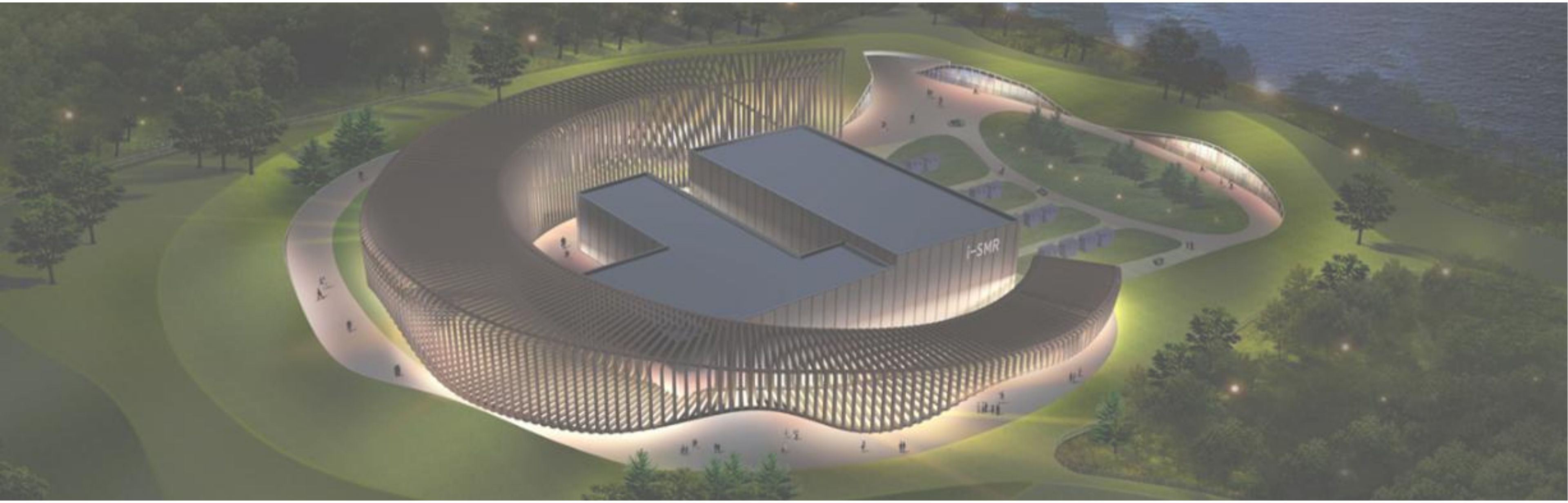
Strategic Modularization for Efficient i-SMR Construction and Deployment



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Wonki Chai & Wooyong Jung

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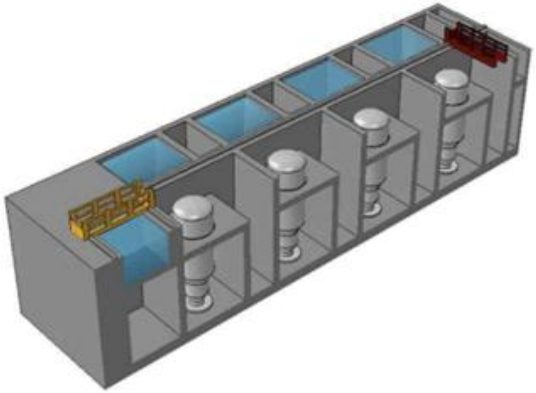

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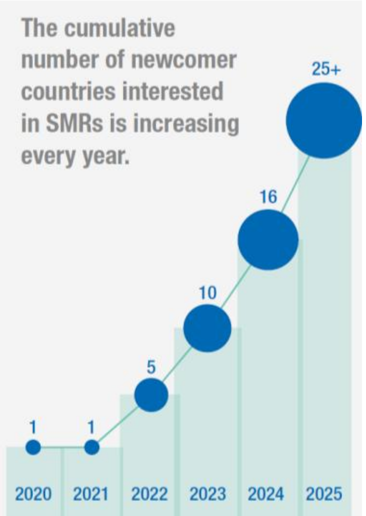
SMR Market Status

- Small Modular Reactors (SMRs) offer a flexible, scalable, and cost-effective clean energy solution (Gaster, 2025).
- **70 SMR** designs in active development worldwide (IAEA, 2024).



[Advances in SMR Developments (IAEA, 2024)]

Korean Initiative

- SMR technology selected as New Growth 4.0 Strategy (MOEF, 2025) and promoted.
- **The Core Economic Competitiveness of SMR is Modularisation**, which promotes off-site fabrication and enhances on-site installation efficiency (Oh et al., 2024).

The Research Gap

☞ Research on **Construction Scheduling and Modularization Effects for the i-SMR remains limited.**

Lloyd's Research (2020)

- **Top-down Power Scaling :** Derived SMR estimates (cost, weight, schedule) by extrapolating from Large Reactor (LR) datasets.
- **Reference Data :** Based on Sizewell B NPP as-built data, encompassing ~3,600 activities categorized into Task Time and Wait Time
- **Degree of Modularization (DoM) :** Defined as the fraction of total work transferred from on-site to off-site factory facilities.

- **Low Modularization :** Scope limited to MEP (Mechanical, Electrical, Piping) systems. Yields marginal reductions of **7-12%** as structural work stays on critical
- **Full Modularization :** Encompasses Structural + MEP systems. Achieves schedule reductions of **> 30%** compared to Large Reactors.

✅ **Strategic Benefit :** Removes structural work from the on-site critical path, **enabling parallel factory production.**

⚡ **Key Finding :** Schedule compression is highly dependent on the scope of work moved off-site; **full structural modularization is required for radical gains.**

Objectives

☞ **By applying Lloyd's methodology**

1. Develop i-SMR Schedule

- Build i-SMR construction schedule, using the APR1400 as a reference large plant.

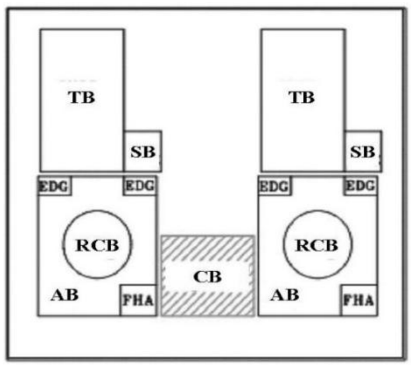
2. Investigate Modularity Impact

- Explore the impact of different modularization strategies.

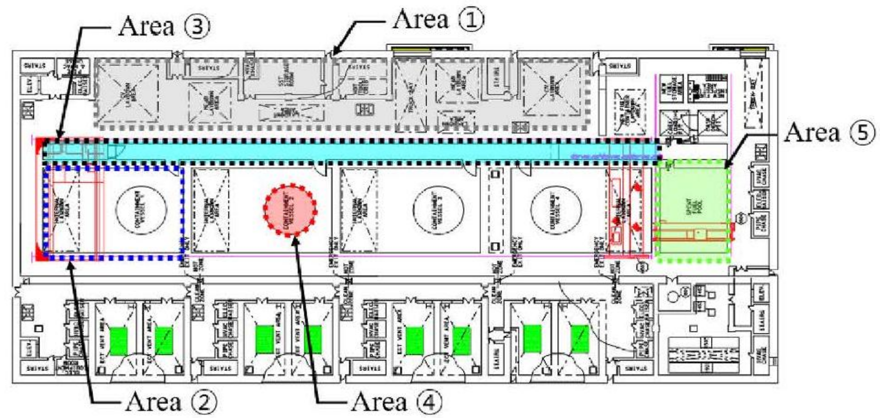
3. Identify Key Factors

- Verify which modularization factors exert the most significant influence for schedule reduction.

APR1400 vs SMR



[General Arrangement of APR1400 (Lee et al., 2009)]



[General arrangement i-SMR (Lim et al., 2025)]

Factors	**APR1400**	**i-SMR**
Developer	KHNP	KHNP & KAERI
Type	PWR	PWR
Module Layout	One unit	Four units
Containment vessel	Reactor Containment Building	Reactor Vessel
Output capability	1,400 MWe	680 Mwe (170 Mwe*4 modules)
Core damage frequency	~ 1.0e-6 /R·Y	~ 1.0e-9 /R·Y
Safety system	Active	Completely Passive
construction unit price	$3,000 /kWe	Under $3,500 /kWe
Construction time	**58 months (Oh & Park, 2004)**	**48 months (four modules) for FOAK (KISTEP, 2022)**

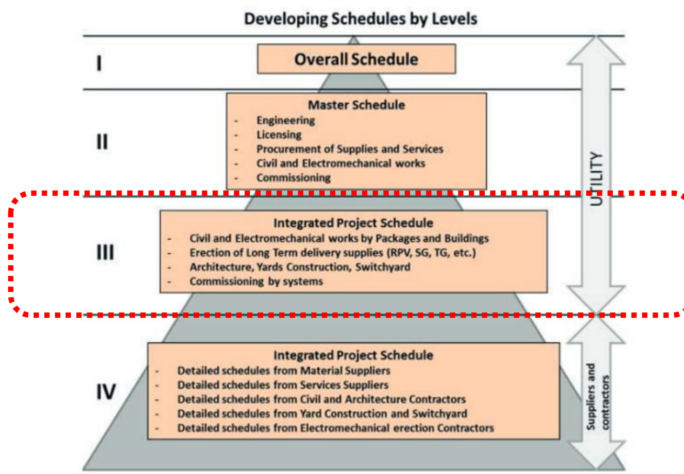
[Comparison of the characteristics of APR1400 and i-SMR]

Construction Package

PKG No.	Package	Components
CP-C1	Foundation Excavation	Site Development Work
		Main building foundation
CP-C2	Concrete Production Work	Concrete production and transportation
		Batch Plant, Crusher Plant
CP-C3	Outdoor Underground Installation	Outdoor Underground Piping (Sewage and Rainwater)
		Outdoor Underground Structure
CP-C4	Cooling Water System	Water Intake structures and drainage channels
CP-Y1	Underwater Drainage Structure	Underwater Water Intake Structure
CP-A1	Construction of Main Building	Reactor Containment Building (RCB)
		Auxiliary Building (AB)
		Compound Building (CPB)
		Turbine Generator Building (TGB)
CP-A2	Architectural Finishing Work	Interior and Exterior Finishing Materials for Buildings
CP-A3	Painting Work	Structural Finish Painting
CP-M1	General Equipment Installation	General Auxiliary Equipment (Pressure Vessels, Pumps, etc.)
		Concrete Liner Plate, Steel Liner Plate, Equipment Hatch
CP-M2	Condenser Installation Work	Condensers and Low-Pressure Water Heaters and Equipment
CP-M3	Turbine Generator Installation	Turbine Generator
		Peripheral Devices and Piping such as Moisture Separator Reheater
CP-M4	HVAC Installation	Duct Manufacturing and Installation
		HVAC equipment
CP-M5	Nuclear Steam Supply System (NSSS) Installation	Reactor Pressure System Lifting and Installation
		Nuclear Fuel Handling and Transport Facility
		NSSS Auxiliary System Equipment
CP-M6	On-Site Assembly Tank Installation	Tank Material Supply, Manufacturing, Assembly and Installation
CP-P1	Piping Installation	Embedded, Buried, Drainage Pipe Supply and Installation
		Supply and Installation of Pipes (Primary & Secondary System)
CP-P2	Insulation Work	Insulation Work for Pipes, Mechanical Equipment, Tanks, etc.
CP-E1	Electrical Equipment Installation	Power and Lighting for Construction Purposes
		Cable Tray, Conduit
CP-E2	Cable Laying and Wiring Work	Cable Laying and Terminal Connection Work
CP-E3	Outdoor Switchyard Installation	Electrical Devices and Cable Laying
CP-E4	Instrumentation and Control (I&C) Installation	I&C Equipment

[Construction Package of APR1400 (Moon et al., 2012)]

Project Scheduling



[Scheduling levels (IAEA, 2012)]

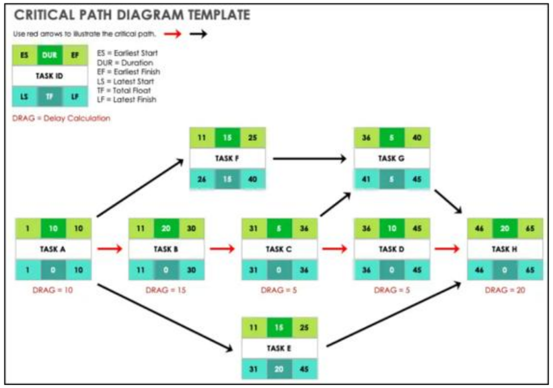
Construction Activities

NPP	Unit	Activities
SHN 1&2	Common	789
	1	1,466
	2	1,457
	Subtotal	**3,712**
SKN 3&4	Common	750
	3	1,418
	4	1,420
	Subtotal	**3,588**

[Analysis of Construction Activity (Kim, 2017)]

Critical Path

- This sequence **determines the shortest possible time** required to complete the entire project
- Any delay in these critical tasks will directly impact the overall project completion date



[Diagram illustrating the Critical Path (Smart sheet)]

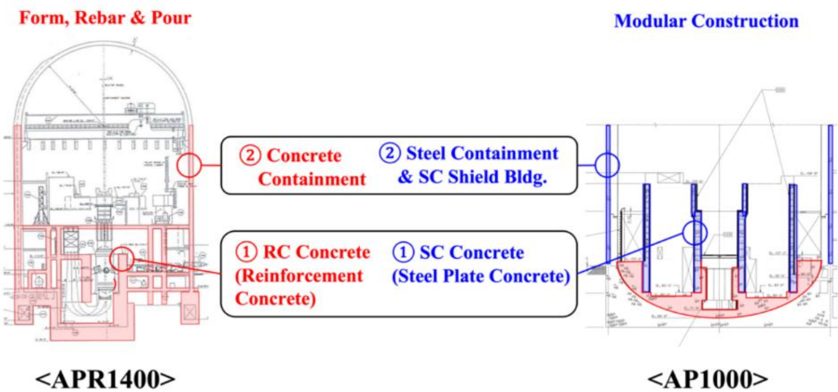
No.	Package	Activities	Critical Path
CP-C1	Foundation Excavation	Power Block Excavation RCB Mudmat Concrete, FR&P Basemat	○
CP-A1	Construction of Main Building	FR&P Basemat, Wall, Dome, Strucural Steel	○
CP-M1	General Equipment Installation	Install Mech. Equipment Wall Liner, Sump Liner, Dome Liner	○
CP-M3	Turbine Generator Installation	Install Turbine Components	○
CP-P1	Piping Installation	Install Embedded Pipe Install L/B, S/B Pipe & Support	○

☞ In the APR1400, the critical path is observed in 5 key packages:

C1 (Excavation), A1 (Building), M1 (Liner), M3 (Turbine), and P1 (Piping).

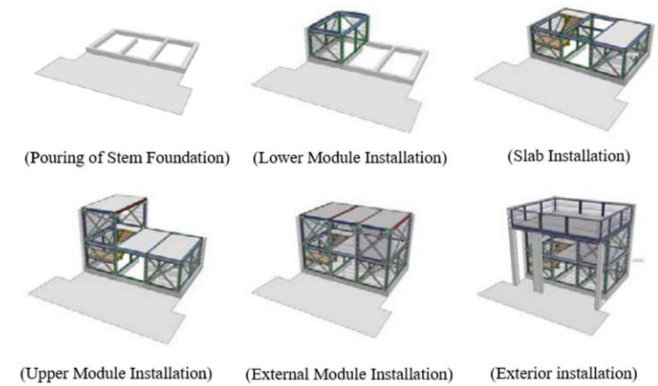
Review of Modularization Method (by CPs)

- **CP-A1**



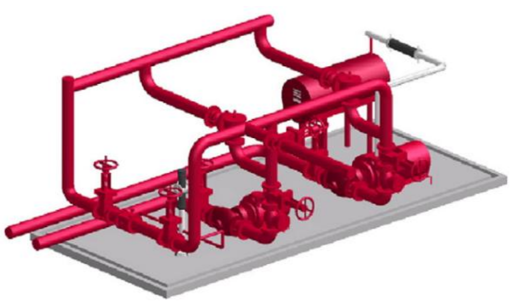
[RC and SC structures in APR1400 and AP1000 (Kwak & Lee, 2024)]

- **CP-A1/M1**



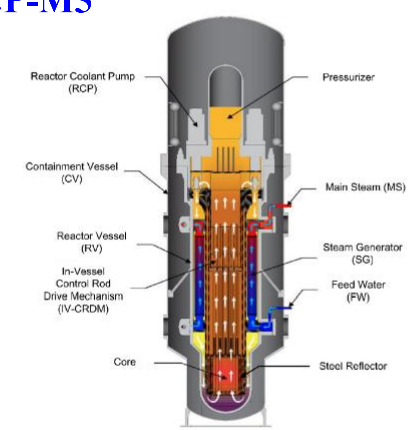
[Modular rooftop construction sequence (Hong et al., 2020)]

- **CP-M1/P1**



[Fire suppression system Module (Tserng et al., 2011)]

- **CP-M5**



[Reactor vessel of i-SMR (Lim et al., 2025)]

- **CP-E**

[Process Equipment Container (PEC) Module (DECHEMA, 2016)]

Overall Methodology

Reference Large Reactor APR1400 Construction Schedule

↓

Selection and Integration of LR Activities Applicable to SMR

↓

Development of SMR Schedule Based on Power Scaling

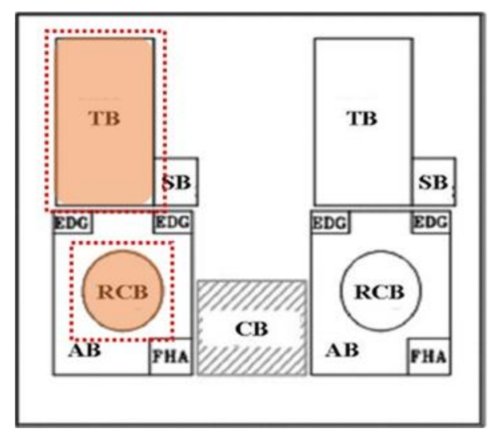
↓

Comparative Analysis of Schedules by Modularization Level

Organized into in 4 Phases

- **PHASE 1 : Selection of Building from APR1400**

- This study assumed that the **RCB and TGB would be part of the Critical Path Building for the i-SMR**, similar to the APR1400
- CPB, YARD and Facility are shared between two units, unsuitable for power scaling for one unit.



▪ PHASE 2: Activity Selection and Integration

■ Step 1. Selection of Target Buildings
- 1 unit of RCB & TGB

1,036 Activities

■ Step 2. Exclusion of Sub-construction Disciplines
- Architecture (painting, finishing), HVAC (non-critical equipment) excluded

828 Activities

■ Step 3. Elimination of Non-scalable or Non-critical Activities
- Liner cover, IRWST, Sump liner, Embedded items, grounding, etc. excluded

581 Activities

■ Step 4. Integration of Activities
- Consolidation of similar works (FR&P by Level, L/B piping, Electrical work)
- Reflection of SMR characteristic (NSSS Main Component, Turbine/Condenser work)

139 Activities

■ Step 5. Adjustment and Generation of Key Activities
- Re-assessment of SMR applicability, deletion/modification of unsuitable tasks
- Adjustment of overlapping durations, terminology standardized

90 Activities

- **PHASE 3: Development of i-SMR Schedule**

① Top Down Modeling: Power Scaling

- Top-down Estimation: Uses scaling exponents (n) to derive parameters (duration) for a new plant (i) based on a reference plant.

$$Parameter_i = Parameter_{ref} \left(\frac{Power_i}{Power_{ref}}\right)^n$$

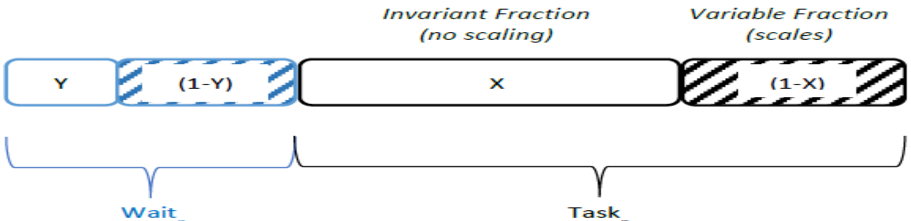
[Eq 1. Power scaling Equation (Lloyd, 2020)]

Account Name & Number	Scaling Exponent, n
Land & Land Rights	0.00
21 - Structures & Improvements	0.59
22 - Reactor/Boiler Plant Equipment	0.53
23 - Turbine Plant Equipment	0.83
24 - Electric Plant Equipment	0.49
25 - Miscellaneous Plant Equipment	0.59
26 - Main Condenser Heat Rejection System	1.06

[Power scaling Exponents (Lloyd, 2020)]

② Type of Construction Time

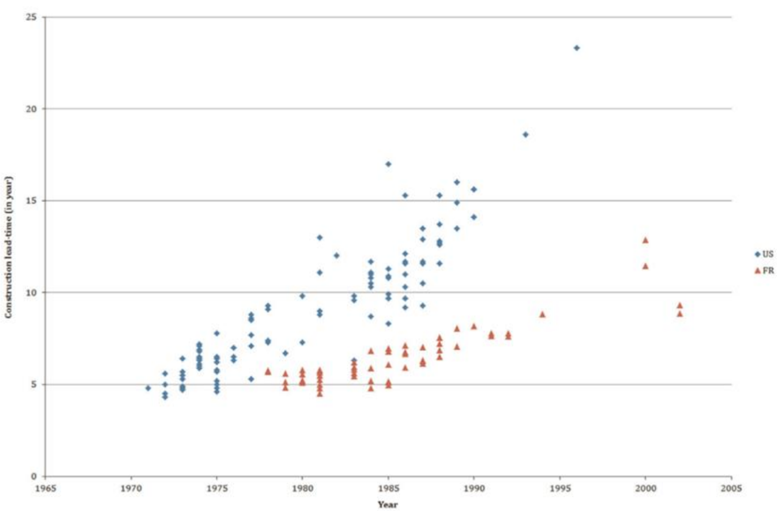
- Task Time (T): Active construction work (e.g., welding, concrete pouring).
- Wait Time (W): Sequencing delays, inspections, resource availability



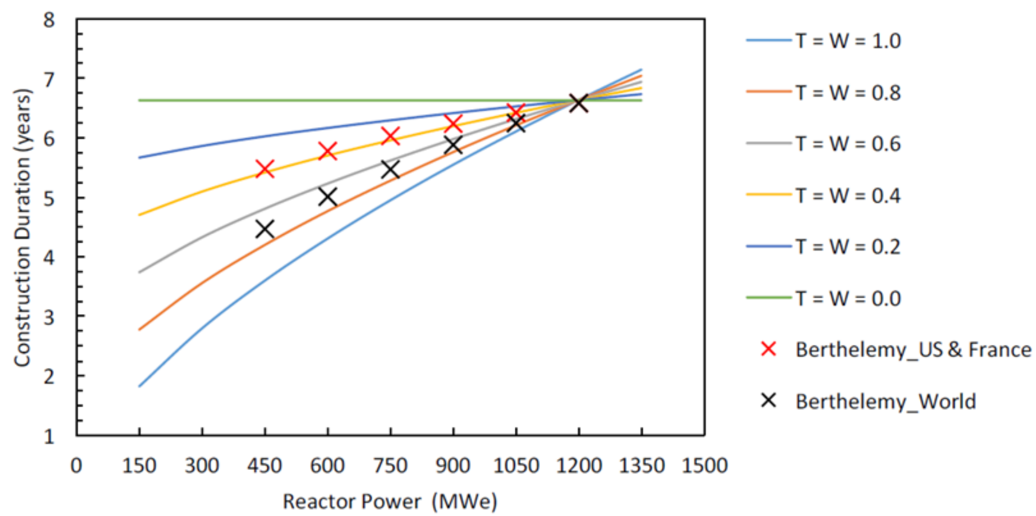
[Wait times (blue) and Task times (black) for activity n (Lloyd & Roulstone, 2018)]

③ Task time (T) and wait time (W) scale

- Model calibrated against historical U.S. & France construction data (Berthélemy & Escobar-Rangel, 2015)
- Adopted Framework: **Scaling Case (T = W = 0.4)**
- This model more closely reproduces the reference critical path.
- Considered more realistic for SMRs with high modularization potential.



[Reactor Construction lead-time in the US and France (Berthélemy & Escobar-Rangel, 2015)]



[Scaling Case II model with T = W for all values (Lloyd, 2020)]

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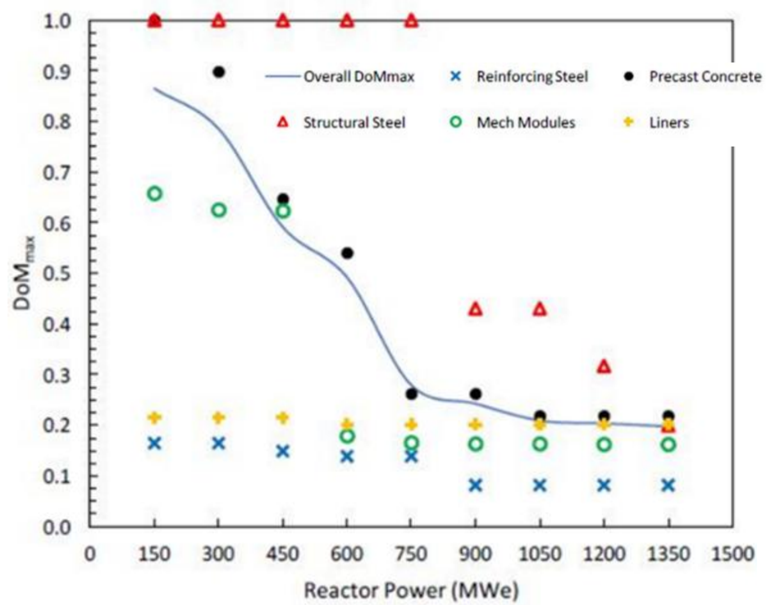
- **PHASE 4: Application of Modularisation**

- Degree of Modularisation (DoM): Proportion of on-site work shifted to off-site factory fabrication
- DoM_max: Limited by transportation. For 680 MWe, the interpolated **Overall DoM_max is 0.4 (40%)**

  *When Modular Division Factor (MDF) = 3



[DOM_max by module type, MDF = 3 (Lloyd, 2020)]

- Adjusted on-site task duration for a given DoM (required 5% duration for on-site module assembly)

$$t_{modular\ task,i} = (1 - DoM)t_{baseline\ task,i} + 0.05(DoM)t_{baseline\ task,i}$$

[Eq 2. Residual on-site construction time after modularization (Lloyd, 2020)]

- On-site wait time for relation type (S-S and F-S)

$$t_{S-S\ modular\ wait,i} = (1 - DoM)t_{S-S\ baseline\ wait,i}$$

[Eq 3. Residual on-site wait time for S-S connection (Lloyd, 2020)]

$$t_{F-S\ modular\ wait,i} = t_{F-S\ baseline\ wait,i}$$

[Eq 4. Residual on-site wait time for F-S connection (Lloyd, 2020)]

Schedule Scenario by Extent of Modularisation

■ Extent of Modularisation: **None, Low, Medium, or Full**

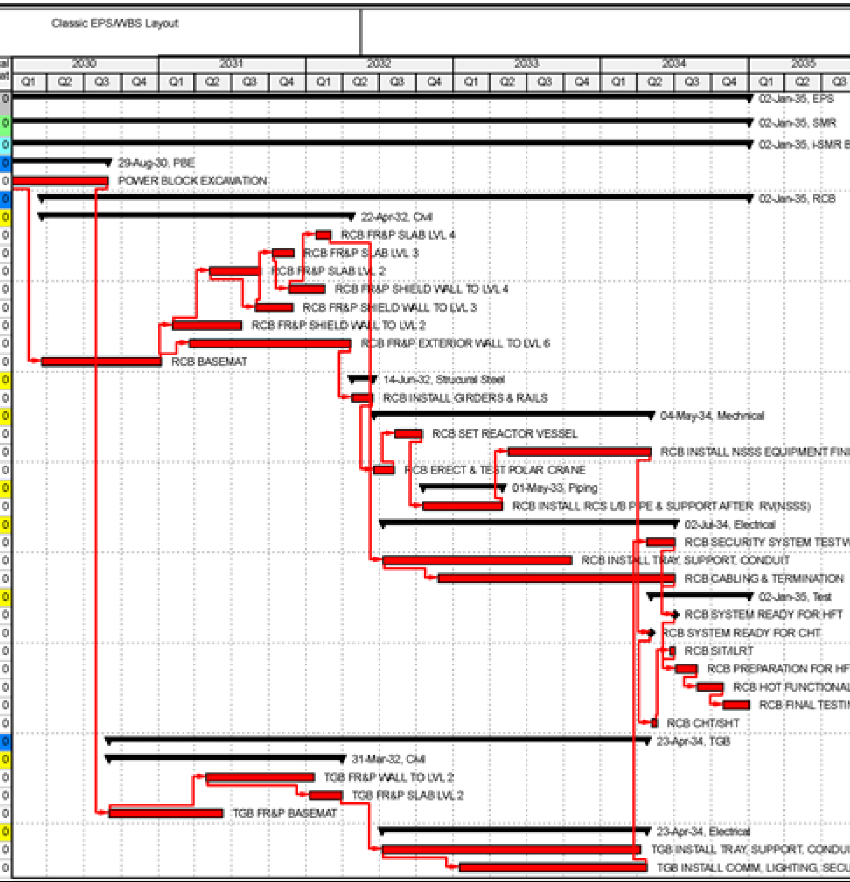
- **Scenario 1. None Modularisation:** Baseline Construction Schedule
- **Scenario 2. Low Modularisation:** Only some **mechanical and steel structures.**
- **Scenario 3. Medium Modularisation:** Mechanical and steel structures plus **major civil works.**
- **Scenario 4. Full Modularisation:** Mechanical, steel, and civil works, as well as **electrical, instrumentation, and auxiliary systems, are fully modularised.**

i-SMR Baseline Schedule

- **Scenario 1(Baseline): None Modularization**, Scaling Model T = W = 0.4
- **Construction Duration: 57.3 Months**

i-SMR Baseline

Activity Name	Original Duration	Start	Finish	Total Float
EPS	1828	01-Jan-30	02-Jan-35	0
SMR	1828	01-Jan-30	02-Jan-35	0
i-SMR Baseline	1828	01-Jan-30	02-Jan-35	0
PBE	241	01-Jan-30	29-Aug-30	0
POWER BLOCK EXCAVATION	241	01-Jan-30*	29-Aug-30	0
RCB	1750	20-Mar-30	02-Jan-35	0
Civil	765	20-Mar-30	22-Apr-32	0
RCB FR&P SLAB LVL 4	38	27-Jan-32	04-Mar-32	0
RCB FR&P SLAB LVL 3	53	11-Oct-31	02-Dec-31	0
RCB FR&P SLAB LVL 2	127	09-May-31	12-Sep-31	0
RCB FR&P SHIELD WALL TO LVL 4	90	21-Nov-31	18-Feb-32	0
RCB FR&P SHIELD WALL TO LVL 3	91	31-Aug-31	29-Nov-31	0
RCB FR&P SHIELD WALL TO LVL 2	170	06-Feb-31	25-Jul-31	0
RCB FR&P EXTERIOR WALL TO LVL 6	401	19-Mar-31	22-Apr-32	0
RCB BASEMAT	295	20-Mar-30	08-Jan-31	0
Strucural Steel	52	24-Apr-32	14-Jun-32	0
RCB INSTALL GIRDERS & RAILS	52	24-Apr-32	14-Jun-32	0
Mechnical	687	17-Jun-32	04-May-34	0
RCB SET REACTOR VESSEL	69	09-Aug-32	16-Oct-32	0
RCB INSTALL NSSS EQUIPMENT FINISHING	353	17-May-33	04-May-34	0
RCB ERECT & TEST POLAR CRANE	52	17-Jun-32	07-Aug-32	0
Piping	196	18-Oct-32	01-May-33	0
RCB INSTALL RCS L/B PIPE & SUPPORT AFTER RV(NSSS)	196	18-Oct-32	01-May-33	0
Electrical	723	10-Jul-32	02-Jul-34	0
RCB SECURITY SYSTEM TEST WITH TGB	69	25-Apr-34	02-Jul-34	0
RCB INSTALL TRAY, SUPPORT, CONDUIT	469	10-Jul-32	21-Oct-33	0
RCB CABLING & TERMINATION	587	23-Nov-32	02-Jul-34	0
Test	242	05-May-34	02-Jan-35	0
RCB SYSTEM READY FOR HFT	0		03-Jul-34	0
RCB SYSTEM READY FOR CHT	0		05-May-34	0
RCB SIT/LRT	13	20-Jun-34	02-Jul-34	0
RCB PREPARATION FOR HFT	52	05-Jul-34	25-Aug-34	0
RCB HOT FUNCTIONAL TEST	64	27-Aug-34	29-Oct-34	0
RCB FINAL TESTING & PLANT ALIGNMENT	65	30-Oct-34	02-Jan-35	0
RCB CHT/SHT	13	07-May-34	19-May-34	0
TGB	1331	01-Sep-30	23-Apr-34	0
Civil	578	01-Sep-30	31-Mar-32	0
TGB FR&P WALL TO LVL 2	266	01-May-31	21-Jan-32	0
TGB FR&P SLAB LVL 2	80	12-Jan-32	31-Mar-32	0
TGB FR&P BASEMAT	281	01-Sep-30	08-Jun-31	0
Electrical	655	08-Jul-32	23-Apr-34	0
TGB INSTALL TRAY, SUPPORT, CONDUIT	642	08-Jul-32	10-Apr-34	0
TGB INSTALL COMM, LIGHTING, SECURITY SYSTEM	465	14-Jan-33	23-Apr-34	0



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Critical Path for CPs

PKG No	Package	Activities	APR1400 Critical Path	i-SMR Baseline Critical Path
CP-C1	Foundation Excavation	Power Block Excavation RCB Mudmat Concrete, FR&P Basemat	○	○
CP-A1	Construction of Main Building	FR&P Basemat, Wall, Dome, Strucural Steel	○	○
CP-M1	General Equipment Installation	Install Mech. Equipment Wall Liner, Sump Liner, Dome Liner	○	
CP-M3	Turbine Generator Installation	Install Turbine Components	○	
CP-M5	NSSS Installation	Install RC Pump Internals & Motor Set Reactor Vessel RPV Internals Installation		○
CP-P1	Piping Installation	Install Embedded Pipe Install L/B, S/B Pipe & Support	○	○
CP-E1 CP-E2 CP-E3	Electrical Equipment Installation Cable Laying and Wiring Work Outdoor Switchyard Installation	Install Cable Tray & Support, Install Misc. Elect. Equipment, Conduit, Cabling & Termination		○

A. Critical Path → Non-Critical

- M1
- M3

B. Non-Critical → Critical Path

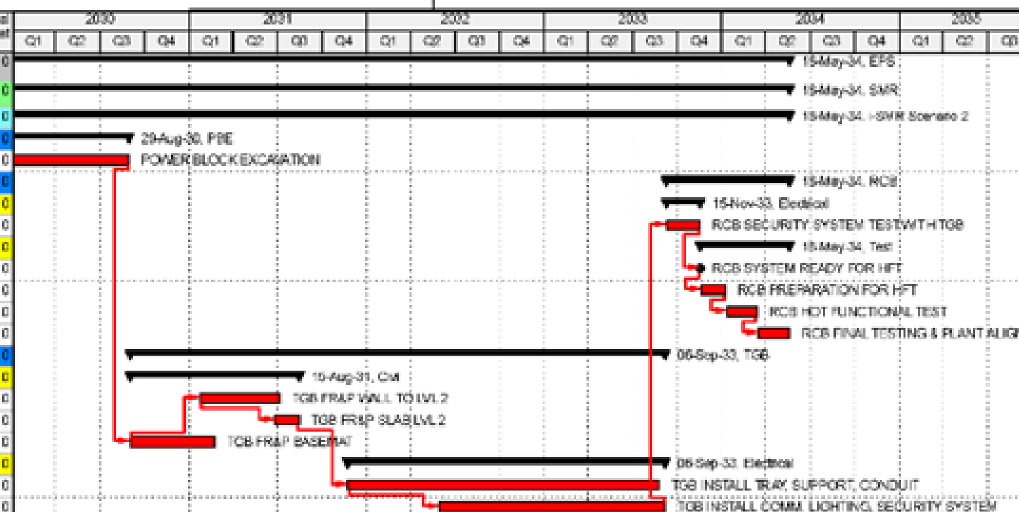
- M5
- E

Low Modularisation

- ■ **Scenario 2**: **Low Modularization**, Scaling Model T = W = 0.4
- ■ **Construction Duration: 57.3 Months (No change)**

i-SMR Scenario 2 — Classic EPS/WBS Layout

Activity Name	Original Duration	Start	Finish	Total Float
EPS	1599	01-Jan-30	18-May-34	0
SMR	1599	01-Jan-30	18-May-34	0
i-SMR Scenario 2	1599	01-Jan-30	18-May-34	0
PBE	241	01-Jan-30	29-Aug-30	0
POWER BLOCK EXCAVATION	241	01-Jan-30*	29-Aug-30	0
RCB	253	08-Sep-33	18-May-34	0
Electrical	69	08-Sep-33	15-Nov-33	0
RCB SECURITY SYSTEM TEST WITH TGB	69	08-Sep-33	15-Nov-33	0
Test	183	16-Nov-33	18-May-34	0
RCB SYSTEM READY FOR HFT	0		16-Nov-33	0
RCB PREPARATION FOR HFT	52	18-Nov-33	08-Jan-34	0
RCB HOT FUNCTIONAL TEST	64	10-Jan-34	14-Mar-34	0
RCB FINAL TESTING & PLANT ALIGNMENT	65	15-Mar-34	18-May-34	0
TGB	1102	01-Sep-30	06-Sep-33	0
Civil	349	01-Sep-30	15-Aug-31	0
TGB FR&P WALL TO LVL 2	165	24-Jan-31	07-Jul-31	0
TGB FR&P SLAB LVL 2	50	27-Jun-31	15-Aug-31	0
TGB FR&P BASEMAT	174	01-Sep-30	21-Feb-31	0
Electrical	655	22-Nov-31	06-Sep-33	0
TGB INSTALL TRAY, SUPPORT, CONDUIT	642	22-Nov-31	24-Aug-33	0
TGB INSTALL COMM, LIGHTING, SECURITY SYSTEM	465	30-May-32	06-Sep-33	0



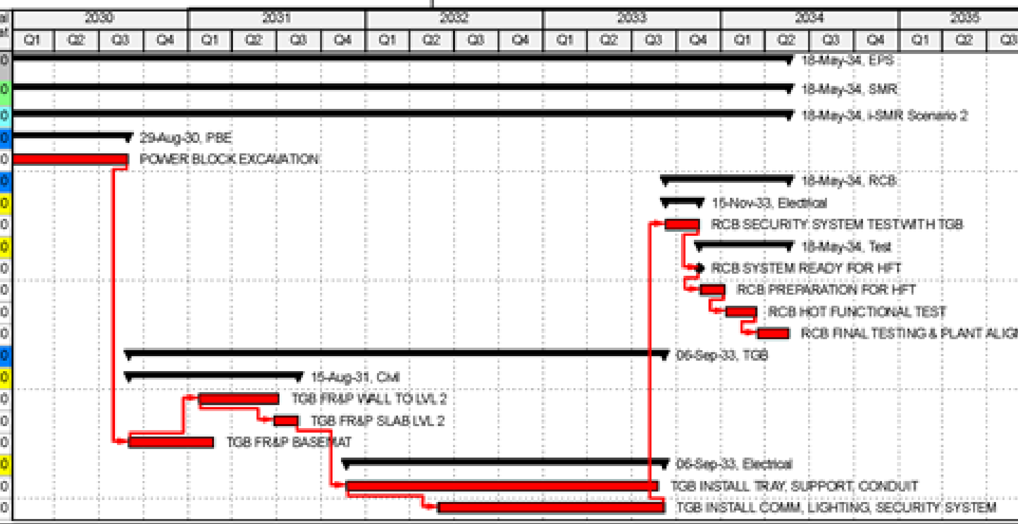
Medium Modularisation

- **Scenario 3**: **Medium Modularization**, Scaling Model T = W = 0.4
- **Construction Duration: 49.7 Months, -7.5 Months (-13.1%)**
- Meaningful schedule reduction begins only **when Civil works are modularized.**

i-SMR Scenario 2

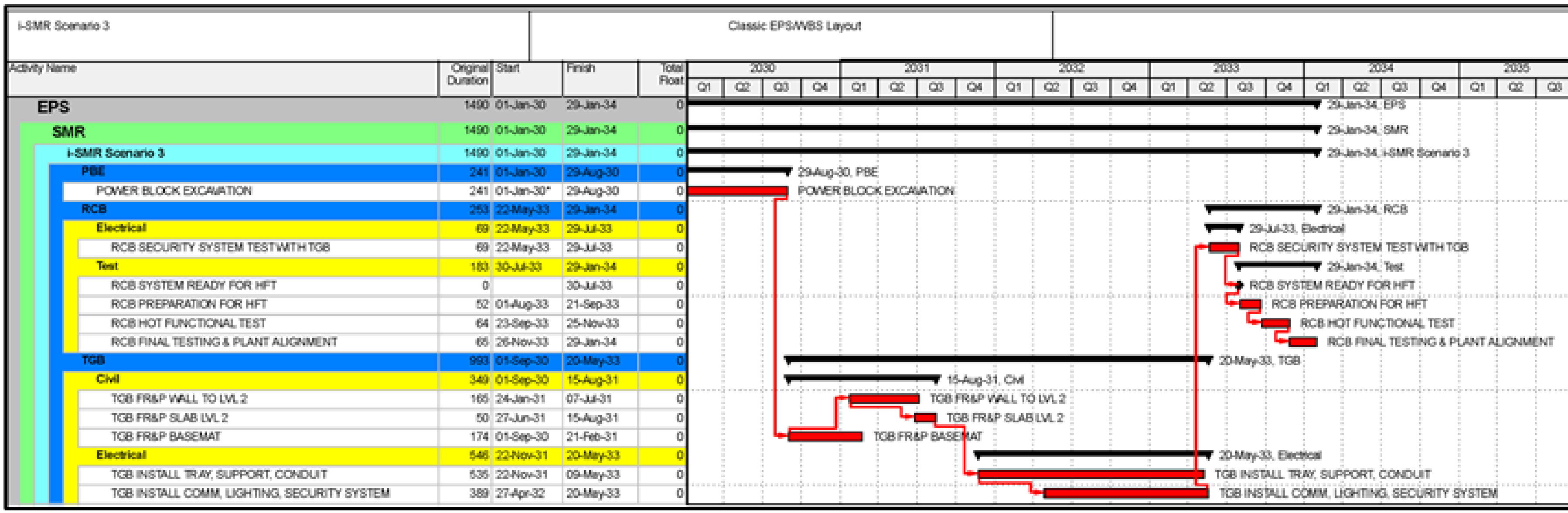
Classic EPS/WBS Layout

Activity Name	Original Duration	Start	Finish	Total Float
EPS	1599	01-Jan-30	18-May-34	0
SMR	1599	01-Jan-30	18-May-34	0
i-SMR Scenario 2	1599	01-Jan-30	18-May-34	0
PBE	241	01-Jan-30	29-Aug-30	0
POWER BLOCK EXCAVATION	241	01-Jan-30*	29-Aug-30	0
RCB	253	08-Sep-33	18-May-34	0
Electrical	69	08-Sep-33	15-Nov-33	0
RCB SECURITY SYSTEM TEST WITH TGB	69	08-Sep-33	15-Nov-33	0
Test	183	16-Nov-33	18-May-34	0
RCB SYSTEM READY FOR HFT	0		16-Nov-33	0
RCB PREPARATION FOR HFT	52	18-Nov-33	08-Jan-34	0
RCB HOT FUNCTIONAL TEST	64	10-Jan-34	14-Mar-34	0
RCB FINAL TESTING & PLANT ALIGNMENT	65	15-Mar-34	18-May-34	0
TGB	1102	01-Sep-30	06-Sep-33	0
Civil	349	01-Sep-30	15-Aug-31	0
TGB FR&P WALL TO LVL 2	165	24-Jan-31	07-Jul-31	0
TGB FR&P SLAB LVL 2	50	27-Jun-31	15-Aug-31	0
TGB FR&P BASEMAT	174	01-Sep-30	21-Feb-31	0
Electrical	656	22-Nov-31	06-Sep-33	0
TGB INSTALL TRAY, SUPPORT, CONDUIT	642	22-Nov-31	24-Aug-33	0
TGB INSTALL COMM, LIGHTING, SECURITY SYSTEM	465	30-May-32	06-Sep-33	0



Full Modularisation

- **Scenario 4**: **Full Modularization**, Scaling Model T = W = 0.4
- **Construction Duration: 46.2 Months, -11.0 Months (-19.2%)**
- Full modularization, **including Electrical, yields the most significant reduction.**



Activity Name	Original Duration	Start	Finish	Total Float
EPS	1490	01-Jan-30	29-Jan-34	0
SMR	1490	01-Jan-30	29-Jan-34	0
i-SMR Scenario 3	1490	01-Jan-30	29-Jan-34	0
PBE	241	01-Jan-30	29-Aug-30	0
POWER BLOCK EXCAVATION	241	01-Jan-30*	29-Aug-30	0
RCB	253	22-May-33	29-Jan-34	0
Electrical	69	22-May-33	29-Jul-33	0
RCB SECURITY SYSTEM TEST WITH TGB	69	22-May-33	29-Jul-33	0
Test	183	30-Jul-33	29-Jan-34	0
RCB SYSTEM READY FOR HFT	0		30-Jul-33	0
RCB PREPARATION FOR HFT	52	01-Aug-33	21-Sep-33	0
RCB HOT FUNCTIONAL TEST	64	23-Sep-33	25-Nov-33	0
RCB FINAL TESTING & PLANT ALIGNMENT	65	26-Nov-33	29-Jan-34	0
TGB	993	01-Sep-30	20-May-33	0
Civil	349	01-Sep-30	15-Aug-31	0
TGB FR&P WALL TO LVL 2	165	24-Jan-31	07-Jul-31	0
TGB FR&P SLAB LVL 2	50	27-Jun-31	15-Aug-31	0
TGB FR&P BASEMAT	174	01-Sep-30	21-Feb-31	0
Electrical	546	22-Nov-31	20-May-33	0
TGB INSTALL TRAY, SUPPORT, CONDUIT	535	22-Nov-31	09-May-33	0
TGB INSTALL COMM, LIGHTING, SECURITY SYSTEM	389	27-Apr-32	20-May-33	0

Change in Construction Schedule

Scenario	Extent of Modularisation	Const. Duration	Schedule Reduction
Scenario 1	None	57.3 Month	Baseline
Scenario 2	Low	57.3 Month	No change
Scenario 3	Medium	49.7 Month	**- 7.5 M (-13.1%) compared to Baseline**
Scenario 4	Full	46.2 Month	**- 11 M (-19.2%) compared to Baseline**

■ **Key Finding**

✓ To achieve the 48-month target, a **"Full Modularization" strategy (Scenario 4) is required.**

✓ Meaningful schedule reduction (Scenario 3) only begins **after Civil Works are modularized.**

Critical Path for CPs

PKG No.	Package	Activities	Critical Path of i-SMR Baseline (Scenario1)	Low (Scenario2)	Medium (Scenario3)	Full (Scenario4)
CP-C1	Foundation Excavation	Power Block Excavation RCB Mudmat Concrete, FR&P Basemat	○	○	○	○
CP-A1	Construction of Main Building	FR&P Basemat, Wall, Dome, Strucural Steel	○	○	○	○
CP-M5	NNSSS Installation	Install RC Pump Internals & Motor Set Reactor Vessel RPV Internals Installation	○			
CP-P1	Piping Installation	Install Embedded Pipe Install L/B, S/B Pipe & Support	○			
CP-E1 CP-E2 CP-E3	Electrical Equipment Installation Cable Laying and Wiring Work Outdoor Switchyard Installation	Install Cable Tray & Support, Install Misc. Elect. Equipment, Conduit, Cabling & Termination	○	○	○	○

■ **Key Finding**

- ✓ M5 (NSSS) & P1 (Piping): They are **no longer critical in Scenarios 2 ~ 4**. Their schedule impact is absorbed by modularization.
- ✓ C1 (Excavation), A1 (Building), E (Electrical): These packages remain on the **critical path even under the 'Full' modularization scenario.**
- ✓ Under modularization Scenario, **TGB civil and electrical works emerge as the new project**

Limitations

- **Design:** This study **does not fully reflect the design features of the i-SMR.** it is based on scaling from the APR1400.
- **Construction conditions:** The scaling methodology (Lloyd, 2020) is based on international data and **does not account for the Korean construction environment** (advanced technologies, labor practices).
- **Simplification:** The process was simplified during the selection and integration of activities.

Recommendation for i-SMR Modularisation Strategy

- **Extensively apply the Steel Plate Concrete (SC) technology** to major reactor building structures. A1(Building) package remains critical in all scenarios and receives the highest priority.
- **Enhance Electrical & Instrument modularization (MEP, PEC)** as this is a new, persistent critical path.
- **Utilize this type of research and Ensure the On-site application of Modularization** from the Design Stage.

THANK YOU