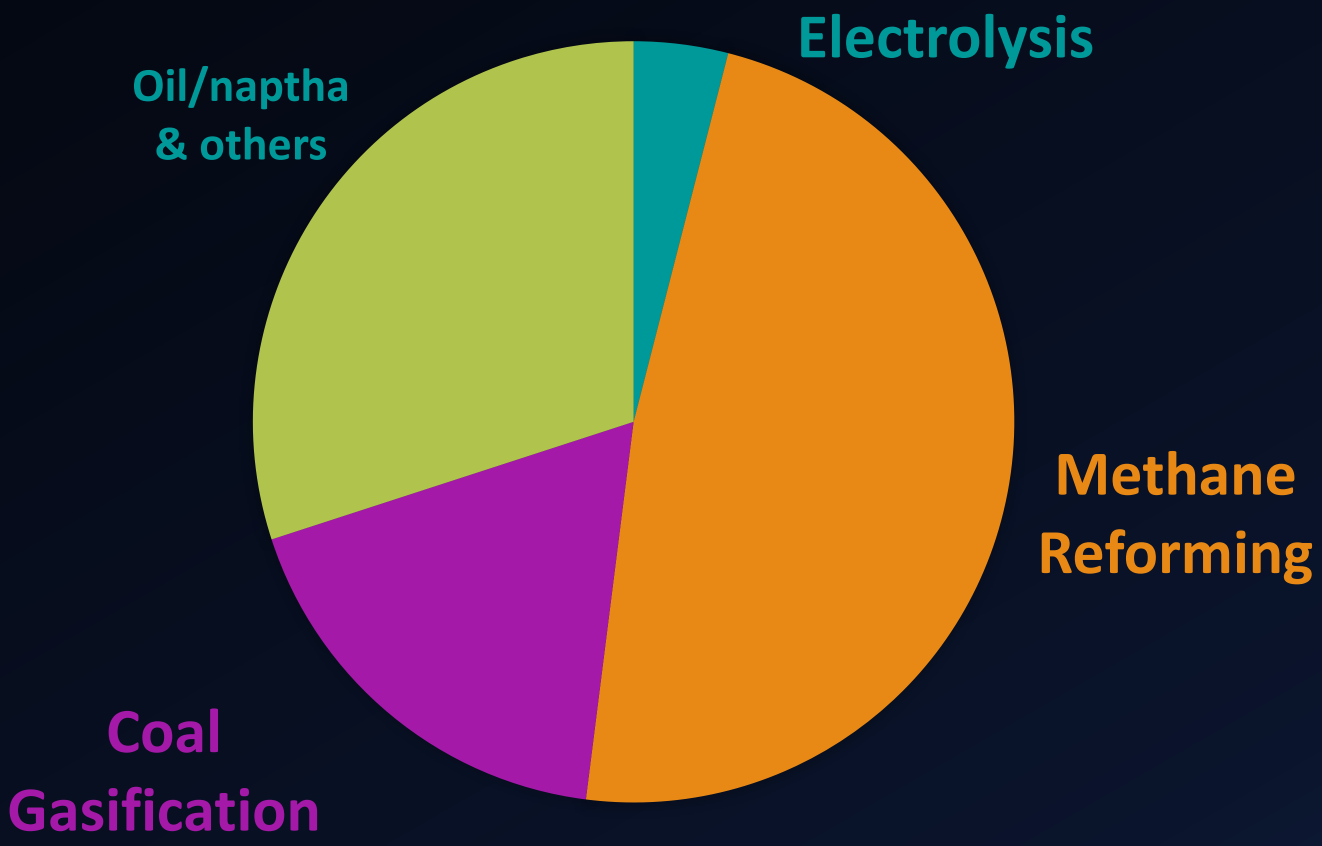
Nuclear Hydrogen Production

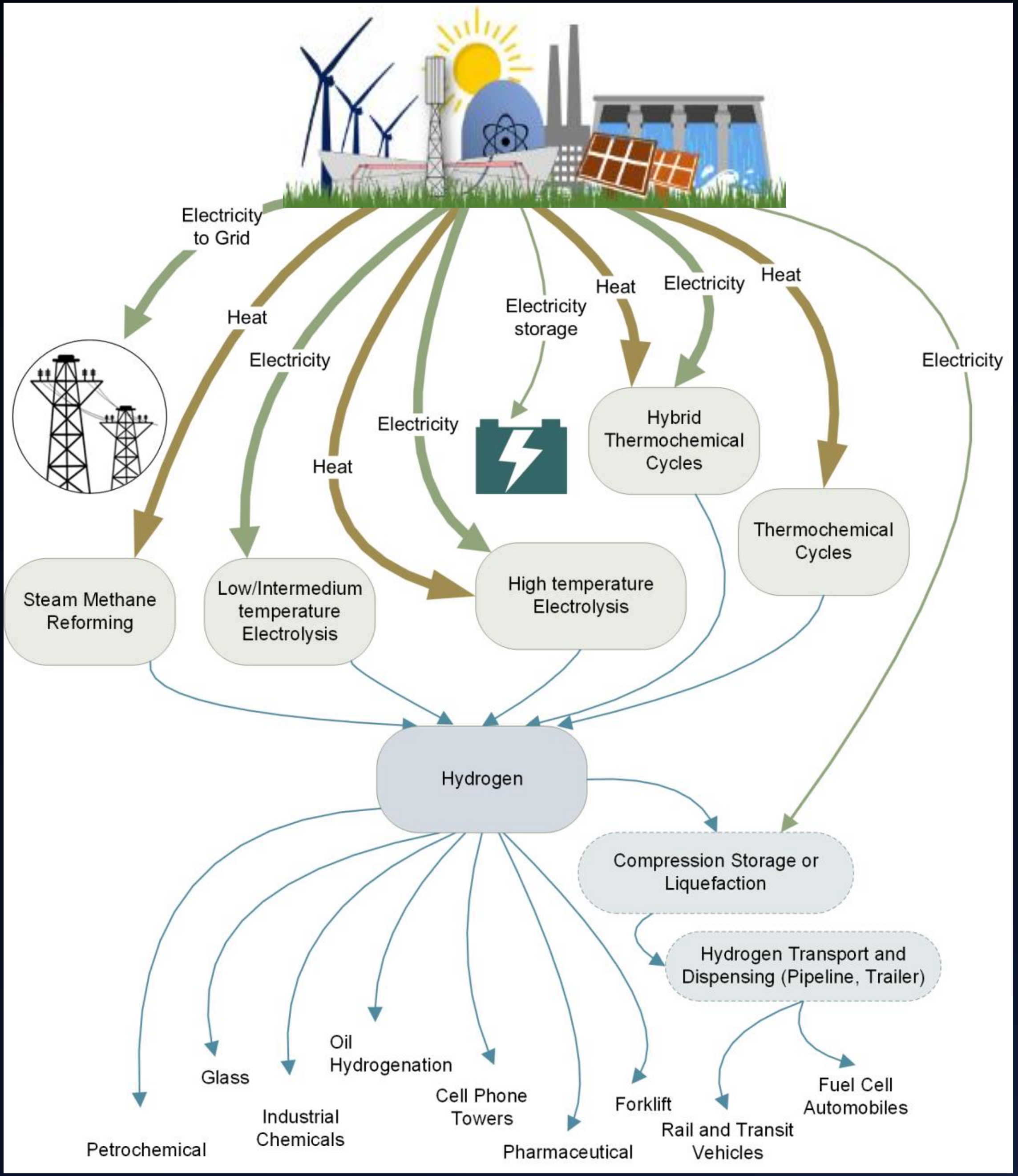
Rami El-Emam

CONTENTS

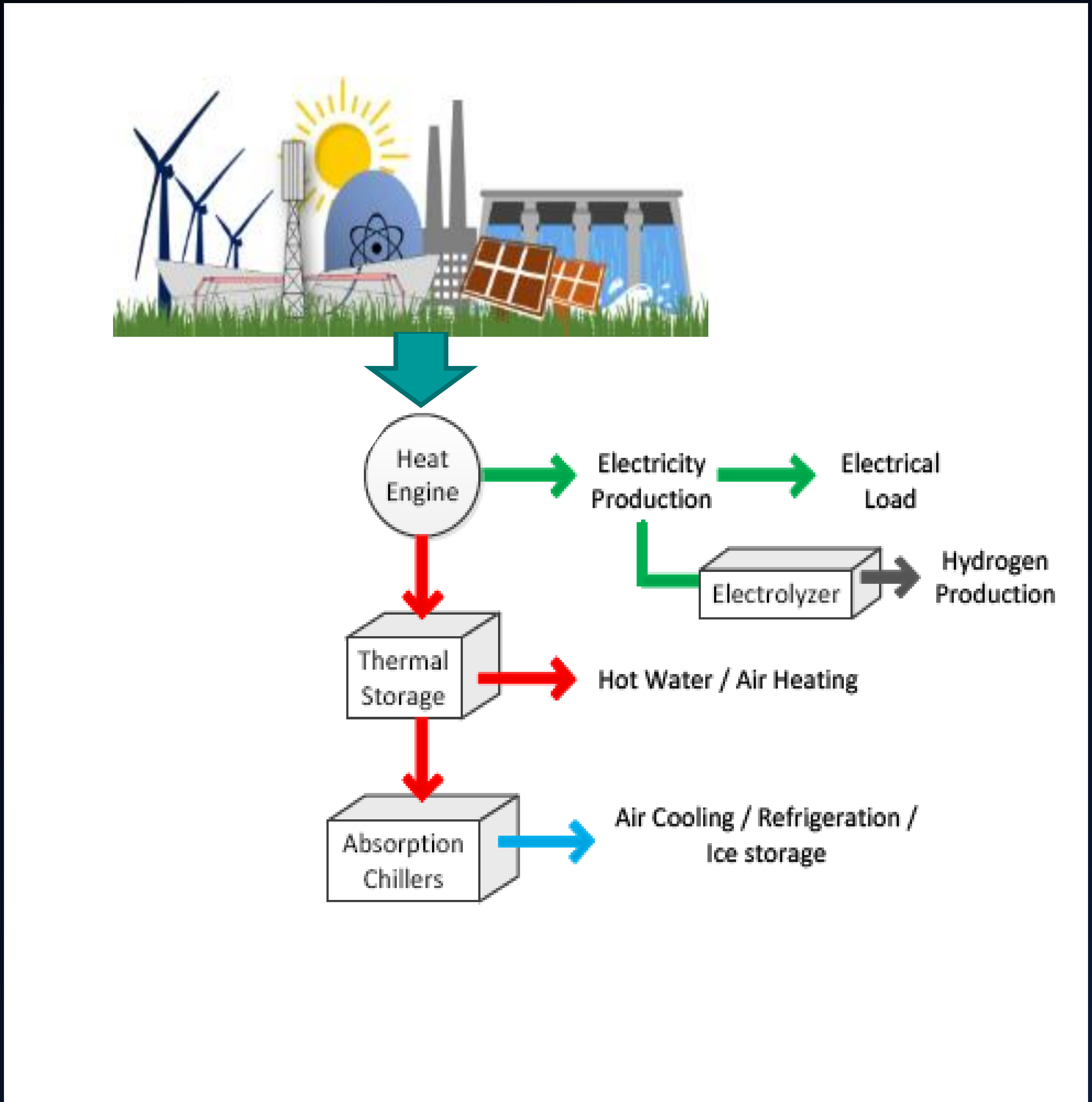
Hydrogen Today!



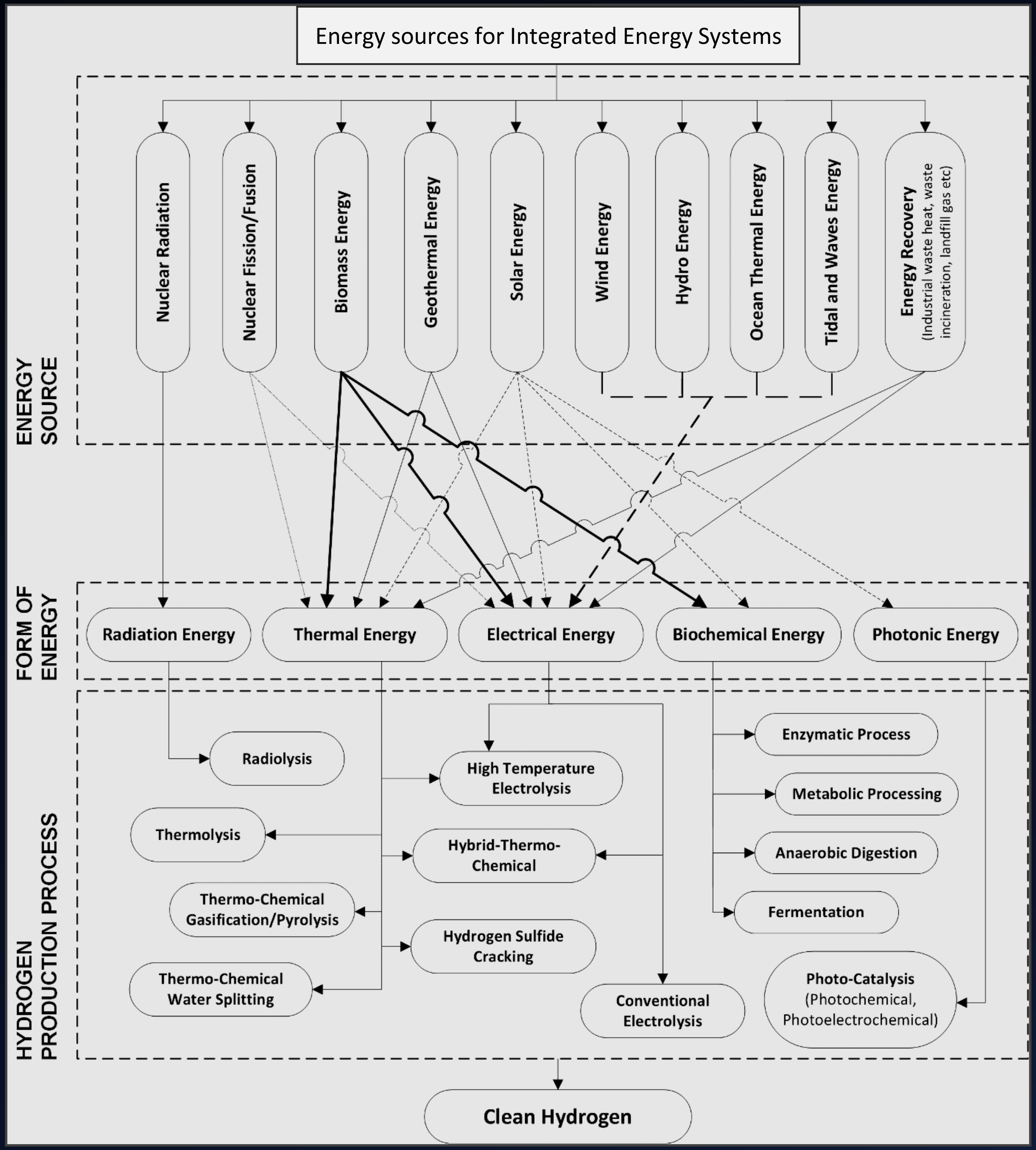
Routes for Clean Hydrogen Production



Why Multi-generation



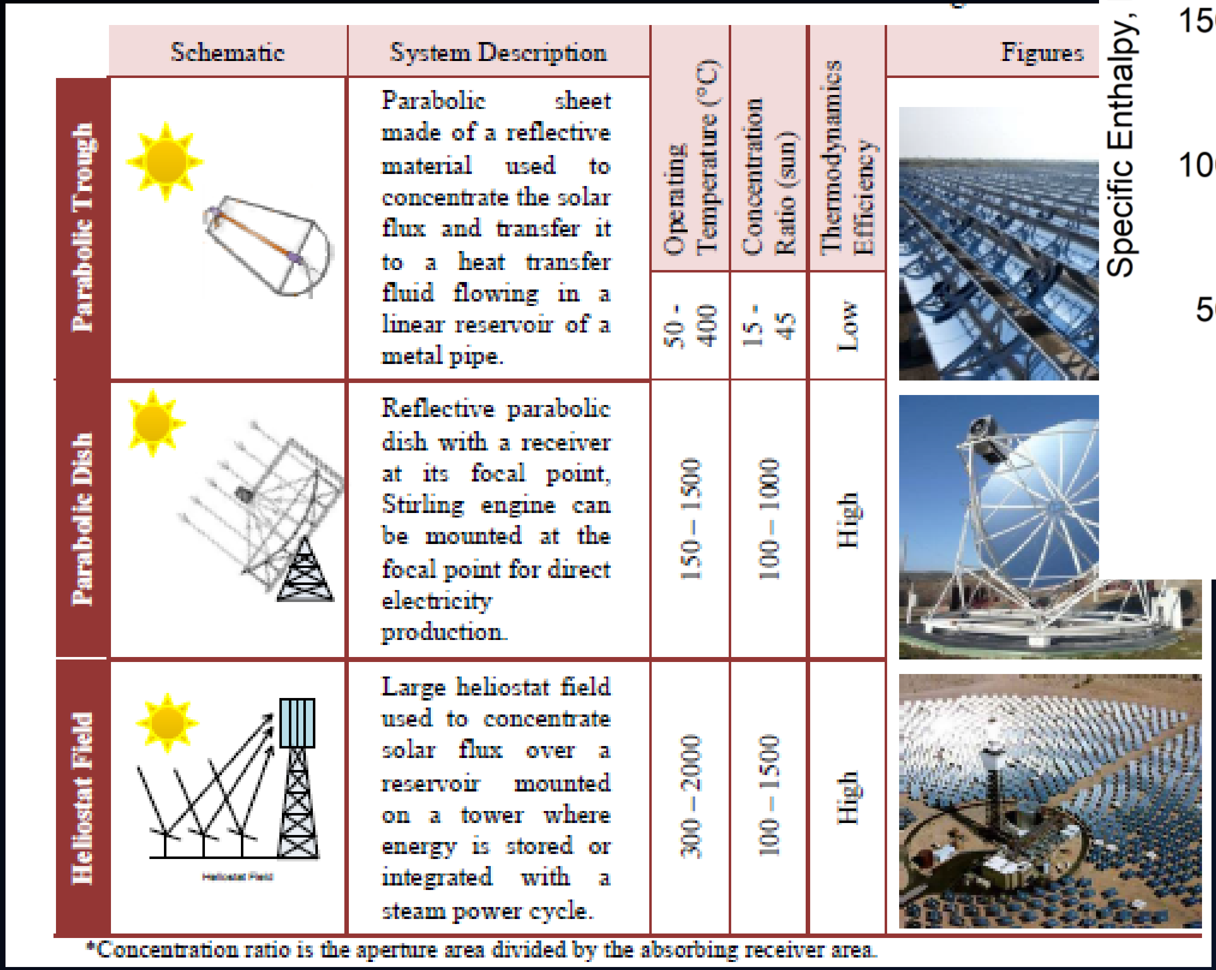
ROUTES FOR CLEAN HYDROGEN USING INTEGRATED ENERGY SYSTEMS



APPLICATIONS OF MULTIGENERATION INTEGRATED ENERGY SYSTEMS

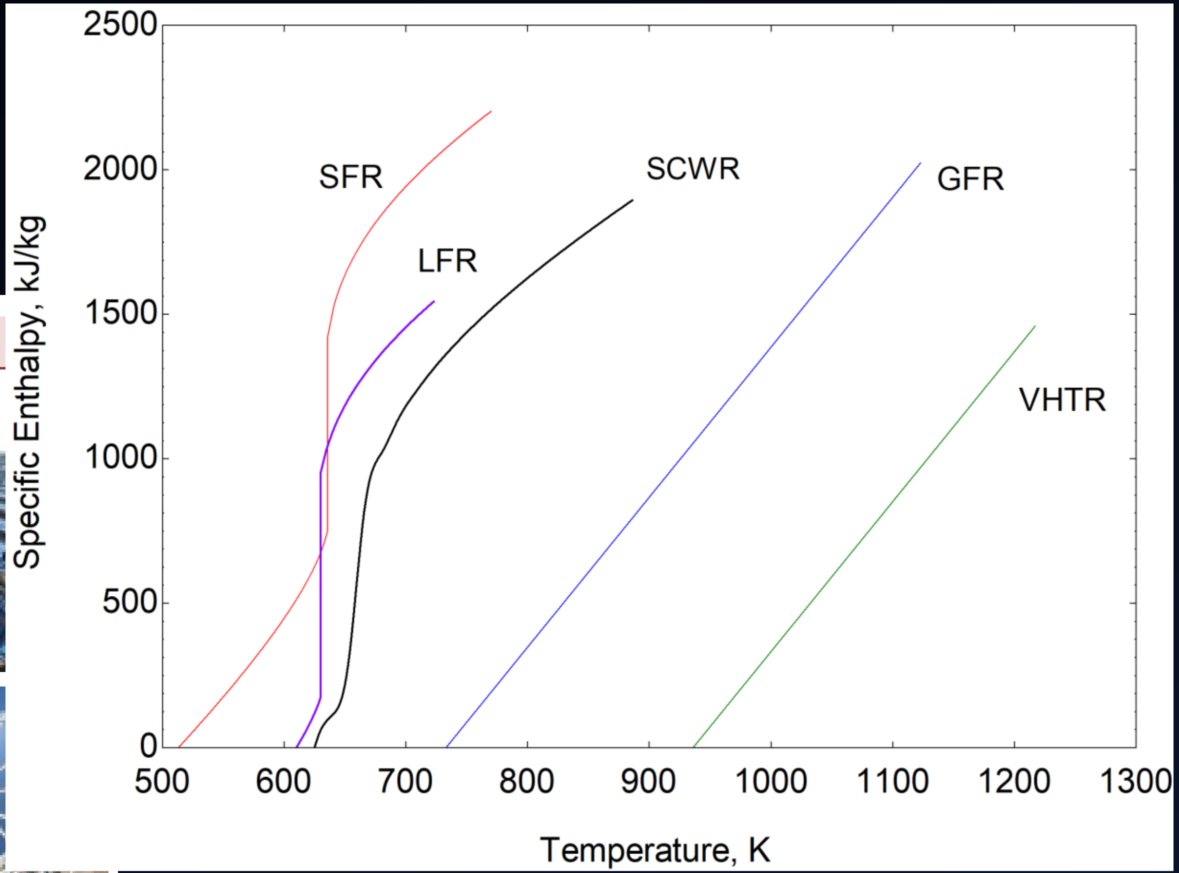
	District/process heating 80–120˚C	Reverse Osmosis desalination	Thermal desalination 85–160˚C	Pulp & paper manufacturing 200–400˚C	Methanol production 250–350˚C	Heavy oil desulfurization 300–500˚C	Petroleum refining 300–400˚C	Methane reforming 700–1000˚C	Thermochemical H2 cycles 800–1000˚C	Hybrid thermochemical cycles 450–800˚C	PEM electrolysis 60–90˚C	Alkaline electrolysis 80–200˚C	High temperature electrolysis 750–1000˚C	Biomass gasification 800–900˚C	Coal gasification 900–1400˚C	Steel making 900–1200˚C
Generation IV reactors																
Super Critical Water Reactor 500–625˚C	•	•	•	•	•	•	•	•		•	•	•				
Very High Temperature Reactor 750–950˚C	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Sodium cooled Fast Reactor 450–550˚C	•	•	•	•	•	•	•	•		•	•	•				
Gas cooled Fast Reactor 750–850˚C	•	•	•	•	•	•	•	•		•	•	•	•	•		
Molten Salt Reactor 650–850˚C	•	•	•	•	•	•	•	•	•	•	•	•	•	•		
Lead cooled Fast Reactor 450–800˚C	•	•	•	•	•	•	•	•	•	•	•	•	•			
Solar Energy Systems																
Photovoltaic ~ 60°C		•									•					
Concentrated Photovoltaic <80°C		•									•					
Parabolic Trough 50–550°C	•	•	•	•							•					
Linear Fresnel Lens 150–250°C	•	•	•								•	•				
Linear Fresnel Reflector >300°C	•	•	•								•	•				
Power Tower/Heliostat 300–800 up to 2,000°C	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Parabolic Dish Engine ~650°C up to 1,200°C	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Wind Turbine Farms		•									•					
Geothermal Energy System	•	•	•								•	•				

CONCENTRATED SOLAR THERMAL



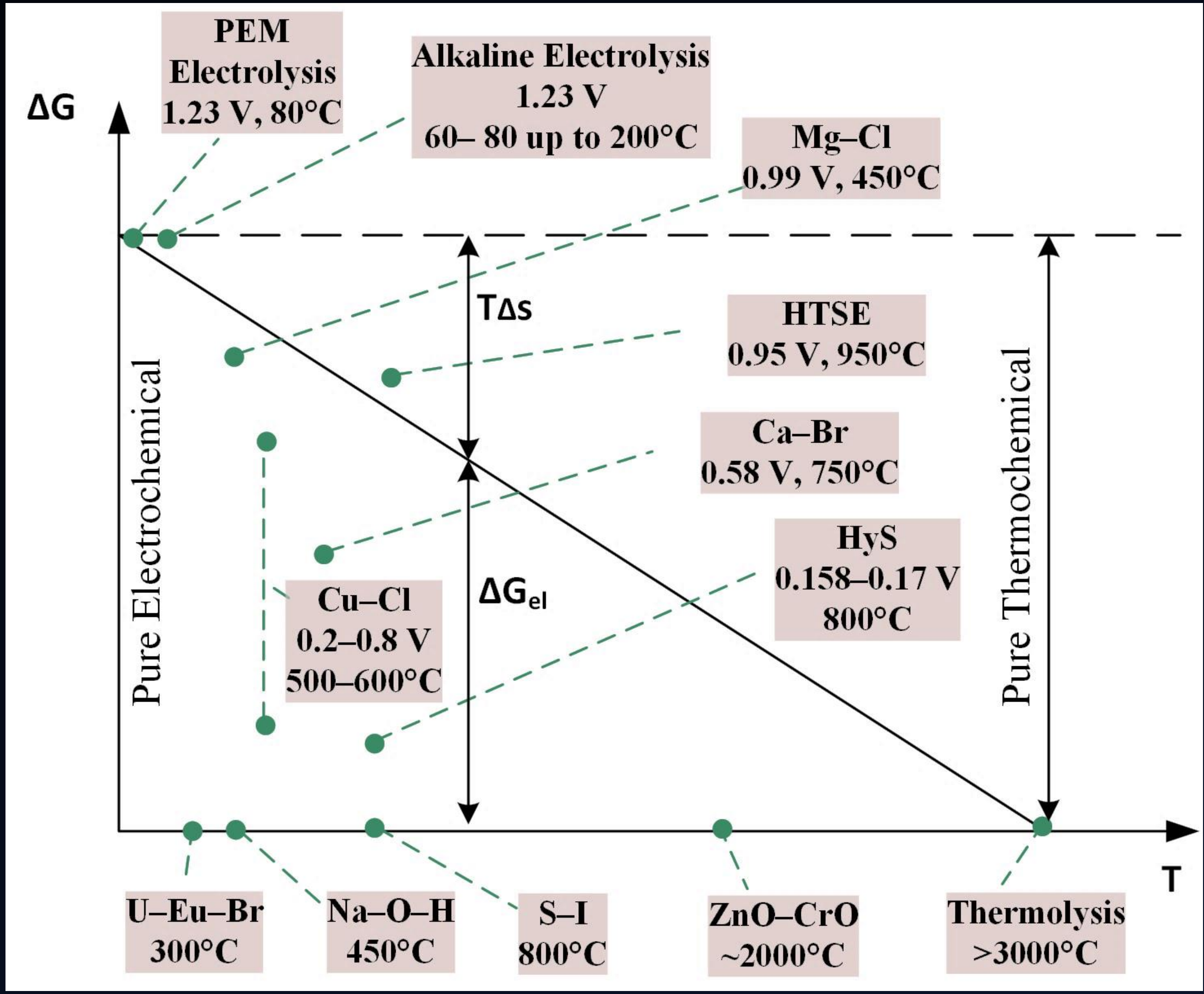
	Schematic	System Description	Operating Temperature (°C)	Concentration Ratio (sun)	Thermodynamics Efficiency	Figures
Parabolic Trough		Parabolic sheet made of a reflective material used to concentrate the solar flux and transfer it to a heat transfer fluid flowing in a linear reservoir of a metal pipe.	50 - 400	15 - 45	Low	
Parabolic Dish		Reflective parabolic dish with a receiver at its focal point, Stirling engine can be mounted at the focal point for direct electricity production.	150 – 1500	100 – 1000	High	
Heliostat Field		Large heliostat field used to concentrate solar flux over a reservoir mounted on a tower where energy is stored or integrated with a steam power cycle.	300 – 2000	100 – 1500	High	

*Concentration ratio is the aperture area divided by the absorbing receiver area.



GENERATION IV

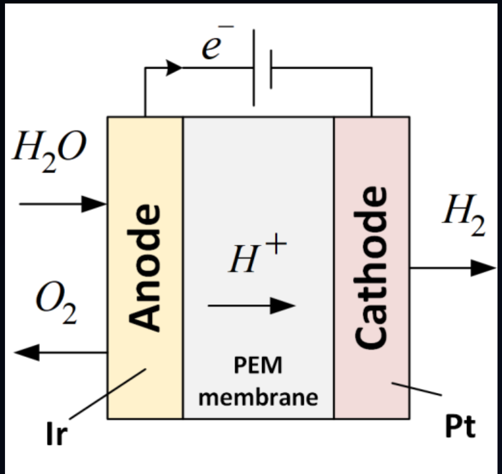
Which Hydrogen Technology to use!



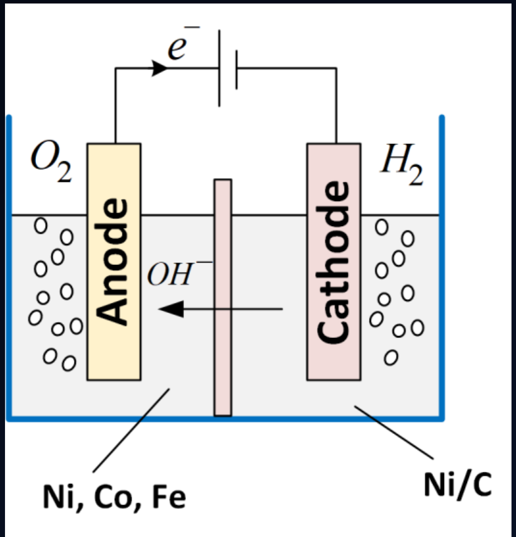
Which Hydrogen Technology to use!

Electrolysis

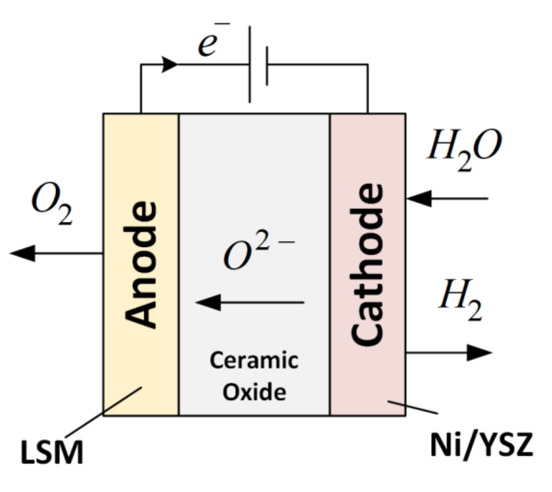
PEM Electrolysis



Alkaline Electrolysis

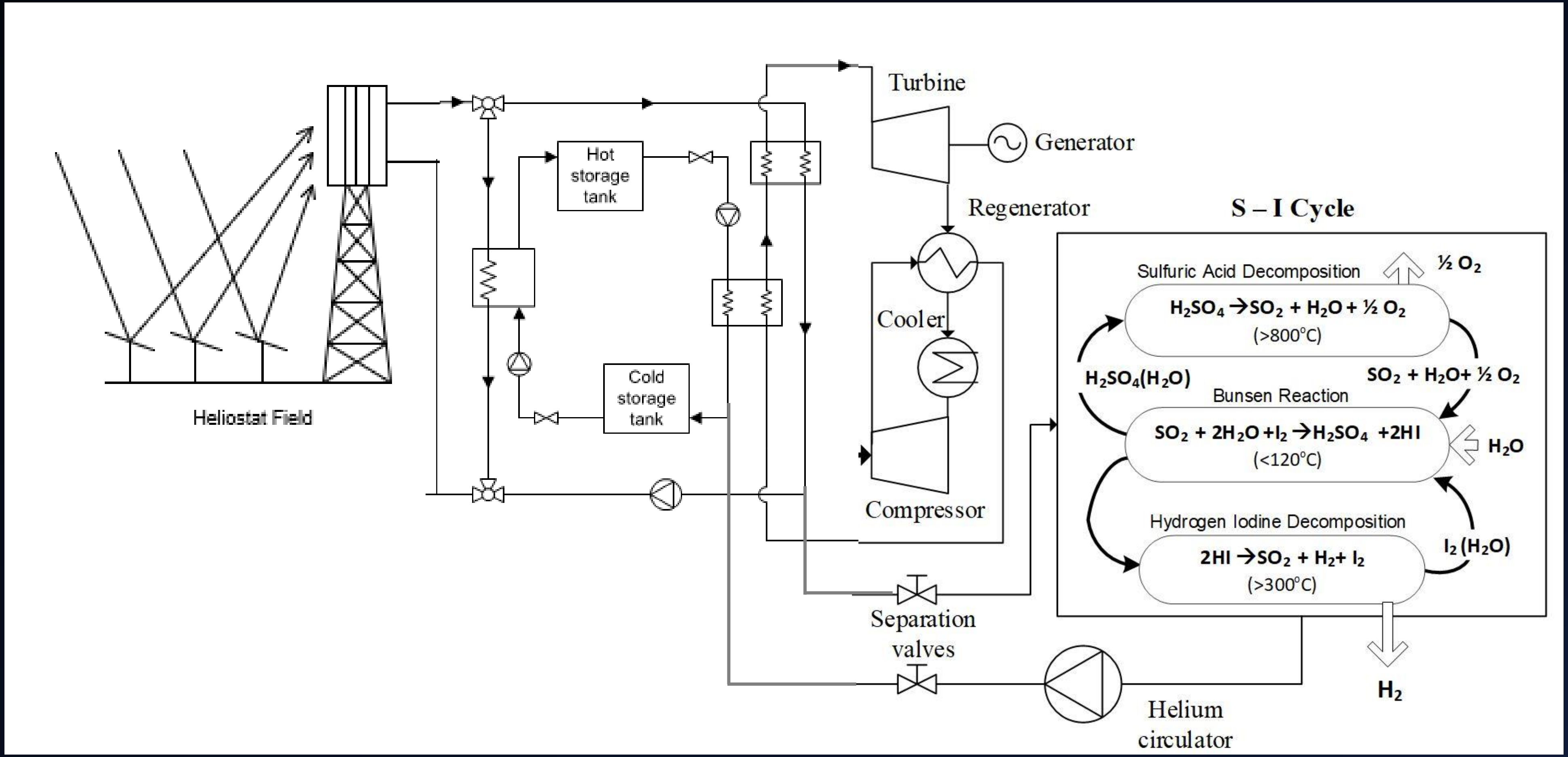


High Temperature Electrolysis



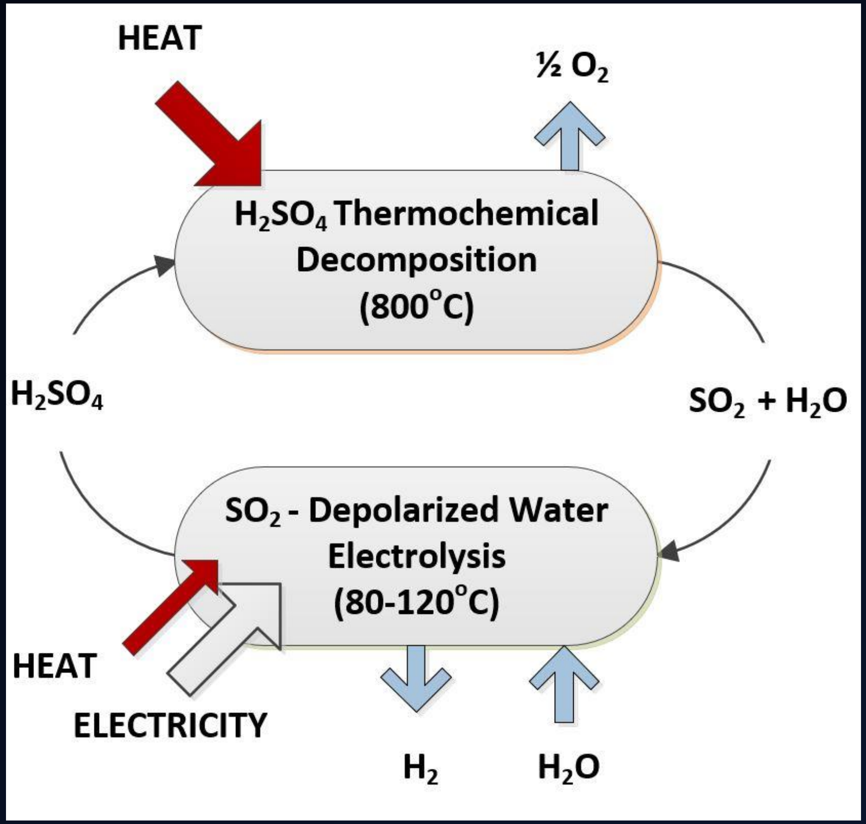
Thermochemical Processes

Sulfur – Iodine



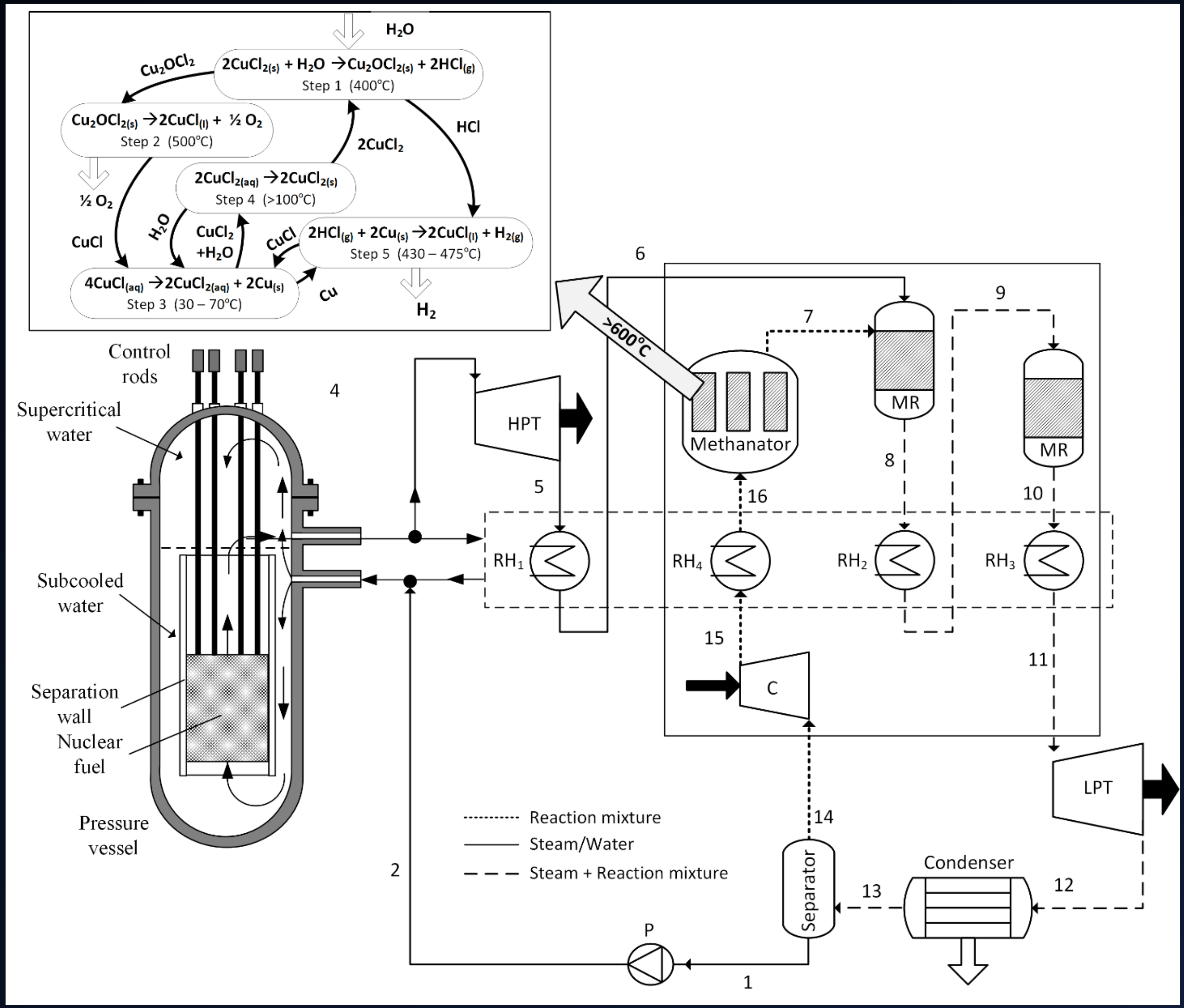
Thermochemical Processes

Hybrid Sulfur Process

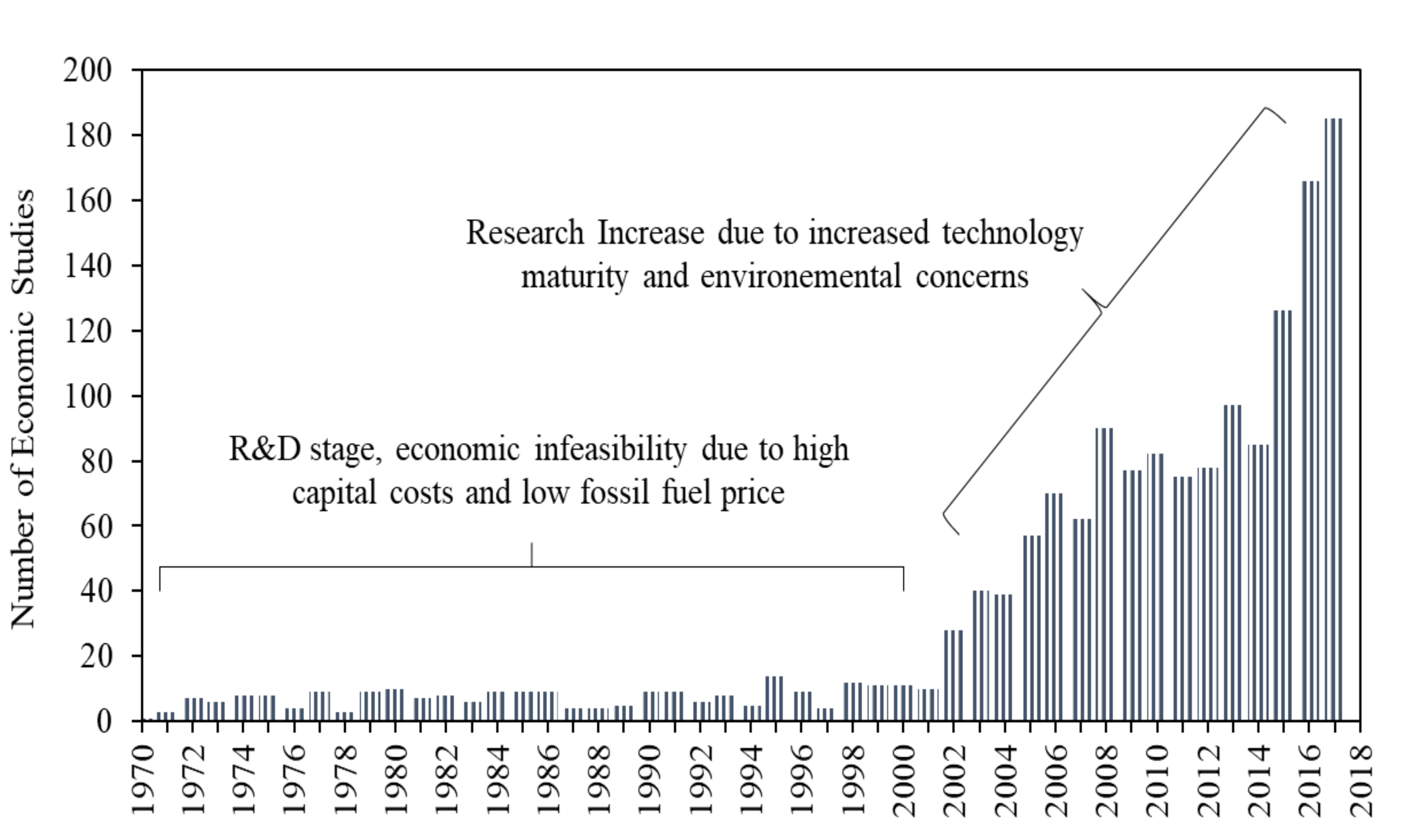


Thermochemical Processes

Hybrid Copper-Chlorine

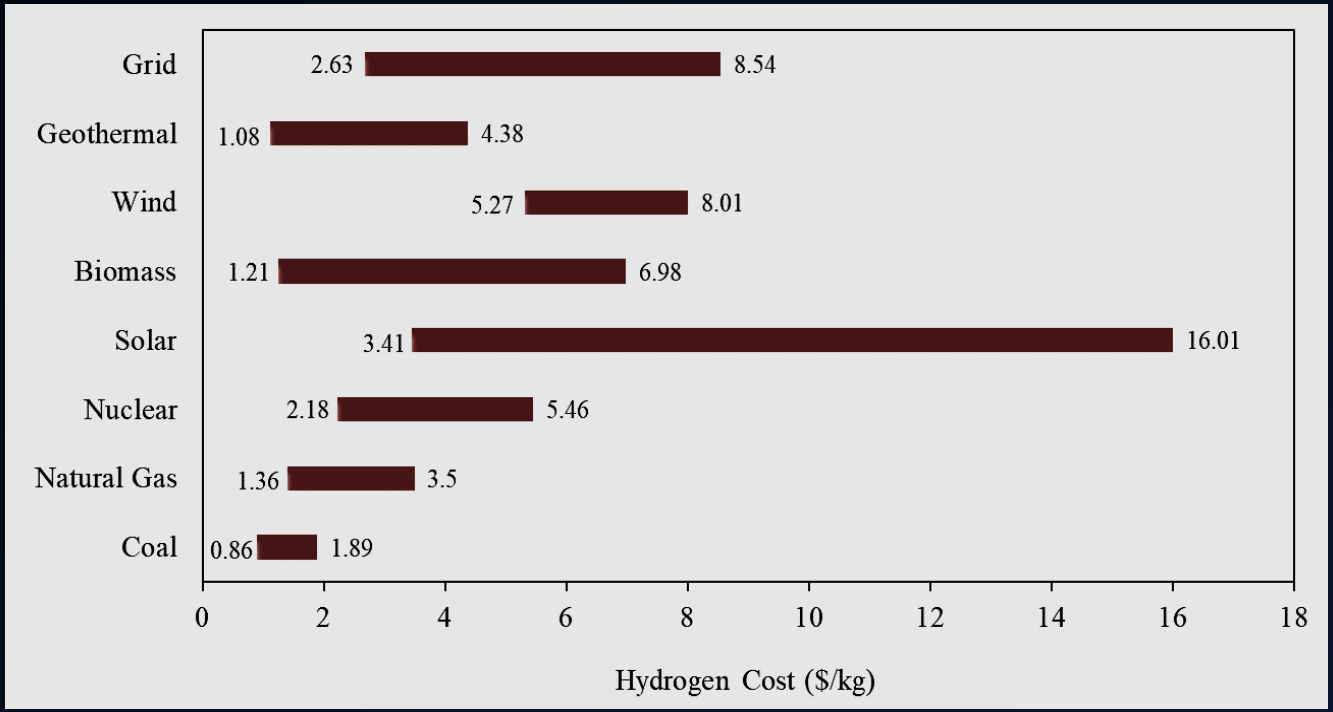


HYDROGEN TECHNOECONOMICS!

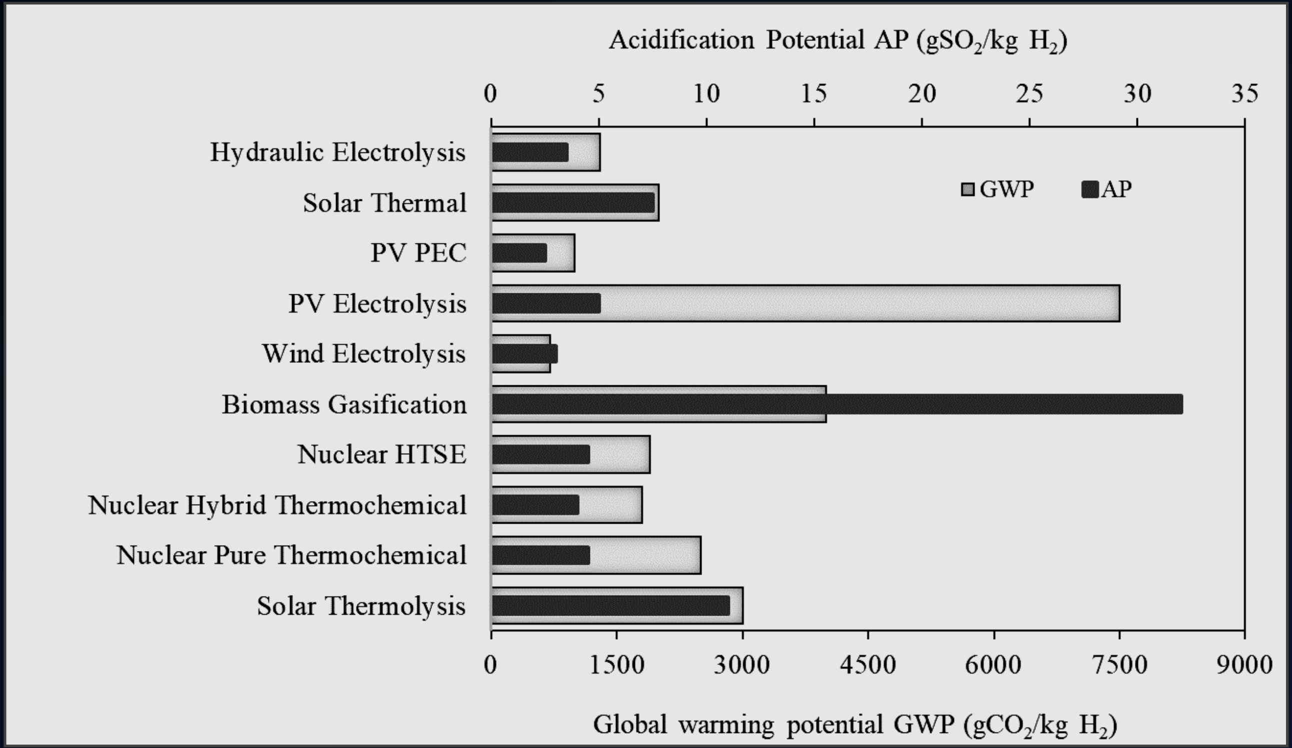


Studies on hydrogen economics by year

COST RANGE OF HYDROGEN PRODUCTION TECHNOLOGIES BASED ON ENERGY SOURCE



AVERAGED VALUES OF GWP AND AP FOR SELECTED HYDROGEN GENERATION TECHNOLOGIES



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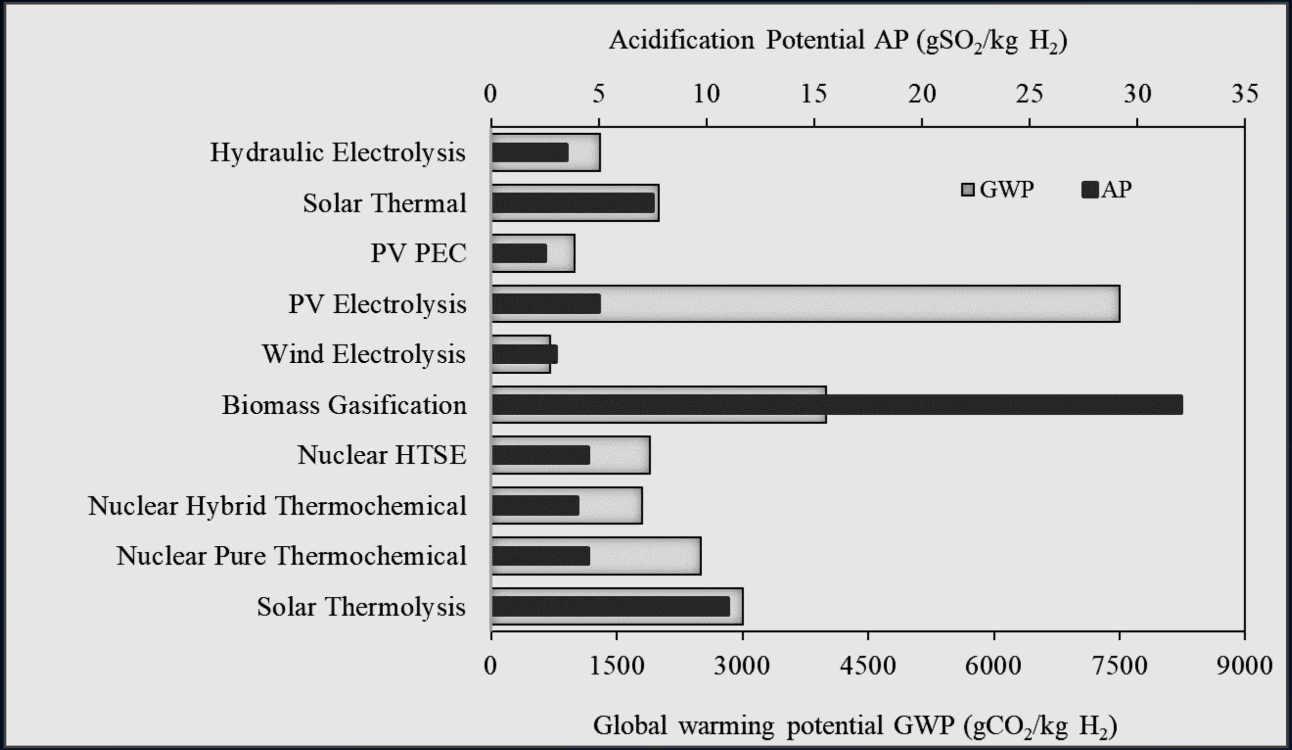


SOME TOOLS OF ASSESSING HYDROGEN ECONOMICS

HEEP

HEEP is a single window-based software, developed by the International Atomic Energy Agency (IAEA) to perform economic analysis for large-scale nuclear hydrogen production. HEEP estimated the levelized cost of produced hydrogen by utilizing around 20 input parameters of technical, economic, and chronological data, using discounted cash flow model. Power credit method is applied for the calculation of thermal and electricity cost when both are needed for the hydrogen plant. The tool can analyze different scenarios of hydrogen storage and transportation.

G4Econs

G4Econs is a Microsoft Excel-based application, developed by the Economic Modelling Working Group (EMWG) of GIF. It calculates the Levelized Unit Electricity Cost (LUEC) from the reactor module, and the Levelized Unit Hydrogen Cost (LUHC) from the energy-products model, based on the required energy type for the hydrogen plant technology. More information on the tool can be found on GIF website (G4Econs, 2018).

H2A

H2A (Hydrogen Analysis) is developed by the Department of Energy (DOE), USA, with the contribution of several national Labs and universities. H2A calculates the levelized cost of hydrogen for various options of large-scale hydrogen production using coal and biomass gasification, natural gas reforming, nuclear and wind energy. H2A Analysis Group also developed three other models for a larger scope of analysis, these are the Hydrogen Delivery Scenario Analysis Model (HDSAM), the Hydrogen Refueling Station Analysis Model (HRSAM), and the Heavy-Duty Refueling Station Analysis Model (HDRSAM). More information can be found at the website of Hydrogen and Fuel Cells Program of DOE (DOE, 2019).

H2FAST

H2FAST (Hydrogen Financial Analysis Scenario Tool) is developed by the NREL to provide a quick and in-depth financial analysis for hydrogen fueling stations. More information on the tool can be found at the website of NREL (NREL - H2FAST, 2018).

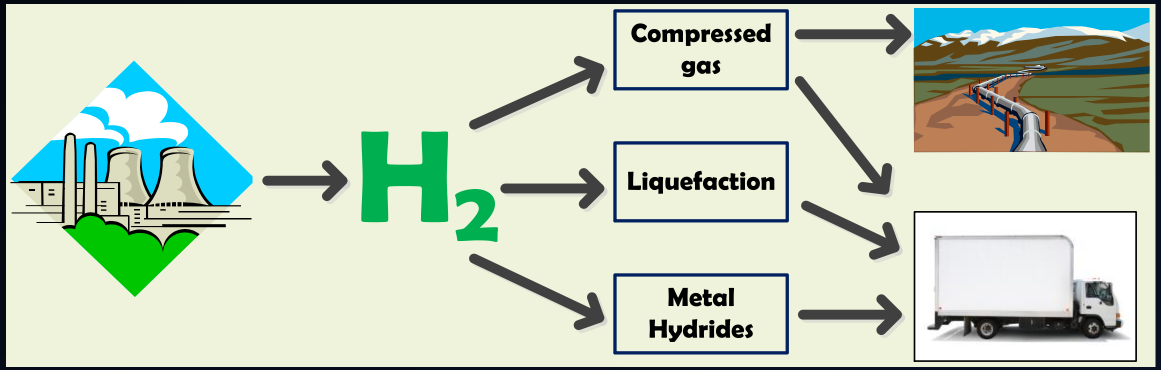
The IAEA HEEP: Description & Case Studies

CONTENTS

- ✓ Introduction to HEEP and its Features
- ✓ Demonstration of HEEP
- ✓ Comparative Case Studies
- ✓ Benchmarking

Hydrogen Economic Evaluation Programme (HEEP)

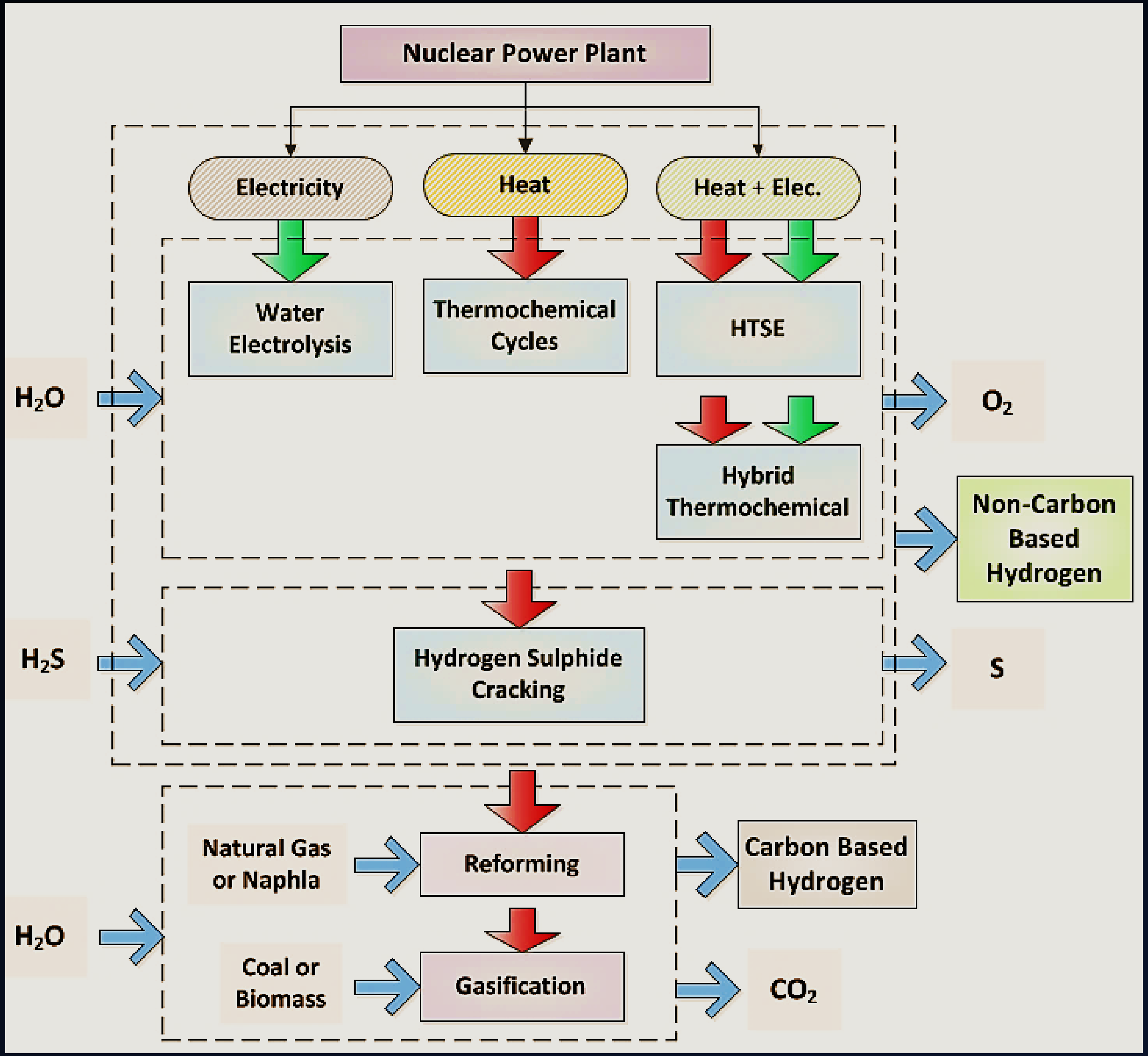
Models different combination of different available options for heat source, process of hydrogen generation and its storage and transportation.



Main Features of HEEP:

1. Single window based tool.
2. Expandable database/library To build new cases using library files.
3. Models effect of location of hydrogen plant with respect to NPP.
4. Models electricity generation and supply along with heat.

H2 Production Technologies in HEEP

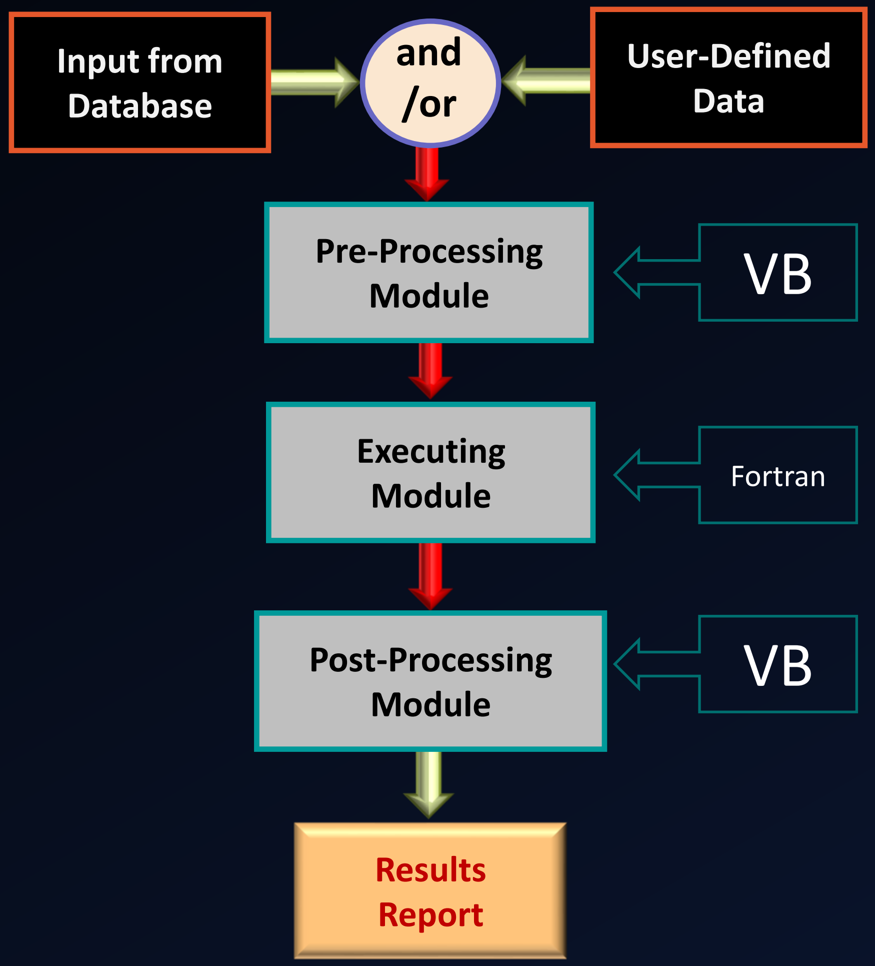


HEEP Modules

Pre-processing module for providing data

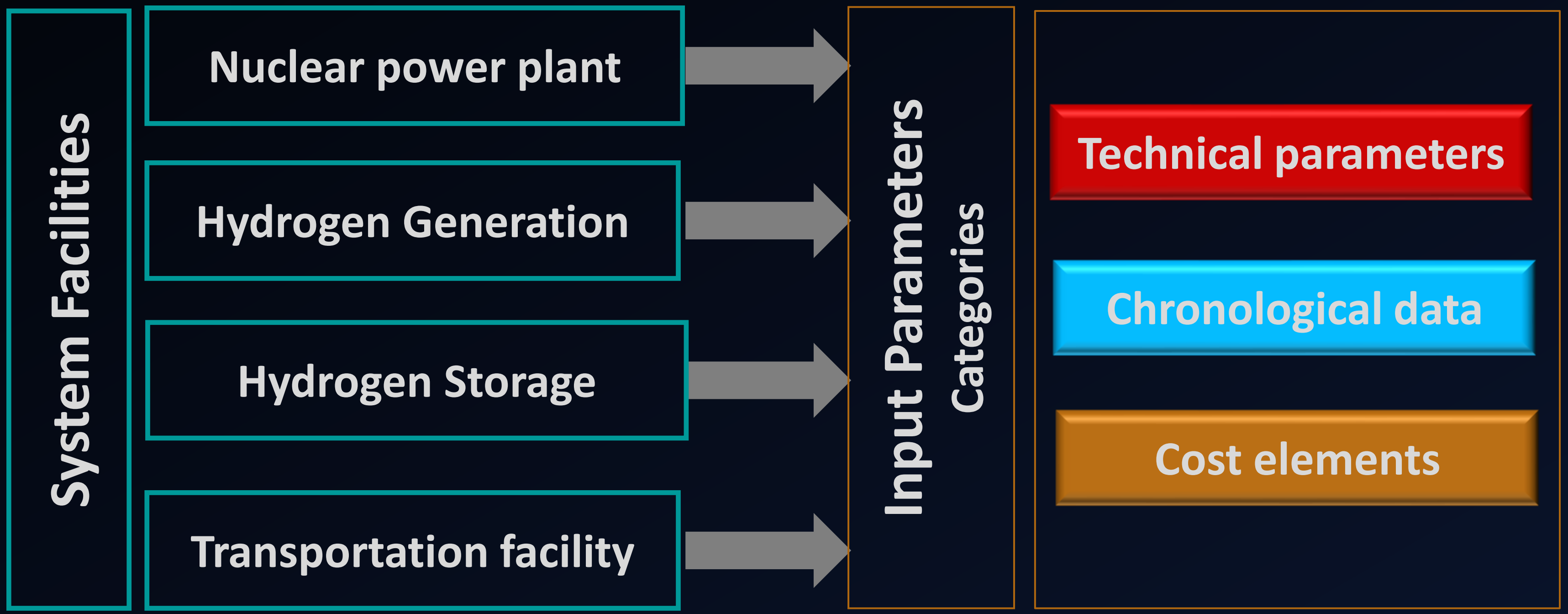
Executing module estimating levelized cost of hydrogen generation

Post-processing module for viewing results generated by HEEP



Type of Data Input to HEEP

Input Information Categorisation



Technical features of HEEP

Technical parameters

Nuclear Power Plant (NPP)

- Installed capacity per unit (MWth)
- Number of units
- Capacity and availability factor of unit
- Thermal power available for Hydrogen generation (MWth)
- Thermal efficiency of unit (if electricity is generated)

Hydrogen Generation Plant (HG)

- Hydrogen generation rate (kg/yr)
- Number of units
- Thermal power required for installed capacity (MWth)
- Capacity and availability factor of unit
- Process efficiency

Hydrogen Storage Facility (HS)

- Type of hydrogen storage (Gaseous/Liquid/Hydride)
- Capacities, power and auxiliary requirements of storage devices

Transportation Facility

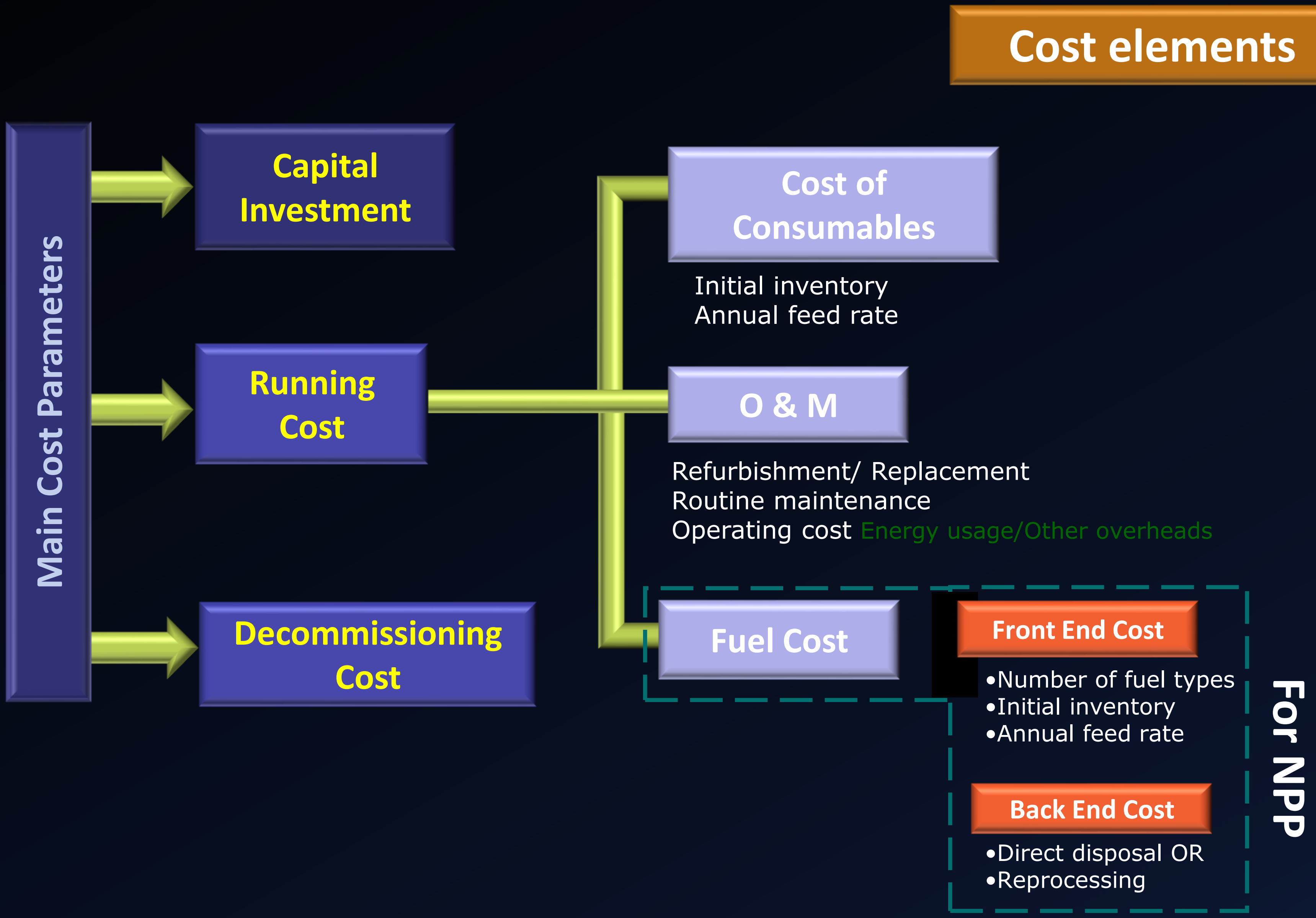
Vehicle	Pipelines
Transportation distance	Transportation distance
Vehicle H_2 Capacity	Pipe equivalent radius
Fuel Cost	Inlet pressure of Hydrogen
Loading Time per trip	Delivery pressure
Average speed	Temperature of Hydrogen
Mileage of vehicle	Friction factor

Time periods of Events affecting Cost Estimation

Chronological data

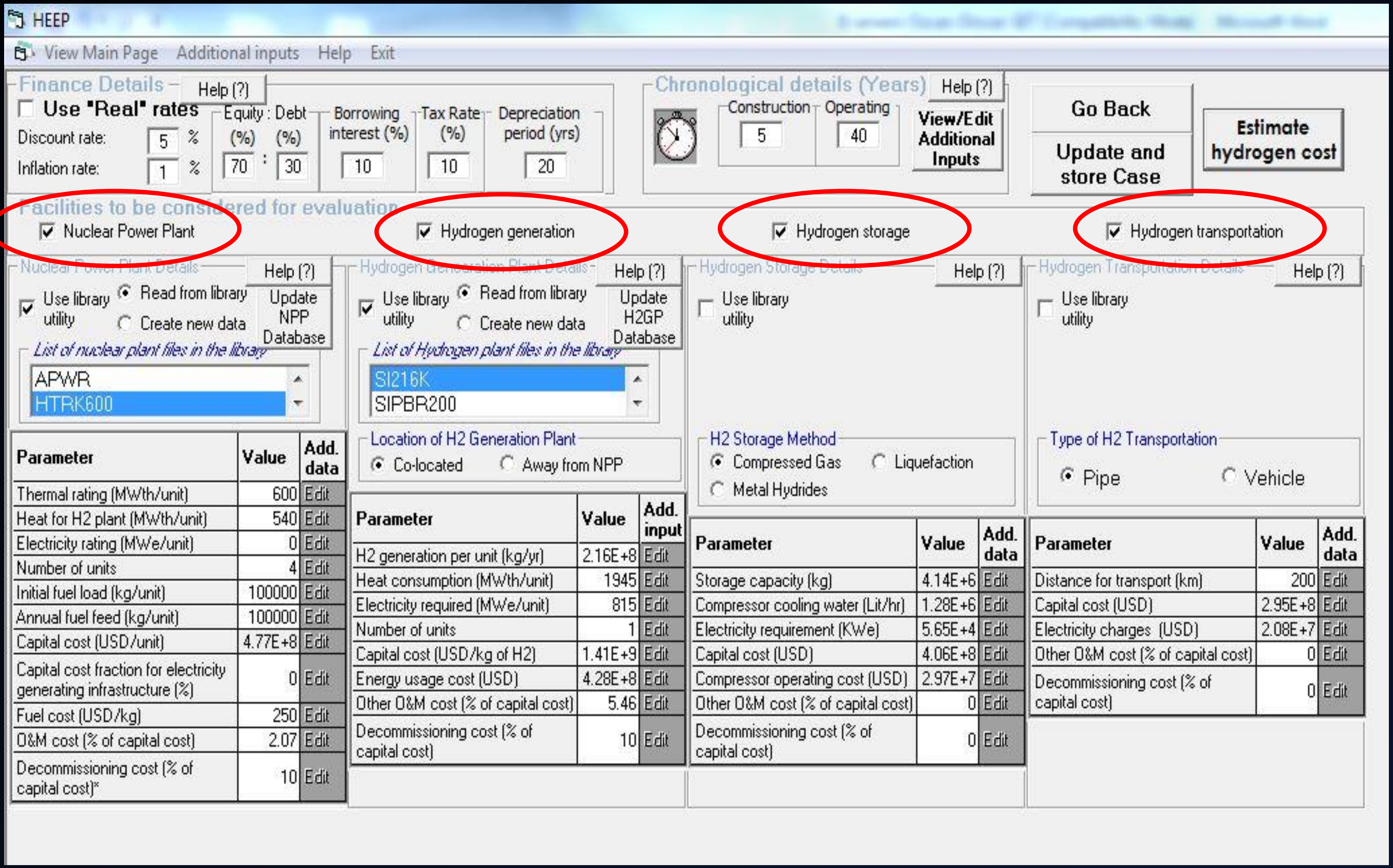
Depreciation period
Construction period
Operation life time/ Return period
Cooling before decommissioning
Decommissioning
Fuel cooling
Waste cooling

Parameters of Cost Calculation



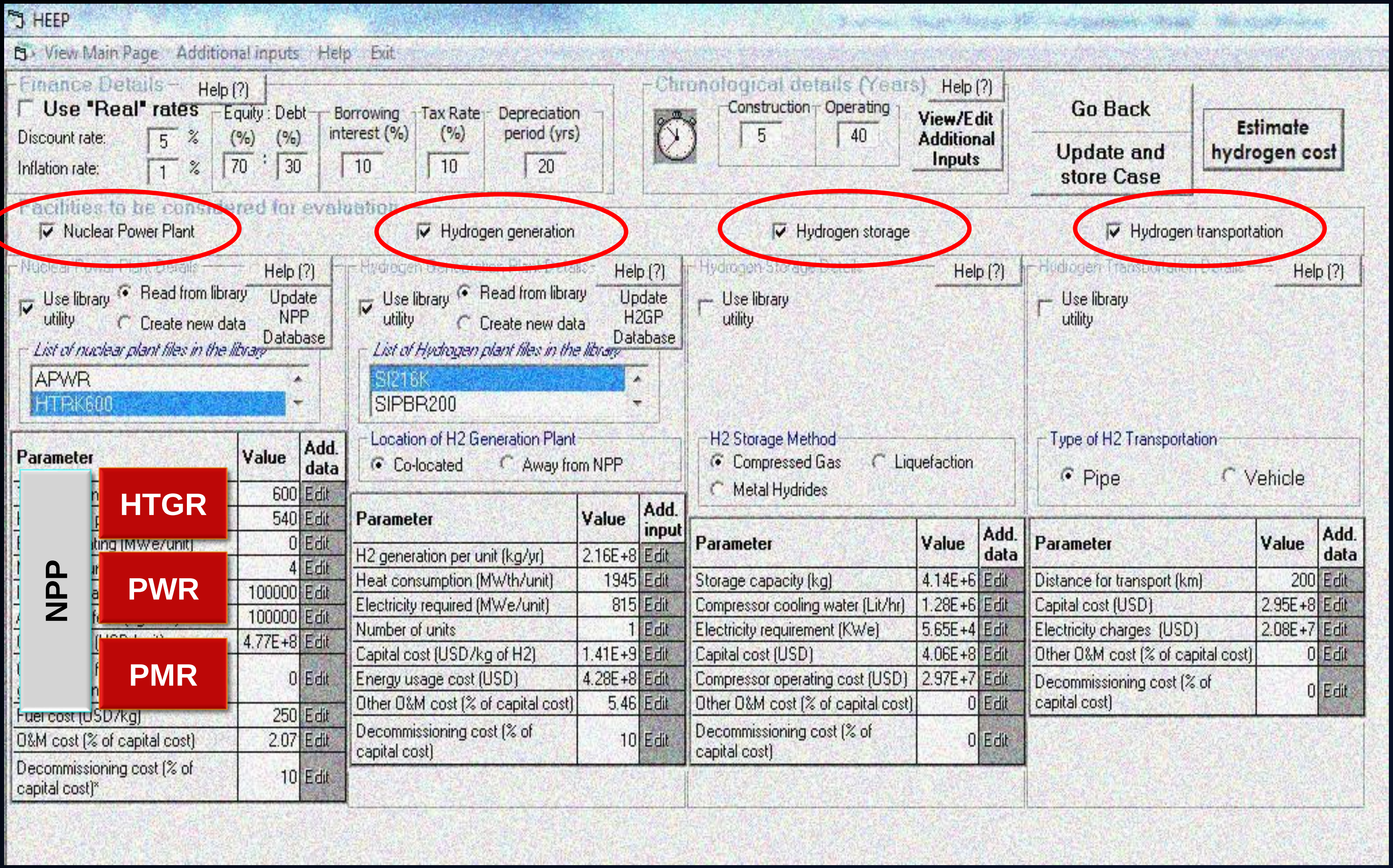
HEEP Features

HEEP Features



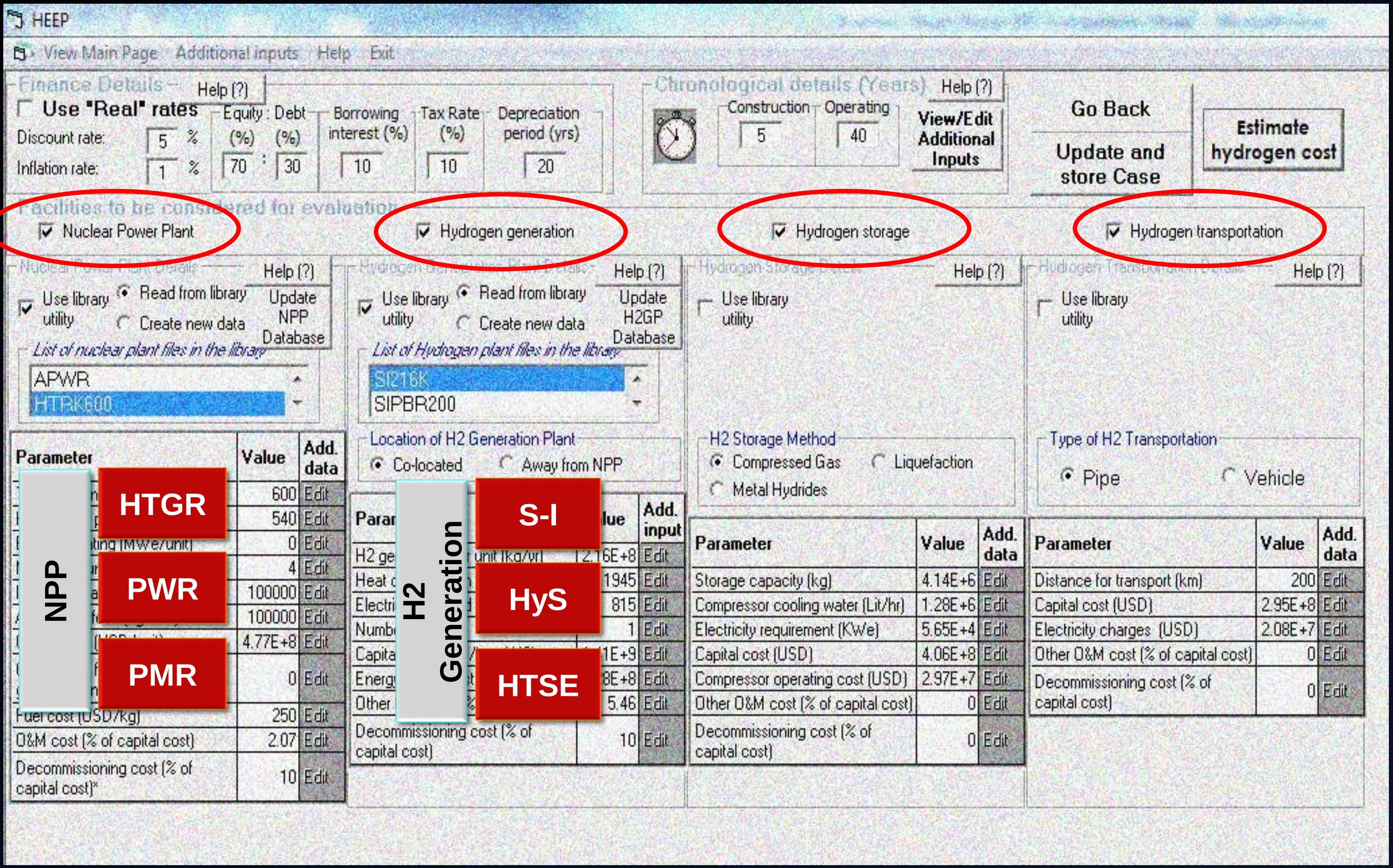
A captured image from main page of HEEP software

HEEP Features



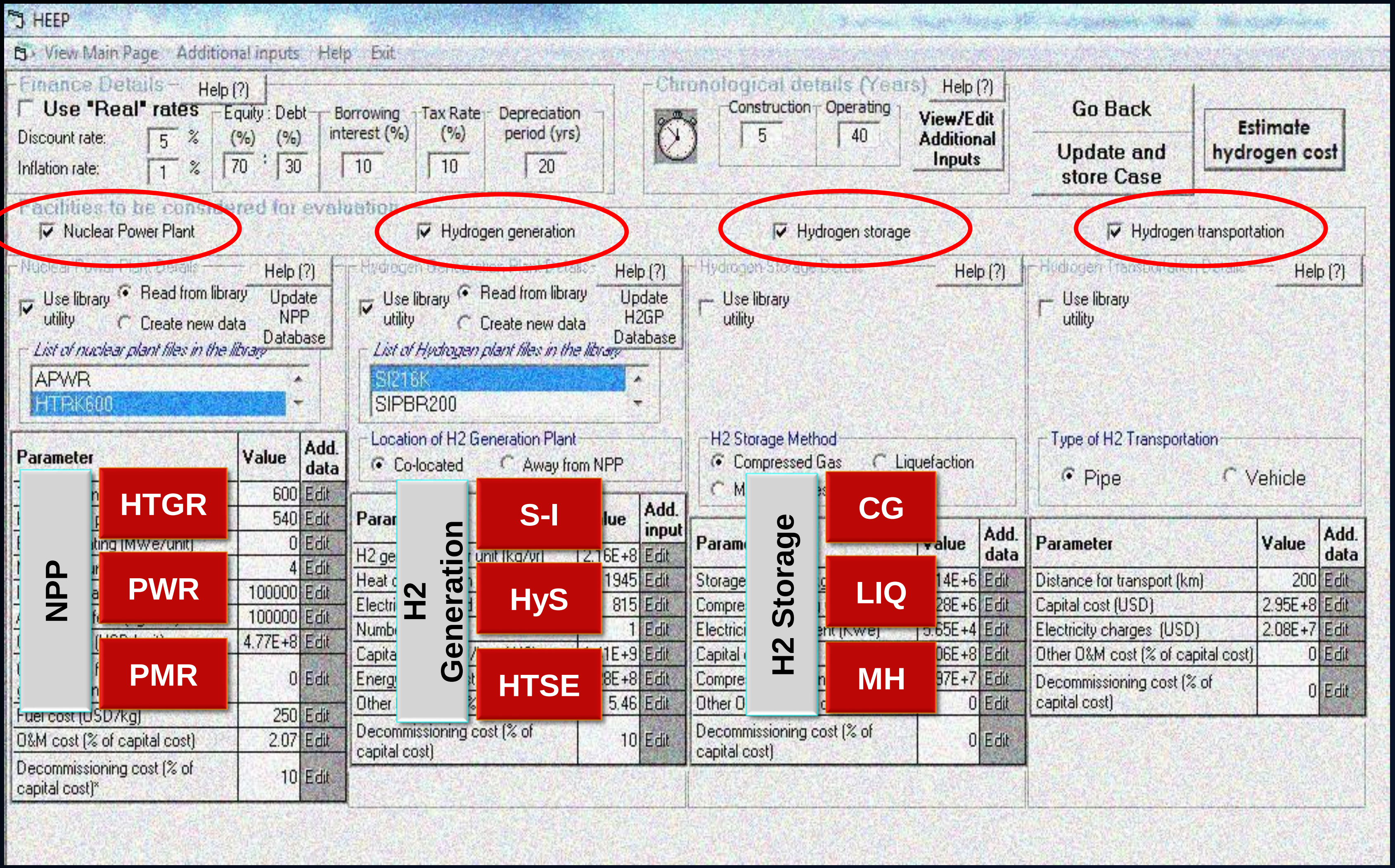
A captured image from main page of HEEP software

HEEP Features



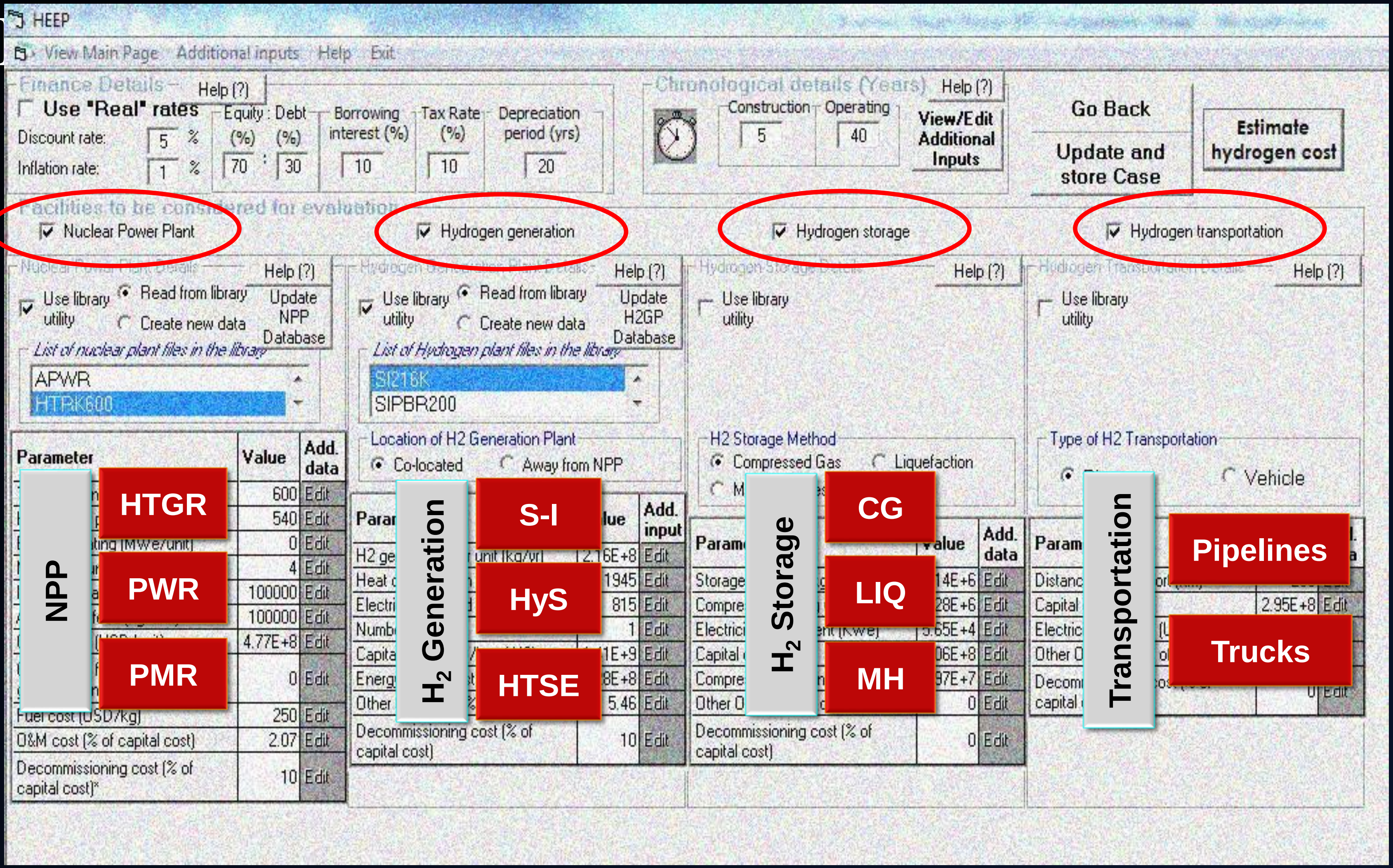
A captured image from main page of HEEP software

HEEP Features



A captured image from main page of HEEP software

HEEP Features



A captured image from main page of HEEP software

Demonstration of HEEP

Nuclear hydrogen production |

https://www.iaea.org/topics/non-electric-applications/nuclear-hydrogen-production

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IAEA
International Atomic Energy Agency

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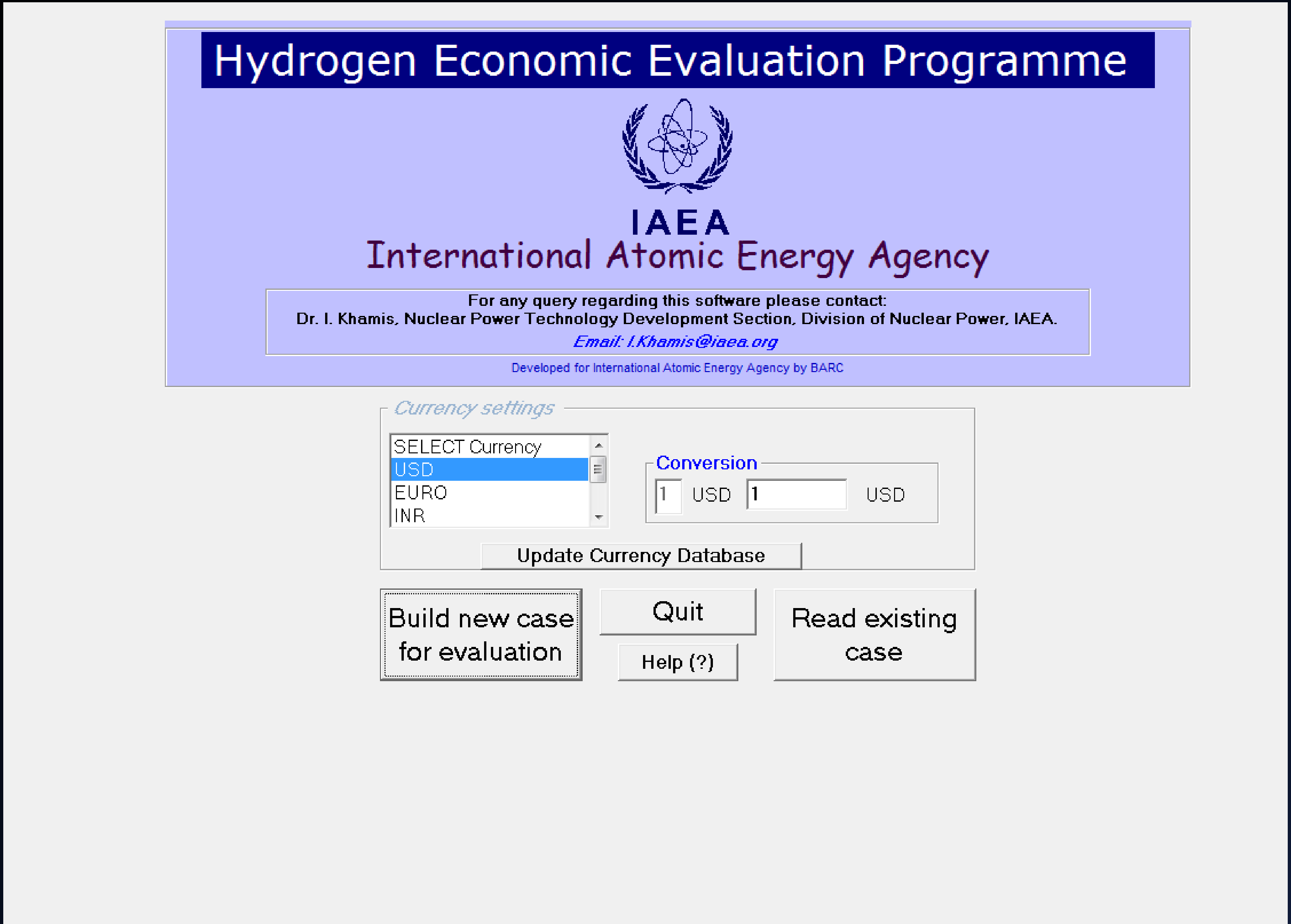
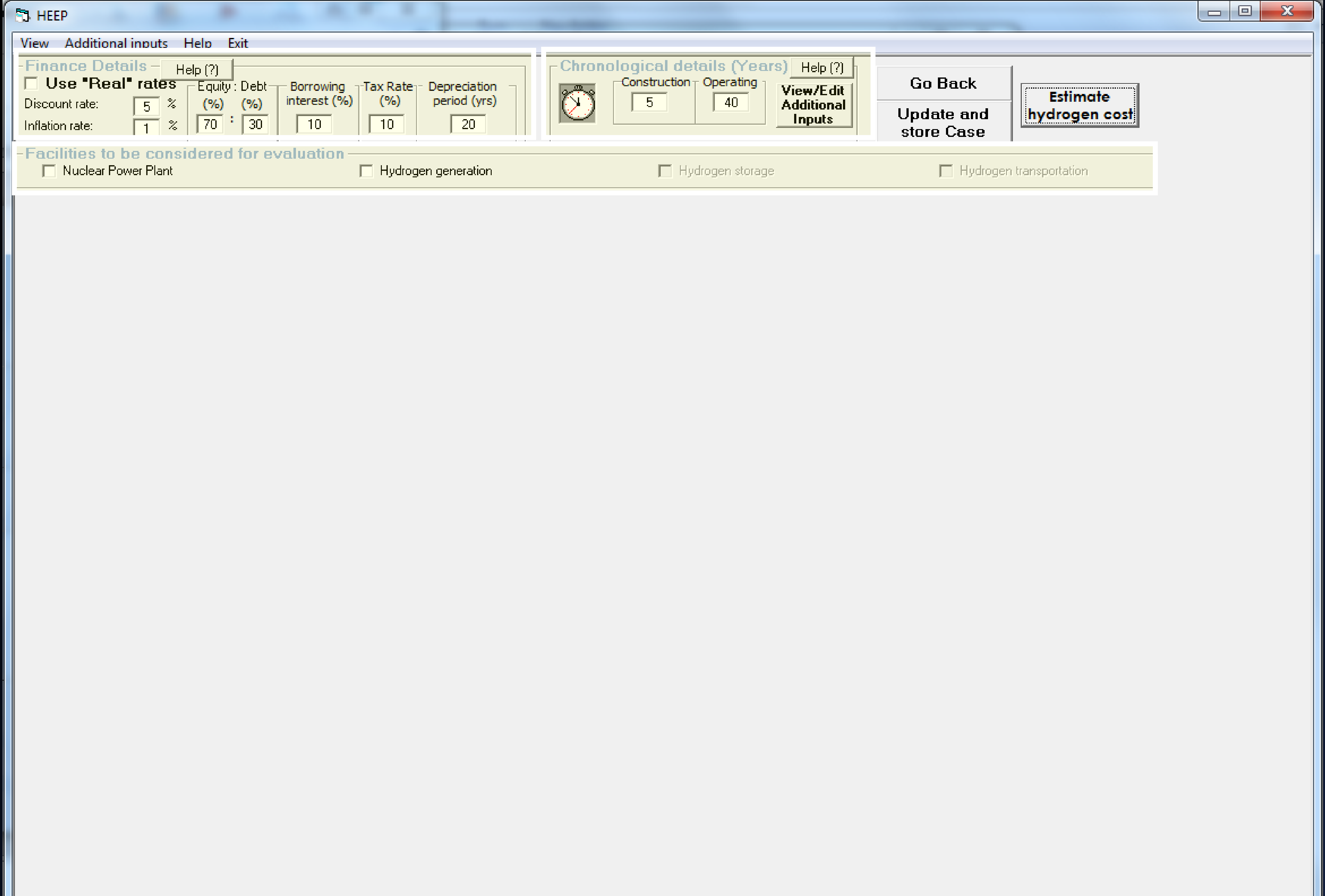
Hydrogen Economic Evaluation Program (HEEP)

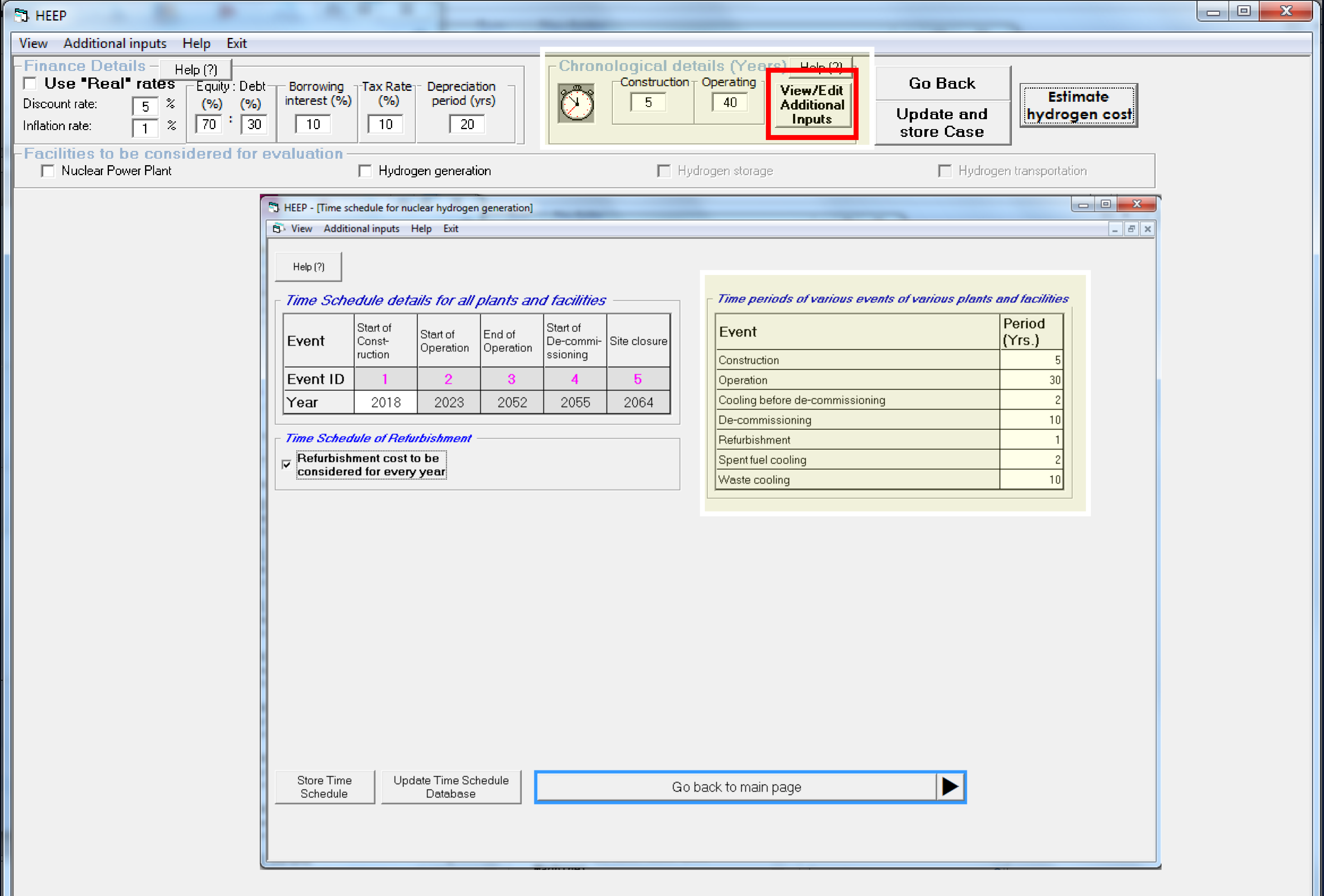
The IAEA Hydrogen Economic Evaluation Program HEEP was developed and released by the International Atomic Energy Agency (IAEA) as a free tool which can be used to assess the economics of large scale hydrogen production using nuclear energy. The software can be used to evaluate the economics of the four most promising processes for hydrogen production: high and low temperature electrolysis, thermochemical processes including S-I process, conventional electrolysis and steam reforming.

The IAEA HEEP software is suitable for comparative studies not only between nuclear and fossil energy sources for hydrogen production but also for solely hydrogen production or cogeneration with electricity. The HEEP models are based on some economic and technical data, and on cost modelling which include various aspects of hydrogen economy including storage, transport, and distribution with options to eliminate or include specific details as required by the users.

Download **HEEP** software


Hydrogen Economic Evaluation Programme
IAEA
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.
Email: I.Khamis@iaea.org
Developed for International Atomic Energy Agency by BARC
Currency settings
SELECT Currency
USD
EURO
INR
Conversion
1 USD 1 USD
Update Currency Database
Build new case for evaluation
Quit
Help (?)
Read existing case


HEEP
View
Additional inputs
Help
Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate:
5
%
Inflation rate:
1
%
Equity : Debt
(%)
(%)
70
:
30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Help (?)
Construction
5
Operating
40
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Hydrogen generation
Hydrogen storage
Hydrogen transportation


HEEP
View Additional inputs Help Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%) 70 : 30
Borrowing interest (%) 10
Tax Rate (%) 10
Depreciation period (yrs) 20
Chronological details (Years)
Construction 5
Operating 40
View/Edit Additional Inputs
Go Back
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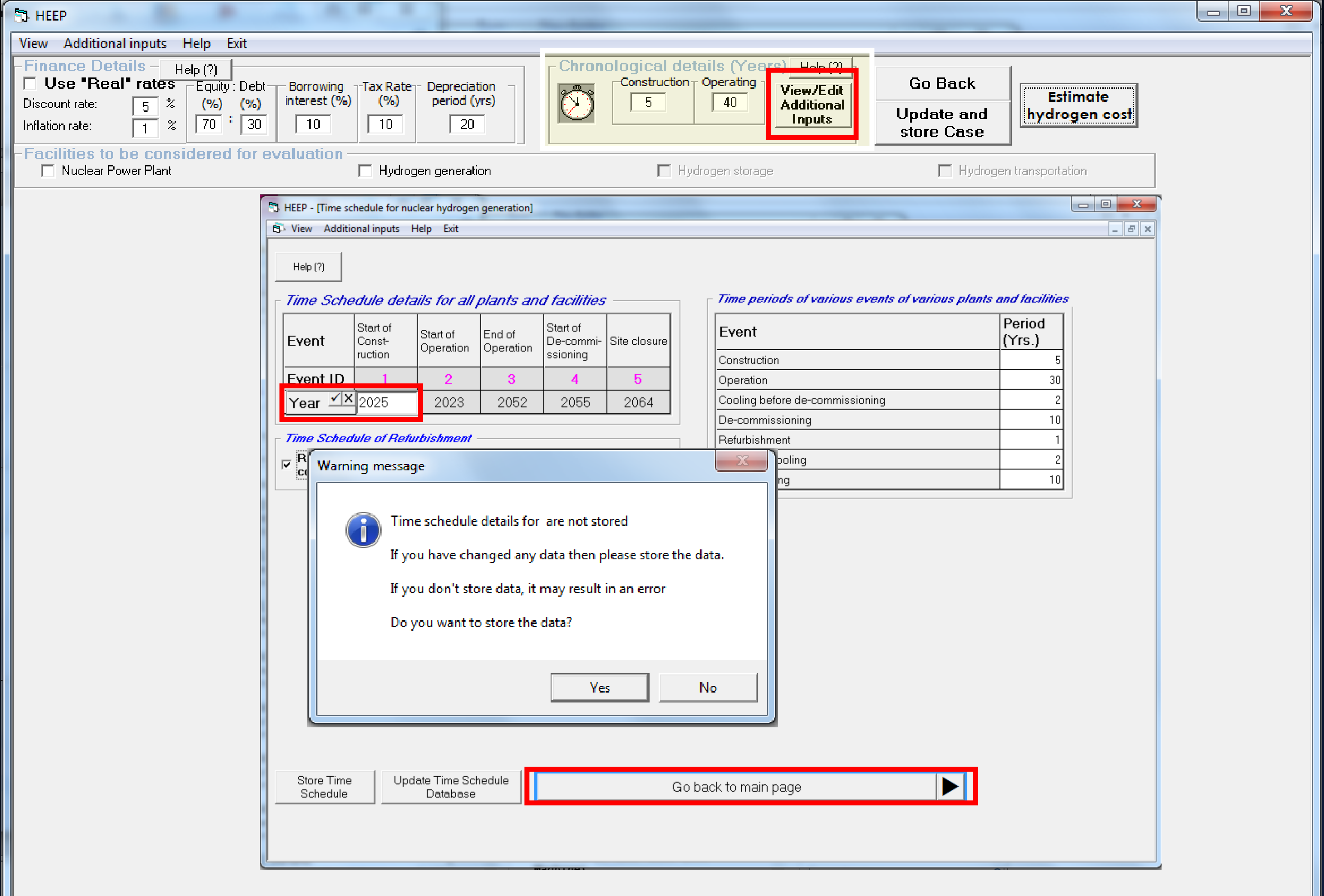
Hydrogen transportation
HEEP - [Time schedule for nuclear hydrogen generation]
Time Schedule details for all plants and facilities
Event | Start of Construction | Start of Operation | End of Operation | Start of De-commissioning | Site closure
Event ID | 1 | 2 | 3 | 4 | 5
Year | 2018 | 2023 | 2052 | 2055 | 2064
Time Schedule of Refurbishment
Refurbishment cost to be considered for every year
Time periods of various events of various plants and facilities
Event | Period (Yrs.)
Construction | 5
Operation | 30
Cooling before de-commissioning | 2
De-commissioning | 10
Refurbishment | 1
Spent fuel cooling | 2
Waste cooling | 10
Store Time Schedule
Update Time Schedule Database
Go back to main page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View
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Exit
Help (?)
Time Schedule details for all plants and facilities
Event
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Start of Operation
End of Operation
Start of De-commi-ssioning
Site closure
Event ID
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Operation
30
Cooling before de-commissioning
2
De-commissioning
10
Refurbishment
1
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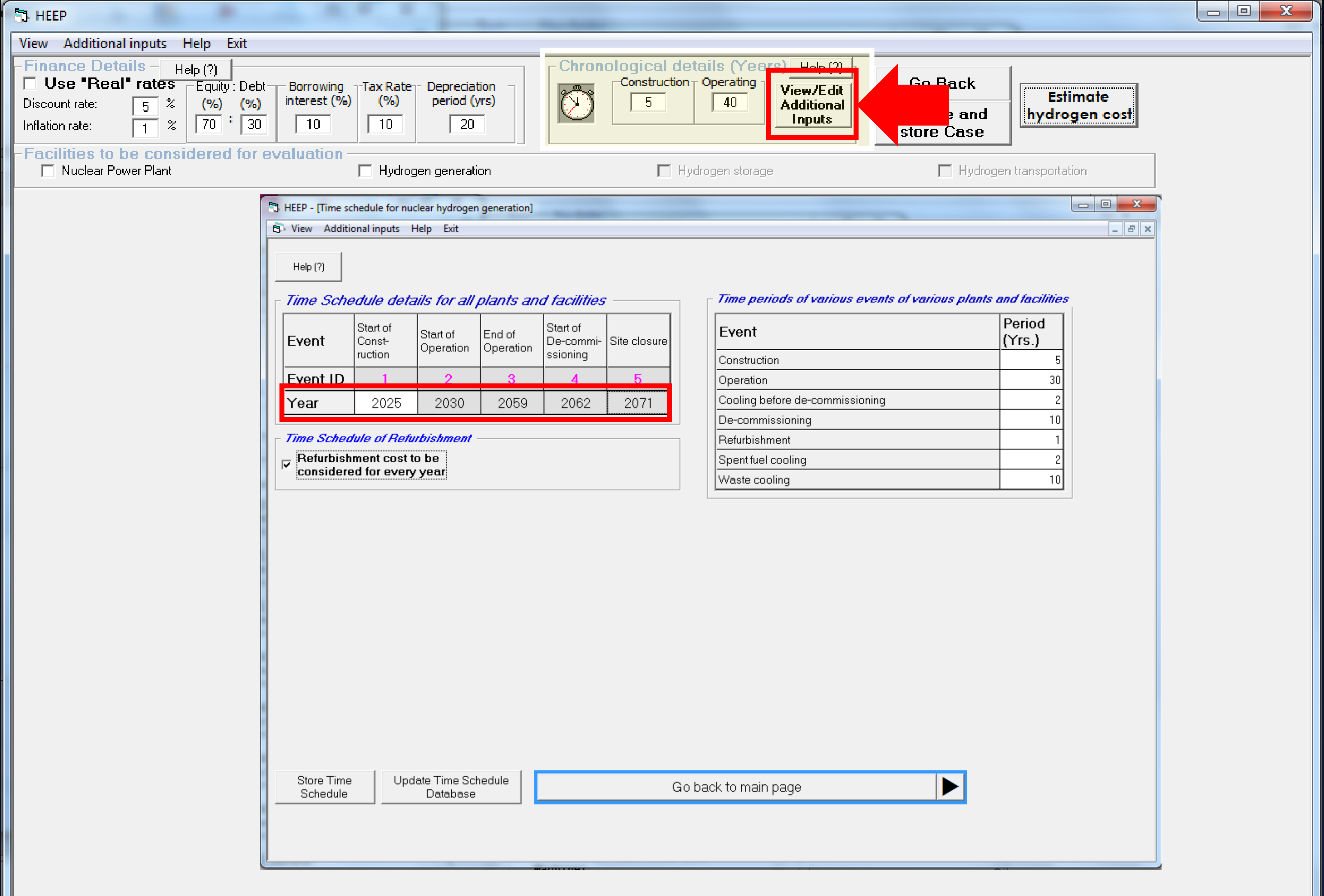
ng
10
Time Schedule of Refurbishment
Warning message
Time schedule details for are not stored
If you have changed any data then please store the data.
If you don't store data, it may result in an error
Do you want to store the data?
Yes
No
Store Time Schedule
Update Time Schedule Database
Go back to main page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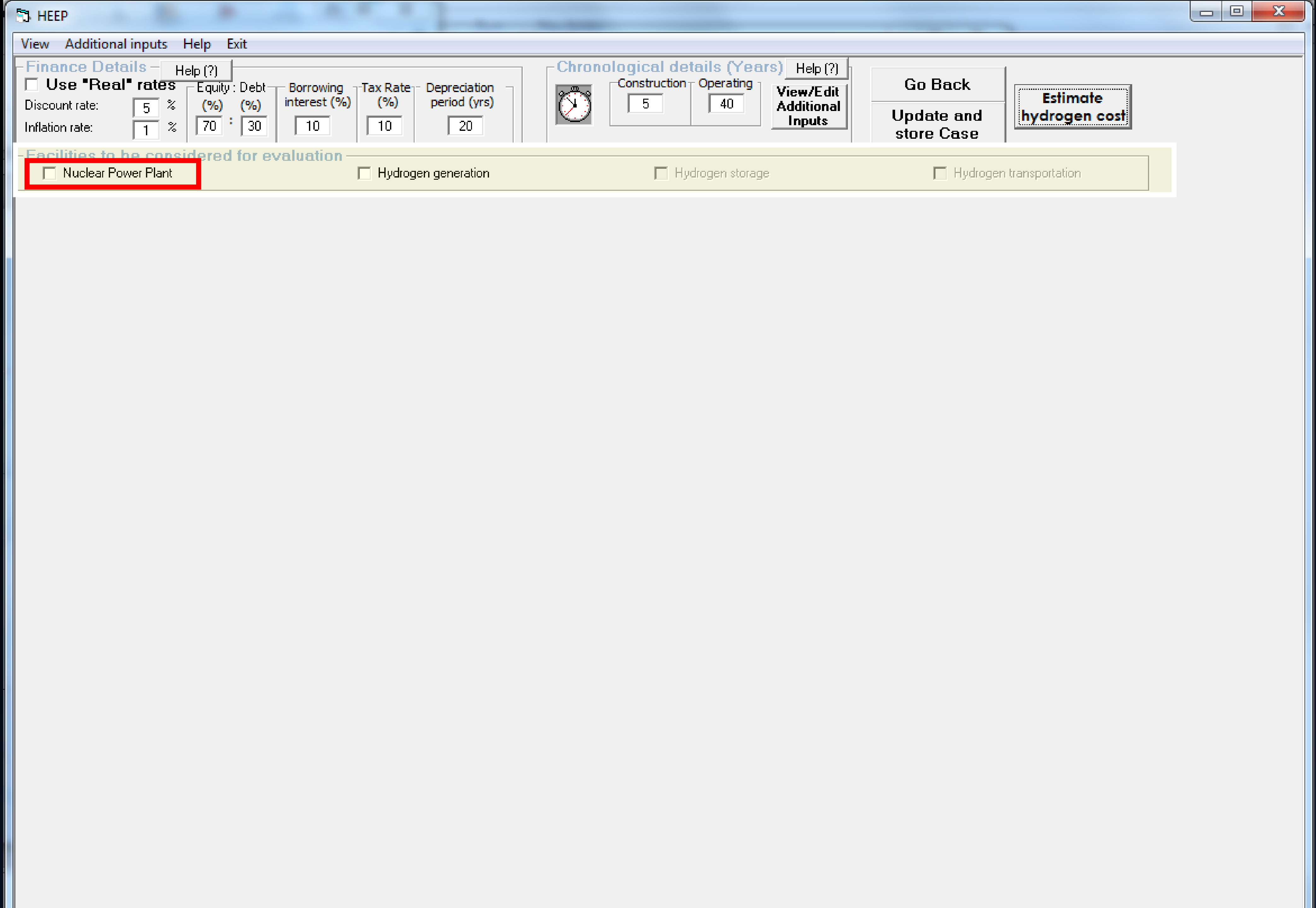
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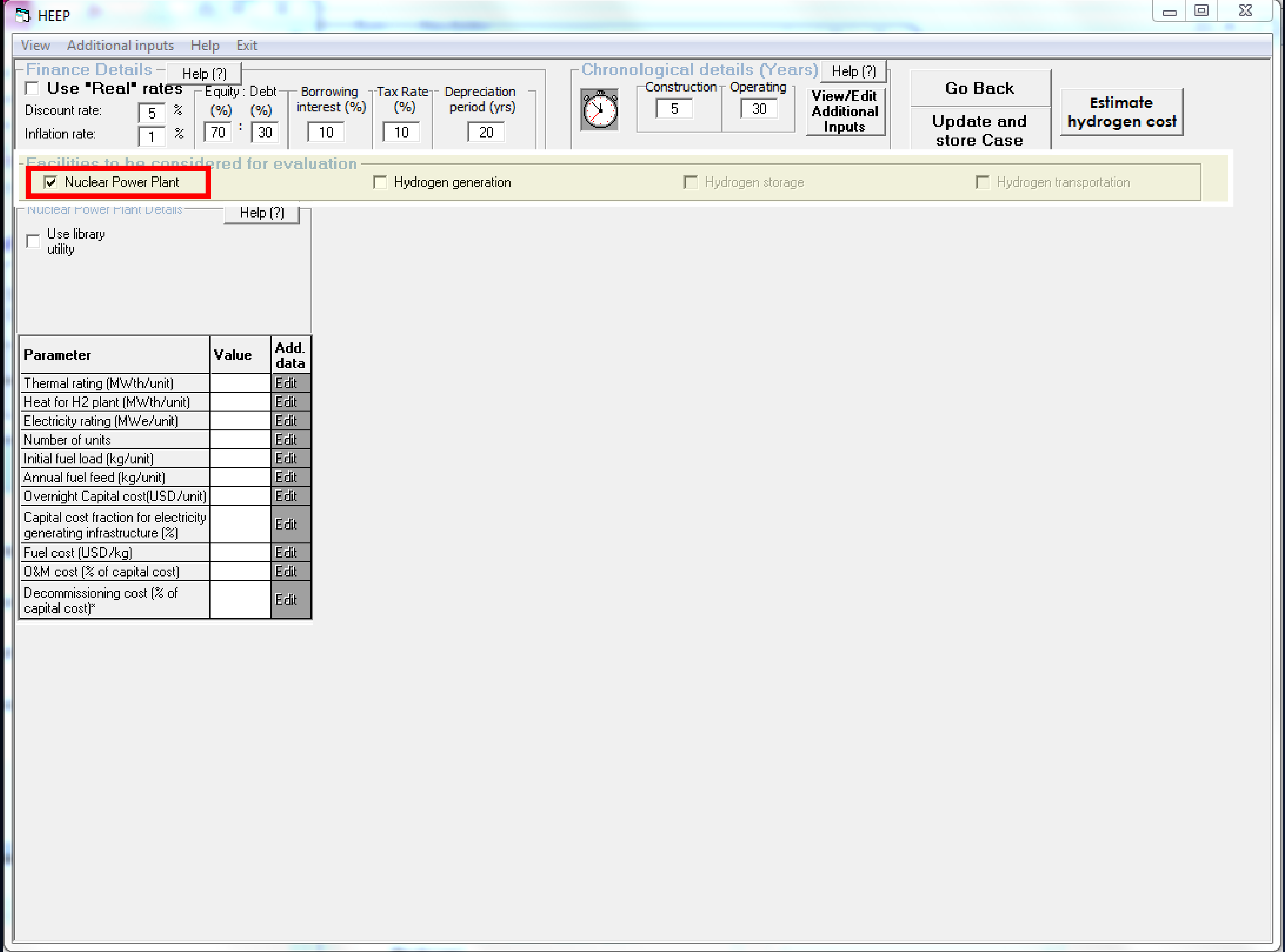
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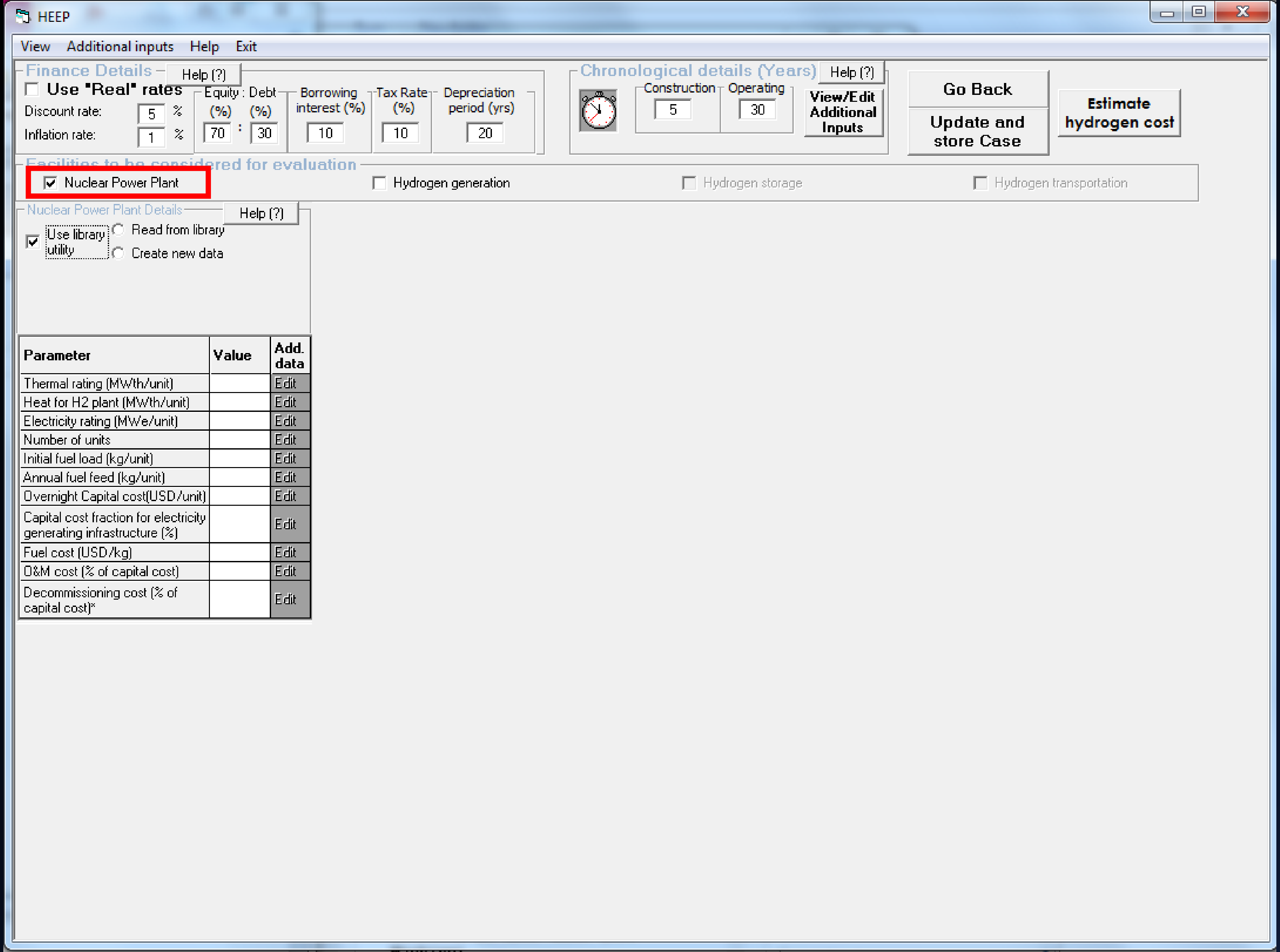
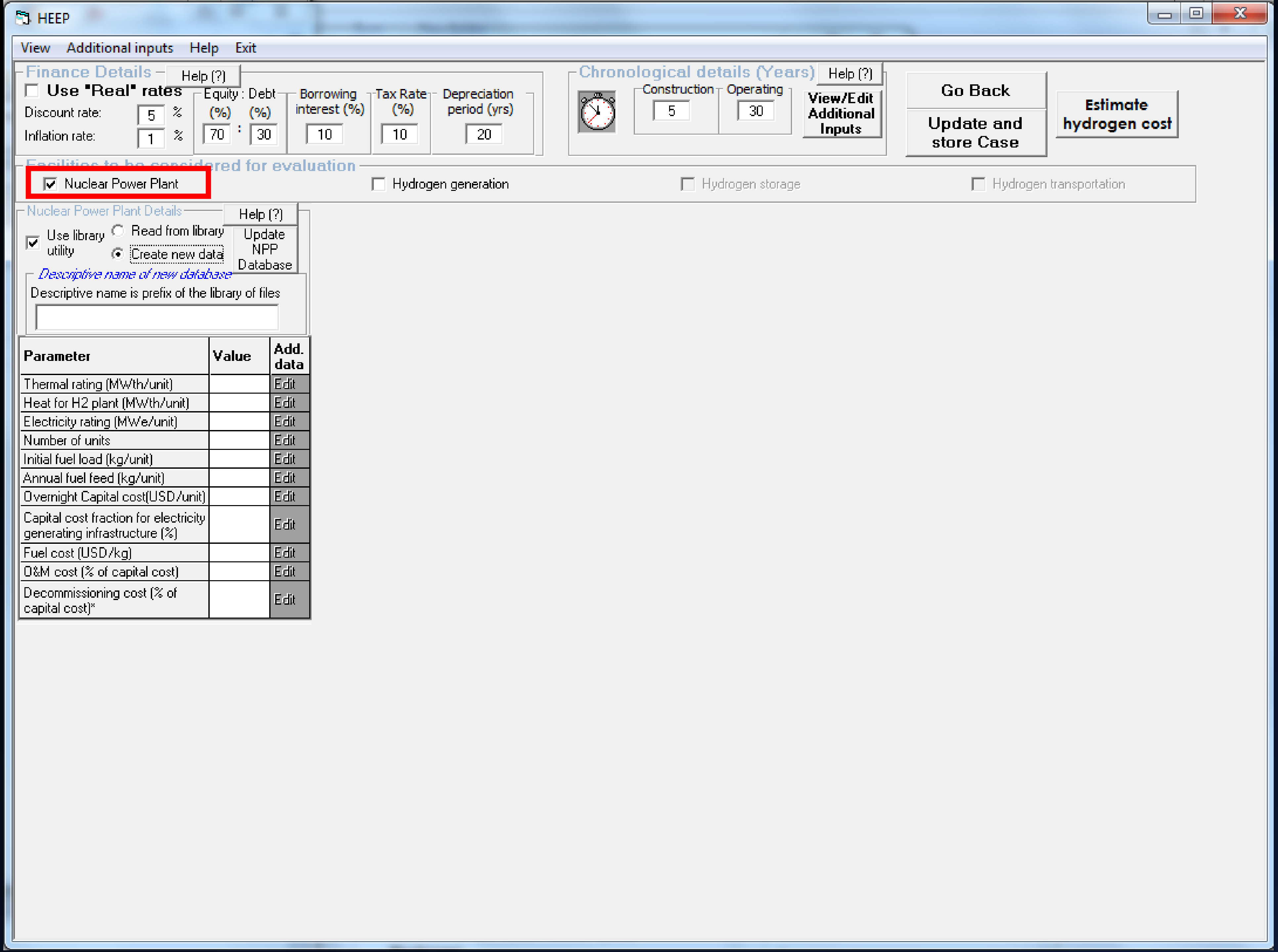
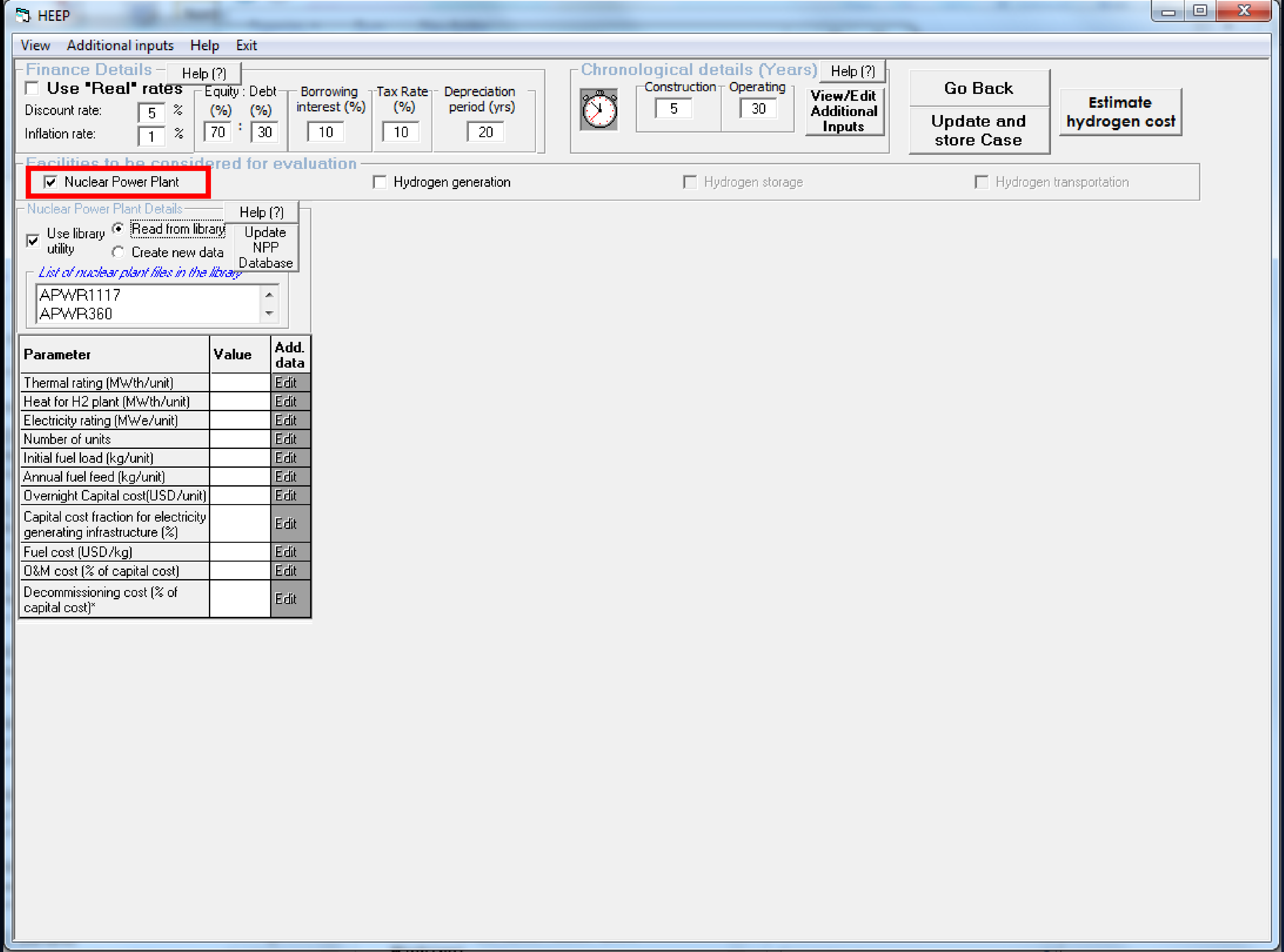
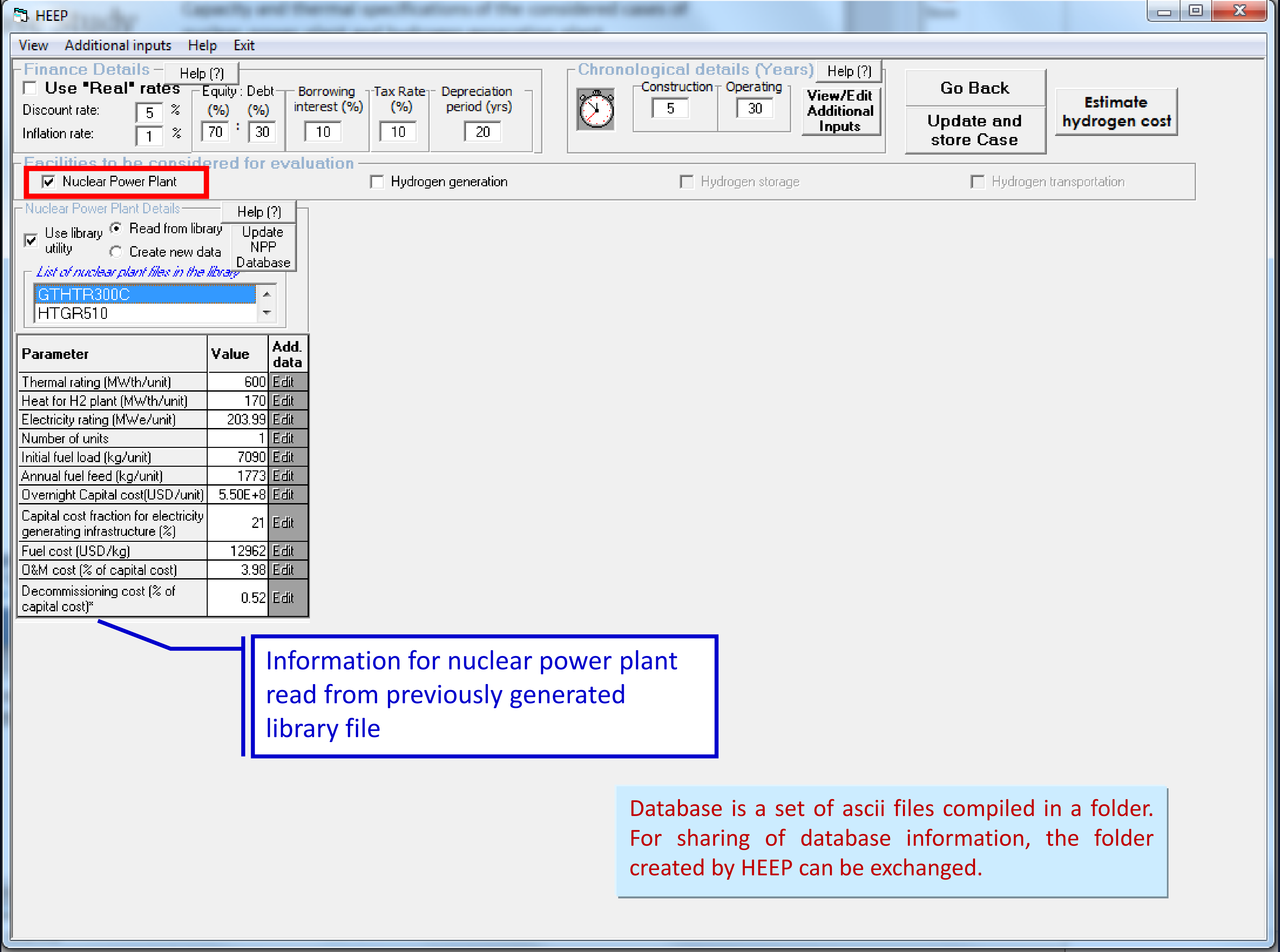
Nuclear Power Plant
Hydrogen generation
Hydrogen storage
Hydrogen transportation
Nuclear Power Plant Details
Help (?)
Use library utility
Parameter
Value
Add. data
Thermal rating (MWth/unit) Edit
Heat for H2 plant (MWth/unit) Edit
Electricity rating (MWe/unit) Edit
Number of units Edit
Initial fuel load (kg/unit) Edit
Annual fuel feed (kg/unit) Edit
Overnight Capital cost(USD/unit) Edit
Capital cost fraction for electricity generating infrastructure (%) Edit
Fuel cost (USD/kg) Edit
O&M cost (% of capital cost) Edit
Decommissioning cost (% of capital cost)* Edit


HEEP
View Additional inputs Help Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%)
70 : 30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Help (?)
Construction
5
Operating
30
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Hydrogen generation
Hydrogen storage
Hydrogen transportation
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Parameter
Value
Add. data
Thermal rating (MWth/unit) Edit
Heat for H2 plant (MWth/unit) Edit
Electricity rating (MWe/unit) Edit
Number of units Edit
Initial fuel load (kg/unit) Edit
Annual fuel feed (kg/unit) Edit
Overnight Capital cost(USD/unit) Edit
Capital cost fraction for electricity generating infrastructure (%) Edit
Fuel cost (USD/kg) Edit
O&M cost (% of capital cost) Edit
Decommissioning cost (% of capital cost)* Edit

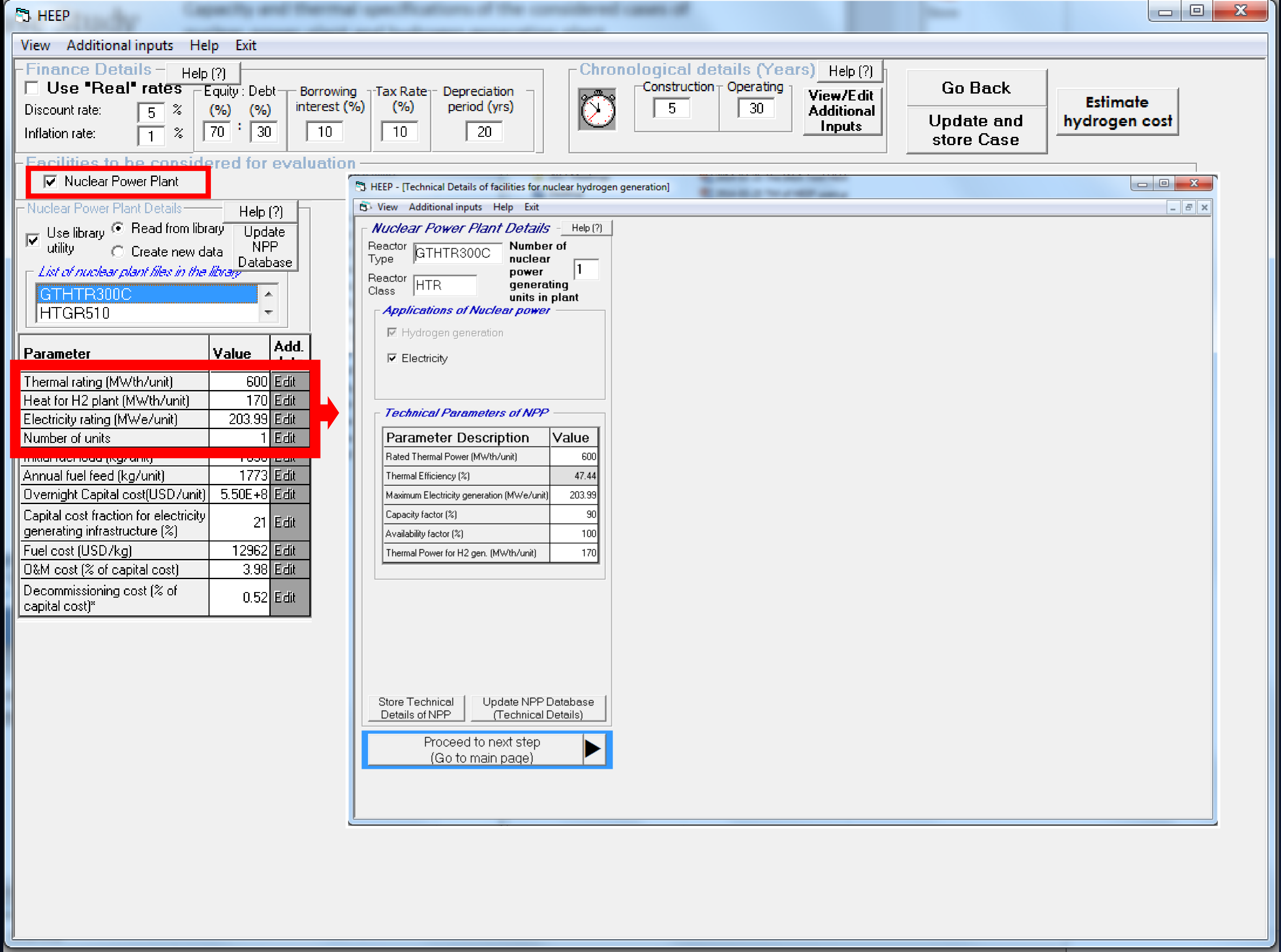

HEEP
View
Additional inputs
Help
Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%)
70 : 30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Help (?)
Construction
5
Operating
30
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Nuclear Power Plant
Hydrogen generation
Hydrogen storage
Hydrogen transportation
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
Descriptive name of new database
Descriptive name is prefix of the library of files
Parameter
Value
Add. data
Thermal rating (MWth/unit) Edit
Heat for H2 plant (MWth/unit) Edit
Electricity rating (MWe/unit) Edit
Number of units Edit
Initial fuel load (kg/unit) Edit
Annual fuel feed (kg/unit) Edit
Overnight Capital cost(USD/unit) Edit
Capital cost fraction for electricity generating infrastructure (%) Edit
Fuel cost (USD/kg) Edit
O&M cost (% of capital cost) Edit
Decommissioning cost (% of capital cost)* Edit

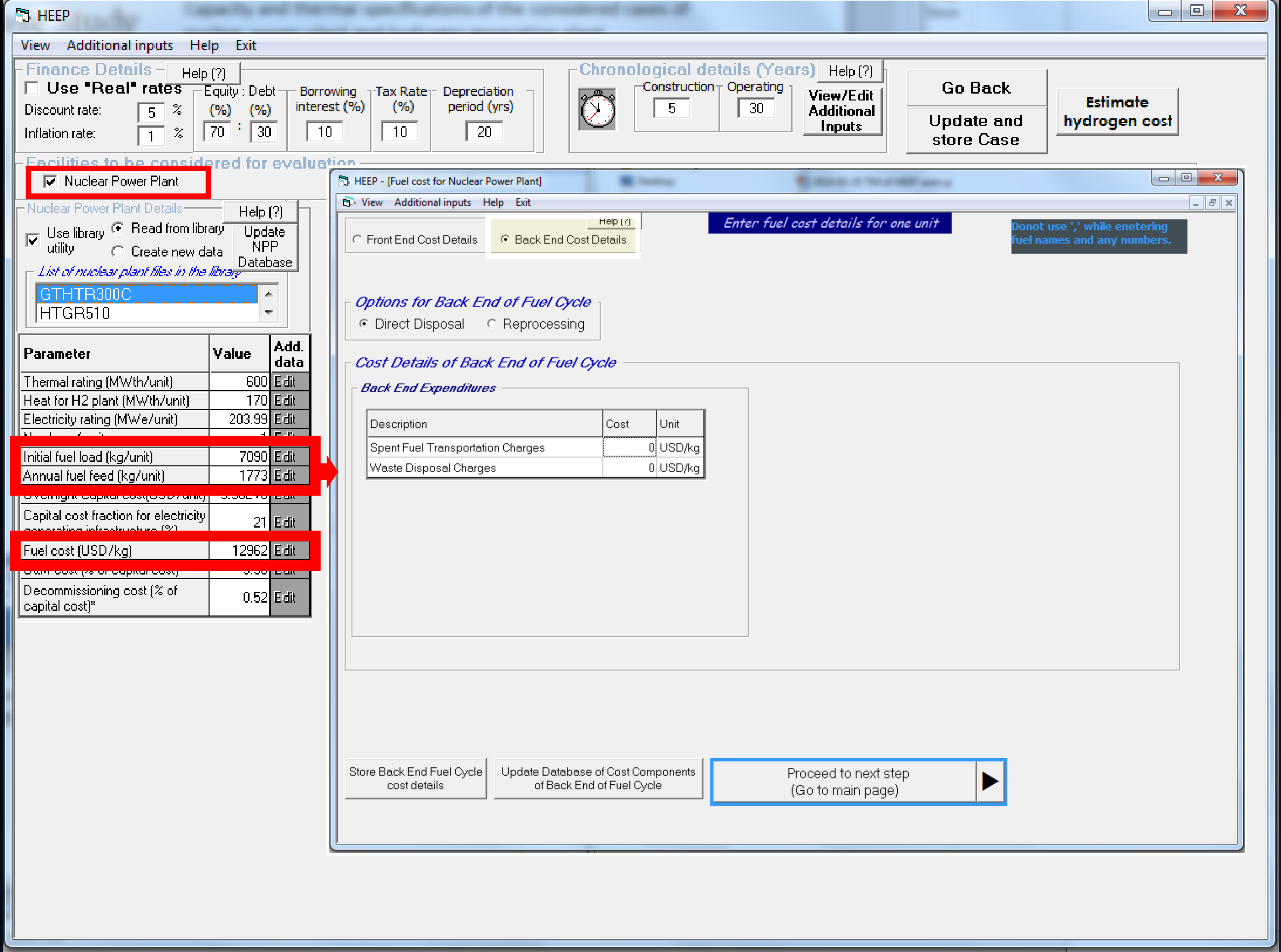

HEEP
View Additional inputs Help Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%)
70 : 30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Help (?)
Construction
5
Operating
30
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Hydrogen generation
Hydrogen storage
Hydrogen transportation
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
APWR1117
APWR360
Parameter
Value
Add. data
Thermal rating (MWth/unit) Edit
Heat for H2 plant (MWth/unit) Edit
Electricity rating (MWe/unit) Edit
Number of units Edit
Initial fuel load (kg/unit) Edit
Annual fuel feed (kg/unit) Edit
Overnight Capital cost(USD/unit) Edit
Capital cost fraction for electricity generating infrastructure (%) Edit
Fuel cost (USD/kg) Edit
O&M cost (% of capital cost) Edit
Decommissioning cost (% of capital cost)* Edit

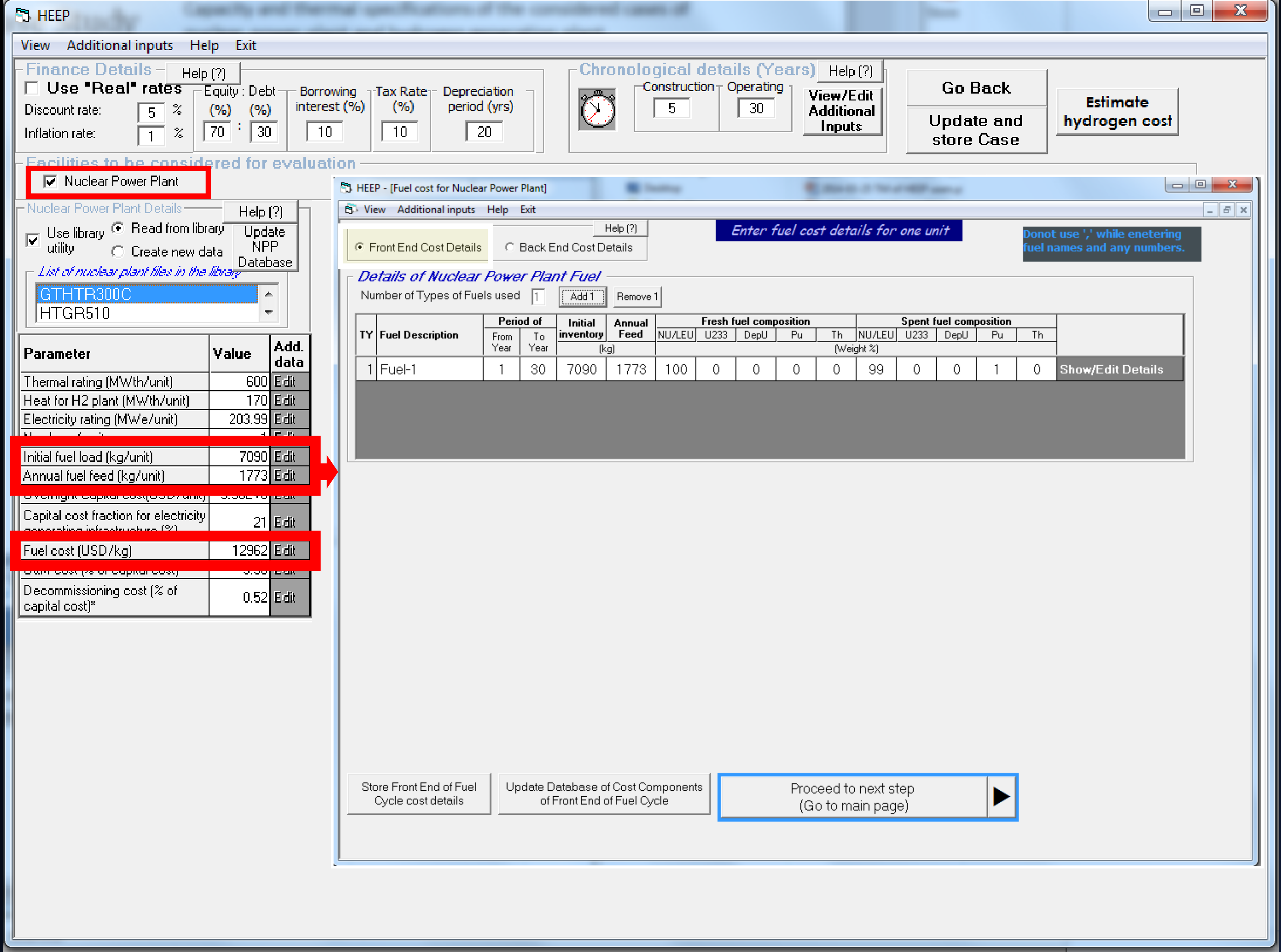


Information for nuclear power plant read from previously generated library file

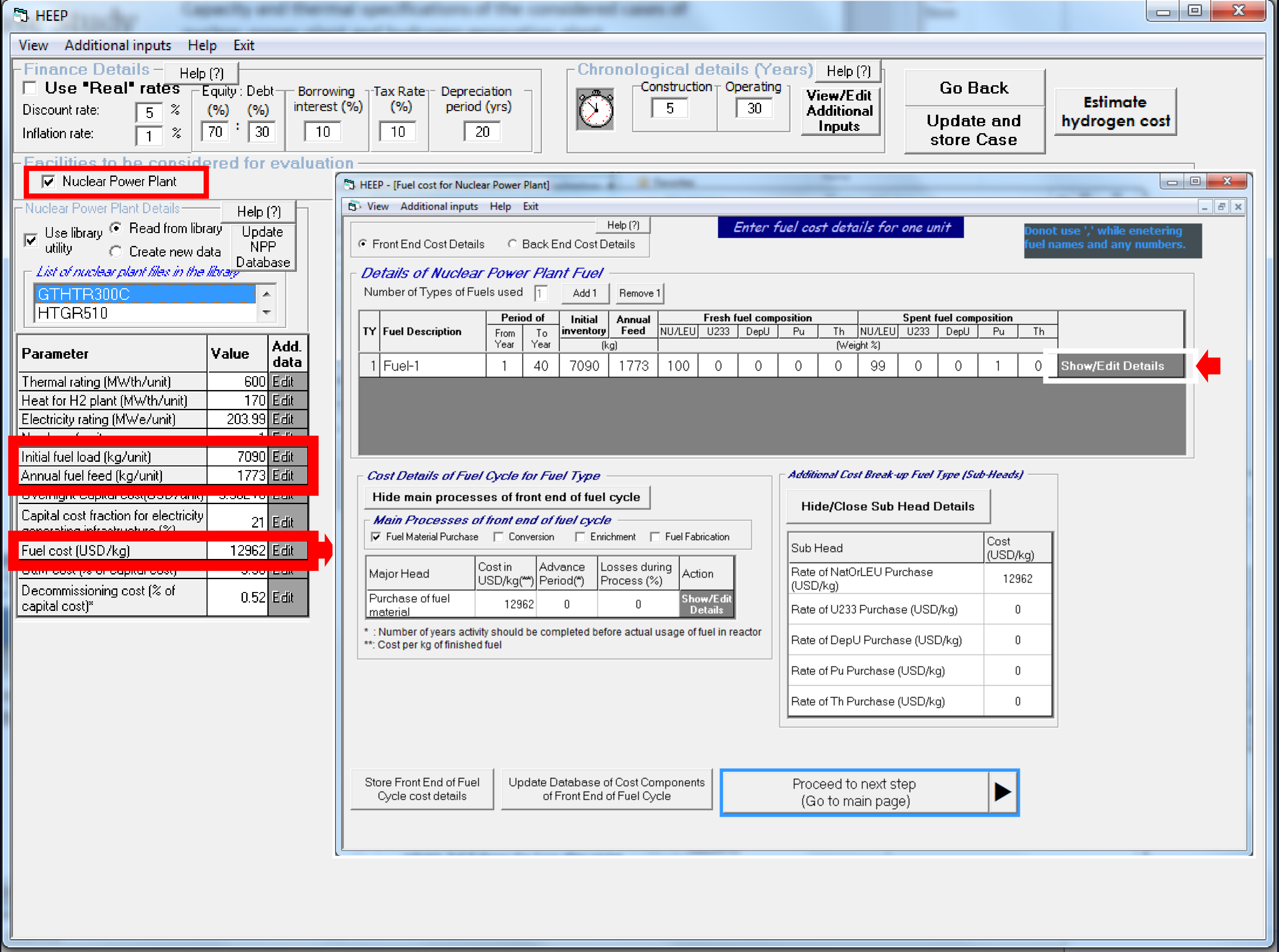
Database is a set of ascii files compiled in a folder. For sharing of database information, the folder created by HEEP can be exchanged.

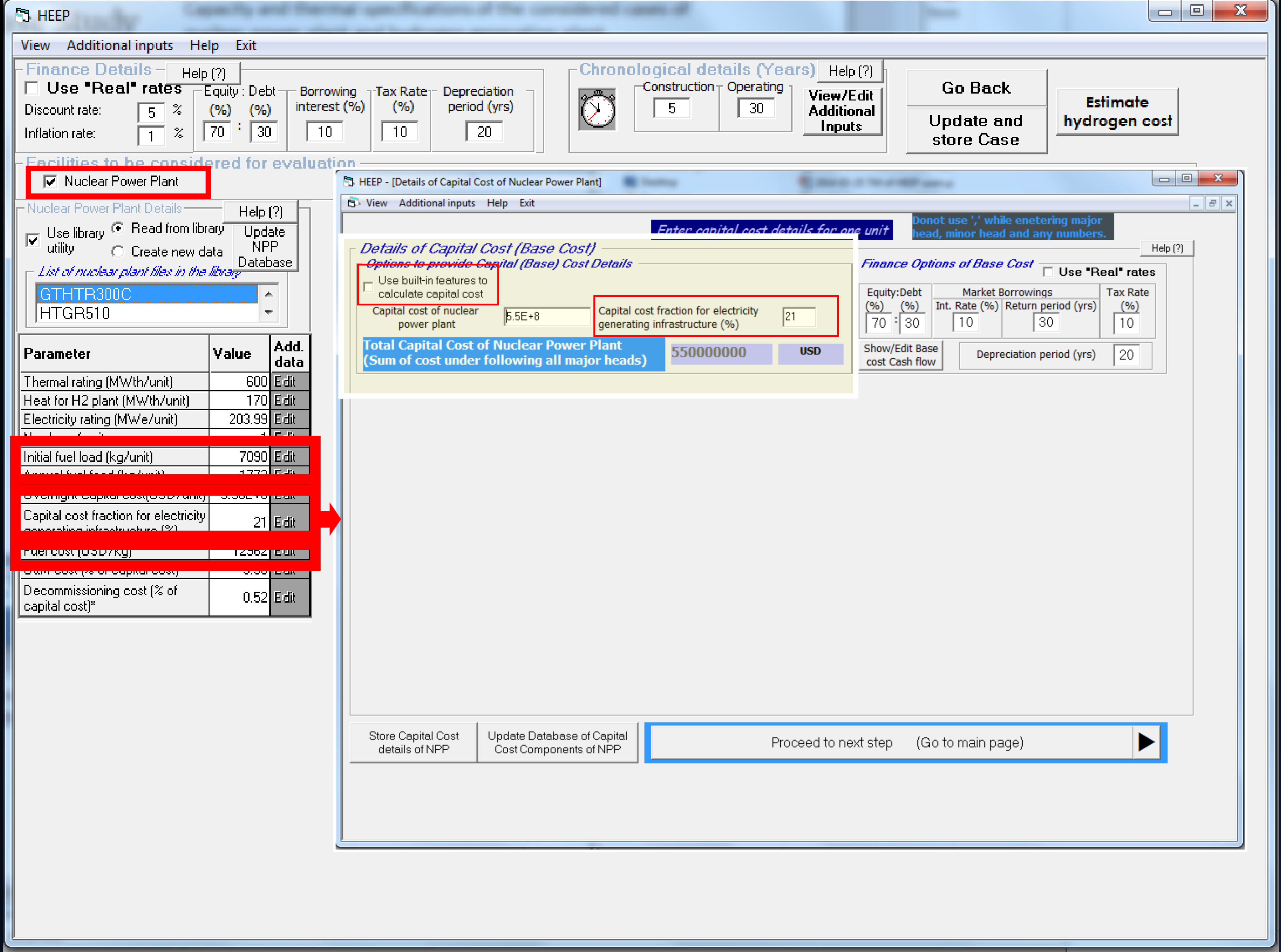

HEEP
View Additional inputs Help Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%) 70 : 30
Borrowing interest (%) 10
Tax Rate (%) 10
Depreciation period (yrs) 20
Chronological details (Years)
Help (?)
Construction 5
Operating 30
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
GTHTR300C
HTGR510
Parameter Value Add.
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Number of units 1 Edit
Annual fuel feed (kg/unit) 1773 Edit
Overnight Capital cost(USD/unit) 5.50E+8 Edit
Capital cost fraction for electricity generating infrastructure (%) 21 Edit
Fuel cost (USD/kg) 12962 Edit
O&M cost (% of capital cost) 3.98 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
HEEP - [Technical Details of facilities for nuclear hydrogen generation]
View Additional inputs Help Exit
Nuclear Power Plant Details
Help (?)
Reactor Type GTHTR300C
Reactor Class HTR
Number of nuclear power generating units in plant 1
Applications of Nuclear power
Hydrogen generation
Electricity
Technical Parameters of NPP
Parameter Description Value
Rated Thermal Power (MWth/unit) 600
Thermal Efficiency (%) 47.44
Maximum Electricity generation (MWe/unit) 203.99
Capacity factor (%) 90
Availability factor (%) 100
Thermal Power for H2 gen. (MWth/unit) 170
Store Technical Details of NPP
Update NPP Database (Technical Details)
Proceed to next step (Go to main page)

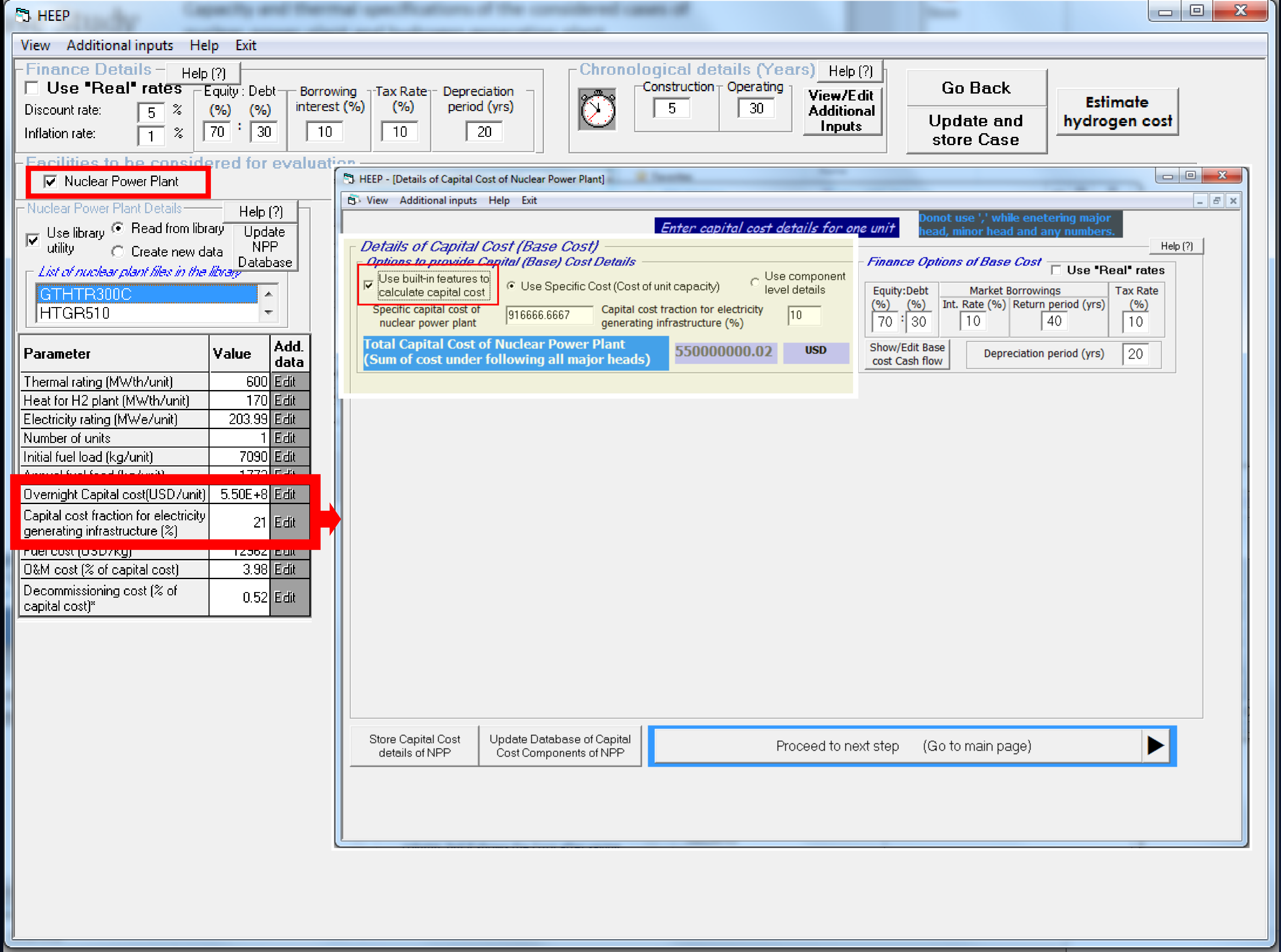

HEEP
View Additional inputs Help Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%) 70 : 30
Borrowing interest (%) 10
Tax Rate (%) 10
Depreciation period (yrs) 20
Chronological details (Years)
Help (?)
Construction 5
Operating 30
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
GTHTR300C
HTGR510
Parameter | Value | Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Initial fuel load (kg/unit) 7090 Edit
Annual fuel feed (kg/unit) 1773 Edit
Capital cost fraction for electricity generating infrastructure (%) 21 Edit
Fuel cost (USD/kg) 12962 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
HEEP - [Fuel cost for Nuclear Power Plant]
View Additional inputs Help Exit
Enter fuel cost details for one unit
Donot use ',' while enetering fuel names and any numbers.
Front End Cost Details
Back End Cost Details
Options for Back End of Fuel Cycle
Direct Disposal
Reprocessing
Cost Details of Back End of Fuel Cycle
Back End Expenditures
Description | Cost | Unit
Spent Fuel Transportation Charges 0 USD/kg
Waste Disposal Charges 0 USD/kg
Store Back End Fuel Cycle cost details
Update Database of Cost Components of Back End of Fuel Cycle
Proceed to next step (Go to main page)

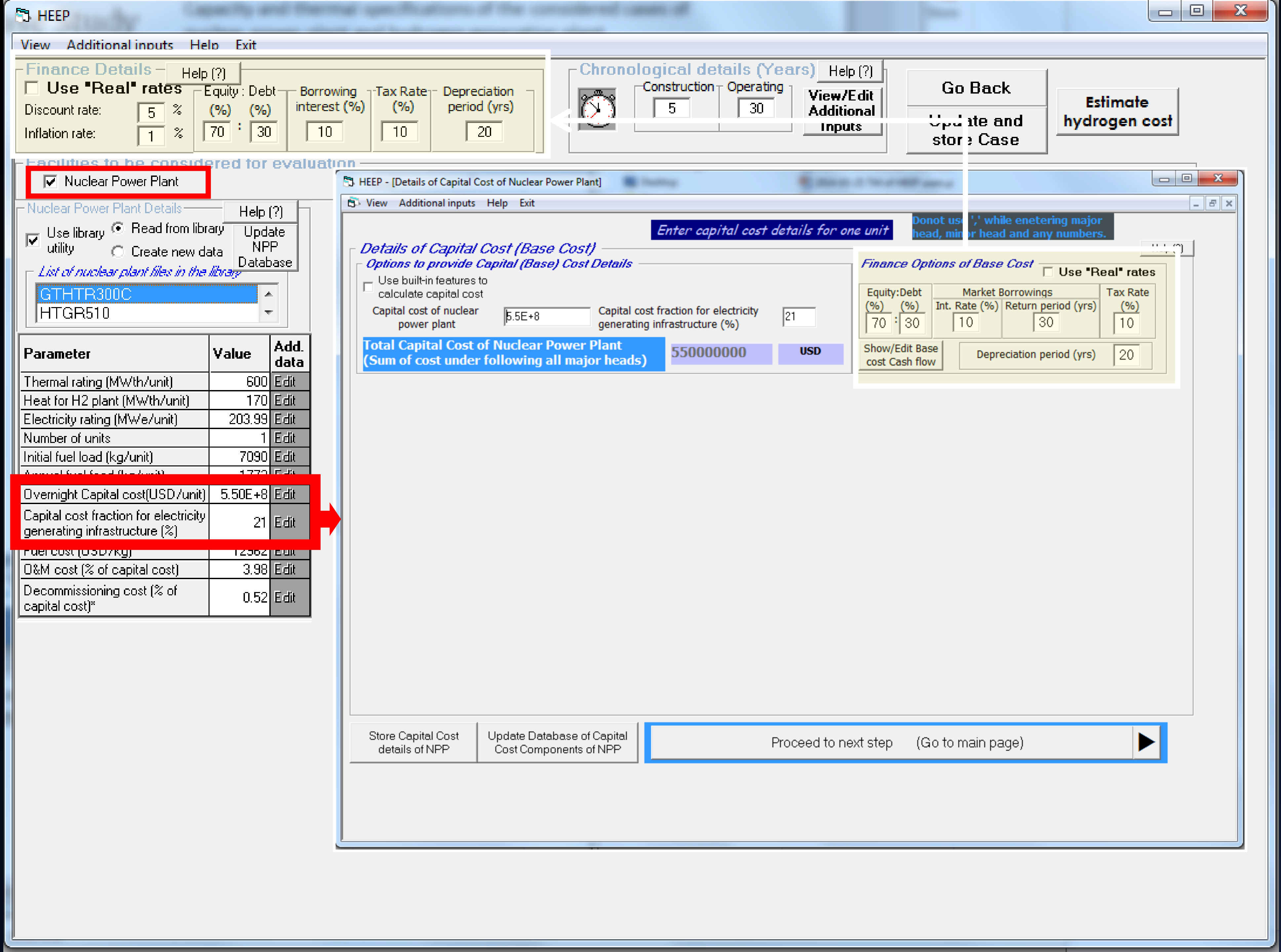


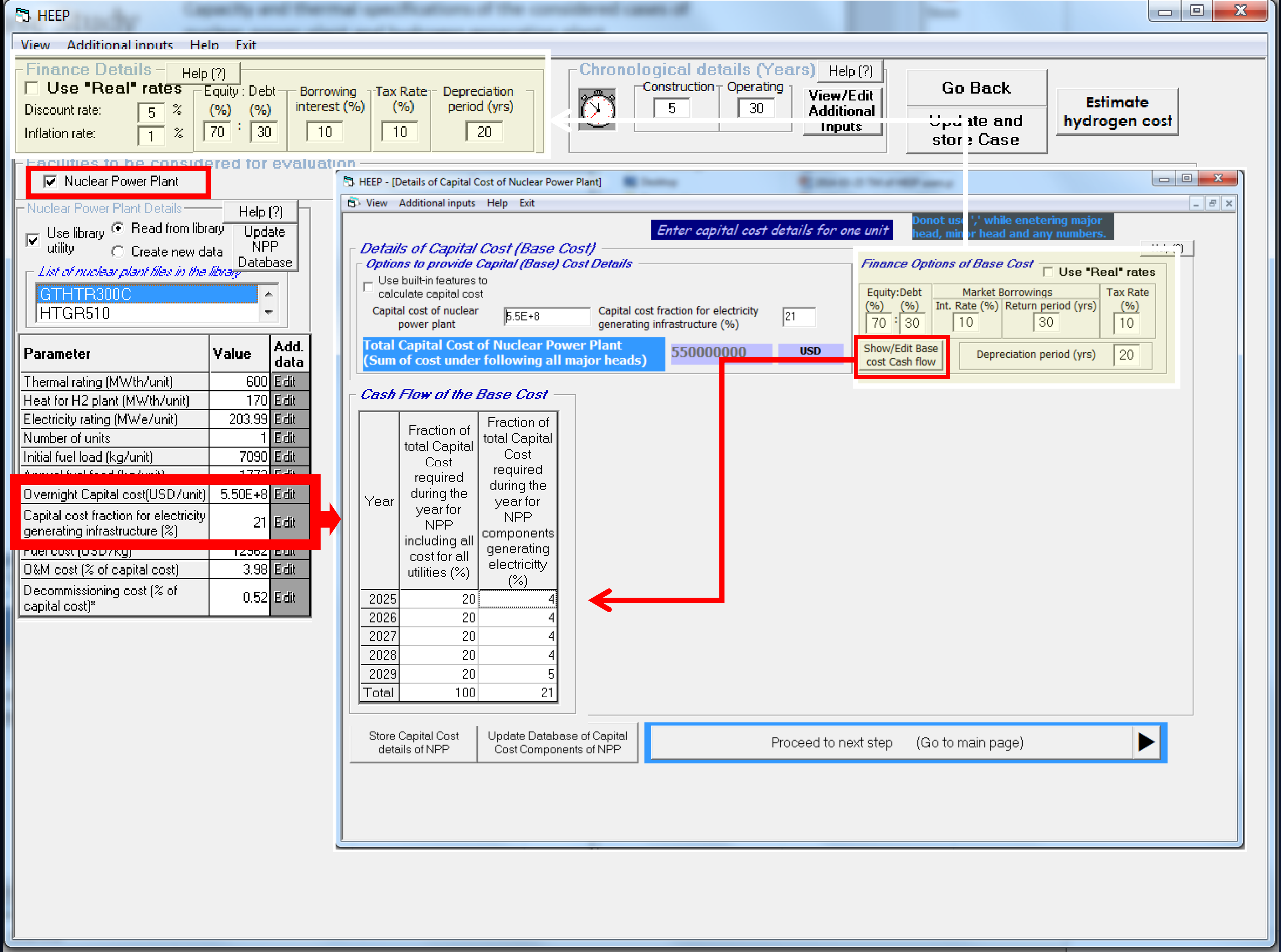
HEEP
View Additional inputs Help Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%)
70 : 30
Borrowing interest (%) 10
Tax Rate (%) 10
Depreciation period (yrs) 20
Chronological details (Years)
Help (?)
Construction 5
Operating 30
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
GTHTR300C
HTGR510
Parameter | Value | Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Initial fuel load (kg/unit) 7090 Edit
Annual fuel feed (kg/unit) 1773 Edit
Capital cost fraction for electricity 21 Edit
Fuel cost (USD/kg) 12962 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
HEEP - [Fuel cost for Nuclear Power Plant]
View Additional inputs Help Exit
Help (?)
Front End Cost Details
Back End Cost Details
Enter fuel cost details for one unit
Donot use ',' while enetering fuel names and any numbers.
Details of Nuclear Power Plant Fuel
Number of Types of Fuels used 1
Add 1
Remove 1
TY | Fuel Description | Period of: From Year, To Year | Initial inventory | Annual Feed (kg) | Fresh fuel composition: NU/LEU, U233, DepU, Pu, Th | Spent fuel composition: NU/LEU, U233, DepU, Pu, Th (Weight %)
1 | Fuel-1 | 1 | 30 | 7090 | 1773 | 100 | 0 | 0 | 0 | 0 | 99 | 0 | 0 | 1 | 0 | Show/Edit Details
Store Front End of Fuel Cycle cost details
Update Database of Cost Components of Front End of Fuel Cycle
Proceed to next step (Go to main page)

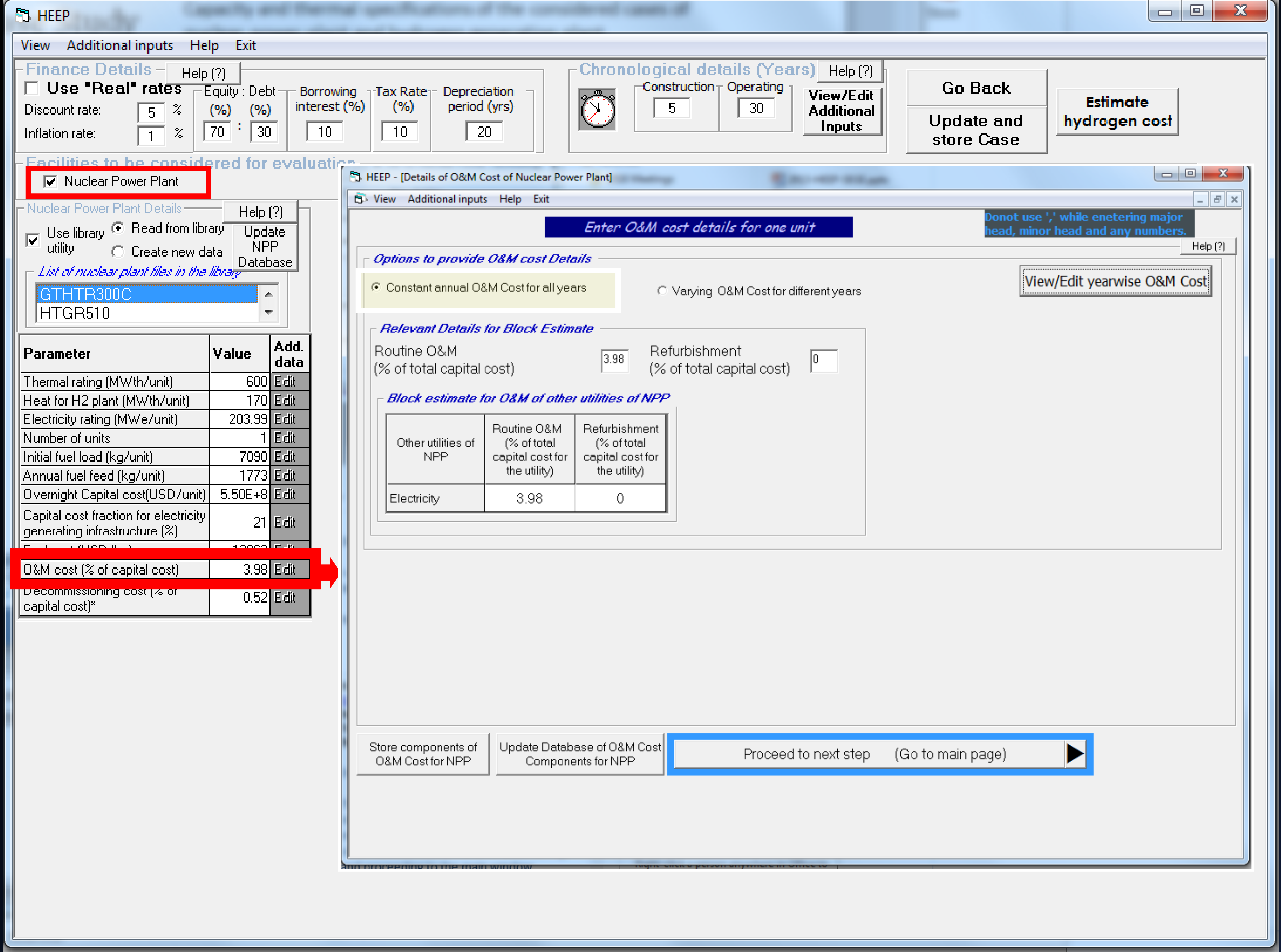

HEEP
View Additional inputs Help Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%)
70 : 30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Help (?)
Construction
5
Operating
30
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
GTHTR300C
HTGR510
Parameter
Value
Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Initial fuel load (kg/unit) 7090 Edit
Annual fuel feed (kg/unit) 1773 Edit
Capital cost fraction for electricity 21 Edit
Fuel cost (USD/kg) 12962 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
HEEP - [Fuel cost for Nuclear Power Plant]
View Additional inputs Help Exit
Help (?)
Enter fuel cost details for one unit
Donot use ',' while enetering fuel names and any numbers.
Front End Cost Details
Back End Cost Details
Details of Nuclear Power Plant Fuel
Number of Types of Fuels used 1
Add 1
Remove 1
TY | Fuel Description | Period of From Year To Year | Initial inventory | Annual Feed (kg) | Fresh fuel composition NU/LEU U233 DepU Pu Th | Spent fuel composition NU/LEU U233 DepU Pu Th (Weight %)
1 | Fuel-1 | 1 | 40 | 7090 | 1773 | 100 | 0 | 0 | 0 | 0 | 99 | 0 | 0 | 1 | 0
Show/Edit Details
Cost Details of Fuel Cycle for Fuel Type
Hide main processes of front end of fuel cycle
Main Processes of front end of fuel cycle
Fuel Material Purchase
Conversion
Enrichment
Fuel Fabrication
Major Head | Cost in USD/kg(**) | Advance Period(*) | Losses during Process (%) | Action
Purchase of fuel material | 12962 | 0 | 0 | Show/Edit Details
* : Number of years activity should be completed before actual usage of fuel in reactor
**: Cost per kg of finished fuel
Additional Cost Break-up Fuel Type (Sub-Heads)
Hide/Close Sub Head Details
Sub Head | Cost (USD/kg)
Rate of NatOrLEU Purchase (USD/kg) | 12962
Rate of U233 Purchase (USD/kg) | 0
Rate of DepU Purchase (USD/kg) | 0
Rate of Pu Purchase (USD/kg) | 0
Rate of Th Purchase (USD/kg) | 0
Store Front End of Fuel Cycle cost details
Update Database of Cost Components of Front End of Fuel Cycle
Proceed to next step (Go to main page)

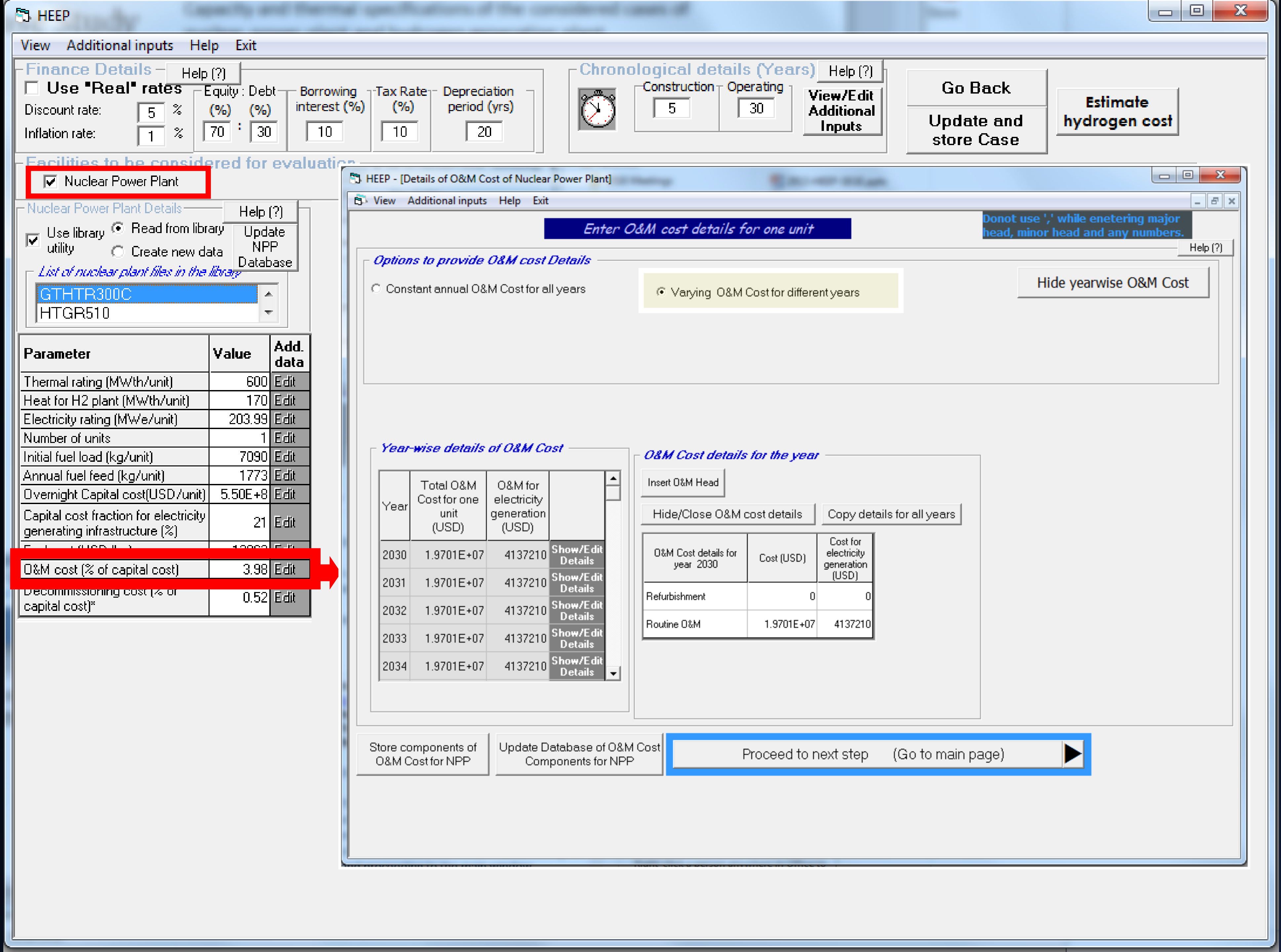

HEEP
View Additional inputs Help Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%) 70 : 30
Borrowing interest (%) 10
Tax Rate (%) 10
Depreciation period (yrs) 20
Chronological details (Years)
Construction 5
Operating 30
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Nuclear Power Plant Details
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
GTHTR300C
HTGR510
Parameter | Value | Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Initial fuel load (kg/unit) 7090 Edit
Capital cost fraction for electricity 21 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
HEEP - [Details of Capital Cost of Nuclear Power Plant]
View Additional inputs Help Exit
Enter capital cost details for one unit
Donot use ',' while enetering major head, minor head and any numbers.
Details of Capital Cost (Base Cost)
Options to provide Capital (Base) Cost Details
Use built-in features to calculate capital cost
Capital cost of nuclear power plant 5.5E+8
Capital cost fraction for electricity generating infrastructure (%) 21
Total Capital Cost of Nuclear Power Plant (Sum of cost under following all major heads)
550000000 USD
Help (?)
Finance Options of Base Cost
Use "Real" rates
Equity:Debt (%) (%) 70 : 30
Market Borrowings
Int. Rate (%) 10
Return period (yrs) 30
Tax Rate (%) 10
Show/Edit Base cost Cash flow
Depreciation period (yrs) 20
Store Capital Cost details of NPP
Update Database of Capital Cost Components of NPP
Proceed to next step (Go to main page)

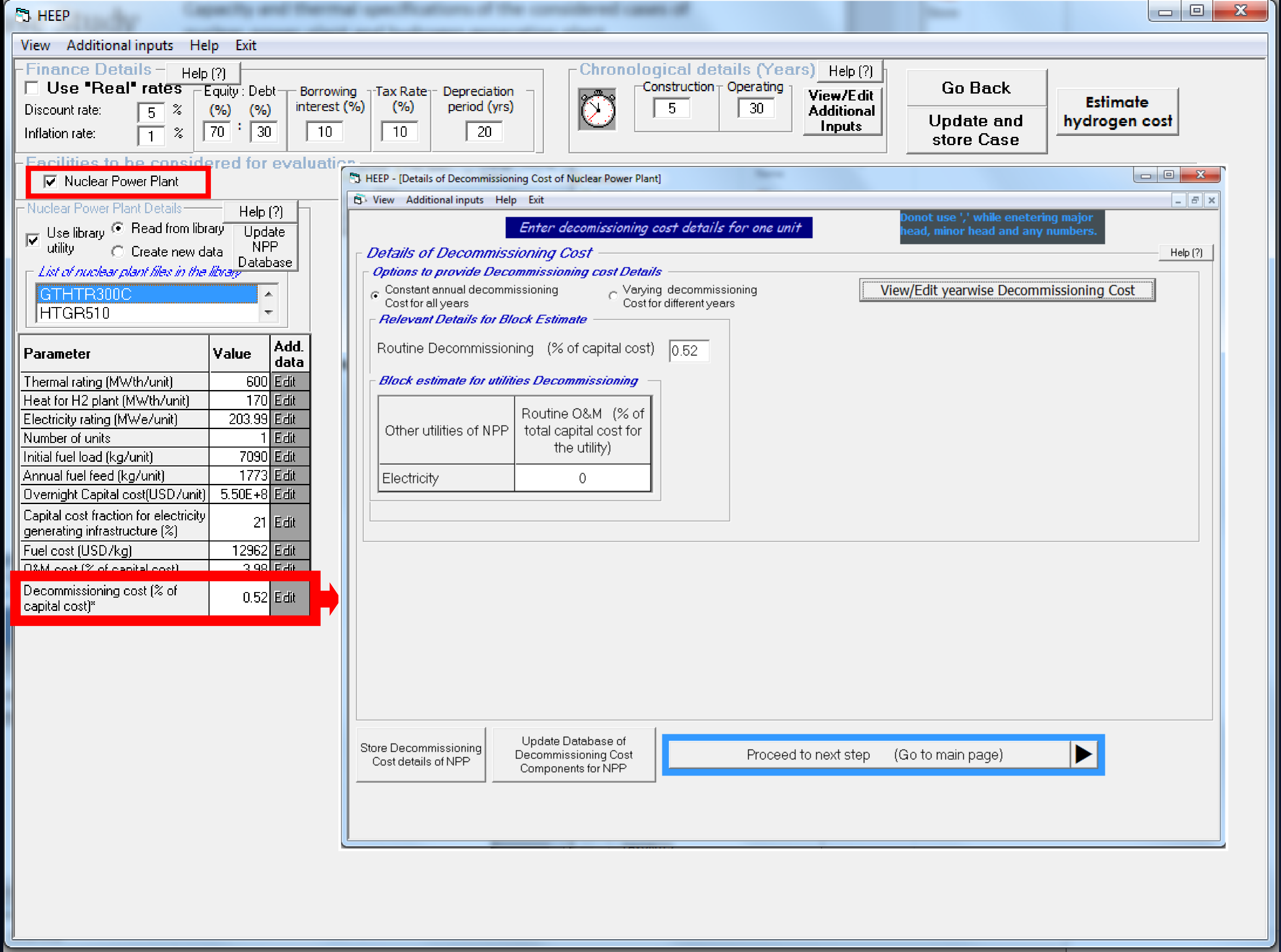

HEEP
View
Additional inputs
Help
Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%)
70 : 30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Help (?)
Construction
5
Operating
30
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Nuclear Power Plant
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
GTHTR300C
HTGR510
Parameter
Value
Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Number of units 1 Edit
Initial fuel load (kg/unit) 7090 Edit
Overnight Capital cost(USD/unit) 5.50E+8 Edit
Capital cost fraction for electricity generating infrastructure (%) 21 Edit
O&M cost (% of capital cost) 3.98 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
HEEP - [Details of Capital Cost of Nuclear Power Plant]
View
Additional inputs
Help
Exit
Enter capital cost details for one unit
Donot use ',' while enetering major head, minor head and any numbers.
Details of Capital Cost (Base Cost)
Options to provide Capital (Base) Cost Details
Use built-in features to calculate capital cost
Use Specific Cost (Cost of unit capacity)
Use component level details
Specific capital cost of nuclear power plant
916666.6667
Capital cost fraction for electricity generating infrastructure (%)
10
Total Capital Cost of Nuclear Power Plant (Sum of cost under following all major heads)
550000000.02
USD
Help (?)
Finance Options of Base Cost
Use "Real" rates
Equity:Debt (%) (%)
70 : 30
Market Borrowings
Int. Rate (%)
10
Return period (yrs)
40
Tax Rate (%)
10
Show/Edit Base cost Cash flow
Depreciation period (yrs)
20
Store Capital Cost details of NPP
Update Database of Capital Cost Components of NPP
Proceed to next step (Go to main page)

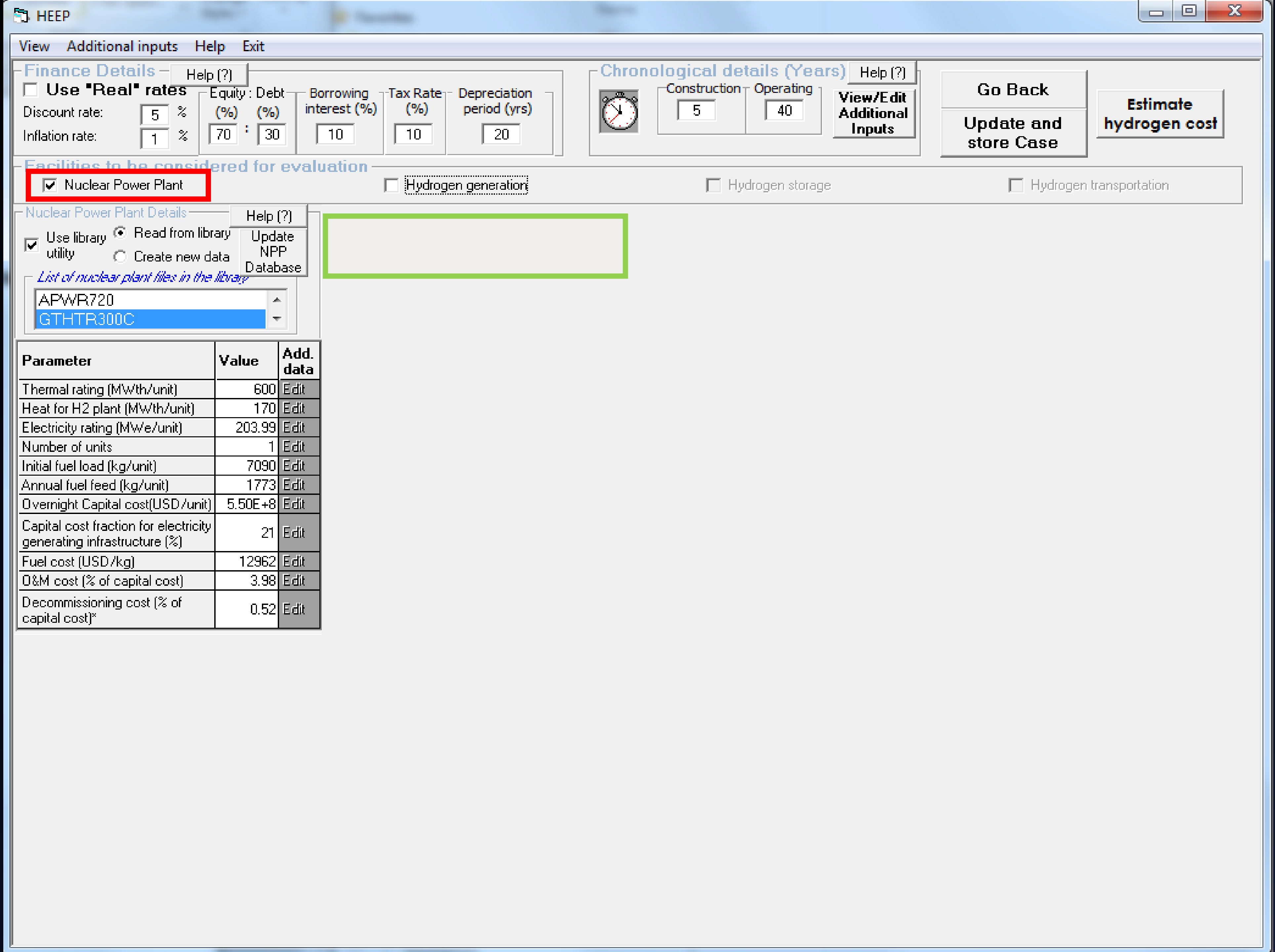

HEEP
View Additional inputs Help Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%) 70 : 30
Borrowing interest (%) 10
Tax Rate (%) 10
Depreciation period (yrs) 20
Chronological details (Years)
Help (?)
Construction 5
Operating 30
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
GTHTR300C
HTGR510
Parameter | Value | Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Number of units 1 Edit
Initial fuel load (kg/unit) 7090 Edit
Overnight Capital cost(USD/unit) 5.50E+8 Edit
Capital cost fraction for electricity generating infrastructure (%) 21 Edit
O&M cost (% of capital cost) 3.98 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
HEEP - [Details of Capital Cost of Nuclear Power Plant]
View Additional inputs Help Exit
Enter capital cost details for one unit
Details of Capital Cost (Base Cost)
Options to provide Capital (Base) Cost Details
Use built-in features to calculate capital cost
Capital cost of nuclear power plant 5.5E+8
Capital cost fraction for electricity generating infrastructure (%) 21
Total Capital Cost of Nuclear Power Plant (Sum of cost under following all major heads)
550000000 USD
Finance Options of Base Cost
Use "Real" rates
Equity:Debt (%) (%) 70 : 30
Market Borrowings Int. Rate (%) 10 Return period (yrs) 30
Tax Rate (%) 10
Show/Edit Base cost Cash flow
Depreciation period (yrs) 20
Store Capital Cost details of NPP
Update Database of Capital Cost Components of NPP
Proceed to next step (Go to main page)

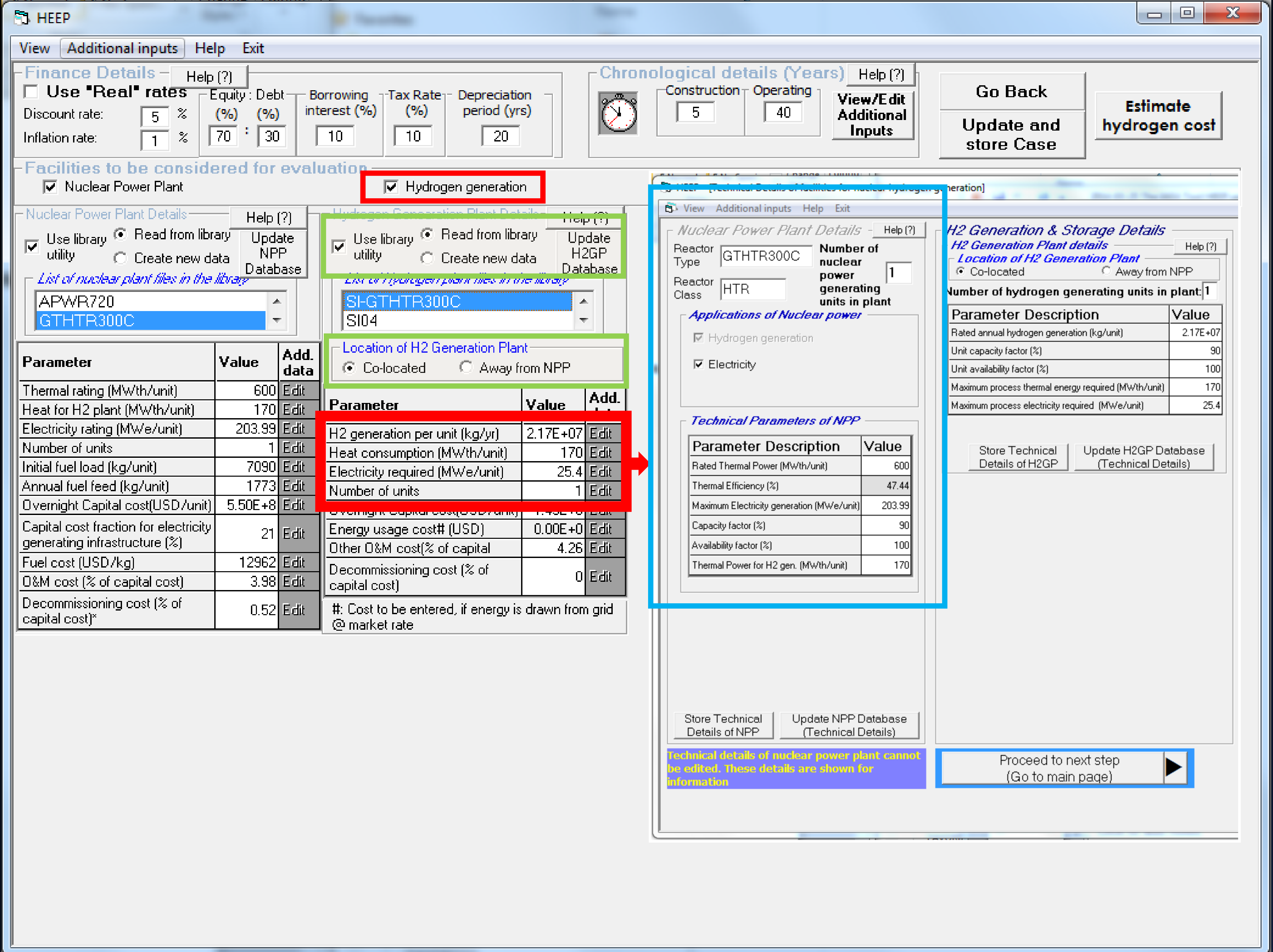

HEEP
View Additional inputs Help Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%) 70 : 30
Borrowing interest (%) 10
Tax Rate (%) 10
Depreciation period (yrs) 20
Chronological details (Years)
Construction 5
Operating 30
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Nuclear Power Plant Details
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
GTHTR300C
HTGR510
Parameter | Value | Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Number of units 1 Edit
Initial fuel load (kg/unit) 7090 Edit
Overnight Capital cost(USD/unit) 5.50E+8 Edit
Capital cost fraction for electricity generating infrastructure (%) 21 Edit
O&M cost (% of capital cost) 3.98 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
HEEP - [Details of Capital Cost of Nuclear Power Plant]
View Additional inputs Help Exit
Enter capital cost details for one unit
Details of Capital Cost (Base Cost)
Options to provide Capital (Base) Cost Details
Use built-in features to calculate capital cost
Capital cost of nuclear power plant 5.5E+8
Capital cost fraction for electricity generating infrastructure (%) 21
Total Capital Cost of Nuclear Power Plant (Sum of cost under following all major heads) 550000000 USD
Finance Options of Base Cost
Use "Real" rates
Equity:Debt (%) (%) 70 : 30
Market Borrowings Int. Rate (%) 10 Return period (yrs) 30
Tax Rate (%) 10
Show/Edit Base cost Cash flow
Depreciation period (yrs) 20
Cash Flow of the Base Cost
Year | Fraction of total Capital Cost required during the year for NPP including all cost for all utilities (%) | Fraction of total Capital Cost required during the year for NPP components generating electricity (%)
2025 20 4
2026 20 4
2027 20 4
2028 20 4
2029 20 5
Total 100 21
Store Capital Cost details of NPP
Update Database of Capital Cost Components of NPP
Proceed to next step (Go to main page)

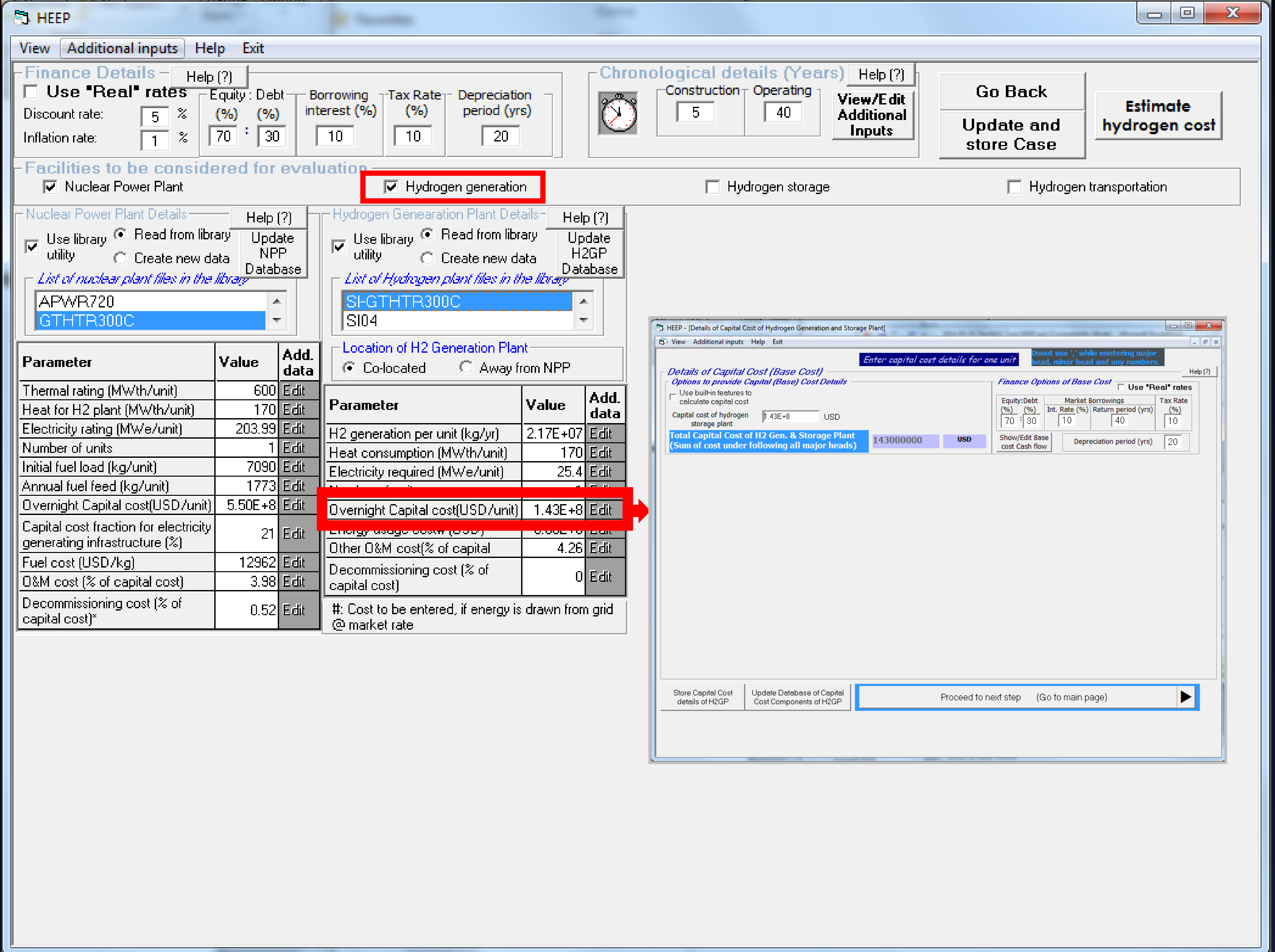

HEEP
View Additional inputs Help Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%)
70 : 30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Help (?)
Construction 5
Operating 30
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
GTHTR300C
HTGR510
Parameter | Value | Add. data
Thermal rating (MWth/unit) | 600 | Edit
Heat for H2 plant (MWth/unit) | 170 | Edit
Electricity rating (MWe/unit) | 203.99 | Edit
Number of units | 1 | Edit
Initial fuel load (kg/unit) | 7090 | Edit
Annual fuel feed (kg/unit) | 1773 | Edit
Overnight Capital cost(USD/unit) | 5.50E+8 | Edit
Capital cost fraction for electricity generating infrastructure (%) | 21 | Edit
O&M cost (% of capital cost) | 3.98 | Edit
Decommissioning cost (% of capital cost)* | 0.52 | Edit
HEEP - [Details of O&M Cost of Nuclear Power Plant]
View Additional inputs Help Exit
Enter O&M cost details for one unit
Donot use ',' while enetering major head, minor head and any numbers.
Help (?)
Options to provide O&M cost Details
Constant annual O&M Cost for all years
Varying O&M Cost for different years
View/Edit yearwise O&M Cost
Relevant Details for Block Estimate
Routine O&M (% of total capital cost) 3.98
Refurbishment (% of total capital cost) 0
Block estimate for O&M of other utilities of NPP
Other utilities of NPP | Routine O&M (% of total capital cost for the utility) | Refurbishment (% of total capital cost for the utility)
Electricity | 3.98 | 0
Store components of O&M Cost for NPP
Update Database of O&M Cost Components for NPP
Proceed to next step (Go to main page)

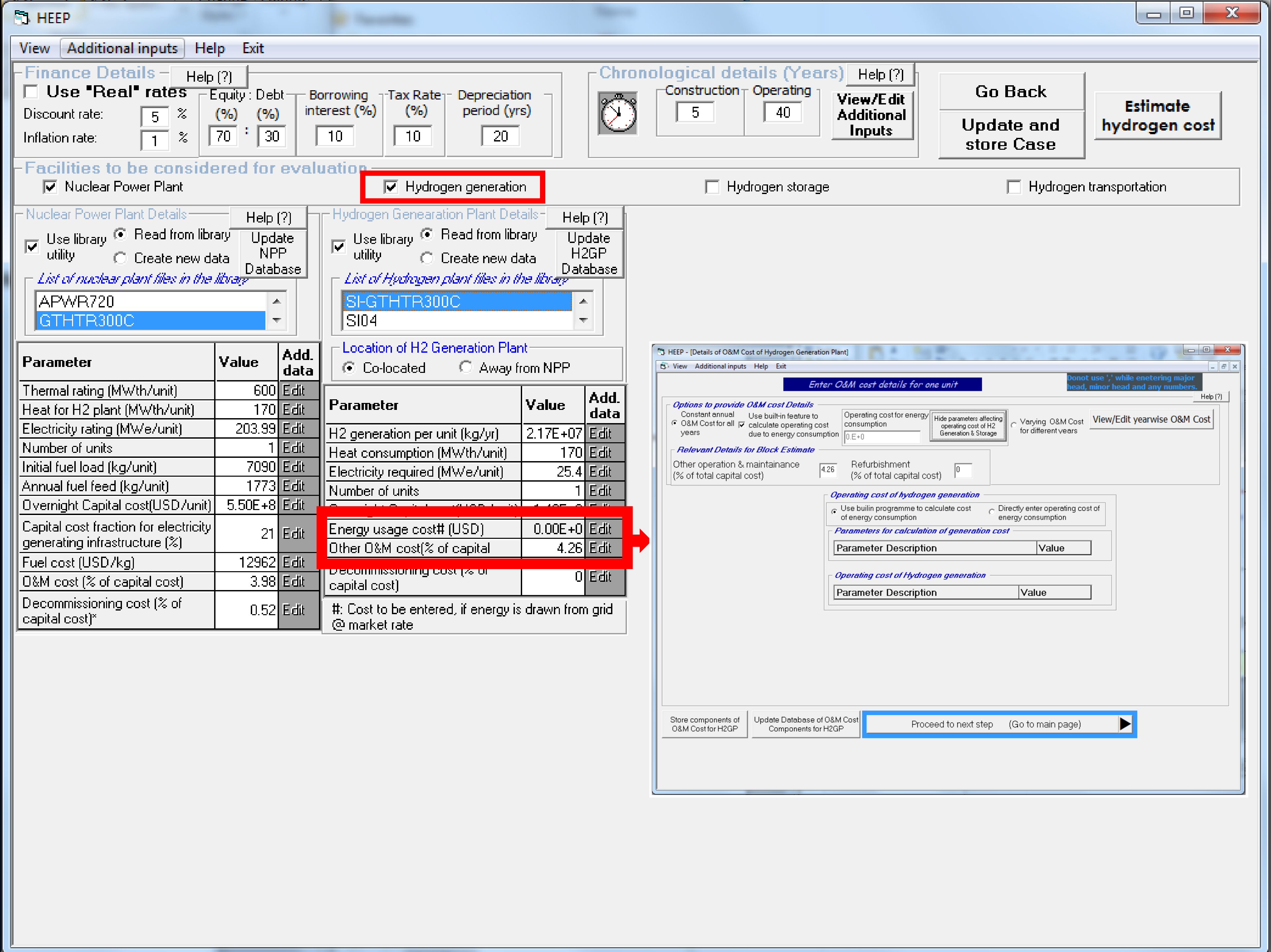

HEEP
View Additional inputs Help Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%)
70 : 30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Help (?)
Construction
5
Operating
30
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Nuclear Power Plant
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
GTHTR300C
HTGR510
Parameter
Value
Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Number of units 1 Edit
Initial fuel load (kg/unit) 7090 Edit
Annual fuel feed (kg/unit) 1773 Edit
Overnight Capital cost(USD/unit) 5.50E+8 Edit
Capital cost fraction for electricity generating infrastructure (%) 21 Edit
O&M cost (% of capital cost) 3.98 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
HEEP - [Details of O&M Cost of Nuclear Power Plant]
View Additional inputs Help Exit
Enter O&M cost details for one unit
Donot use ',' while enetering major head, minor head and any numbers.
Help (?)
Options to provide O&M cost Details
Constant annual O&M Cost for all years
Varying O&M Cost for different years
Hide yearwise O&M Cost
Year-wise details of O&M Cost
Year
Total O&M Cost for one unit (USD)
O&M for electricity generation (USD)
2030 1.9701E+07 4137210 Show/Edit Details
2031 1.9701E+07 4137210 Show/Edit Details
2032 1.9701E+07 4137210 Show/Edit Details
2033 1.9701E+07 4137210 Show/Edit Details
2034 1.9701E+07 4137210 Show/Edit Details
O&M Cost details for the year
Insert O&M Head
Hide/Close O&M cost details
Copy details for all years
O&M Cost details for year 2030
Cost (USD)
Cost for electricity generation (USD)
Refurbishment 0 0
Routine O&M 1.9701E+07 4137210
Store components of O&M Cost for NPP
Update Database of O&M Cost Components for NPP
Proceed to next step (Go to main page)


HEEP
View Additional inputs Help Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%)
70 : 30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Help (?)
Construction
5
Operating
30
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
GTHTR300C
HTGR510
Parameter
Value
Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Number of units 1 Edit
Initial fuel load (kg/unit) 7090 Edit
Annual fuel feed (kg/unit) 1773 Edit
Overnight Capital cost(USD/unit) 5.50E+8 Edit
Capital cost fraction for electricity generating infrastructure (%) 21 Edit
Fuel cost (USD/kg) 12962 Edit
O&M cost (% of capital cost) 3.98 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
HEEP - [Details of Decommissioning Cost of Nuclear Power Plant]
View Additional inputs Help Exit
Enter decomissioning cost details for one unit
Donot use ',' while enetering major head, minor head and any numbers.
Details of Decommissioning Cost
Help (?)
Options to provide Decommissioning cost Details
Constant annual decommissioning Cost for all years
Varying decommissioning Cost for different years
View/Edit yearwise Decommissioning Cost
Relevant Details for Block Estimate
Routine Decommissioning (% of capital cost) 0.52
Block estimate for utilities Decommissioning
Other utilities of NPP
Routine O&M (% of total capital cost for the utility)
Electricity 0
Store Decommissioning Cost details of NPP
Update Database of Decommissioning Cost Components for NPP
Proceed to next step (Go to main page)

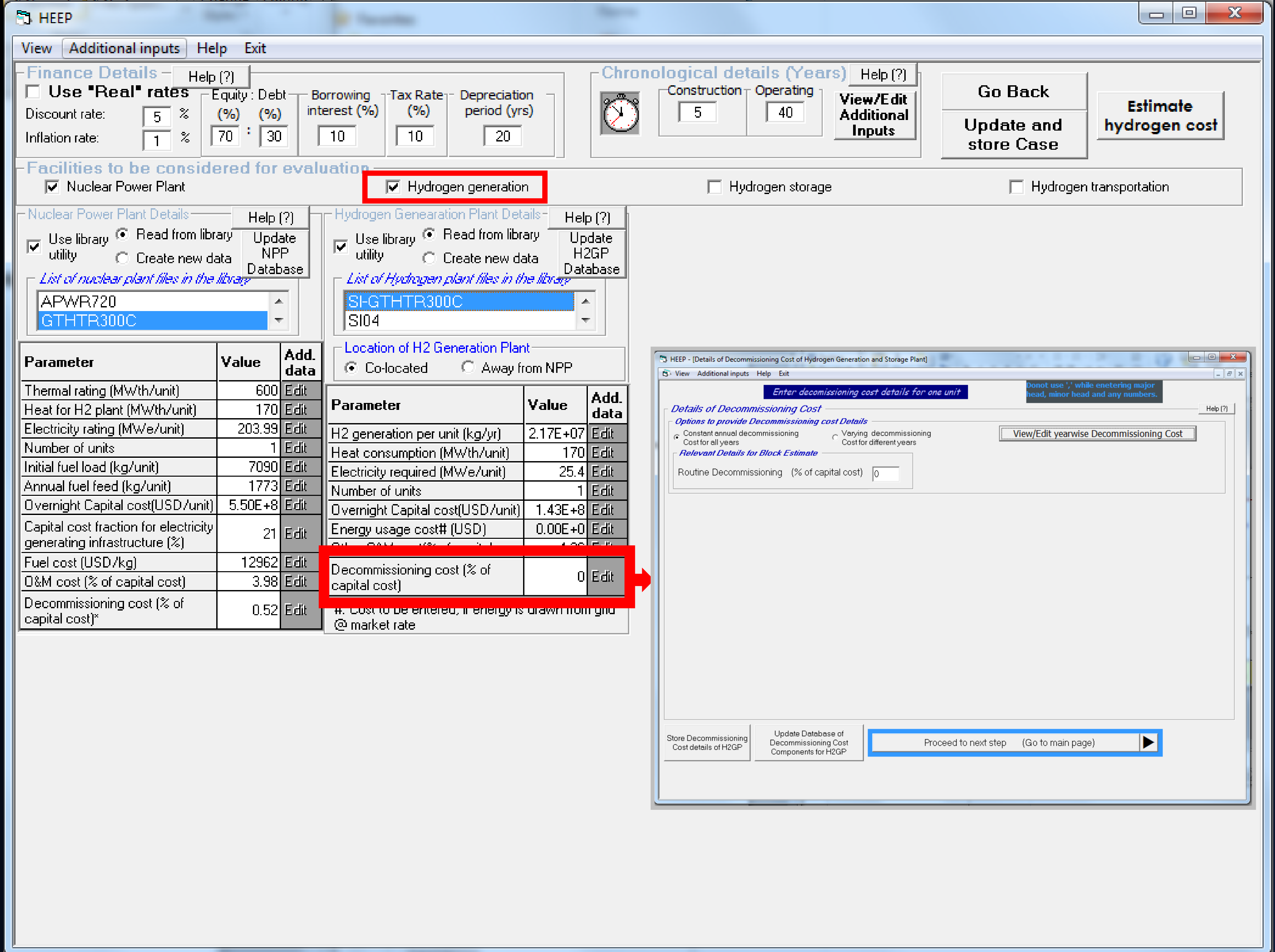

HEEP
View
Additional inputs
Help
Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%)
70 : 30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Help (?)
Construction
5
Operating
40
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Hydrogen generation
Hydrogen storage
Hydrogen transportation
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
APWR720
GTHTR300C
Parameter
Value
Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Number of units 1 Edit
Initial fuel load (kg/unit) 7090 Edit
Annual fuel feed (kg/unit) 1773 Edit
Overnight Capital cost(USD/unit) 5.50E+8 Edit
Capital cost fraction for electricity generating infrastructure (%) 21 Edit
Fuel cost (USD/kg) 12962 Edit
O&M cost (% of capital cost) 3.98 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit

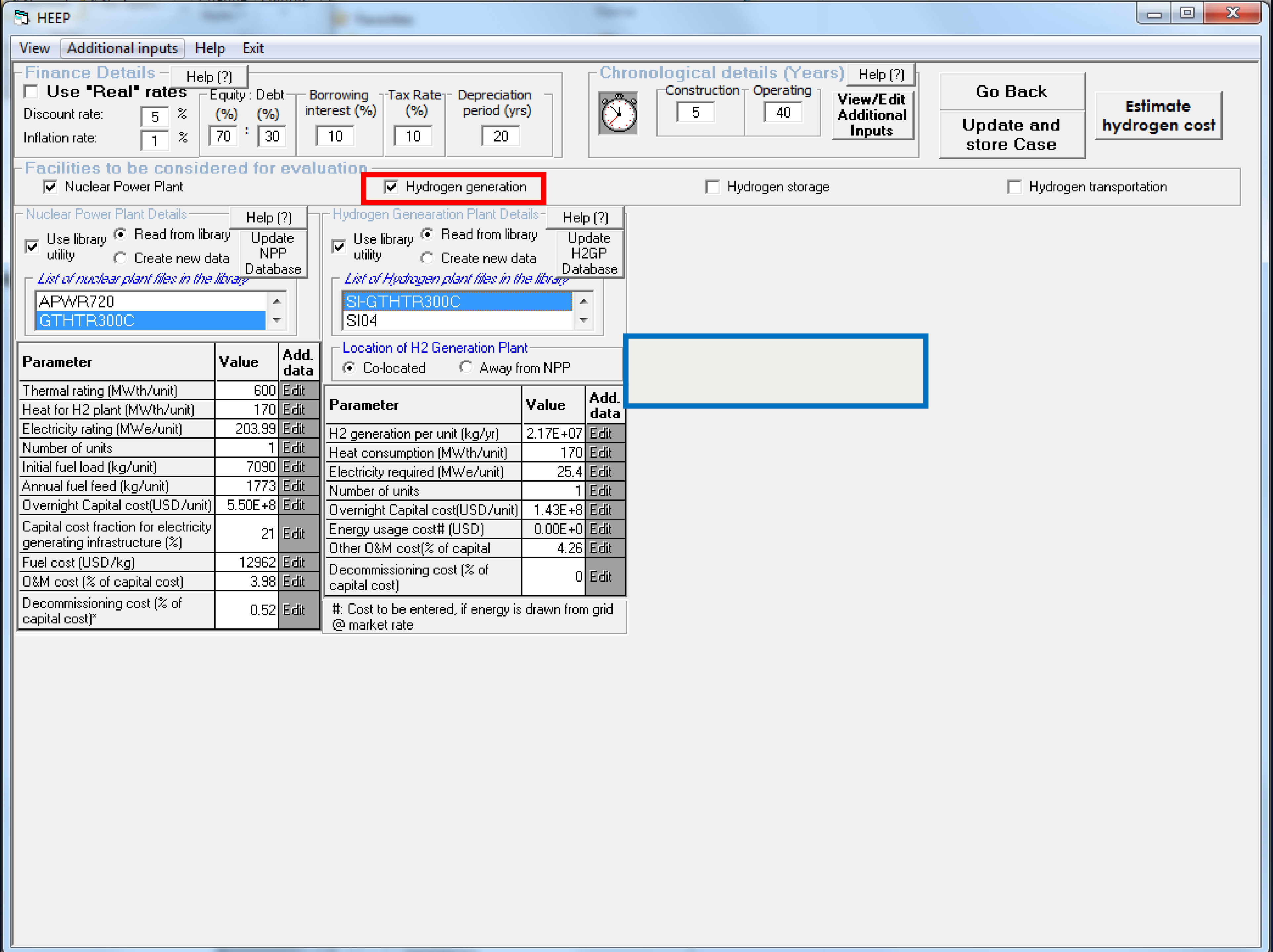

HEEP
View
Additional inputs
Help
Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%)
70 : 30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Help (?)
Construction
5
Operating
40
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Hydrogen generation
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
APWR720
GTHTR300C
Parameter | Value | Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Number of units 1 Edit
Initial fuel load (kg/unit) 7090 Edit
Annual fuel feed (kg/unit) 1773 Edit
Overnight Capital cost(USD/unit) 5.50E+8 Edit
Capital cost fraction for electricity generating infrastructure (%) 21 Edit
Fuel cost (USD/kg) 12962 Edit
O&M cost (% of capital cost) 3.98 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
Use library utility
Read from library
Create new data
Update H2GP Database
SI-GTHTR300C
SI04
Location of H2 Generation Plant
Co-located
Away from NPP
Parameter | Value | Add. data
H2 generation per unit (kg/yr) 2.17E+07 Edit
Heat consumption (MWth/unit) 170 Edit
Electricity required (MWe/unit) 25.4 Edit
Number of units 1 Edit
Energy usage cost# (USD) 0.00E+0 Edit
Other O&M cost(% of capital) 4.26 Edit
Decommissioning cost (% of capital cost) 0 Edit
#: Cost to be entered, if energy is drawn from grid @ market rate
View Additional inputs Help Exit
Nuclear Power Plant Details
Help (?)
Reactor Type GTHTR300C
Reactor Class HTR
Number of nuclear power generating units in plant 1
Applications of Nuclear power
Hydrogen generation
Electricity
Technical Parameters of NPP
Parameter Description | Value
Rated Thermal Power (MWth/unit) 600
Thermal Efficiency (%) 47.44
Maximum Electricity generation (MWe/unit) 203.99
Capacity factor (%) 90
Availability factor (%) 100
Thermal Power for H2 gen. (MWth/unit) 170
Store Technical Details of NPP
Update NPP Database (Technical Details)
Technical details of nuclear power plant cannot be edited. These details are shown for information
H2 Generation & Storage Details
H2 Generation Plant details
Help (?)
Location of H2 Generation Plant
Co-located
Away from NPP
Number of hydrogen generating units in plant: 1
Parameter Description | Value
Rated annual hydrogen generation (kg/unit) 2.17E+07
Unit capacity factor (%) 90
Unit availability factor (%) 100
Maximum process thermal energy required (MWth/unit) 170
Maximum process electricity required (MWe/unit) 25.4
Store Technical Details of H2GP
Update H2GP Database (Technical Details)
Proceed to next step (Go to main page)

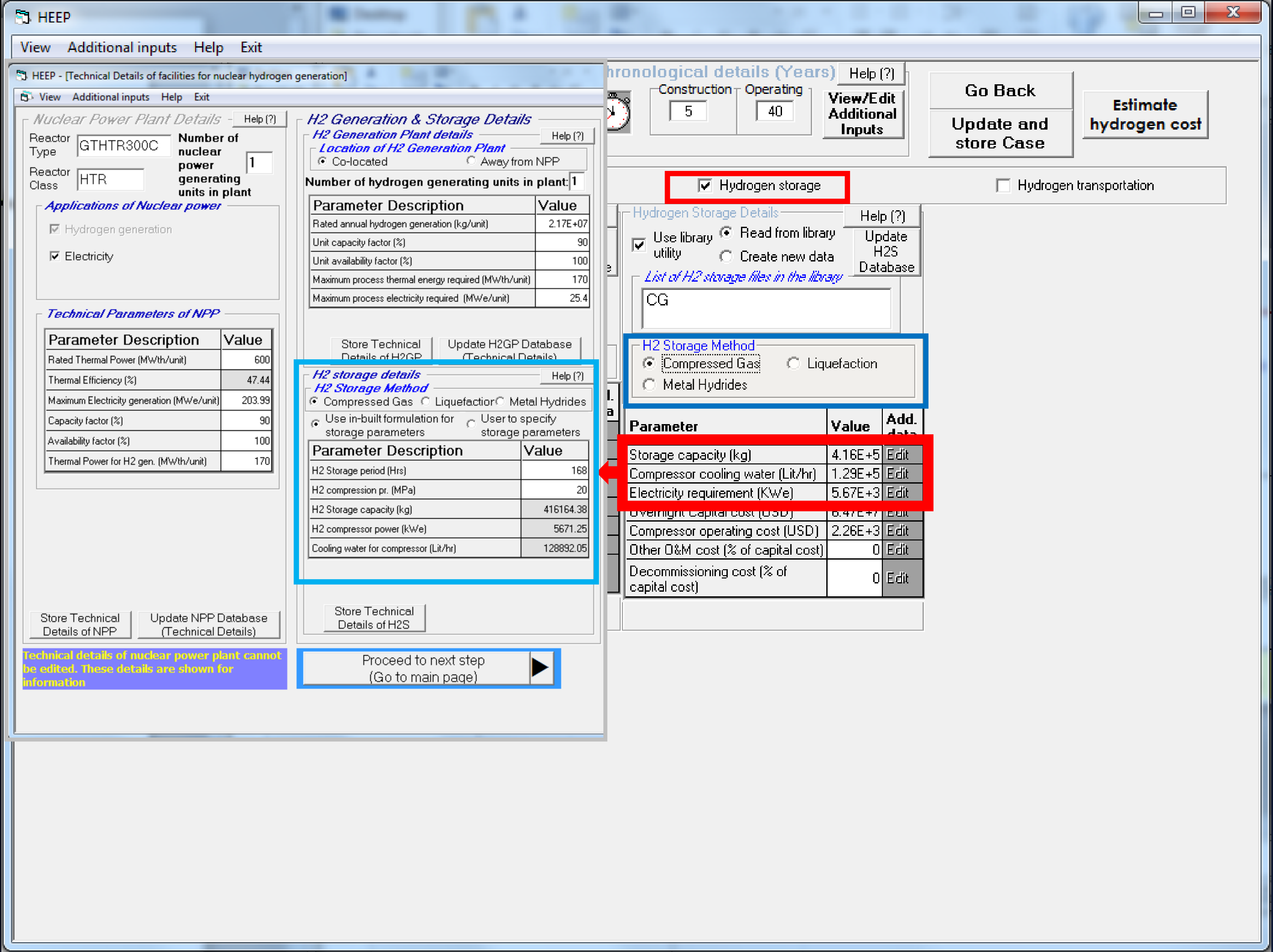

HEEP
View
Additional inputs
Help
Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%) 70 : 30
Borrowing interest (%) 10
Tax Rate (%) 10
Depreciation period (yrs) 20
Chronological details (Years)
Help (?)
Construction 5
Operating 40
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Hydrogen generation
Hydrogen storage
Hydrogen transportation
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
APWR720
GTHTR300C
Parameter | Value | Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Number of units 1 Edit
Initial fuel load (kg/unit) 7090 Edit
Annual fuel feed (kg/unit) 1773 Edit
Overnight Capital cost(USD/unit) 5.50E+8 Edit
Capital cost fraction for electricity generating infrastructure (%) 21 Edit
Fuel cost (USD/kg) 12962 Edit
O&M cost (% of capital cost) 3.98 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
Hydrogen Genearation Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update H2GP Database
List of Hydrogen plant files in the library
SI-GTHTR300C
SI04
Location of H2 Generation Plant
Co-located
Away from NPP
Parameter | Value | Add. data
H2 generation per unit (kg/yr) 2.17E+07 Edit
Heat consumption (MWth/unit) 170 Edit
Electricity required (MWe/unit) 25.4 Edit
Overnight Capital cost(USD/unit) 1.43E+8 Edit
Other O&M cost(% of capital) 4.26 Edit
Decommissioning cost (% of capital cost) 0 Edit
#: Cost to be entered, if energy is drawn from grid @ market rate
HEEP - [Details of Capital Cost of Hydrogen Generation and Storage Plant]
Enter capital cost details for one unit
Details of Capital Cost (Base Cost)
Options to provide Capital (Base) Cost Details
Use built-in features to calculate capital cost
Capital cost of hydrogen storage plant 1.43E+8 USD
Total Capital Cost of H2 Gen. & Storage Plant (Sum of cost under following all major heads)
143000000 USD
Finance Options of Base Cost
Use "Real" rates
Equity:Debt (%) (%) 70 30
Market Borrowings
Int. Rate (%) 10
Return period (yrs) 40
Tax Rate (%) 10
Show/Edit Base cost Cash flow
Depreciation period (yrs) 20
Store Capital Cost details of H2GP
Update Database of Capital Cost Components of H2GP
Proceed to next step (Go to main page)



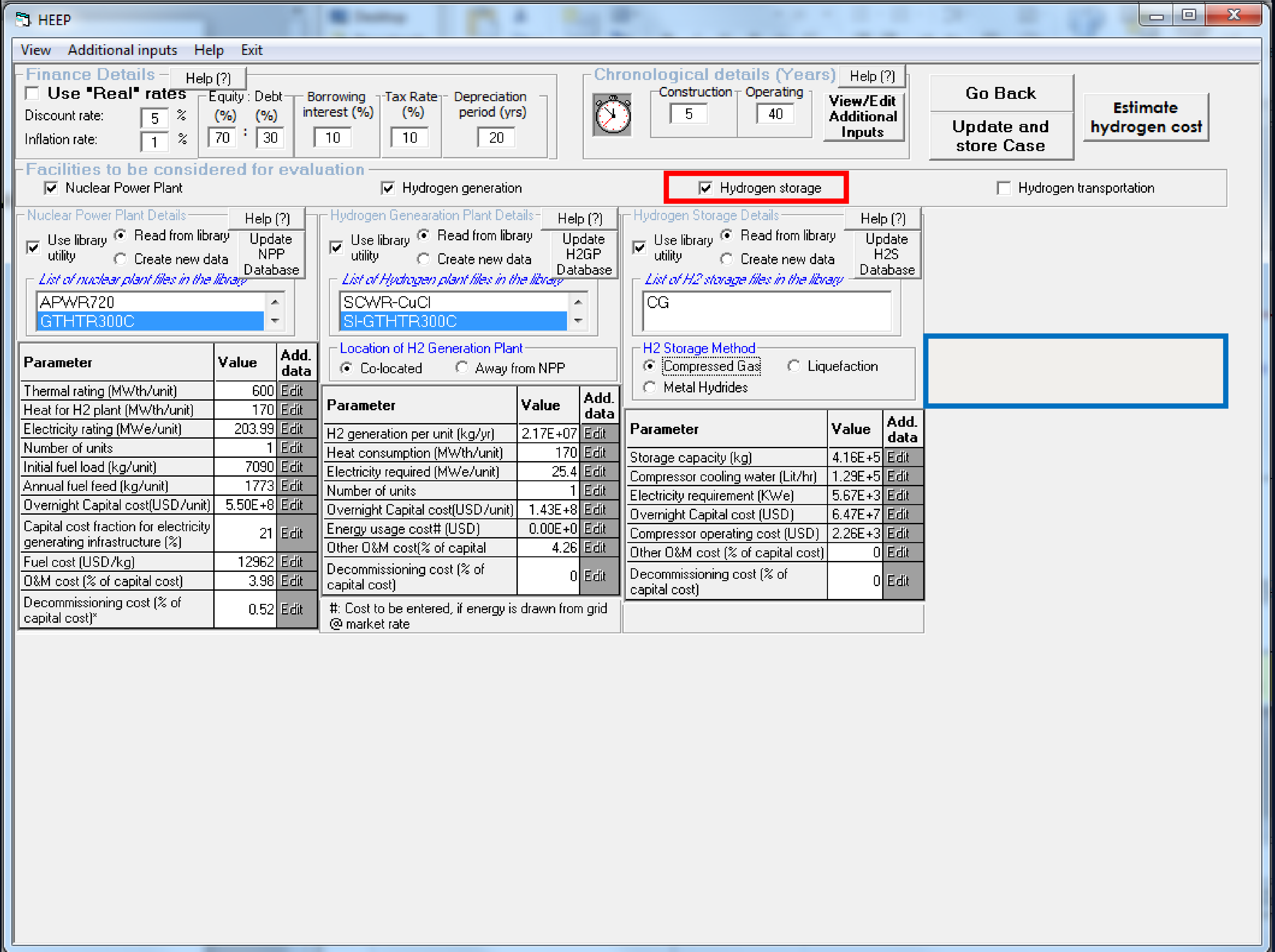
HEEP
View
Additional inputs
Help
Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate:
5
%
Inflation rate:
1
%
Equity : Debt
(%) (%)
70 : 30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Help (?)
Construction
5
Operating
40
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Hydrogen generation
Hydrogen storage
Hydrogen transportation
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
APWR720
GTHTR300C
Parameter | Value | Add. data
Thermal rating (MWth/unit) | 600 | Edit
Heat for H2 plant (MWth/unit) | 170 | Edit
Electricity rating (MWe/unit) | 203.99 | Edit
Number of units | 1 | Edit
Initial fuel load (kg/unit) | 7090 | Edit
Annual fuel feed (kg/unit) | 1773 | Edit
Overnight Capital cost(USD/unit) | 5.50E+8 | Edit
Capital cost fraction for electricity generating infrastructure (%) | 21 | Edit
Fuel cost (USD/kg) | 12962 | Edit
O&M cost (% of capital cost) | 3.98 | Edit
Decommissioning cost (% of capital cost)* | 0.52 | Edit
Hydrogen Geneáration Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update H2GP Database
List of Hydrogen plant files in the library
SI-GTHTR300C
SI04
Location of H2 Generation Plant
Co-located
Away from NPP
Parameter | Value | Add. data
H2 generation per unit (kg/yr) | 2.17E+07 | Edit
Heat consumption (MWth/unit) | 170 | Edit
Electricity required (MWe/unit) | 25.4 | Edit
Number of units | 1 | Edit
Energy usage cost# (USD) | 0.00E+0 | Edit
Other O&M cost(% of capital | 4.26 | Edit
Decommissioning cost (% of capital cost) | 0 | Edit
#: Cost to be entered, if energy is drawn from grid @ market rate
HEEP - [Details of O&M Cost of Hydrogen Generation Plant]
Enter O&M cost details for one unit
Donot use ',' while enetering major head, minor head and any numbers.
Options to provide O&M cost Details
Constant annual O&M Cost for all years
Use built-in feature to calculate operating cost due to energy consumption
Operating cost for energy consumption
Hide parameters affecting operating cost of H2 Generation & Storage
Varying O&M Cost for different years
View/Edit yearwise O&M Cost
Relevant Details for Block Estimate
Other operation & maintainance (% of total capital cost)
4.26
Refurbishment (% of total capital cost)
0
Operating cost of hydrogen generation
Use builin programme to calculate cost of energy consumption
Directly enter operating cost of energy consumption
Parameters for calculation of generation cost
Parameter Description
Value
Operating cost of Hydrogen generation
Parameter Description
Value
Store components of O&M Cost for H2GP
Update Database of O&M Cost Components for H2GP
Proceed to next step (Go to main page)

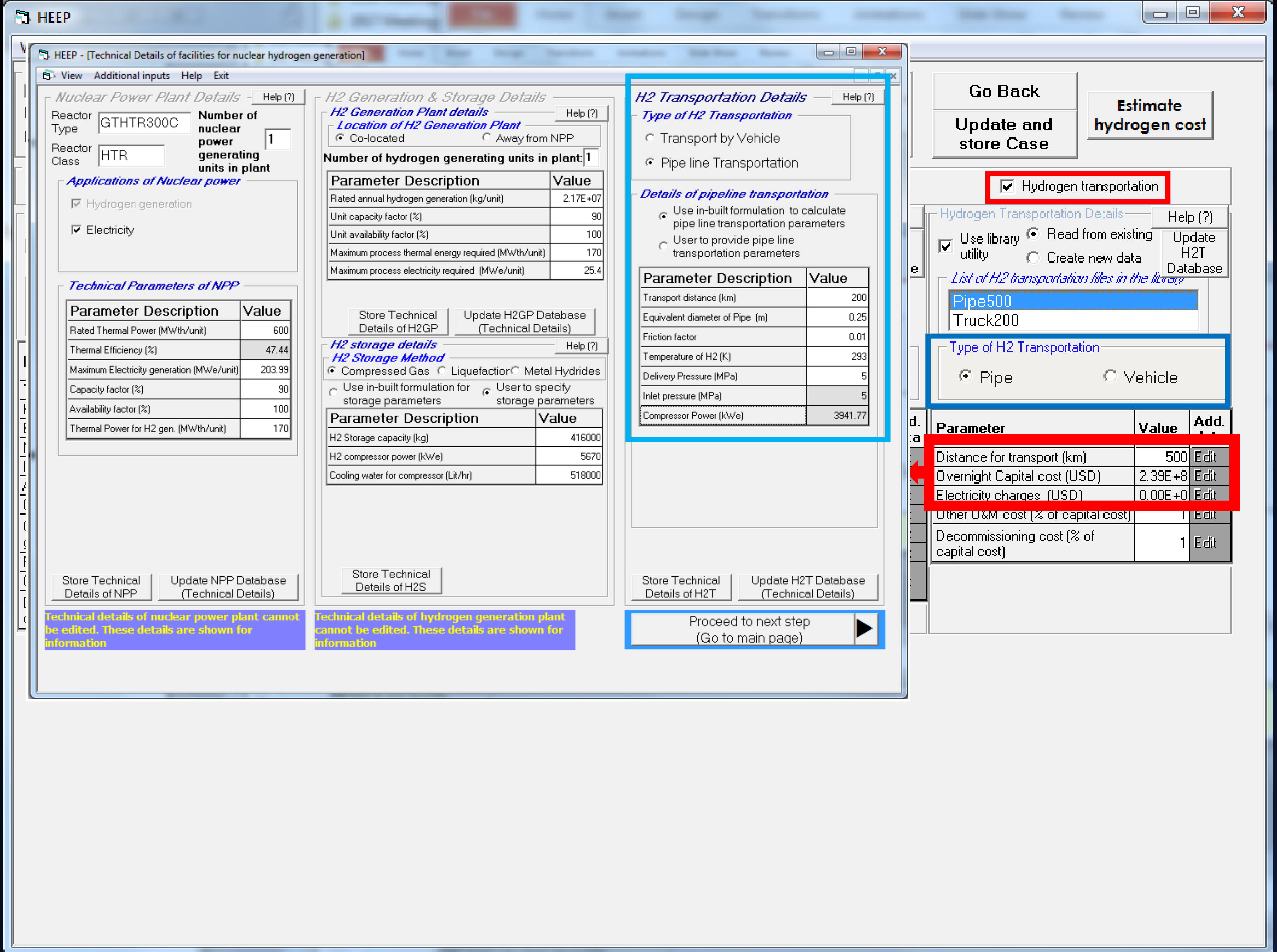

HEEP
View
Additional inputs
Help
Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%)
70 : 30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Help (?)
Construction
5
Operating
40
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Hydrogen generation
Hydrogen storage
Hydrogen transportation
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
APWR720
GTHTR300C
Parameter | Value | Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Number of units 1 Edit
Initial fuel load (kg/unit) 7090 Edit
Annual fuel feed (kg/unit) 1773 Edit
Overnight Capital cost(USD/unit) 5.50E+8 Edit
Capital cost fraction for electricity generating infrastructure (%) 21 Edit
Fuel cost (USD/kg) 12962 Edit
O&M cost (% of capital cost) 3.98 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
Hydrogen Genearation Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update H2GP Database
List of Hydrogen plant files in the library
SI-GTHTR300C
SI04
Location of H2 Generation Plant
Co-located
Away from NPP
Parameter | Value | Add. data
H2 generation per unit (kg/yr) 2.17E+07 Edit
Heat consumption (MWth/unit) 170 Edit
Electricity required (MWe/unit) 25.4 Edit
Number of units 1 Edit
Overnight Capital cost(USD/unit) 1.43E+8 Edit
Energy usage cost# (USD) 0.00E+0 Edit
Decommissioning cost (% of capital cost) 0 Edit
#: Cost to be entered, if energy is drawn from grid @ market rate
HEEP - [Details of Decommissioning Cost of Hydrogen Generation and Storage Plant]
View Additional inputs Help Exit
Enter decommissioning cost details for one unit
Donot use ',' while enetering major head, minor head and any numbers.
Details of Decommissioning Cost
Help (?)
Options to provide Decommissioning cost Details
Constant annual decommissioning Cost for all years
Varying decommissioning Cost for different years
View/Edit yearwise Decommissioning Cost
Relevant Details for Block Estimate
Routine Decommissioning (% of capital cost) 0
Store Decommissioning Cost details of H2GP
Update Database of Decommissioning Cost Components for H2GP
Proceed to next step (Go to main page)

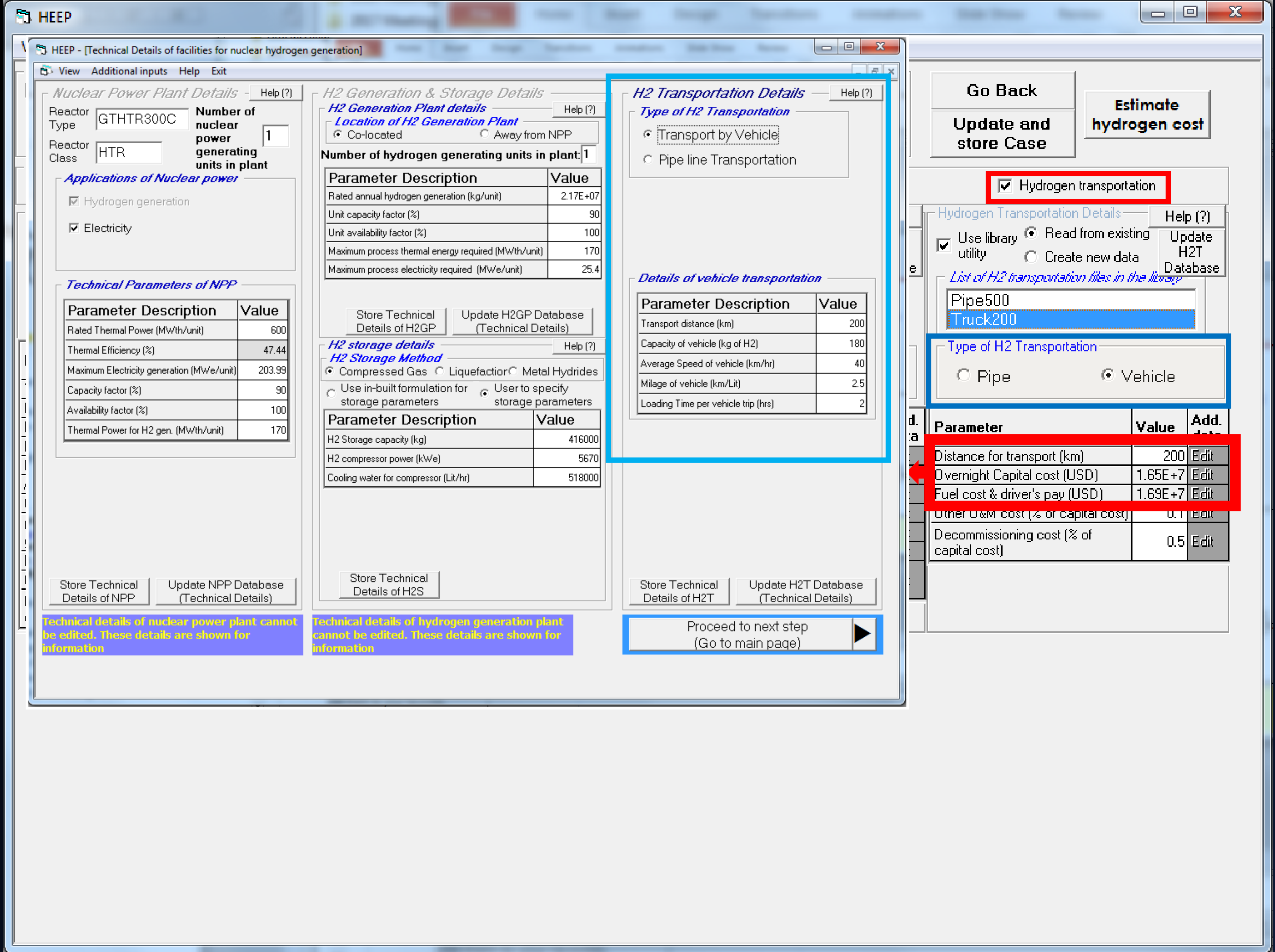

HEEP
View
Additional inputs
Help
Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt
(%) (%)
70 : 30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Help (?)
Construction
5
Operating
40
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Hydrogen generation
Hydrogen storage
Hydrogen transportation
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
APWR720
GTHTR300C
Parameter
Value
Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Number of units 1 Edit
Initial fuel load (kg/unit) 7090 Edit
Annual fuel feed (kg/unit) 1773 Edit
Overnight Capital cost(USD/unit) 5.50E+8 Edit
Capital cost fraction for electricity generating infrastructure (%) 21 Edit
Fuel cost (USD/kg) 12962 Edit
O&M cost (% of capital cost) 3.98 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
Hydrogen Genearation Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update H2GP Database
List of Hydrogen plant files in the library
SI-GTHTR300C
SI04
Location of H2 Generation Plant
Co-located
Away from NPP
Parameter
Value
Add. data
H2 generation per unit (kg/yr) 2.17E+07 Edit
Heat consumption (MWth/unit) 170 Edit
Electricity required (MWe/unit) 25.4 Edit
Number of units 1 Edit
Overnight Capital cost(USD/unit) 1.43E+8 Edit
Energy usage cost# (USD) 0.00E+0 Edit
Other O&M cost(% of capital 4.26 Edit
Decommissioning cost (% of capital cost) 0 Edit
#: Cost to be entered, if energy is drawn from grid @ market rate

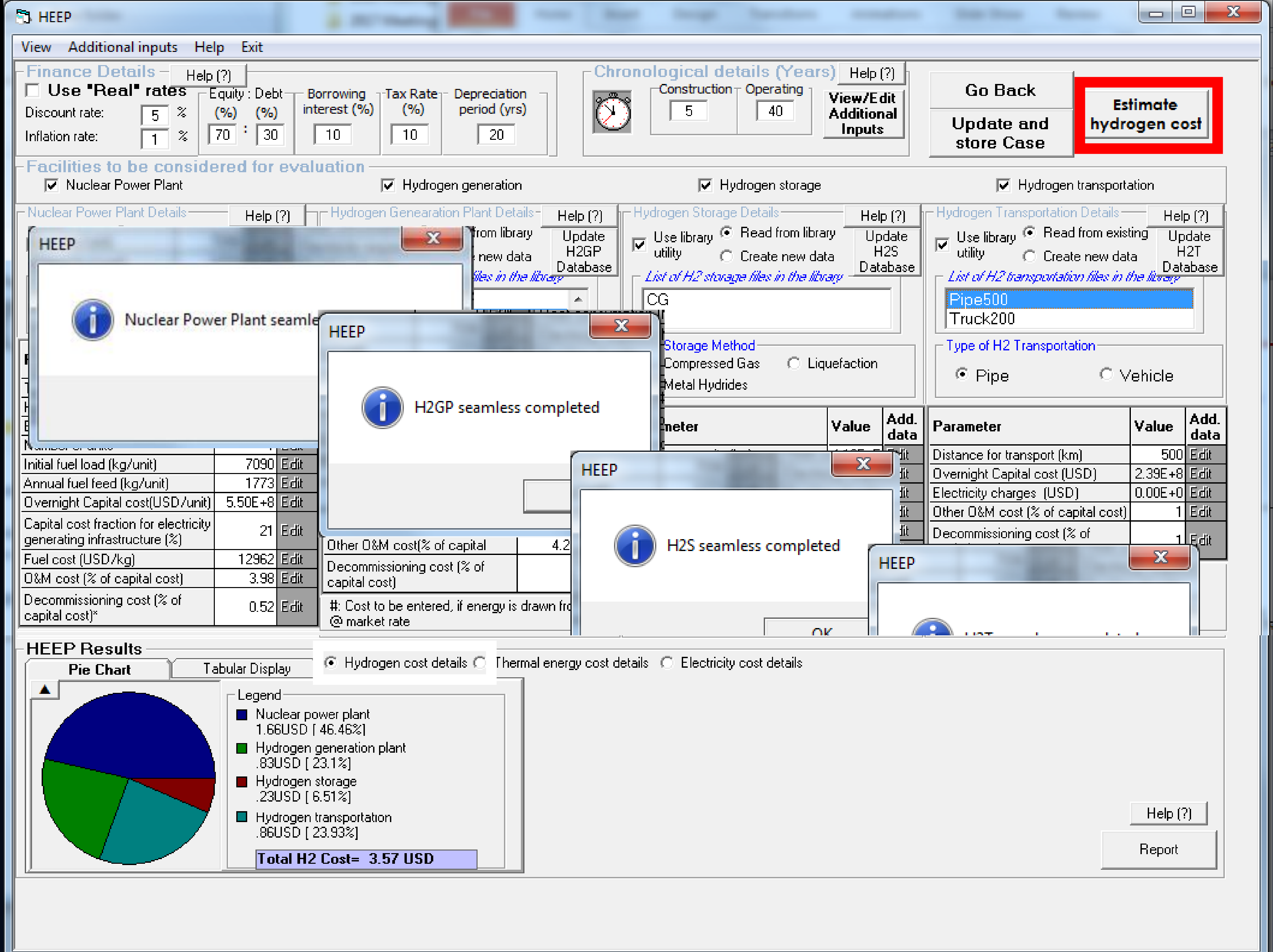


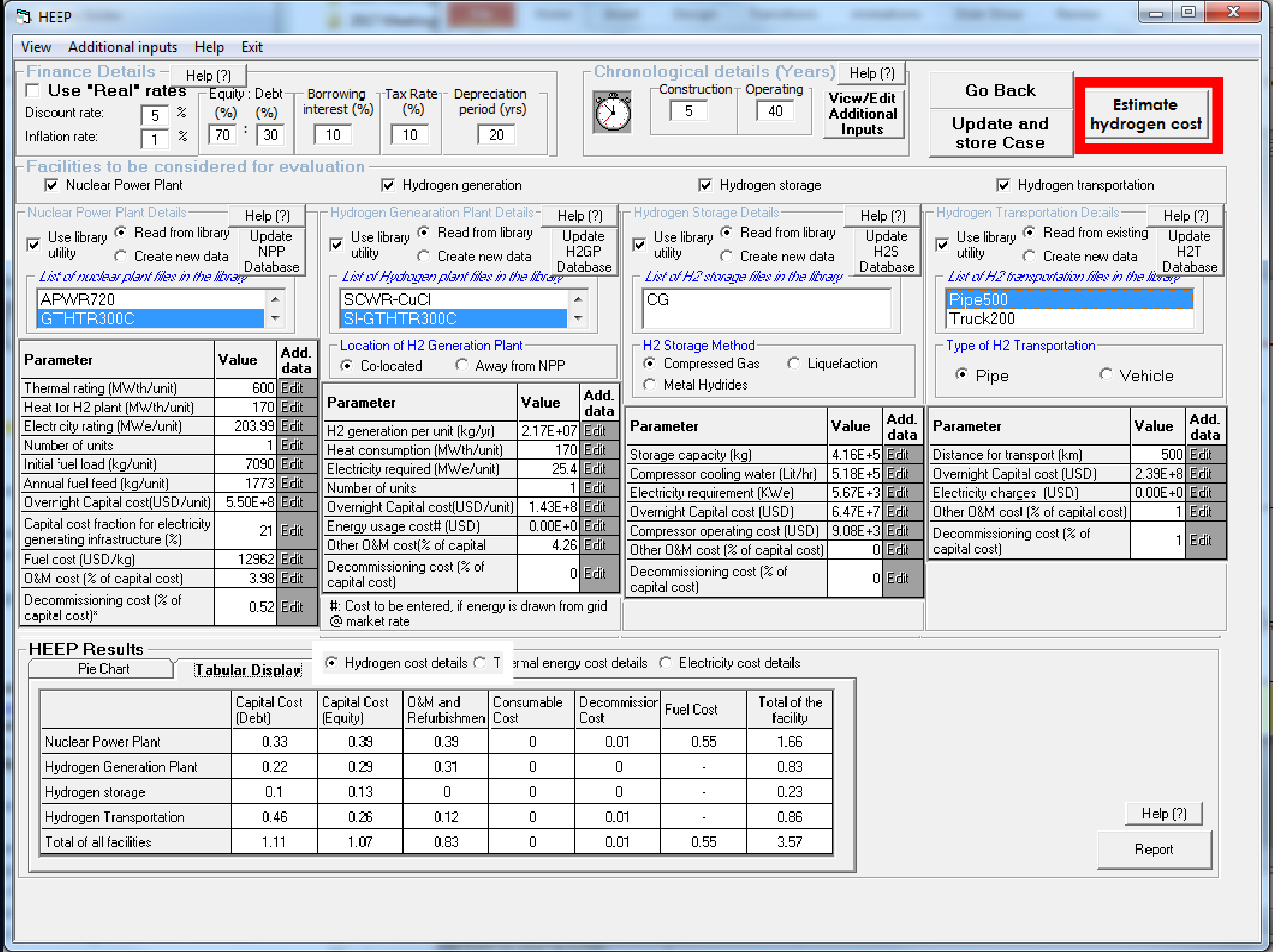
HEEP
View Additional inputs Help Exit
HEEP - [Technical Details of facilities for nuclear hydrogen generation]
View Additional inputs Help Exit
Nuclear Power Plant Details
Help (?)
Reactor Type GTHTR300C
Number of nuclear power generating units in plant 1
Reactor Class HTR
Applications of Nuclear power
Hydrogen generation
Electricity
Technical Parameters of NPP
Parameter Description Value
Rated Thermal Power (MWth/unit) 600
Thermal Efficiency (%) 47.44
Maximum Electricity generation (MWe/unit) 203.99
Capacity factor (%) 90
Availability factor (%) 100
Thermal Power for H2 gen. (MWth/unit) 170
Store Technical Details of NPP
Update NPP Database (Technical Details)
Technical details of nuclear power plant cannot be edited. These details are shown for information
H2 Generation & Storage Details
H2 Generation Plant details
Location of H2 Generation Plant
Co-located
Away from NPP
Number of hydrogen generating units in plant: 1
Parameter Description Value
Rated annual hydrogen generation (kg/unit) 2.17E+07
Unit capacity factor (%) 90
Unit availability factor (%) 100
Maximum process thermal energy required (MWth/unit) 170
Maximum process electricity required (MWe/unit) 25.4
Store Technical Details of H2GP
Update H2GP Database (Technical Details)
H2 storage details
H2 Storage Method
Compressed Gas
Liquefaction
Metal Hydrides
Use in-built formulation for storage parameters
User to specify storage parameters
Parameter Description Value
H2 Storage period (Hrs) 168
H2 compression pr. (MPa) 20
H2 Storage capacity (kg) 416164.38
H2 compressor power (kWe) 5671.25
Cooling water for compressor (Lit/hr) 128892.05
Store Technical Details of H2S
Proceed to next step (Go to main page)
hronological details (Years)
Construction 5
Operating 40
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Hydrogen storage
Hydrogen transportation
Hydrogen Storage Details
Use library utility
Read from library
Create new data
Update H2S Database
List of H2 storage files in the library
CG
H2 Storage Method
Compressed Gas
Liquefaction
Metal Hydrides
Parameter Value Add. data
Storage capacity (kg) 4.16E+5 Edit
Compressor cooling water (Lit/hr) 1.29E+5 Edit
Electricity requirement (KWe) 5.67E+3 Edit
Overnight Capital cost (USD) 6.47E+7 Edit
Compressor operating cost (USD) 2.26E+3 Edit
Other O&M cost (% of capital cost) 0 Edit
Decommissioning cost (% of capital cost) 0 Edit

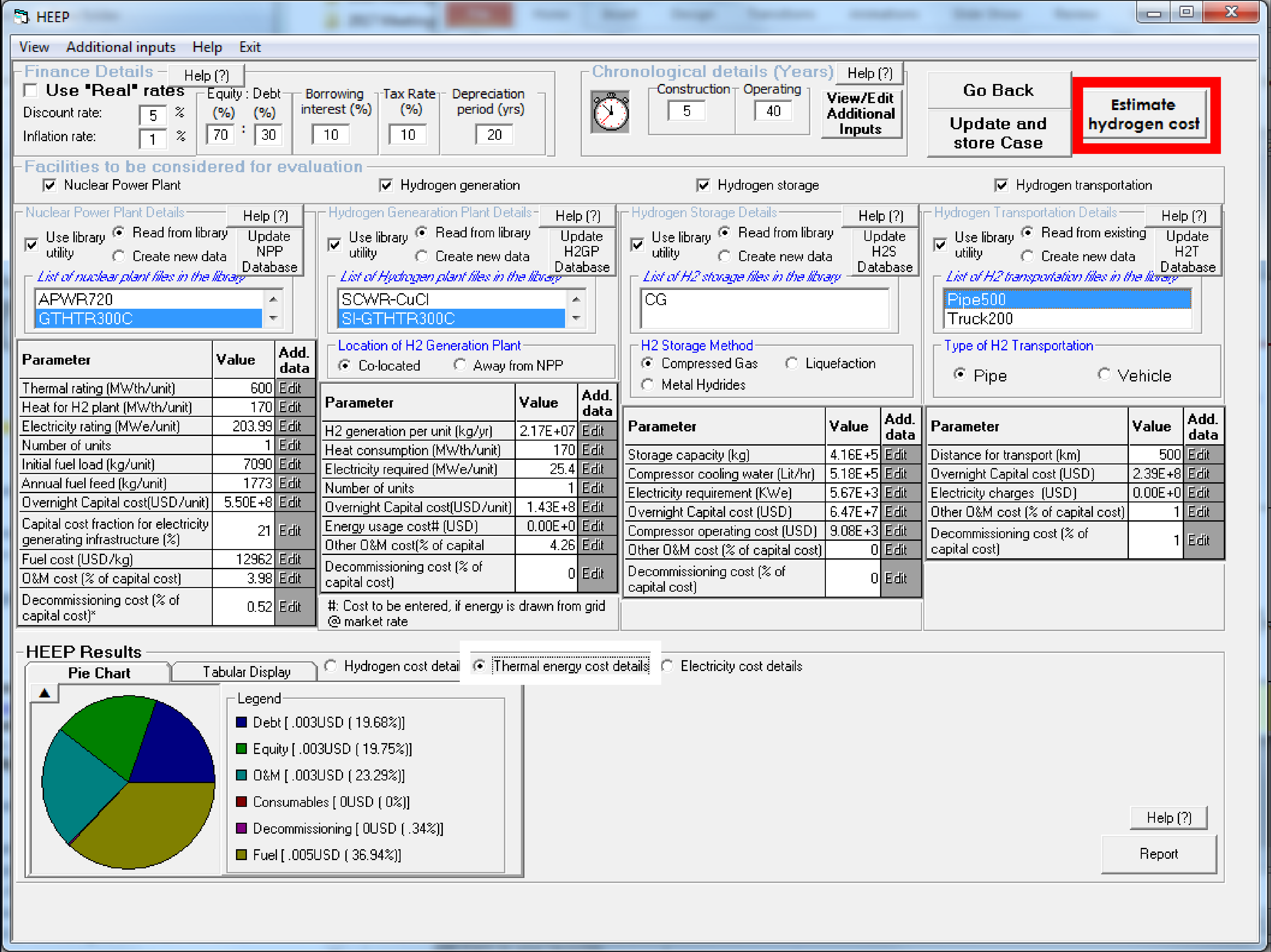

HEEP
View
Additional inputs
Help
Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%) 70 : 30
Borrowing interest (%) 10
Tax Rate (%) 10
Depreciation period (yrs) 20
Chronological details (Years)
Help (?)
Construction 5
Operating 40
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Hydrogen generation
Hydrogen storage
Hydrogen transportation
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
APWR720
GTHTR300C
Parameter | Value | Add. data
Thermal rating (MWth/unit) | 600 | Edit
Heat for H2 plant (MWth/unit) | 170 | Edit
Electricity rating (MWe/unit) | 203.99 | Edit
Number of units | 1 | Edit
Initial fuel load (kg/unit) | 7090 | Edit
Annual fuel feed (kg/unit) | 1773 | Edit
Overnight Capital cost(USD/unit) | 5.50E+8 | Edit
Capital cost fraction for electricity generating infrastructure (%) | 21 | Edit
Fuel cost (USD/kg) | 12962 | Edit
O&M cost (% of capital cost) | 3.98 | Edit
Decommissioning cost (% of capital cost)* | 0.52 | Edit
Hydrogen Genearation Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update H2GP Database
List of Hydrogen plant files in the library
SCWR-CuCl
SI-GTHTR300C
Location of H2 Generation Plant
Co-located
Away from NPP
Parameter | Value | Add. data
H2 generation per unit (kg/yr) | 2.17E+07 | Edit
Heat consumption (MWth/unit) | 170 | Edit
Electricity required (MWe/unit) | 25.4 | Edit
Number of units | 1 | Edit
Overnight Capital cost(USD/unit) | 1.43E+8 | Edit
Energy usage cost# (USD) | 0.00E+0 | Edit
Other O&M cost(% of capital | 4.26 | Edit
Decommissioning cost (% of capital cost) | 0 | Edit
#: Cost to be entered, if energy is drawn from grid @ market rate
Hydrogen Storage Details
Help (?)
Use library utility
Read from library
Create new data
Update H2S Database
List of H2 storage files in the library
CG
H2 Storage Method
Compressed Gas
Liquefaction
Metal Hydrides
Parameter | Value | Add. data
Storage capacity (kg) | 4.16E+5 | Edit
Compressor cooling water (Lit/hr) | 1.29E+5 | Edit
Electricity requirement (KWe) | 5.67E+3 | Edit
Overnight Capital cost (USD) | 6.47E+7 | Edit
Compressor operating cost (USD) | 2.26E+3 | Edit
Other O&M cost (% of capital cost) | 0 | Edit
Decommissioning cost (% of capital cost) | 0 | Edit


HEEP
HEEP - [Technical Details of facilities for nuclear hydrogen generation]
View Additional inputs Help Exit
Nuclear Power Plant Details
Help (?)
Reactor Type GTHTR300C
Reactor Class HTR
Number of nuclear power generating units in plant 1
Applications of Nuclear power
Hydrogen generation
Electricity
Technical Parameters of NPP
Parameter Description Value
Rated Thermal Power (MWth/unit) 600
Thermal Efficiency (%) 47.44
Maximum Electricity generation (MWe/unit) 203.99
Capacity factor (%) 90
Availability factor (%) 100
Thermal Power for H2 gen. (MWth/unit) 170
Store Technical Details of NPP
Update NPP Database (Technical Details)
Technical details of nuclear power plant cannot be edited. These details are shown for information
H2 Generation & Storage Details
H2 Generation Plant details
Location of H2 Generation Plant
Co-located
Away from NPP
Number of hydrogen generating units in plant: 1
Parameter Description Value
Rated annual hydrogen generation (kg/unit) 2.17E+07
Unit capacity factor (%) 90
Unit availability factor (%) 100
Maximum process thermal energy required (MWth/unit) 170
Maximum process electricity required (MWe/unit) 25.4
Store Technical Details of H2GP
Update H2GP Database (Technical Details)
H2 storage details
H2 Storage Method
Compressed Gas
Liquefaction
Metal Hydrides
Use in-built formulation for storage parameters
User to specify storage parameters
Parameter Description Value
H2 Storage capacity (kg) 416000
H2 compressor power (kWe) 5670
Cooling water for compressor (Lit/hr) 518000
Store Technical Details of H2S
Technical details of hydrogen generation plant cannot be edited. These details are shown for information
H2 Transportation Details
Type of H2 Transportation
Transport by Vehicle
Pipe line Transportation
Details of pipeline transportation
Use in-built formulation to calculate pipe line transportation parameters
User to provide pipe line transportation parameters
Parameter Description Value
Transport distance (km) 200
Equivalent diameter of Pipe (m) 0.25
Friction factor 0.01
Temperature of H2 (K) 293
Delivery Pressure (MPa) 5
Inlet pressure (MPa) 5
Compressor Power (kWe) 3941.77
Store Technical Details of H2T
Update H2T Database (Technical Details)
Proceed to next step (Go to main page)
Go Back
Update and store Case
Estimate hydrogen cost
Hydrogen transportation
Hydrogen Transportation Details
Help (?)
Use library utility
Read from existing
Create new data
Update H2T Database
List of H2 transportation files in the library
Pipe500
Truck200
Type of H2 Transportation
Pipe
Vehicle
Parameter Value Add.
Distance for transport (km) 500 Edit
Overnight Capital cost (USD) 2.39E+8 Edit
Electricity charges (USD) 0.00E+0 Edit
Other O&M cost (% of capital cost) 1 Edit
Decommissioning cost (% of capital cost) 1 Edit

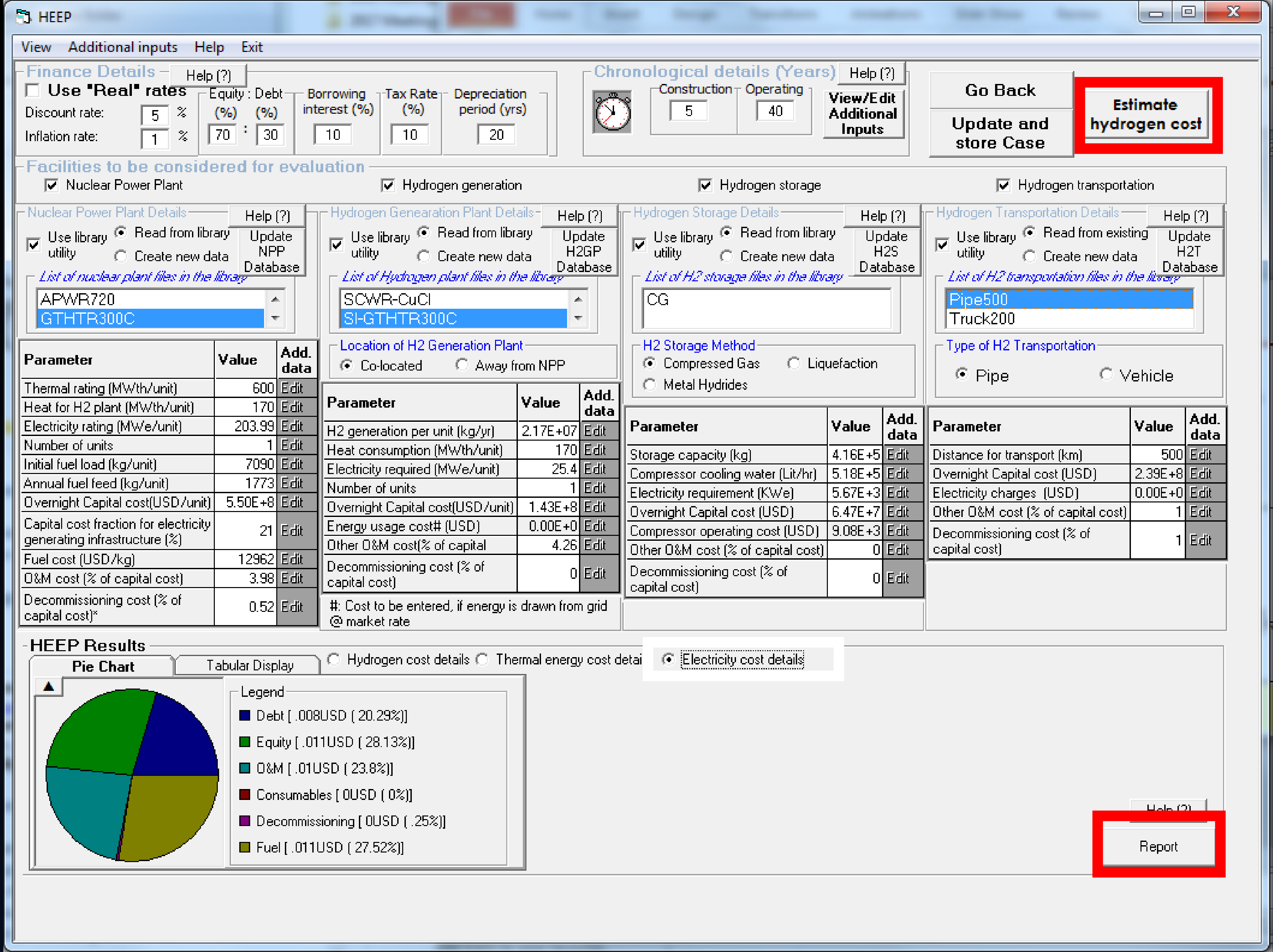

HEEP
HEEP - [Technical Details of facilities for nuclear hydrogen generation]
View Additional inputs Help Exit
Nuclear Power Plant Details
Help (?)
Reactor Type GTHTR300C
Reactor Class HTR
Number of nuclear power generating units in plant 1
Applications of Nuclear power
Hydrogen generation
Electricity
Technical Parameters of NPP
Parameter Description | Value
Rated Thermal Power (MWth/unit) | 600
Thermal Efficiency (%) | 47.44
Maximum Electricity generation (MWe/unit) | 203.99
Capacity factor (%) | 90
Availability factor (%) | 100
Thermal Power for H2 gen. (MWth/unit) | 170
Store Technical Details of NPP
Update NPP Database (Technical Details)
Technical details of nuclear power plant cannot be edited. These details are shown for information
H2 Generation & Storage Details
H2 Generation Plant details
Location of H2 Generation Plant
Co-located
Away from NPP
Number of hydrogen generating units in plant: 1
Parameter Description | Value
Rated annual hydrogen generation (kg/unit) | 2.17E+07
Unit capacity factor (%) | 90
Unit availability factor (%) | 100
Maximum process thermal energy required (MWth/unit) | 170
Maximum process electricity required (MWe/unit) | 25.4
Store Technical Details of H2GP
Update H2GP Database (Technical Details)
H2 storage details
H2 Storage Method
Compressed Gas
Liquefaction
Metal Hydrides
Use in-built formulation for storage parameters
User to specify storage parameters
Parameter Description | Value
H2 Storage capacity (kg) | 416000
H2 compressor power (kWe) | 5670
Cooling water for compressor (Lit/hr) | 518000
Store Technical Details of H2S
Technical details of hydrogen generation plant cannot be edited. These details are shown for information
H2 Transportation Details
Type of H2 Transportation
Transport by Vehicle
Pipe line Transportation
Details of vehicle transportation
Parameter Description | Value
Transport distance (km) | 200
Capacity of vehicle (kg of H2) | 180
Average Speed of vehicle (km/hr) | 40
Milage of vehicle (km/Lit) | 2.5
Loading Time per vehicle trip (hrs) | 2
Store Technical Details of H2T
Update H2T Database (Technical Details)
Proceed to next step (Go to main page)
Go Back
Update and store Case
Estimate hydrogen cost
Hydrogen transportation
Hydrogen Transportation Details
Use library utility
Read from existing
Create new data
Update H2T Database
List of H2 transportation files in the library
Pipe500
Truck200
Type of H2 Transportation
Pipe
Vehicle
Parameter | Value | Add. data
Distance for transport (km) | 200 | Edit
Overnight Capital cost (USD) | 1.65E+7 | Edit
Fuel cost & driver's pay (USD) | 1.69E+7 | Edit
Other O&M cost (% of capital cost) | 0.1 | Edit
Decommissioning cost (% of capital cost) | 0.5 | Edit


HEEP
View
Additional inputs
Help
Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%)
70 : 30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Construction
5
Operating
40
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Hydrogen generation
Hydrogen storage
Hydrogen transportation
Nuclear Power Plant Details
Hydrogen Geneartion Plant Details
Hydrogen Storage Details
Hydrogen Transportation Details
Use library utility
Read from library
Create new data
Update H2GP Database
Update H2S Database
Read from existing
Update H2T Database
List of H2 storage files in the library
CG
List of H2 transportation files in the library
Pipe500
Truck200
Storage Method
Compressed Gas
Liquefaction
Metal Hydrides
Type of H2 Transportation
Pipe
Vehicle
HEEP
Nuclear Power Plant seamle
HEEP
H2GP seamless completed
HEEP
H2S seamless completed
HEEP
Initial fuel load (kg/unit) 7090 Edit
Annual fuel feed (kg/unit) 1773 Edit
Overnight Capital cost(USD/unit) 5.50E+8 Edit
Capital cost fraction for electricity generating infrastructure (%) 21 Edit
Fuel cost (USD/kg) 12962 Edit
O&M cost (% of capital cost) 3.98 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
Other O&M cost(% of capital 4.2
Decommissioning cost (% of capital cost)
#: Cost to be entered, if energy is drawn fro @ market rate
Value
Add. data
Parameter
Value
Add. data
Distance for transport (km) 500 Edit
Overnight Capital cost (USD) 2.39E+8 Edit
Electricity charges (USD) 0.00E+0 Edit
Other O&M cost (% of capital cost) 1 Edit
Decommissioning cost (% of 1 Edit
HEEP Results
Pie Chart
Tabular Display
Hydrogen cost details
Thermal energy cost details
Electricity cost details
Legend
Nuclear power plant 1.66USD [46.46%]
Hydrogen generation plant .83USD [23.1%]
Hydrogen storage .23USD [6.51%]
Hydrogen transportation .86USD [23.93%]
Total H2 Cost= 3.57 USD
Help (?)
Report


HEEP
View Additional inputs Help Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%)
70 : 30
Borrowing interest (%)
10
Tax Rate (%)
10
Depreciation period (yrs)
20
Chronological details (Years)
Help (?)
Construction 5
Operating 40
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Hydrogen generation
Hydrogen storage
Hydrogen transportation
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
APWR720
GTHTR300C
Parameter | Value | Add. data
Thermal rating (MWth/unit) | 600 | Edit
Heat for H2 plant (MWth/unit) | 170 | Edit
Electricity rating (MWe/unit) | 203.99 | Edit
Number of units | 1 | Edit
Initial fuel load (kg/unit) | 7090 | Edit
Annual fuel feed (kg/unit) | 1773 | Edit
Overnight Capital cost(USD/unit) | 5.50E+8 | Edit
Capital cost fraction for electricity generating infrastructure (%) | 21 | Edit
Fuel cost (USD/kg) | 12962 | Edit
O&M cost (% of capital cost) | 3.98 | Edit
Decommissioning cost (% of capital cost)* | 0.52 | Edit
Hydrogen Geneаration Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update H2GP Database
List of Hydrogen plant files in the library
SCWR-CuCl
SI-GTHTR300C
Location of H2 Generation Plant
Co-located
Away from NPP
Parameter | Value | Add. data
H2 generation per unit (kg/yr) | 2.17E+07 | Edit
Heat consumption (MWth/unit) | 170 | Edit
Electricity required (MWe/unit) | 25.4 | Edit
Number of units | 1 | Edit
Overnight Capital cost(USD/unit) | 1.43E+8 | Edit
Energy usage cost# (USD) | 0.00E+0 | Edit
Other O&M cost(% of capital | 4.26 | Edit
Decommissioning cost (% of capital cost) | 0 | Edit
#: Cost to be entered, if energy is drawn from grid @ market rate
Hydrogen Storage Details
Help (?)
Use library utility
Read from library
Create new data
Update H2S Database
List of H2 storage files in the library
CG
H2 Storage Method
Compressed Gas
Liquefaction
Metal Hydrides
Parameter | Value | Add. data
Storage capacity (kg) | 4.16E+5 | Edit
Compressor cooling water (Lit/hr) | 5.18E+5 | Edit
Electricity requirement (KWe) | 5.67E+3 | Edit
Overnight Capital cost (USD) | 6.47E+7 | Edit
Compressor operating cost (USD) | 9.08E+3 | Edit
Other O&M cost (% of capital cost) | 0 | Edit
Decommissioning cost (% of capital cost) | 0 | Edit
Hydrogen Transportation Details
Help (?)
Use library utility
Read from existing
Create new data
Update H2T Database
List of H2 transportation files in the library
Pipe500
Truck200
Type of H2 Transportation
Pipe
Vehicle
Parameter | Value | Add. data
Distance for transport (km) | 500 | Edit
Overnight Capital cost (USD) | 2.39E+8 | Edit
Electricity charges (USD) | 0.00E+0 | Edit
Other O&M cost (% of capital cost) | 1 | Edit
Decommissioning cost (% of capital cost) | 1 | Edit
HEEP Results
Pie Chart
Tabular Display
Hydrogen cost details
T ermal energy cost details
Electricity cost details
| Capital Cost (Debt) | Capital Cost (Equity) | O&M and Refurbishmen | Consumable Cost | Decommission Cost | Fuel Cost | Total of the facility
Nuclear Power Plant | 0.33 | 0.39 | 0.39 | 0 | 0.01 | 0.55 | 1.66
Hydrogen Generation Plant | 0.22 | 0.29 | 0.31 | 0 | 0 | - | 0.83
Hydrogen storage | 0.1 | 0.13 | 0 | 0 | 0 | - | 0.23
Hydrogen Transportation | 0.46 | 0.26 | 0.12 | 0 | 0.01 | - | 0.86
Total of all facilities | 1.11 | 1.07 | 0.83 | 0 | 0.01 | 0.55 | 3.57
Help (?)
Report



HEEP
View Additional inputs Help Exit
Finance Details
Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%) 70 : 30
Borrowing interest (%) 10
Tax Rate (%) 10
Depreciation period (yrs) 20
Chronological details (Years)
Help (?)
Construction 5
Operating 40
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Hydrogen generation
Hydrogen storage
Hydrogen transportation
Nuclear Power Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
APWR720
GTHTR300C
Parameter Value Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Number of units 1 Edit
Initial fuel load (kg/unit) 7090 Edit
Annual fuel feed (kg/unit) 1773 Edit
Overnight Capital cost(USD/unit) 5.50E+8 Edit
Capital cost fraction for electricity generating infrastructure (%) 21 Edit
Fuel cost (USD/kg) 12962 Edit
O&M cost (% of capital cost) 3.98 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
Hydrogen Genearation Plant Details
Help (?)
Use library utility
Read from library
Create new data
Update H2GP Database
List of Hydrogen plant files in the library
SCWR-CuCl
SI-GTHTR300C
Location of H2 Generation Plant
Co-located
Away from NPP
Parameter Value Add. data
H2 generation per unit (kg/yr) 2.17E+07 Edit
Heat consumption (MWth/unit) 170 Edit
Electricity required (MWe/unit) 25.4 Edit
Number of units 1 Edit
Overnight Capital cost(USD/unit) 1.43E+8 Edit
Energy usage cost# (USD) 0.00E+0 Edit
Other O&M cost(% of capital 4.26 Edit
Decommissioning cost (% of capital cost) 0 Edit
#: Cost to be entered, if energy is drawn from grid @ market rate
Hydrogen Storage Details
Help (?)
Use library utility
Read from library
Create new data
Update H2S Database
List of H2 storage files in the library
CG
H2 Storage Method
Compressed Gas
Liquefaction
Metal Hydrides
Parameter Value Add. data
Storage capacity (kg) 4.16E+5 Edit
Compressor cooling water (Lit/hr) 5.18E+5 Edit
Electricity requirement (KWe) 5.67E+3 Edit
Overnight Capital cost (USD) 6.47E+7 Edit
Compressor operating cost (USD) 9.08E+3 Edit
Other O&M cost (% of capital cost) 0 Edit
Decommissioning cost (% of capital cost) 0 Edit
Hydrogen Transportation Details
Help (?)
Use library utility
Read from existing
Create new data
Update H2T Database
List of H2 transportation files in the library
Pipe500
Truck200
Type of H2 Transportation
Pipe
Vehicle
Parameter Value Add. data
Distance for transport (km) 500 Edit
Overnight Capital cost (USD) 2.39E+8 Edit
Electricity charges (USD) 0.00E+0 Edit
Other O&M cost (% of capital cost) 1 Edit
Decommissioning cost (% of capital cost) 1 Edit
HEEP Results
Pie Chart
Tabular Display
Hydrogen cost detai
Thermal energy cost details
Electricity cost details
Legend
Debt [.003USD (19.68%)]
Equity [.003USD (19.75%)]
O&M [.003USD (23.29%)]
Consumables [0USD (0%)]
Decommissioning [0USD (.34%)]
Fuel [.005USD (36.94%)]
Help (?)
Report


HEEP
View Additional inputs Help Exit
Finance Details Help (?)
Use "Real" rates
Discount rate: 5 %
Inflation rate: 1 %
Equity : Debt (%) (%) 70 : 30
Borrowing interest (%) 10
Tax Rate (%) 10
Depreciation period (yrs) 20
Chronological details (Years) Help (?)
Construction 5
Operating 40
View/Edit Additional Inputs
Go Back
Update and store Case
Estimate hydrogen cost
Facilities to be considered for evaluation
Nuclear Power Plant
Hydrogen generation
Hydrogen storage
Hydrogen transportation
Nuclear Power Plant Details Help (?)
Use library utility
Read from library
Create new data
Update NPP Database
List of nuclear plant files in the library
APWR720
GTHTR300C
Parameter Value Add. data
Thermal rating (MWth/unit) 600 Edit
Heat for H2 plant (MWth/unit) 170 Edit
Electricity rating (MWe/unit) 203.99 Edit
Number of units 1 Edit
Initial fuel load (kg/unit) 7090 Edit
Annual fuel feed (kg/unit) 1773 Edit
Overnight Capital cost(USD/unit) 5.50E+8 Edit
Capital cost fraction for electricity generating infrastructure (%) 21 Edit
Fuel cost (USD/kg) 12962 Edit
O&M cost (% of capital cost) 3.98 Edit
Decommissioning cost (% of capital cost)* 0.52 Edit
Hydrogen Genearation Plant Details Help (?)
Use library utility
Read from library
Create new data
Update H2GP Database
List of Hydrogen plant files in the library
SCWR-CuCl
SI-GTHTR300C
Location of H2 Generation Plant
Co-located
Away from NPP
Parameter Value Add. data
H2 generation per unit (kg/yr) 2.17E+07 Edit
Heat consumption (MWth/unit) 170 Edit
Electricity required (MWe/unit) 25.4 Edit
Number of units 1 Edit
Overnight Capital cost(USD/unit) 1.43E+8 Edit
Energy usage cost# (USD) 0.00E+0 Edit
Other O&M cost(% of capital 4.26 Edit
Decommissioning cost (% of capital cost) 0 Edit
#: Cost to be entered, if energy is drawn from grid @ market rate
Hydrogen Storage Details Help (?)
Use library utility
Read from library
Create new data
Update H2S Database
List of H2 storage files in the library
CG
H2 Storage Method
Compressed Gas
Liquefaction
Metal Hydrides
Parameter Value Add. data
Storage capacity (kg) 4.16E+5 Edit
Compressor cooling water (Lit/hr) 5.18E+5 Edit
Electricity requirement (KWe) 5.67E+3 Edit
Overnight Capital cost (USD) 6.47E+7 Edit
Compressor operating cost (USD) 9.08E+3 Edit
Other O&M cost (% of capital cost) 0 Edit
Decommissioning cost (% of capital cost) 0 Edit
Hydrogen Transportation Details Help (?)
Use library utility
Read from existing
Create new data
Update H2T Database
List of H2 transportation files in the library
Pipe500
Truck200
Type of H2 Transportation
Pipe
Vehicle
Parameter Value Add. data
Distance for transport (km) 500 Edit
Overnight Capital cost (USD) 2.39E+8 Edit
Electricity charges (USD) 0.00E+0 Edit
Other O&M cost (% of capital cost) 1 Edit
Decommissioning cost (% of capital cost) 1 Edit
HEEP Results
Pie Chart
Tabular Display
Hydrogen cost details
Thermal energy cost detai
Electricity cost details
Legend
Debt [.008USD (20.29%)]
Equity [.011USD (28.13%)]
O&M [.01USD (23.8%)]
Consumables [0USD (0%)]
Decommissioning [0USD (.25%)]
Fuel [.011USD (27.52%)]
Report

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

1

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

2

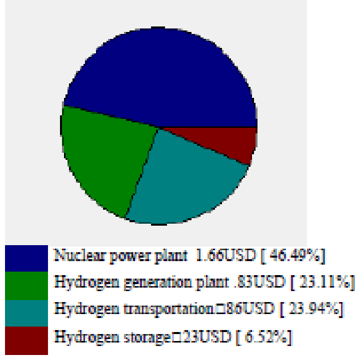


Figure - 1: Cost breakup for hydrogen production

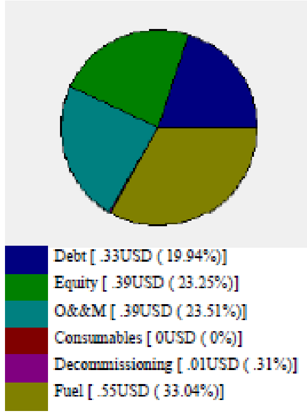


Figure - 2: Cost breakup for hydrogen production (Nuclear power plant segment)

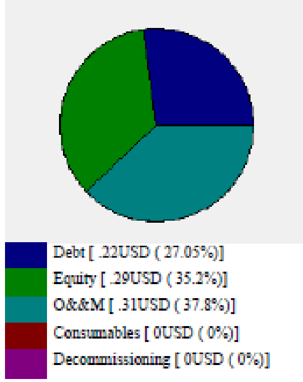


Figure - 3: Cost breakup for hydrogen production (Hydrogen generation plant segment)

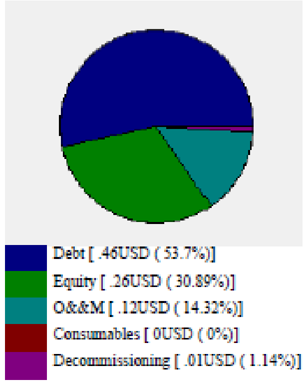


Figure - 4: Cost breakup for hydrogen production (Hydrogen transportation segment)

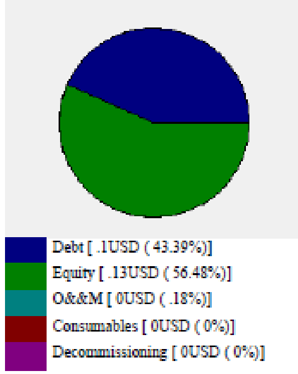


Figure - 5: Cost breakup for hydrogen production (Hydrogen storage segment)

Comparative Case Study

Capacity and thermal specifications of the considered cases of nuclear power plant and hydrogen generation plant

Parameter	CASE I	CASE II	CASE III	CASE IV
Nuclear Power Plant	**PBR NPP**	**PMR NPP**	**HTGR NPP**	
Thermal rating per unit	200 MW_{th}	200 MW_{th}	600 MW_{th}	600 MW_{th}
Number of Units	4	6	4	6
Electricity rating, MW_e/unit (eff.)	-	160 (40%)	-	110 (40%)
Thermal heat of H_2 plant, MW_{th}/unit	200	200	540	324.167
Specific capital cost, $/$MW_{th}$	1,495,000	367,500	874,500	874,500
Capital cost, M$	1,196	441	2,100	3,465
O&M cost, %	1.79	1.94	2.07	2.07
Fuel cost, $/kg	77	110.55	275	275
Hydrogen Generation Plant				
Annual Hydrogen generation, ton	72,000	72,000	216,000	216,000
Thermal energy required, MW_{th}	800	800	1945	1945
Electric energy required, MW_e	272	272	815	815
Capital cost, M$	762	673	1,550	1,550
Energy usage cost M$	157	64.75	441	89.60
O$M cost, %	5.34	5.5	5.46	5.46

H2 Storage

Hydrogen storage period, h	168
Unit cost of cooling water for storage, $/ML	0.00022
O&M cost for hydrogen storage, %	5
Liquefaction	
Cooling water flow rate of Liquefaction, L/kg H_2	209
Daily Boil-off rate, %	0.1
Metal Hydride	
Specific Heating power, MJ/kg H_2	23.26
Hydride cooling, L/kg H_2	209

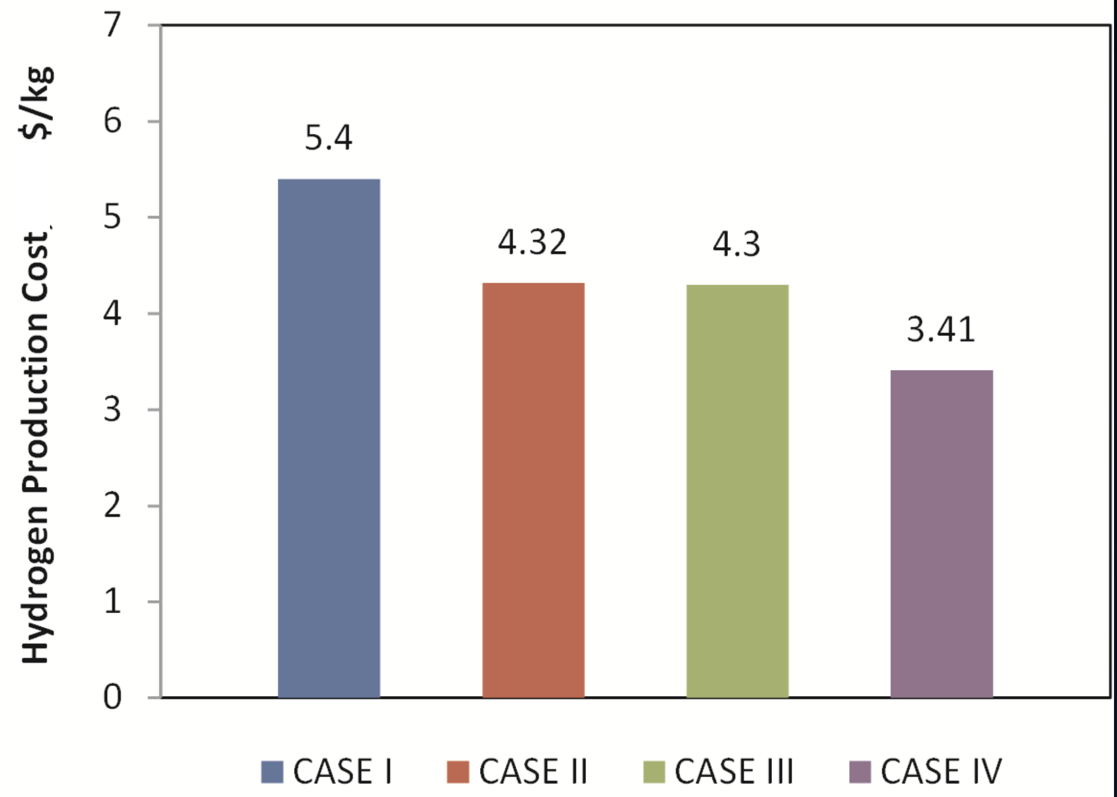
H2 Transportation

Vehicle		Pipelines	
Transportation distance, km	300	Transportation distance, km	500
Vehicle H_2 Capacity, kg	180	Pipe equivalent radius, mm	125
Fuel Cost, c$	125	Inlet pressure of Hydrogen, bar	53.2
Loading Time per trip, min	120	Delivery pressure, bar	50.0
Average speed, km/h	40	Temperature of Hydrogen, K	293
Mileage of vehicle, km/L	2.5	Friction factor	0.01
Decommissioning cost, %	0.5	Decommissioning cost, %	1
O&M cost, %	0.1	O&M cost, %	1

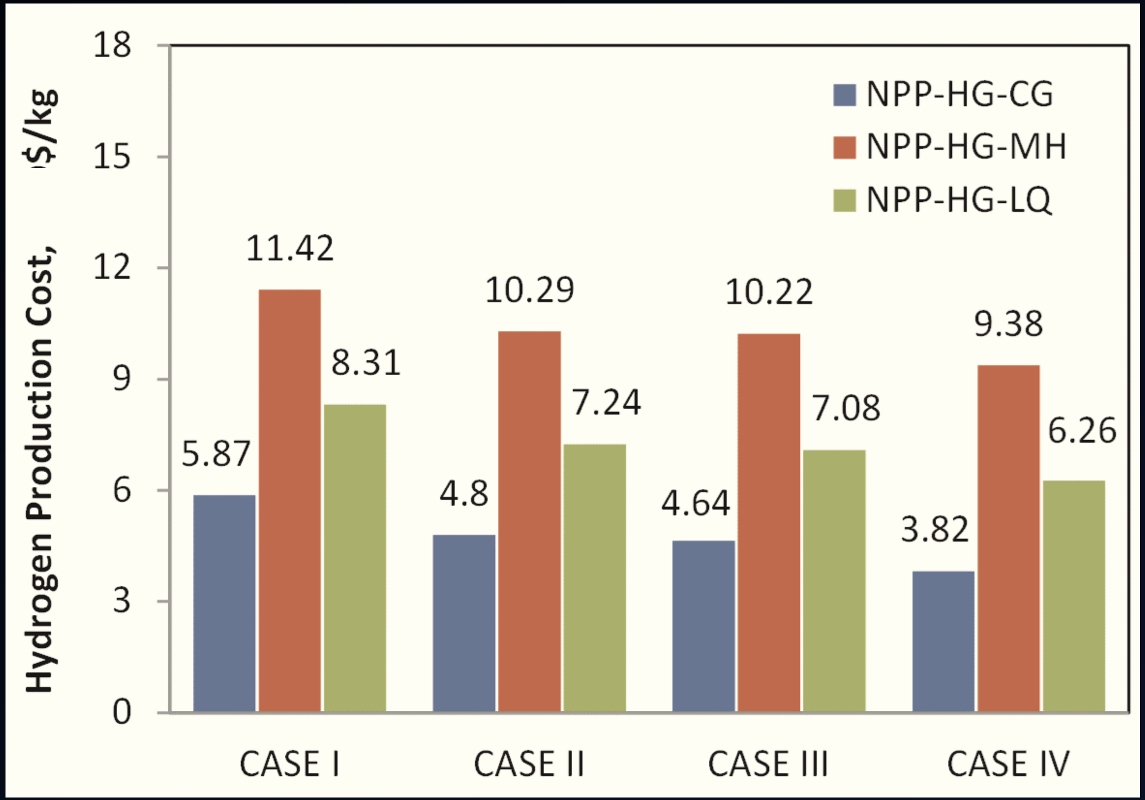
Time periods and financial parameters considered in the analysis

General Cost and Operating parameters	
Discount rate	5%
Inflation rate	1.2%
Interest rate	10%
Tax rate	10%
Equity : debt	70%:30%
Depreciation period	20 year
Construction period	3 year
Operation life time/ Return period	60 year
Cooling before decommissioning	12 month
Decommissioning	10 year
Fuel cooling	24 month
Waste cooling	24 month
Capacity factor	90%
availability factor	100%
Unit cost of grid electricity, c$/kWh	6.6

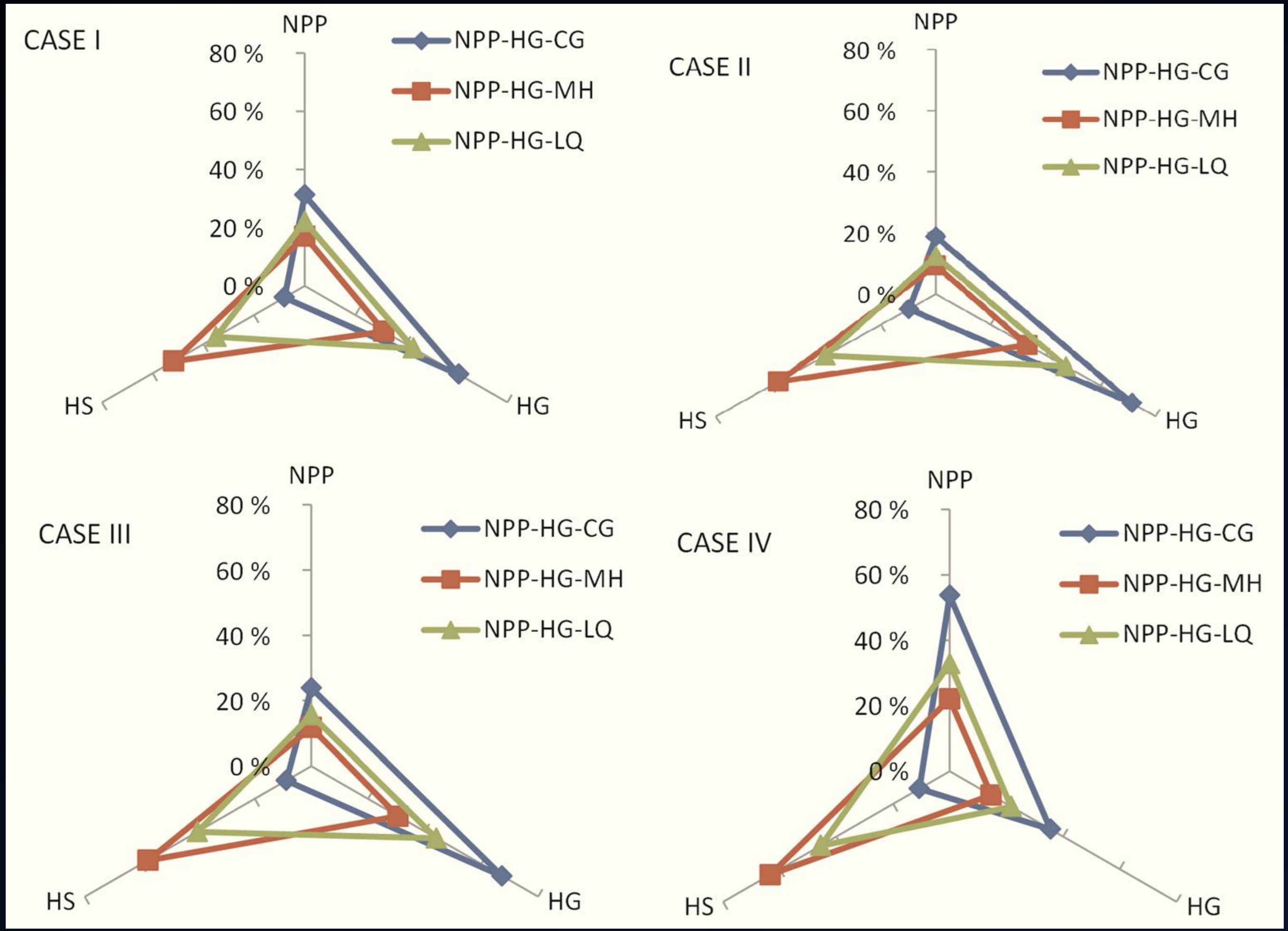
	CASE I. II	CASE III, IV
HYDROGEN STORAGE		
Compressed Gas		
Storage capacity, ton	1,381	4,142
Electric power required, MW_e	18.80	56.45
Compressor cooling water, L/s	118.79	356.18
Capital cost, M$	186	447
Compressor operating cost, M$	10.9	32.7
Cooling water charges, $	8,248.42	24,668.16
Liquefaction		
Storage capacity, ton	1,390	4,171
Electric power required, MW_e	82.76	248.3
Liquefier cooling water, L/s	480.5	1441.5
Capital cost, M$	192	397
Storage electricity charges, M$	54.9	164.8
Cooling water charges, $	38,158	114,668
Metal Hydrides		
Storage capacity, ton	1,380	4,142
Heating power required, MW_{th}	53.10	159.3
Hydride cooling water, L/s	477.16	1,431.7
Capital cost, M$	3340	10000
Cost of energy for hydride cooling, $	30,134	90,228
HYDROGEN TRANSPORTATION		
Vehicle Transportation		
Capital cost, M$	77.60	232.8
Fuel cost, M$	120	360
Annual drivers' wages, M$	12.80	38.41
Pipe Transportation for Compressed Gas Storage		
Compressor power, MW_e	13.12	11.79
Capital cost, M$	272	263
Electric power charges, M$	7.58	6.82



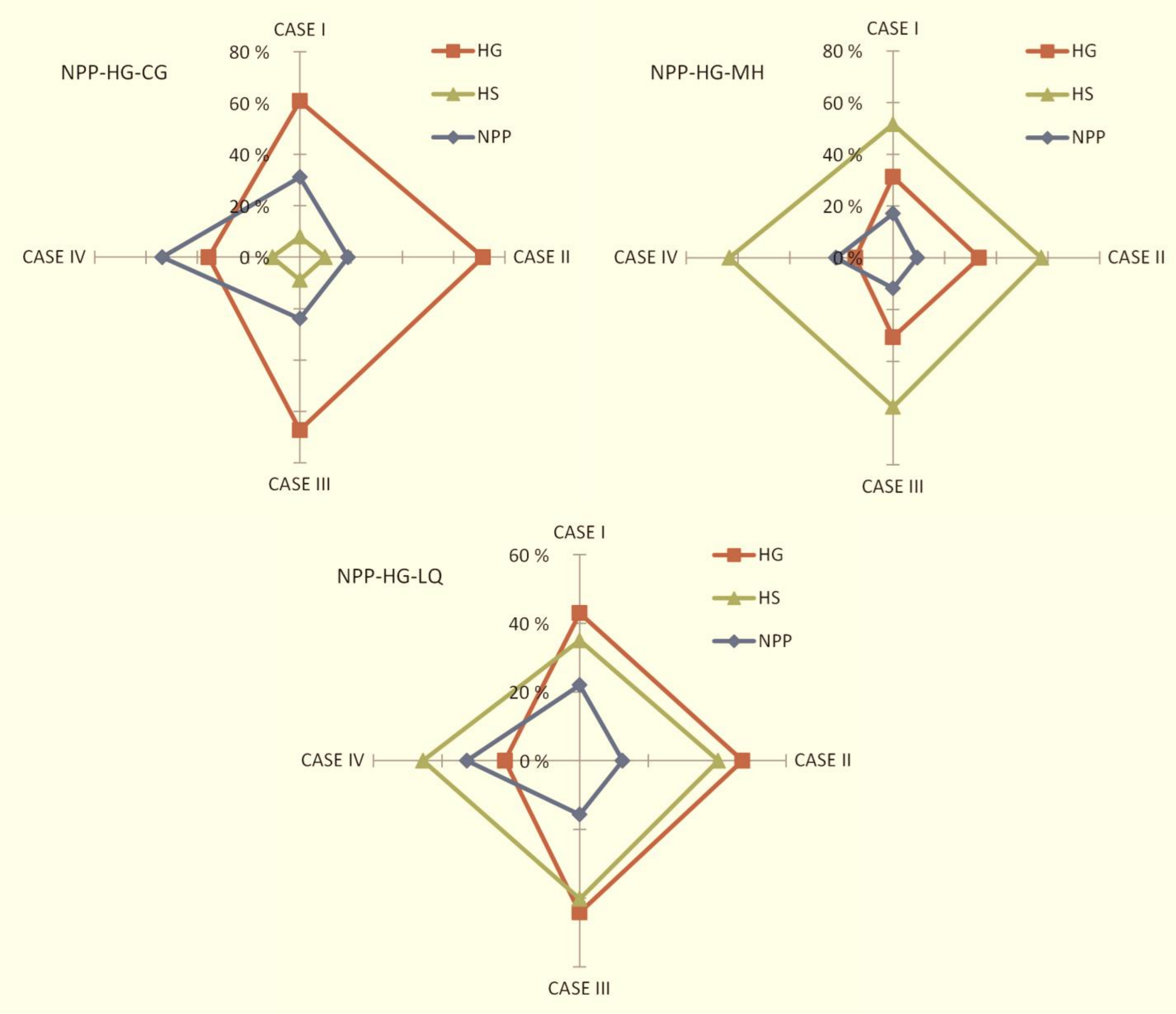
Comparison of hydrogen cost for hydrogen production only



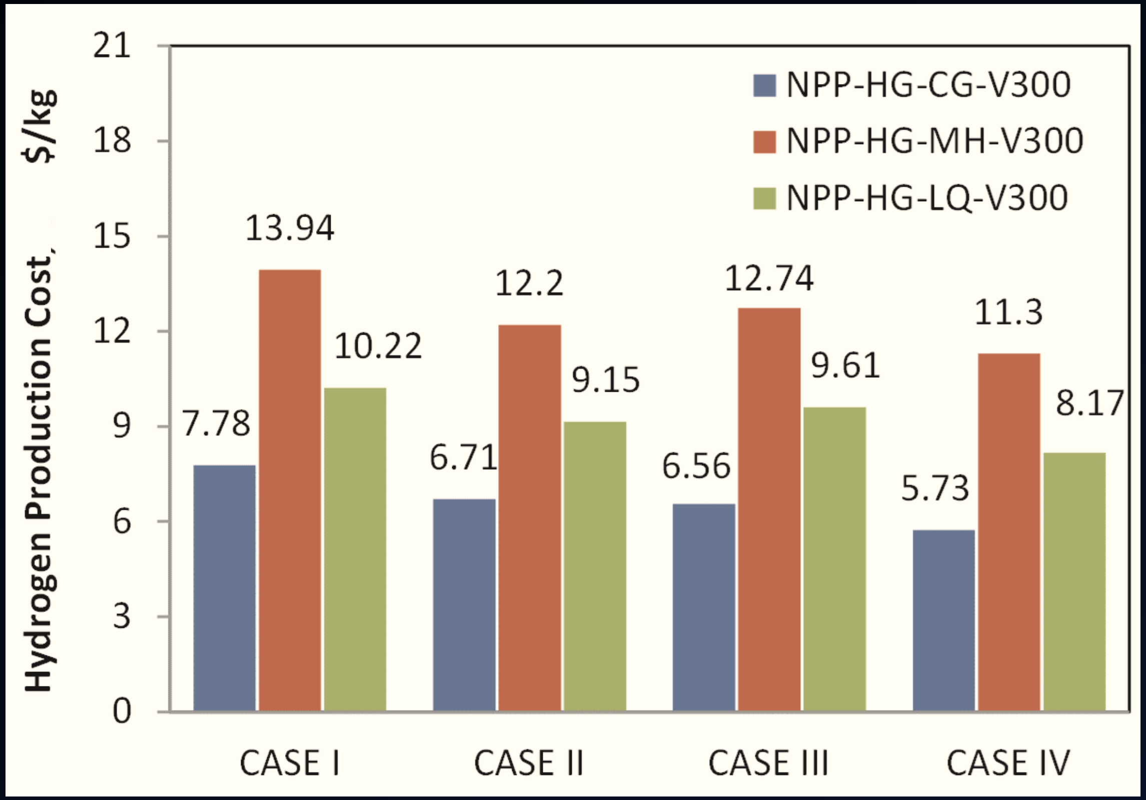
Cost of hydrogen for different storage options at the different cases



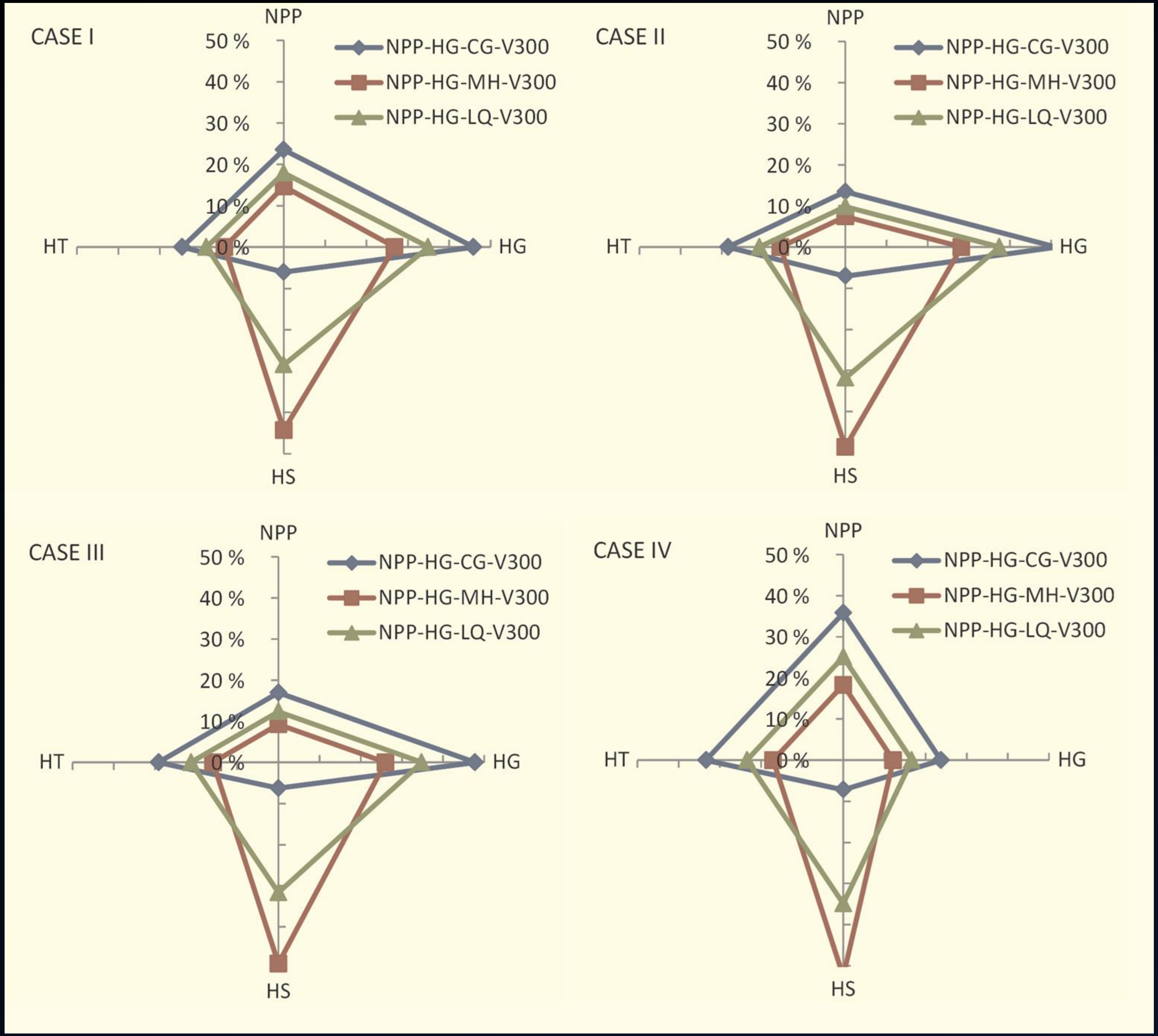
Contribution percentage of plant units on hydrogen generation cost for the different cases considering different storage plants shown for each case



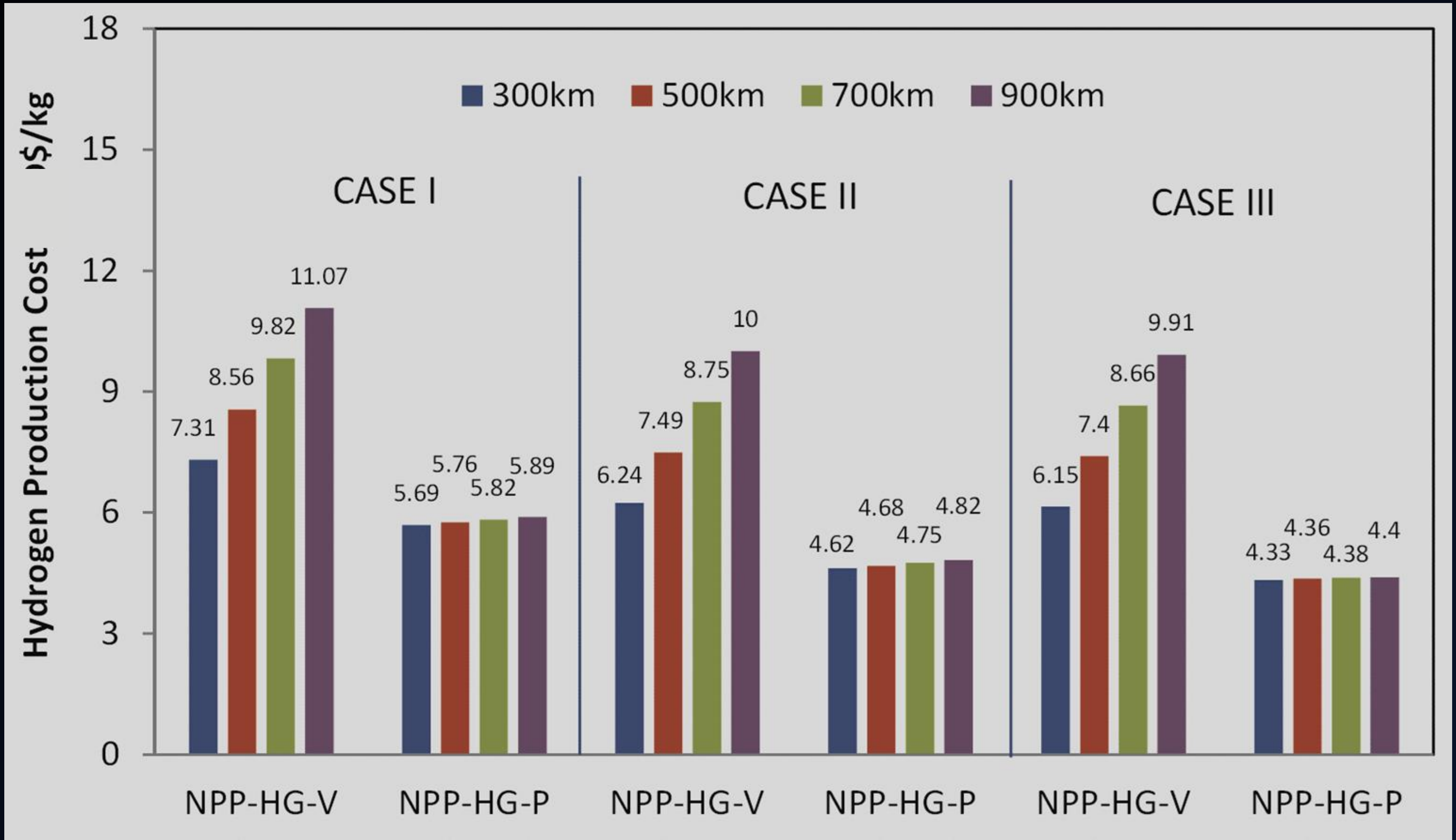
Contribution percentage of plant units on hydrogen generation cost for the different cases shown with respect to the storage method.



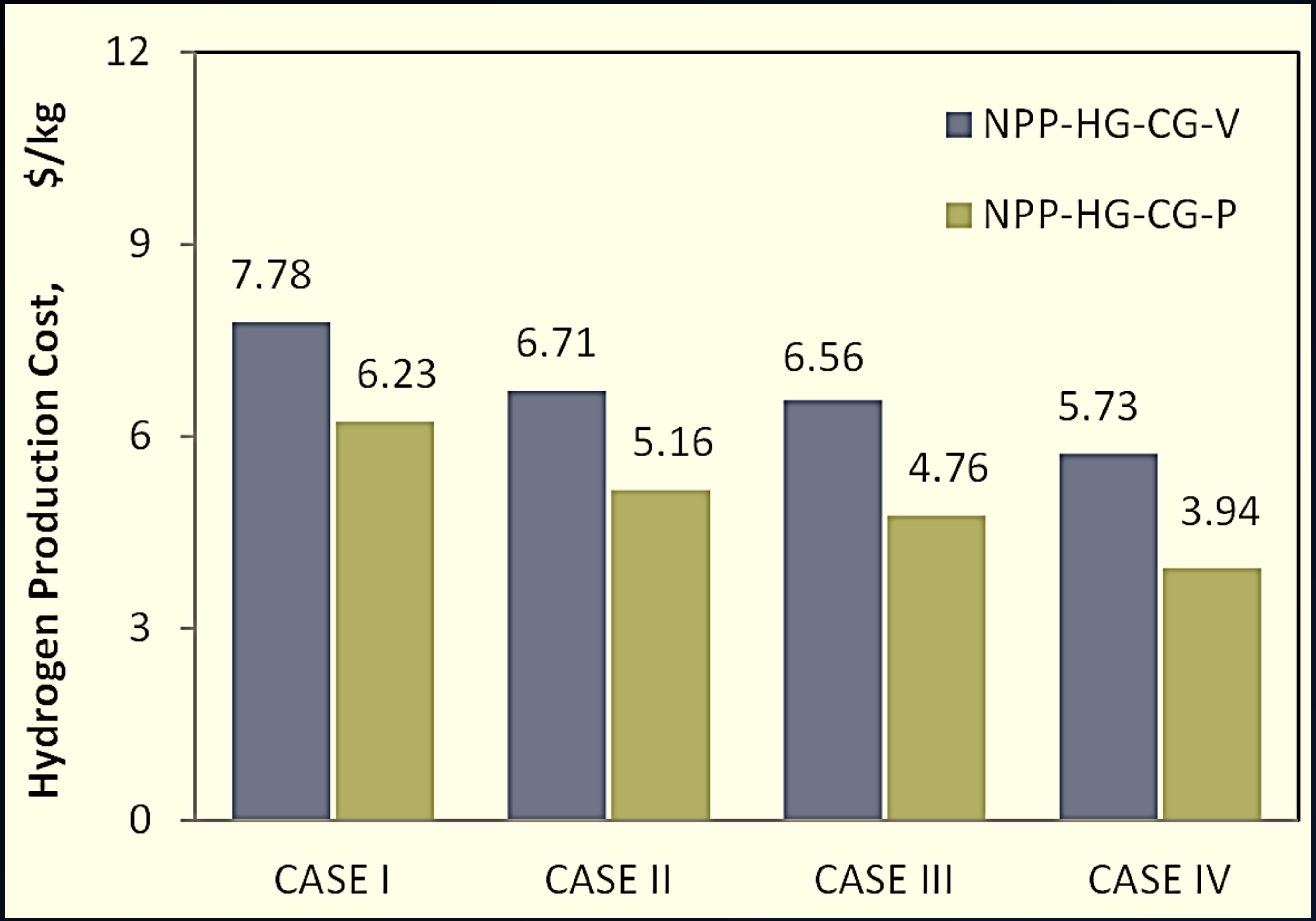
Cost of hydrogen production for different storage and transportation options



Contribution percentage of plant units on hydrogen generation cost for the different cases considering different storage plants shown for each case.



Cost of hydrogen for the considered cases at different transportation distances



Cost comparison for vehicle and pipeline transportation considering the integration of compressed gas storage plant to the generation system

I. GENERIC CASES

Case Studies

	Case I	Case II	Case III	Case IV	Case V
Nuclear Power Plant	2 x 359.5 MWe **APWR**	2 x 719.0 MWe **APWR**	2 x 1117.1 MWe **APWR**	2 x 509.3 MWth **HTGR**	2 x 630.7 MWth **HTGR**
Hydrogen Generation Plant	**CE** 4 kg/s	**CE** 8 kg/s	**CE** 12 kg/s	**HTSE** 4 kg/s	**SI** 4 kg/s

Technical and Financial Features:
Nuclear Power Plants

	Case I	Case II	Case III	Case IV	Case V
Nuclear Power Plant	APWR	APWR	APWR	HTGR	HTGR
Number of units	2	2	2	2	2
Capacity factor (%)	93	93	93	90	90
Availability factor (%)	100	100	100	100	100
Thermal rating (MW_{th}/unit)	1089	2178	3385	510	630.7
Heat for H_2 plant (MW_{th}/unit)	0	0	0	510	630.7
Electricity rating (MW_e/unit)	359.5	719.0	1117	0	0
Initial fuel load (kg/unit)	27000	54000	75000	14000	18000
Annual fuel feed (kg/unit)	9000	18000	25000	5000	6000
Capital cost (CC) (USD/unit)	3.16×10^9	4.66×10^9	5.96×10^9	4.02×10^8	6.05×10^8
CC for power gen. infrastructure	10%	10%	10%	0	0
Fuel cost (USD/kg)	1850	1365	1260	3660	5535
O&M cost (% of cc)	1.66	1.67	1.66	5.84	1.82
Decommissioning cost (% of cc)	2.8	2.8	2.8	10	10

Technical and Financial Features:
Hydrogen Generation Plants

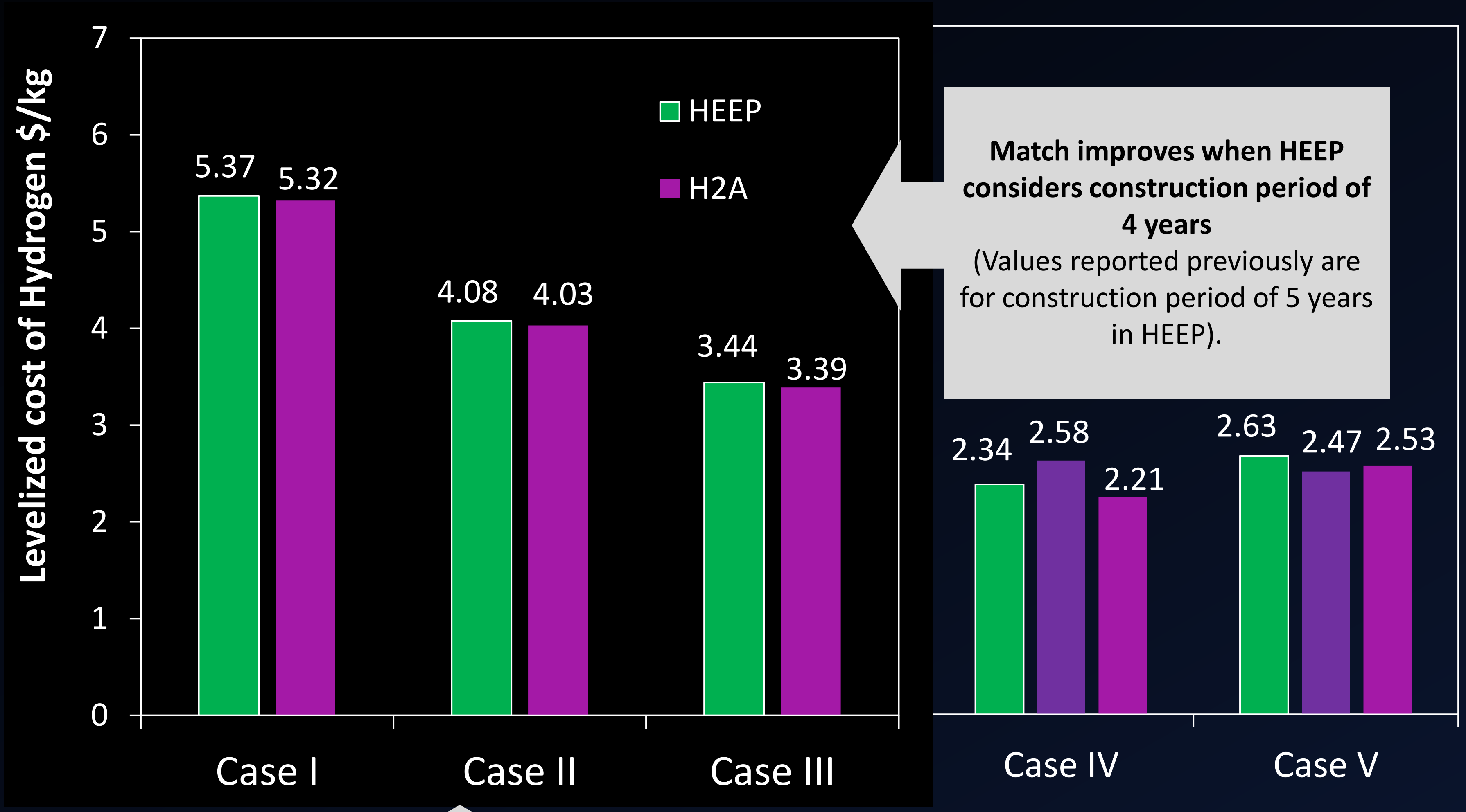
	Case I	Case II	Case III	Case IV	Case V
Hydrogen plant design	CE	CE	CE	HTSE	SI
Number of units	1	1	1	1	1
Capacity factor (%)	80	93	80	90	90
Availability factor (%)	100	100	100	100	100
H_2 generation rate (kg/year/unit)	1.26×10^8	2.53×10^8	3.92×10^8	1.26×10^8	1.26×10^8
Heat consumption (MW_{th}/unit)	0	0	0	1020	1261.4
Electricity consumption (MW_e/unit)	719	1438	2234	0	0
Non-process electricity consumption (MW_e/unit)	0	0	0	0	42.8
Capital cost (USD/unit)	4.28×10^8	8.45×10^8	1.31×10^9	4.59×10^8	6.66×10^8
Energy usage cost (USD)	0	0	0	0	2.7×10^8
O&M cost (% of cc)	4	4	4	17.23	6.68
Decommissioning cost (% of cc)	10	10	10	10	10

Technical and Financial Features:
Chronological and Financial Data

	Case I	Case II	Case III	Case IV	Case V
Construction period (yr)	5	5	5	3	3
Operation period (yr)	40	40	40	40	40
Decommissioning (yr)	10	10	10	10	10
Refurbishment (yr)	1	1	1	1	1
Spent fuel cooling (yr)	2	2	2	2	2
Waste cooling (yr)	10	10	10	10	10
Cooling before decommissioning (yr)	2	2	2	2	2

Discount rate	5%
Inflation rate	1%
Finance equity: debt	70%:30%
Borrowing interest	10%
Tax rate	10%
Depreciation period	20 year

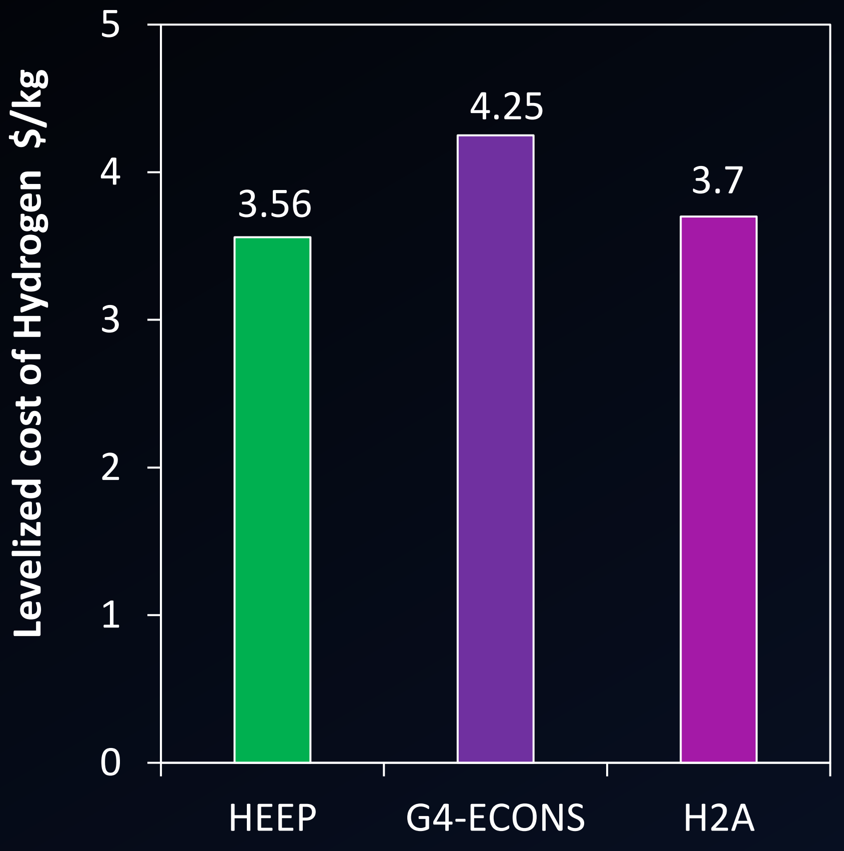
Results



Match improves when HEEP considers construction period of 4 years
(Values reported previously are for construction period of 5 years in HEEP).

Cases I, III, III: after modifying HEEP construction periods to match the 4 years criteria of H2A

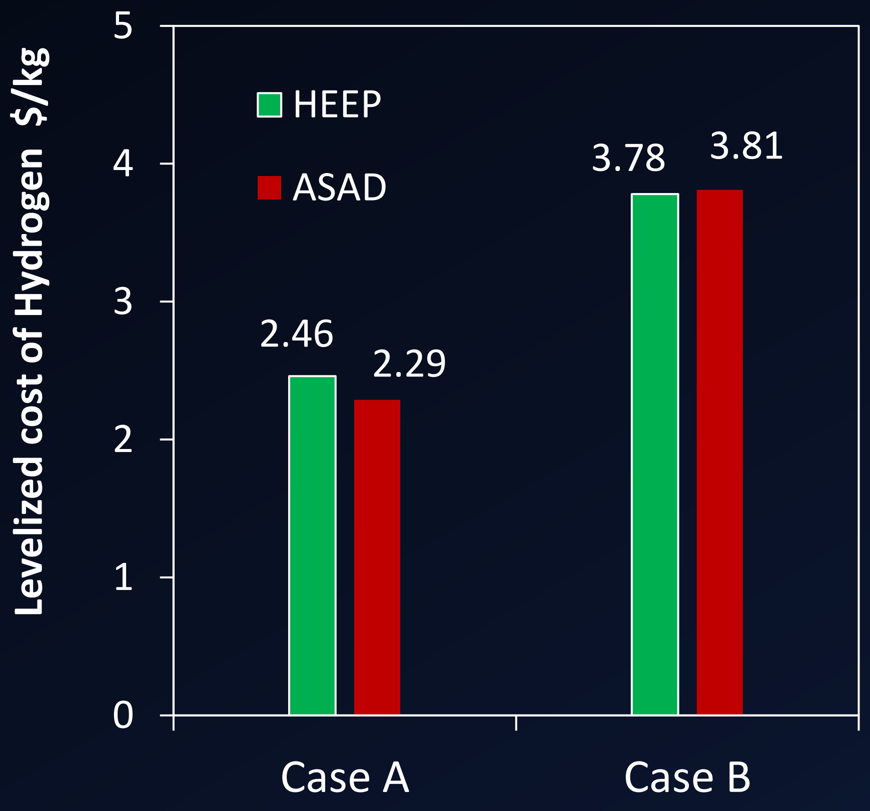
HEEP Benchmarking: Results of Other Studies



CANADA (AECL)

Source: R.Sadhankar, AECL, Canada

PAKISTAN (PAEC)



Comparison of HEEP vs H2A

H2A	HEEP
• Debt portion of the construction cost is assumed to be incurred in the first year of the construction period itself. • The repayment of this entire debt component (market borrowing) starts from the first year of construction period distributed over debt repayment period evaluated at the given interest rate.	• Debt part is incurred in each year of the construction period. • The debt part is calculated based on the fraction of cash flow during that year and debt to equity ratio. • The repayment of debt part borrowed in each year starts from the respective year in which they have been incurred, for a duration of debt repayment period.
• MS Excel spreadsheet based interface for modeling the hydrogen generation plant alone.	• An input interface and post-processing module developed in Microsoft Visual Basic • Mathematical computations are done using Fortran routines.
• The costs details of plants and facilities (source of heat/electricity, storage and transportation) associated with hydrogen production are to be provided as externalities. • Construction period – 4 years only	• The costs details of plants and facilities (source of heat/electricity, storage and transportation) associated with hydrogen production can be provided as input parameters • Construction period – no limits

Justification for the variation between HEEP & H2A:

- The construction period specified is 5 years.
- H2A cannot account for construction period more than 4 years.

II. COUNTY BASED CASES

Four detailed Case studies for HEEP Benchmark:

GEN-IV reactors for hydrogen production

Country Specific Case Studies

	JAPAN	CHINA	GERMANY	CANADA		
Nuclear power plant	GTHTR300	HTR-PM	HTR-SR	SCWR		
H2 production process	S-I	S-I	SR	S-I	HyS	CuCl
Thermal efficiency%	46.98	-	20.34	46.98	-	32.2
Hydrogen production ($kg/MW_{th}h$)	12.28	10.90	102.8	4.16	6.9	7.5
Hydrogen cost ($/kg)	2.46	3.78	3.61	4.1	4.74	5.34