

Data to be filled in the various pages of HEEP – A guide

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Types of input interfaces

In general, there are two forms of cells that have been created in the programme for data entry, viz. independent box and tabular. The forms in this document indicate the heading/label across the data item, its nature, format and general remarks. In addition, in some places input is sought in the form of tick boxes and radio buttons.

Table 1: Technical details of the Nuclear Power Plant

S. No.	Field to be completed	Mandatory /Optional	Format	Remarks
1	Reactor type	Mandatory	Text	This is an introductory text on the reactor type e.g. PWR, BWR, PHWR, HTR etc. The exact text is user's choice/
2	Reactor class	Mandatory	Text	This is an introductory text on the reactor class e.g. LWR-1000 etc. The exact text is user's choice/
3	Number of nuclear power generating units in a plant	Mandatory	Number	Total number of energy generating reactors in a given plant
4	Electricity	Optional	Click	User's choice regarding the generation of electricity along side hydrogen
5	Installed thermal power	Mandatory	Number	This is the rated thermal capacity of each unit of the nuclear power plant. It is assumed that multiple identical units may be installed at one site.
6	Capacity factor	Mandatory	Number	The lifetime capacity factor for the nuclear power plant.
7	Availability factor	Mandatory	Number	The lifetime availability factor for the nuclear power plant.
8	Thermal efficiency	Optional	Number	If option at 4 is chosen, then input the average efficiency expected.
9	Thermal power for H2 gen.	Mandatory	Number	The number entered here will be cross-checked against the rated heat production. If option at 4 is chosen, then the difference between the thermal power for H2 generation and rated thermal power is converted to electricity.

Once all the mandatory fields are completed, click on the update button (if there is a need to write the data into the database) or the store button (this will keep the values in the working memory).

NOTE: The store button does not write data in the database. Once the program finishes execution, all changes in the data will be lost. If you think there will be a need to refer to the data afterwards, it is advisable that the update button be clicked.

Then click on the proceed button. The next step is to provide details of the timeline for the construction, operation and decommissioning of the nuclear power plant.

Table 2: Timeline details for the Nuclear Power Plant

S. No.	Field to be completed	Mandatory/ Optional	Format	Remarks
Time Schedule details of the Nuclear Power Plant				
1	Start of construction	Mandatory	Number	The calendar year needs to be entered.
2	Start of Operation	Mandatory	Number	The calendar year needs to be entered (later than the one entered above).
3	End of Operation	Mandatory	Number	The calendar year needs to be entered (later than the one entered above).
4	Start of De-commissioning	Mandatory	Number	The calendar year needs to be entered (later than the one entered above).
5	Site Closure	Mandatory	Number	The calendar year needs to be entered (later than the one entered above).
Time periods for various events of Nuclear Power Plant				
1	Spent fuel cooling	Mandatory	Number	The time period for which the fuel is to be kept in the spent fuel bay.
2	Waste cooling	Mandatory	Number	The time period for which the waste is to be stored at the utilities site for cooling.
Time Schedule of Refurbishment of Nuclear Power Plant¹				
1	Number of refurbishments during operation	Optional	Click on buttons to the right of the box	<ul style="list-style-type: none"> • The default value is 0. • When “Increase by 1” is clicked the value is incremented to the next higher integer. • Simultaneously, corresponding text box is created for data entry. • Exact reverse actions happen when “Decrease by 1” is clicked. • Please note that if the

¹ Please note that the fields with a background of grey colour are computed by the program and are not editable.

				button “Decrease by 1” is clicked after entering data in the new box, the data may be lost.
2	Refurbishments year	Optional	Number	Enter the calendar year in which the planned refurbishment will take place. Logically, it should lie between the years entered under “Start of Operation” and “End of Operation”

Once all the mandatory fields are completed, click on the update button (if there is a need to write the data into the database) or the store button (this will keep the values in the working memory).

Then click on the proceed button. The next step is to provide details of the cost components for the nuclear power plant.

Table 3: General Cost Details for Nuclear Power Plant

S. No.	Field to be completed	Mandatory/ Optional	Format	Remarks
Currency Settings				
1	Select from one of the existing choices	Mandatory	Text	An existing currency can be chosen or else new currency can be added ² to the existing list.
Discount rate settings				
1	Real discount rate	Mandatory	Number	The real discount rate expressed as percentage should be provided here. These values will be used for the entire timeline under consideration
2	Inflation rate	Mandatory	Number	The inflation rate expressed as percentage should be provided here.

Once all the mandatory fields are completed, click on the “Update Database of Economic Parameters for NPP” button (if there is a need to write the data into the database) or the “Store Economic Parameters for NPP” button (this will keep the values in the working memory).

Then click on the proceed button. The next step is to provide details of the Capital Cost components for the nuclear power plant.

² After adding a new currency to the list, click on the button “Update the currency list database”

Table 4: Details of Capital Cost of Nuclear Power Plant

S. No.	Field to be completed	Mandatory/ Optional	Format	Remarks
Finance options for Base cost				
1	Equity to Debt ratio	Mandatory	Number	Enter the percentage of cost sourced from equity (or debt). The remaining portion will be calculated by the programme.
2	Return on equity	Mandatory	Number	Enter the percentage that is to be returned on the equity.
3	Int. rate	Mandatory	Number	Enter the percentage interest rate on the market borrowings.
4	Return period	Mandatory	Number	Enter the total number of years in which the borrowed capital is to be returned.
Details of Capital costs (Base costs)				
<i>Use Specific costs (radio button activated)</i>				
1	Specific capital cost (Cost of unit capacity)	Optional	Number	Enter the cost per unit capacity
<i>Use component level details</i>				
Major heads				
1	Click “Insert Major Head” button	Optional	Text	Enter the title of the major cost component. Click on the ‘Show/Edit details’ grey area to insert components of this item. The HEEP program will accumulate the costs of each minor head in this major head and reflect it.
By using similar procedure, more major heads can be added.				
Minor heads				
1	Click “Insert Minor Head” button	Optional	Text	Enter the title of the minor cost components.
2	Cost	Optional	Number	Enter the cost of the listed minor head
By using similar procedure, more minor heads can be added.				
Base cost cash flow				
1	Fill in the table to apportion the cash flow	Mandatory	Number	Enter the value as percentage of the total cost
2	Select the cost on which the Equity to Debt ratio will apply	Mandatory	Radio-button	Select equity to debt ratio as applied on either the overnight cost or the total cost

Once all the mandatory fields are completed, click on the update button (if there is a need to write the data into the database) or the store button (this will keep the values in the working memory).

Then click on the proceed button. The next step is to provide details of the front-end fuel costs for the nuclear power plant.

On this form to provide front-end fuel cost, click on “Add 1” to add one fuel type. Add as many types of fuels as required.

Table 5: Details of Fuel Cost for Nuclear Power Plant (Front end)

S. No.	Field to be completed	Mandatory/ Optional	Format	Remarks
Details of Nuclear Power Plant fuel				
1	Fuel Description	Mandatory ³	Text	Click on the white cell to enter a brief description of the fuel type.
	Period of			
2	From year	Mandatory	Number	Enter the calendar year from which this fuel type is required (Should be commensurate with the values committed in the time schedule earlier)
3	To year	Mandatory	Number	Enter the calendar year till which this fuel type is required (Should be commensurate with the values committed in the time schedule earlier)
4	Initial inventory	Mandatory	Number	Enter the weight of the initial inventory of this fuel type (in kilogram)
5	Annual feed	Mandatory	Number	Enter the weight of the annual feed of this fuel type (in kilogram)
	Fresh Core composition			
6	NU/LEU	Mandatory	Number	Enter as percentage the fraction ⁴ of the fuel type that is made up by NU/LEU
7	U233	Mandatory	Number	Enter as percentage the fraction of the fuel type that is made up by U ²³³
8	DepU	Mandatory	Number	Enter as percentage the fraction of the fuel type that is made up by depleted uranium

³ At least one fuel type needs to be entered

⁴ Not to be mixed up with enrichment. This is the mass ratio with respect to total fuel mass.

9	Pu	Mandatory	Number	Enter as percentage the fraction of the fuel type that is made up by plutonium
10	Th	Mandatory	Number	Enter as percentage the fraction of the fuel type that is made up by thorium
Spent fuel composition				
6	NU/LEU	Mandatory	Number	Enter as percentage the fraction ⁵ of the spent fuel of this type that is made up by NU/LEU
7	U ²³³	Mandatory	Number	Enter as percentage the fraction of the spent fuel of this type that is made up by U ²³³
8	DepU	Mandatory	Number	Enter as percentage the fraction of the spent fuel of this type that is made up by depleted uranium
9	Pu	Mandatory	Number	Enter as percentage the fraction of the spent fuel of this type that is made up by plutonium
10	Th	Mandatory	Number	Enter as percentage the fraction of the spent fuel of this type that is made up by thorium
Cost details of fuel cycle for fuel type (click on the respective Show/Edit button)				
<i>Click the check boxes to activate individual steps of the fuel cycle for each fuel type</i>				
1	Purchase of fuel material	Mandatory	Number	Enter the advance period of fuel material purchase and click the “Show/Edit details” to enter data on individual cost of each fuel material component.
2	Conversion to suitable chemical	Optional	Number	Enter the advance period of fuel material purchase, losses during the process and click the “Show/Edit details” to enter data on individual cost of conversion.
3	Uranium enrichment	Optional	Number	Enter the advance period of fuel material purchase, losses during

⁵ Not to be mixed up with enrichment. This is the mass ratio with respect to total spent fuel mass.

				the process and click the “Show/Edit details” to enter data on individual cost of enrichment.
4	Fuel fabrication	Optional	Number	Enter the advance period of fuel material purchase, losses during the process and click the “Show/Edit details” to enter data on individual cost of fuel fabrication.

Once all the mandatory fields are completed, click on the update button (if there is a need to write the data into the database) or the store button (this will keep the values in the working memory).

Then click on the proceed button. The next step is to provide details of the back-end fuel costs for the nuclear power plant.

Table 6: Details of Fuel Cost for Nuclear Power Plant (Back end)

S. No.	Field to be completed	Mandatory/ Optional	Format	Remarks
Options for backend of the fuel cycle				
<i>Direct Disposal (Radio button choice)</i>				
1	Spent fuel transportation charges	Mandatory	Number	Enter the cost of transporting the spent fuel per kilogram of spent fuel.
2	Waste disposal charges	Mandatory	Number	Enter the cost of disposing the waste per kilogram of waste.
<i>Reprocessing (Radio button choice)</i>				
1	Spent fuel transportation charges	Mandatory	Number	Enter the cost of transporting the spent fuel per kilogram of spent fuel.
2	Spent fuel transportation charges	Mandatory	Number	Enter the cost of transporting the spent fuel per kilogram of spent fuel.
3	Waste disposal charges	Mandatory	Number	Enter the cost of disposing the waste per kilogram of waste.
4	Cost of reprocessed uranium	Mandatory	Number	Enter the value of the recovered uranium
5	Cost of recovered fissile Pu	Mandatory	Number	Enter the value of the recovered plutonium
6	Cost of recovered Th	Mandatory	Number	Enter the value of the recovered thorium

Once all the mandatory fields are completed, click on the update button (if there is a need to write the data into the database) or the store button (this will keep the values in the working memory).

Then click on the proceed button. The next step is to provide details of the costs of the consumables for the nuclear power plant.

On this form to provide consumable cost, click on “Add 1” to add one fuel type. Add as many consumables as required.

Table 7: Details of consumables for Nuclear Power Plant

S. No.	Field to be completed	Mandatory/ Optional	Format	Remarks
1	Consumable Description	Mandatory	Text	Click on the white cell to enter a brief description of the fuel type.
2	Units	Mandatory	Number	Enter the units for which the consumable is charged for e.g. kg, lt. etc.
4	Initial inventory	Mandatory	Number	Enter the weight of the initial inventory of each consumable (in kilogram)
5	Annual feed	Mandatory	Number	Enter the weight of the annual feed of each consumable (in kilogram)
6	Cost of consumable	Mandatory	Number	Enter the cost of the consumable per unit
7	Advance period	Mandatory	Number	Enter the number of years, before use, that the purchase needs to be made.

Once all the mandatory fields are completed, click on the update button (if there is a need to write the data into the database) or the store button (this will keep the values in the working memory).

Then click on the proceed button. The next step is to provide details of the O&M costs for the nuclear power plant.

Table 8: Details of O&M Cost of Nuclear Power Plant

S. No.	Field to be completed	Mandatory/ Optional	Format	Remarks
Options to provide O&M cost details				
<i>Use block estimates for annual O&M cost (radio button activated)</i>				
1	Routine O&M (% of total capital cost)	Optional	Number	Enter the routine O&M cost as a percentage of the total capital cost

2	Refurbishment (% of total capital cost)	Optional	Number	Enter the refurbishment cost as a percentage of the total capital cost
<i>Use component level details for annual O&M costs (radio button activated)</i>				
1	Click “View/Edit year wise O&M cost” button	Optional	-	Enter the cost details for each year of operation

Once all the mandatory fields are completed, click on the update button (if there is a need to write the data into the database) or the store button (this will keep the values in the working memory).

Then click on the proceed button. The next step is to provide details of the decommissioning costs for the nuclear power plant.

Table 9: Details of Decommissioning Cost of Nuclear Power Plant

S. No.	Field to be completed	Mandatory/ Optional	Format	Remarks
Options to provide Decommissioning cost details				
<i>Use block estimates for every year (radio button activated)</i>				
1	Routine decommissioning (% of capital cost)	Optional	Number	Enter the routine decommissioning cost as a percentage of the capital cost
<i>Use component level details for each year (radio button activated)</i>				
1	Click “View/Edit year wise decommissioning cost” button	Optional	-	Enter the cost details for each year of decommissioning task

Once all the mandatory fields are completed, click on the update button (if there is a need to write the data into the database) or the store button (this will keep the values in the working memory).

Then click on the proceed button. The next step is to provide details of the decommissioning costs for the nuclear power plant.

Table 10: Technical details of the Hydrogen Generation Plant

S. No.	Field to be completed	Mandatory/ Optional	Format	Remarks
Location of H2 generation plant				
1	Choice of the plant location	Mandatory	Radio-button	Choose between either co-located or away from NPP
Technical details of hydrogen generation plant				
1	Number of hydrogen generating units	Mandatory	Number	Enter the total number of units of hydrogen generation plant. The default value is 1.
2	Rated annual hydrogen generation per unit	Mandatory	Number	This number indicates the plant capacity. Enter the number in terms of kilograms per unit.
3	Efficiency of the H2	Mandatory	Number	The efficiency of the

	generation process			process expressed as percentage
4	Unit capacity factor	Mandatory	Number	The lifetime capacity factor for the hydrogen generation plant.
5	Unit availability factor	Mandatory	Number	The lifetime availability factor for the hydrogen generation plant.
6	Maximum process thermal energy requirement per unit	Mandatory	Number	This number indicates the total process thermal energy required by each unit of the hydrogen generation plant.
7	Maximum process electricity for H ₂ generation per unit	Mandatory	Number	This number indicates the total process electrical energy required by each unit of the hydrogen generation plant.
8	Maximum non-process electricity for H ₂ generation per unit	Mandatory	Number	This number indicates the total non-process electrical energy required by each unit of the hydrogen generation plant.
Hydrogen storage details⁶				
1	Hydrogen storage method	Mandatory	Radio-button	Choose between the three options available viz. Compressed gas, Liquefaction and metal hydride
<i>Compressed gas storage (Choose one of “Programme to calculate storage parameters” or “User to specify Storage parameters”)</i>				
1	H ₂ Storage period	Mandatory	Number	Enter the time in hours for which the generated hydrogen will be stored at site.
2	H ₂ compression pressure	Mandatory	Number	Enter the pressure in MPa (Mega Pascal) at which the generated hydrogen will be stored at site.
3	H ₂ Storage capacity	Optional ⁷	Number	Enter the storage capacity in kilogram
4	H ₂ compressor power	Optional ⁷	Number	Enter the compressor electric power

⁶ There needs to be an interim storage for the hydrogen generated by the plant. This storage will require, depending upon the method of storage, various equipment and services. The technical aspects of these are included along with the technical details of the generating plant.

⁷ When the option “Programme to calculate storage parameters” is chosen, these cells will be greyed out and the programme will calculate the values.

				requirement in KW
5	Cooling water for compressor	Optional ⁷	Number	Enter the cooling water requirement in litres per hour
<i>Liquefaction (Choose one of “Programme to calculate storage parameters” or “User to specify Storage parameters”)</i>				
1	H2 Storage period	Mandatory	Number	Enter the time in hours for which the generated hydrogen will be stored at site.
2	H2 Liquefaction energy	Mandatory	Number	Enter the energy needed in kWh per kg of hydrogen generated.
3	Cooling water flow rate	Mandatory	Number	Enter the water flow needed in litres per kg of hydrogen generated.
4	Boil off rate (%/day)	Mandatory	Number	Enter the percentage of the hydrogen that will boil-off per day
5	H2 Storage capacity	Optional ⁸	Number	Enter the storage capacity in kilogram
6	H2 liquefaction power	Optional ⁸	Number	Enter the compressor electric power requirement in KW
7	Cooling water for liquefaction	Optional ⁸	Number	Enter the cooling water requirement in litres per hour
<i>Metal hydride (Choose one of “Programme to calculate storage parameters” or “User to specify Storage parameters”)</i>				
1	H2 Storage period	Mandatory	Number	Enter the time in hours for which the generated hydrogen will be stored at site.
2	Hydride cooling	Mandatory	Number	Enter the water flow needed in litres per kg of hydrogen generated
3	Hydride heating	Mandatory	Number	Enter the energy needed in kJ per kg of hydrogen generated.
4	H2 Storage capacity	Optional ⁸	Number	Enter the storage capacity in kilogram
5	H2 liquefaction power	Optional ⁸	Number	Enter the compressor electric power requirement in KW
6	Cooling water for liquefaction	Optional ⁸	Number	Enter the cooling water requirement in litres per hour

⁸ When the option “Programme to calculate storage parameters” is chosen, these cells will be greyed out and the programme will calculate the values.

Once all the mandatory fields are completed, click on the update button (if there is a need to write the data into the database) or the store button (this will keep the values in the working memory).

Then click on the proceed button. The next steps are to provide details of the timeline for the hydrogen generation plant and the various cost details. To complete these steps, refer to Table – 2, Table – 3, Table – 4, Table – 7, Table – 8 and Table – 9.

Proceed next to the technical details for the hydrogen transportation and distribution.

Table 11: Technical details of the Hydrogen Transportation and distribution

S. No.	Field to be completed	Mandatory/ Optional	Format	Remarks
Type of H2 transportation				
1	Choice of the transportation method	Mandatory	Radio-button	Choose between either vehicle or pipeline transport
<i>Vehicular transport</i>				
1	Transport distance	Mandatory	Number	Enter the distance over which the hydrogen will be transported in kilometre units
2	Capacity of vehicle	Mandatory	Number	Enter the storage capacity of the vehicle in kilogram of hydrogen
3	Average speed of vehicle	Mandatory	Number	Enter the average vehicle speed km/hr
4	Mileage of the vehicle	Mandatory	Number	Enter the average vehicle mileage km/lt
5	Loading time per vehicle trip	Mandatory	Number	Enter the loading time per vehicle trip in hours.
<i>Pipeline transport(Choose one of or)</i>				
<i>“Programme to calculate pipeline transport parameters”</i>				
1	Transport distance	Mandatory	Number	Enter the distance over which the hydrogen will be transported in kilometre units
2	Equivalent diameter of pipe	Mandatory	Number	Enter the equivalent diameter of the pipe in meters.
3	Friction factor	Mandatory	Number	Enter the friction factor for the prevalent flow conditions.
4	Temperature of hydrogen	Mandatory	Number	Enter the temperature of hydrogen in Kelvin
5	Delivery pressure	Optional ⁹	Number	Enter the delivery pressure in Mega Pascal (MPa)
<i>“User to specify pipeline transport parameters”</i>				
1	Transport distance	Mandatory	Number	Enter the distance over which the hydrogen will be transported in kilometre units
2	Compressor power	Mandatory	Number	Enter the compressor electric power requirement in kilowatt

⁹ When the option “Programme to calculate storage parameters” is chosen, these cells will be greyed out and the programme will calculate the values.

Once all the mandatory fields are completed, click on the update button (if there is a need to write the data into the database) or the store button (this will keep the values in the working memory).

Then click on the proceed button. The next steps are to provide details of the timeline for the hydrogen generation plant and the various cost details. To complete these steps, refer to Table – 2, Table – 3, Table – 4, Table – 7, Table – 8 and Table – 9.