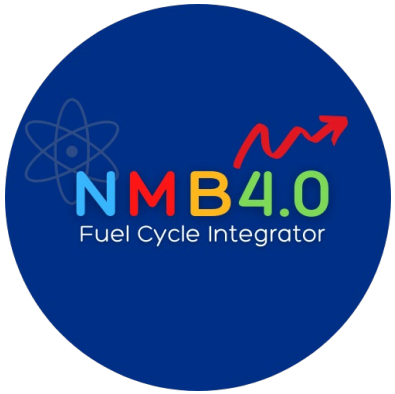
Elementary Practice of NMB 4.0



User application

1. Search “NMB code” on Web, or go to https://nmb-code.jp/english
2. Click “Application form” and fill it.
3. Wait for a reply from TEAM NMB. (A online interview will be required.)
4. Follow instruction from TEAM NMB to download NMB 4.0.

Tasks

Number	Content
Task 0	Minimum input
Task 1	Operation of NPP
Task 2	Direct disposal of spent fuel
Task 3	Reprocessing of spent fuel
Task 4	Pu utilization by MOX in LWR
Task 5	Prolongation of cooling term (Practice for “Override function”)
Task 6	Operation of fast breeding reactor

Task 0　Minimum input

- NMB finds a cell filled by "Search string" in your input sheet, then read/write to right or down from the cell. Search string is always enclosed in parentheses [].
- Any position of the cell is allowed as long as it does not interfere others.
- The mandatory search strings are follows. They are colored by red in "XLS manual" (manual_ver????.xlsx).

You may copy search strings from XLS manual.

[Input for NMB4.0]
- User declares that this is an input sheet for NMB4.0.

Take care for SPACE in search string

[BasicData], [WasteData], [PlantData], [CycleData], [PredefineData]
- User specifies XLS book and sheet name where NMB database is written.
- NMB reads two cells below each search string in order of "book name" and "sheet name".

[Messages]
- NMB displays analysis status in the lower right cell.

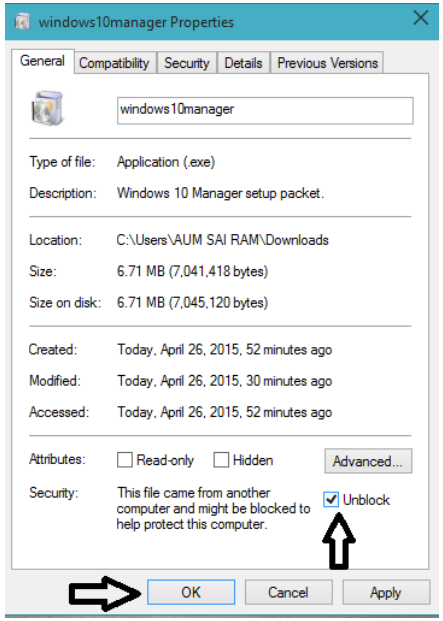
[A.D.]

Start from 2000 and end at 2080.
- User specifies year to be analyzed.
- NMB reads one column from two cells down to a blank cell.

Let's run the NMB!

How to run NMB

1. Open NMB4.0.?.xlsm and your input book.
   - Enable macro function in the EXCEL trust center.
   - In property of xlsm file, general tab, check “unblock”.
   - NMB4.0.?.xlsm and MatrixCal64.dll must be at the same folder.
2. Display your input sheet.
3. Push Alt+F8, and execute “A_singleRun” macro!



Typical error after running:

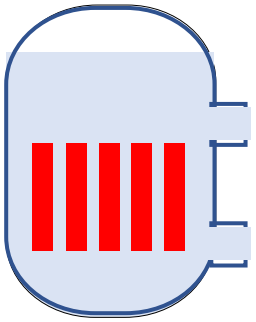
- If NMB stops at “Call CalInitialize”, your excel in 32-bit. Please use NMB4.0.?.xlsm and MatrixCal32.dll in “32bit” folder in distributed package.
- If NMB stops at “Set shBasic = ….”, your specification in [BasicData] is wrong.
- If NMB stops at “ChDrive ThisWorkbook.Path” or “ChDir ThisWorkbook.Path”, you are using cloud environment. Please download all files to your local computer.

In NMB 4.0.7 excel manual, there is an errata of search keyword, intentionally ;-)

Task 1　Introduce PWR

Condition
- A PWR (1GWe and 45GWd/tHM) is operated during 2000 to 2020.

Write PWR-UO2-MB at [NewPlant1]
Write 1 at [PlantPower1]
Write 20 at [PlantLife1]



Output *
- Weight of consumed natural U (t/y) → *write [prtMining[t/y]]*
- U235 Enrichment → *write [prtU235EnrInNewFuel]*
- Annual electricity generation → *write [prtPowerGeneration[GWeY]]*
- Annual demand of fresh fuel → *write [prtNewFuel[t/y]]*
- Annual production of SF → *write [prtSpentfuel[t/y]]*
- SF storage → *write [prtInterimStorage[t]]*

* The maximum number of output column is specified in the right cell of search string.

Write 2 as the maximum column

Run the NMB and look into the result

Output of task 1

[prtMining[t/y]]

- Consumed uranium resource is the highest at initial loading (A.D. 2000).
- It becomes 1/3 after 2001, because this PWR is operated by “3-batch fuel exchange”.

[prtU235EnrInNewFuel]

- Constant at 4.1wt%.

[prtPowerGeneration[GWeY]]

- Electricity generation (GWe x year) is not 1 GWeY but 0.85 GWeY because load factor is defined as 85% in the “PlantDataJ40” database sheet.

[prtNewFuel[t/y]]

- Production of SF is 81 t/y at the first year, then it reduces to 1/3 because the PWR is in three-batch operation.

[prtSpentfuel[t/y]]

- Production of SF is 27 t/y at most of period. When the PWR is shutdown, it becomes 3 times larger.

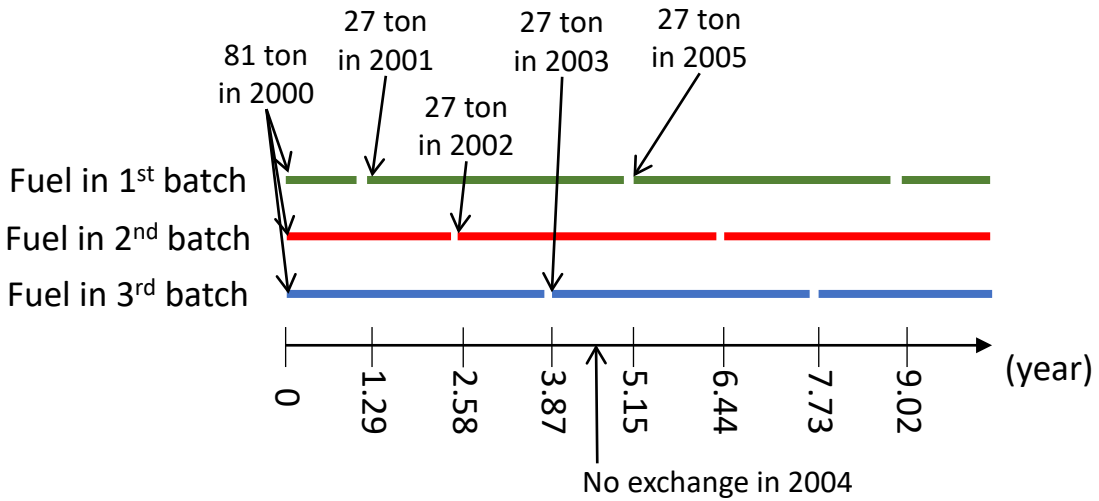
[prtInterimStorage[t]]

- SF storage increases up to 485 ton at the end. This does not decrease because reprocessing or direct disposal is not introduced.

3-batch operation

Result of [prtNewFuel[t/y]]

	sUO2_PWR
2000	80.80808
2001	26.93603
2002	26.93603
2003	26.93603
2004	0
2005	26.93603
2006	26.93603
2007	26.93603
2008	0
2009	26.93603
2010	26.93603



Why zero in 2004 and 2008?

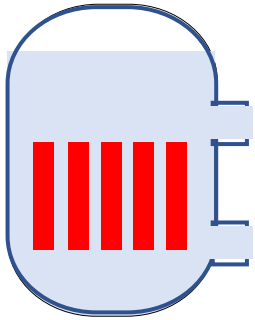
- Operation period of "PWR-MB=UO2" is supposed to be 1.095 year in NMB database without considering maintenance.
- Considering load factor of 85%, the actual interval of fuel exchange is 1.29 year.
- In 2000, fuels in whole batches are loaded.
- In 2001 (actually at 2001.29), fuel of 27 ton is exchanged.
- In 2004 (and 2008), no fuel is exchanged.

Task 2　Direct disposal of spent fuel

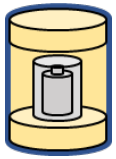
Copy the input sheet of "task ", and rename to "task2".

Condition:
- SF from PWR is directly disposed of without reprocessing.

Write DD-PWR below [ReprocessingCapacity[t/y]]
Write maximum annual throughput of 100tHM/year till 2050.



PWR



Disposal

Output:
In addition to Task 1,
- Waste production　→*[NumDisposedCanister]*
- Footprint of disposal site　→*[Waste_footprint[m2]]*

Run the NMB and look into the result

Output of task 2

[prtInterimStorage[t]]

- SF Storage is kept at small amount comparing to Task 1.

Note: SFs are stored for 50 years before direct disposal in practice. However, in NMB this storage is treated as a "waste storage" (not the "SF storage") Therefore, SFs are immediately removed from SF storage.

[NumDisposedCanister]

- The final amount of SF canister is 860.

[Waste_footprint[m2]]

- Necessary area of disposal site is 106,000 m^2.

EXCEL tips: In order to easily look excel result, activate "freeze panes".

Task 3　Reprocessing of spent fuel

Do not forget to copy the input sheet

Condition:

- Run the reprocessing plant until all the spent fuel is reprocessed, with a processing capacity same to annual production of spent fuel.

Change DD-PWR in task 2 to UO2(Pu) with annual throughput of 27tHM/year.

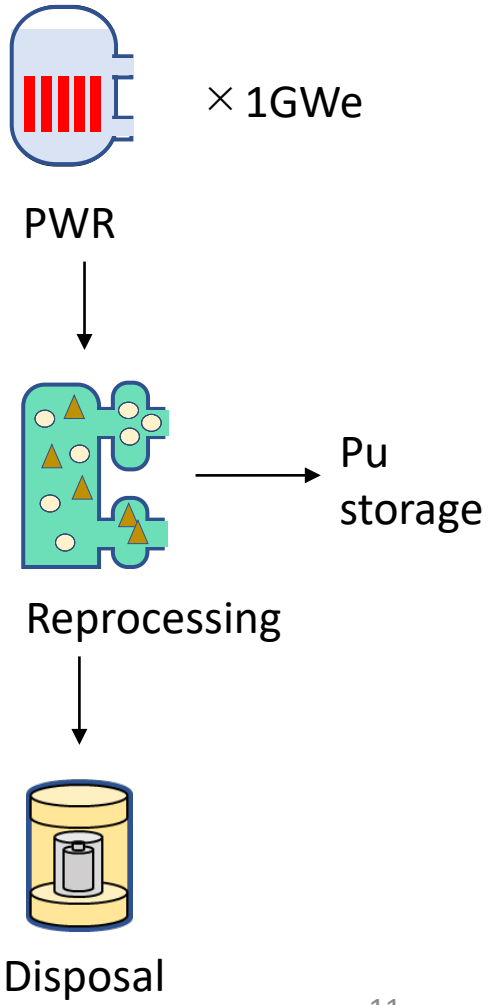
Output:

In addition to Task 2,

- Annual reprocessing amount　→*[prtReprocessing[t/y]]*
- Pu storage　→*[prtPu[t]] with 8 columns*

Run NMB and compare results toTask2.

- *[prtInterimStorage[t]]*
- *[Waste_footprint[m2]]*
- *[NumDisposedCanister]*



Output of task 3

[prtReprocessing[t/y]]

- Reprocessing is started from 2004 till 2025.

[prtInterimStorage[t]]

- SF Storage is kept at small amount but larger than Task 1 because of 3 years of storage is needed before reprocessing.

[NumDisposedCanister]

- 500 glass wastes is produced at the end.

[Waste_footprint[m2]]

- Necessary area of disposal site is 22,000 m^2, which is 20% of direct disposal (task 2).

[prtPu[t]]

- All Pu in spent fuel is extracted and 4.5 ton of Pu remains.

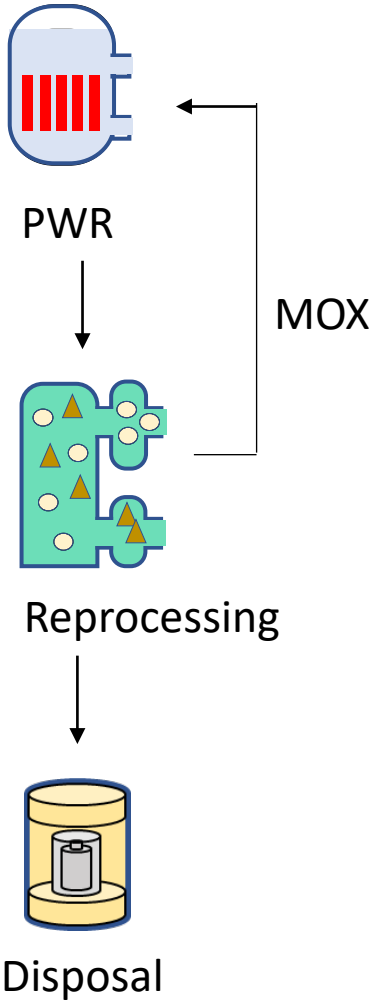
Task 4　Utilize Pu in PWR

Condition:
- Recovered plutonium is used as MOX fuel in PWR

Write [@PuThermalRatio] and fill a column by 15%.

Output:
In addition to Task 3,
- Pu content in MOX fuel　→　*[prtPuRatioInNewFuel]*

Run NMB and compare results toTask3.
- Electricity generation by MOX fuel　*[prtPowerGeneration[GWeY]]*
- SF storage　*[prtInterimStorage[t]]*
- Waste production　*[NumDisposedCanister]*
- Repository footprint　*[Waste_footprint[m2]]*
- Plutonium storage　*[prtPu[t]]*



Note about "@": For some parts of the Database, yearly input in the scenario sheet is allowed. To do so, fill in the time-dependent tags starting with @ in the Database sheet (e.g. @PuThermalRatio; note that strings starting with @ should be entered as '@ in EXCEL) Correspondingly, in the scenario sheet, the input for each year is read vertically in a single column (calculated years) from a time-dependent tag with [] key brackets added to the string. (e.g., [@PuThermalRatio])

Output of task 4

[prtPowerGeneration[GWeY]]

- Around 15% is generated by MOX.

[prtPuRatioInNewFuel]

- Pu content ratio is 5 to 8 %, which increases because fissile Pu content is rich at the initial loading fuel with low burn-up.

[prtInterimStorage[t]]

- Storage for UO2 spent fuel becomes zero, while that for MOX spent fuel is 41 ton at the end. MOX SF is not reprocessed.

[NumDisposedCanister] , [Waste_footprint[m2]]

- Number of waste and footprint slightly decreases because production of UO2 spent fuel declines.

[prtPu[t]]

- Pu remained is 1.4 ton that is much smaller than task 3.

Task 5　Change cooling period before reprocessing (Override function)

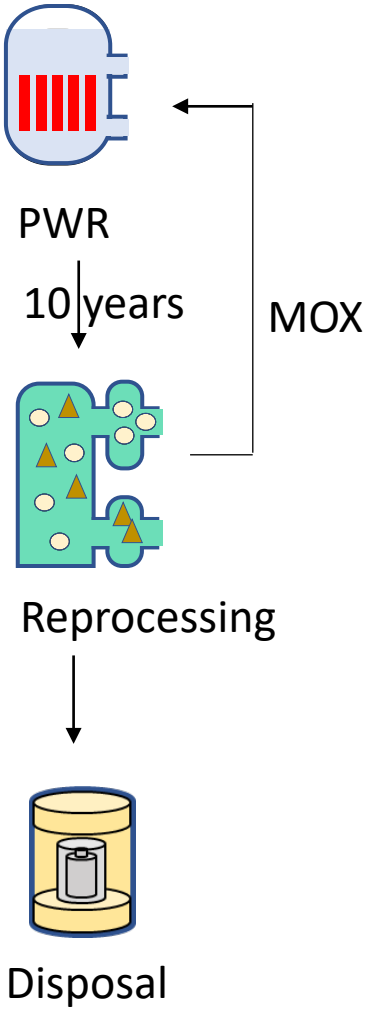
Condition:
- Cooling period of spent fuel before reprocessing is changed from 3 years to 10 years.

To override one parameter in NMB original database,
1. *Copy [RepIndex] to [MixSpentFuel] in "PredefineData" sheet.*
2. *Copy UO2(Pu) row to row below.*
3. *Change 3 to 10 years.*

Direct change of the original database is NOT recommended!

Output:　Same to Task4

Run NMB and compare results toTask4.
- Electricity generation by MOX fuel　*[prtPowerGeneration[GWeY]]*



Output of task 5

[prtPowerGeneration[GWeY]]

- MOX loading starts from 2012 later than task 4.

Task 6　Introduction of FBR

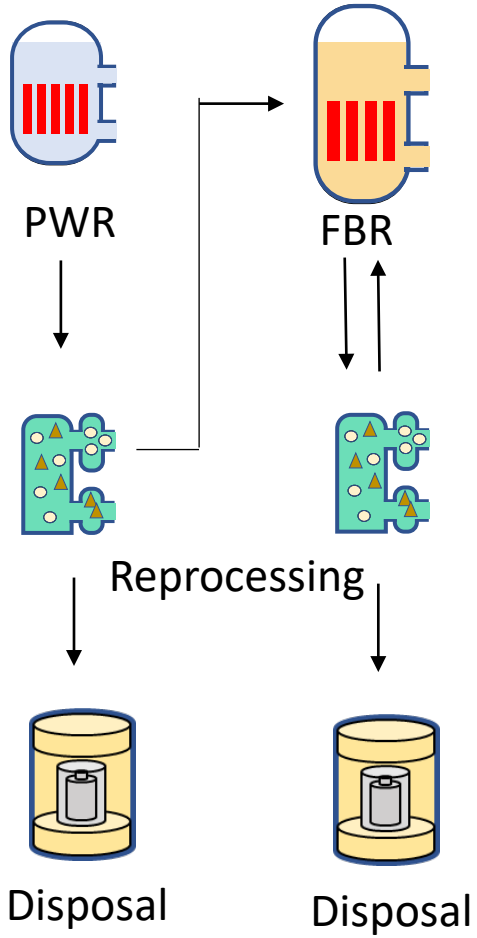
Condition
- FBR with high breeding ratio is operated from 2033 to 2072 with XXX GWe. Estimate XXX.
- Reprocessing of FBR MOX spent fuel is implemented from 2033 with 27 t/year.

1. *Write FBR_HB at [NewPlant1], 0.5 at [PlantPower1] and 40 at [PlantLife1].*
2. *Add MOX(Pu) in [ReprocessingCapacity[t/y]] filled with 27.*

Output:
In addition to task 5,
- Analysis information → [Information]

1. *Run NMB. FBR_HB construction will be failed as written in [information]*
2. *Change capacity to 0.25 GWe and run again.*
3. *Check the result*

- Uranium mining　*[prtMining[t/y]]*
- Waste production　*[NumDisposedCanister]*
- Repsitory footprint　*[Waste_footprint[m2]]*
- Pu storage　*[prtPu[t]]*



Note: NMB will skip construction of NPP if raw material is not enough, or construct [[BackupPlant1] if specified by user.

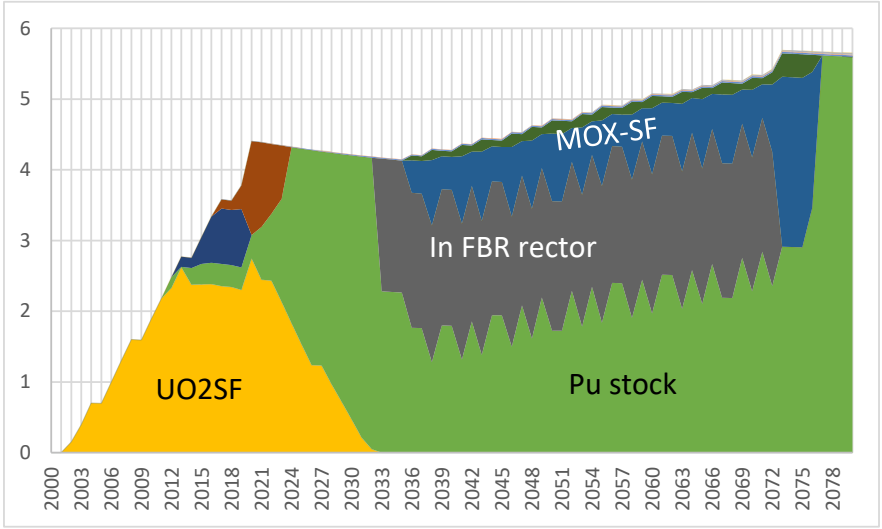
Output of task 6

[prtMining[t/y]]

- No uranium is mined after 2033.

[prtPu[t]]

- Pu stock was around 4.1 t after PWR operation (2033).
- Pu stock decreases to 1.3 t (2038) by introducing FBR.
- Pu stock gradually increases because breeding ratio of FBR_HB is 1.1. (see [BreadingRatio] in PlantdataJ40 sheet)



EXCEL tips: stacked surface graph is convenient to look into Pu inventory in NFC.