

Evaluation of EDG On-Line Maintenance Effect on Outage Schedule

- Using OPR 1000 Standard OH Schedule



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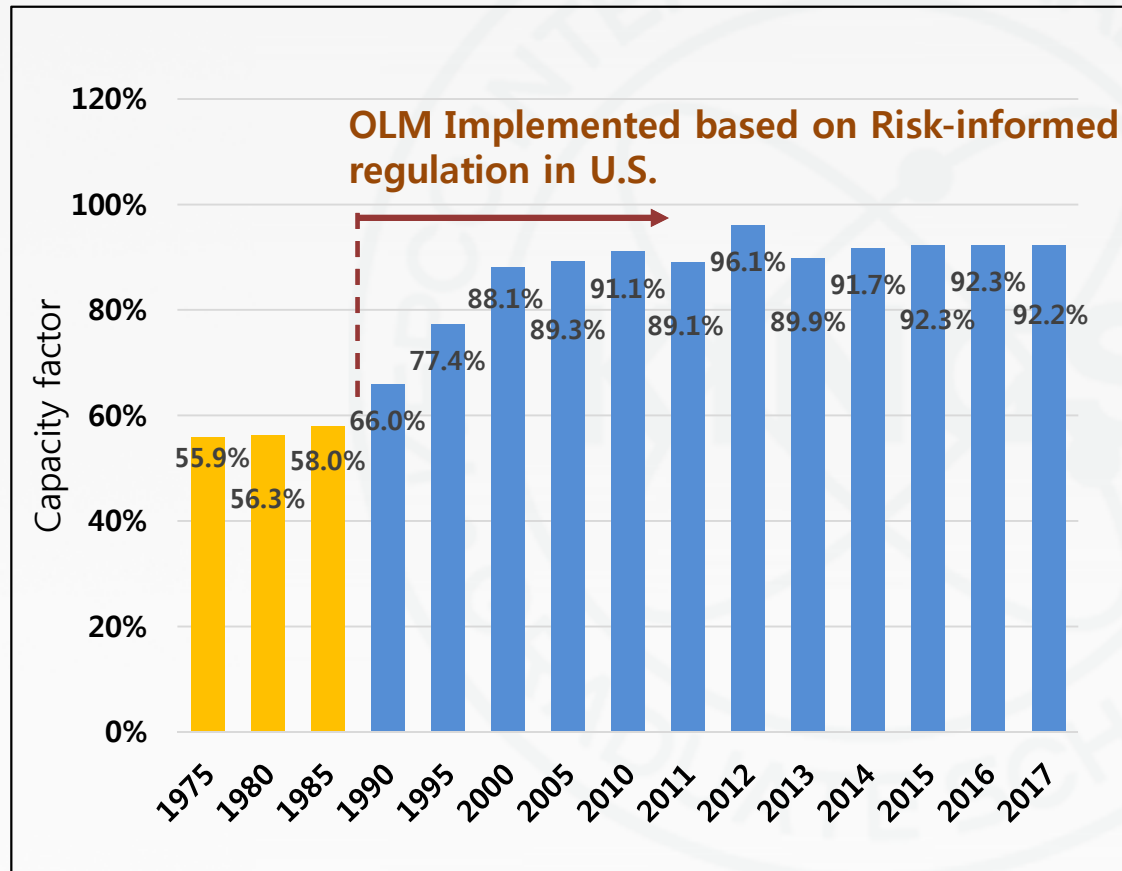
3.1 OLM Implemented based on Risk-informed regulation (RIR)

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4. Summary

1. Introduction

□ Capacity factor of NPPs in the U.S. from 1975 to 2017



- The average availability of all US NPPs is 92.2% in 2017
- One of the contributing factors for the excellent record is the on-line maintenance (OLM)
- The OLM is the preventive maintenance activity of safety equipment that is carried out during the operation

Source: U.S. Energy Information Administration, May 2018

1. Introduction

□ OLM in the U.S.

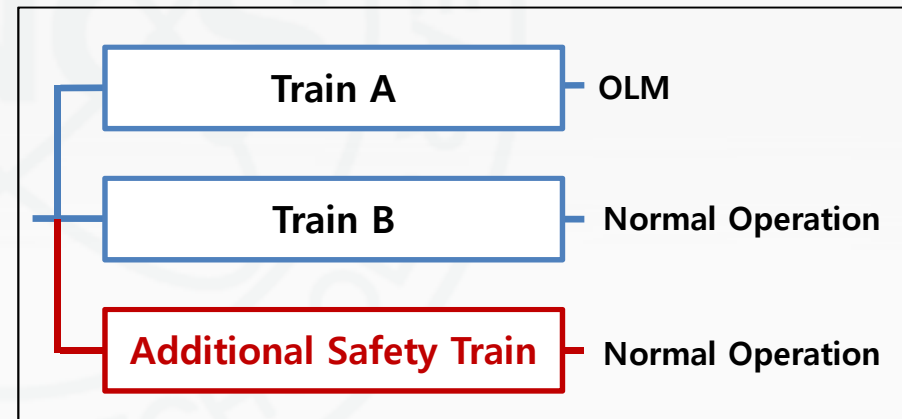
- The U.S. utilities applied the extension of the allowed outage times (AOT) under the risk-informed regulation (Risk Informed Technical Specifications Initiative 4b).
- Examples are,



Vogtle Diablo Canyon Lucie Turkey Point

□ OLM in European countries

- Some of European countries mandated N+2 requirements for safety equipment for new NPPs.
- The additional safety train is used to satisfy the single failure criterion while performing OLM.



- OLM has proven to be beneficial not only in improving plant safety and equipment reliability, but also in improving the utilization rate of NPPs.

1. Introduction

□ Evaluation of OLM Effect on Outage Schedule

- **Assumption:** a voluntary entrance into limiting conditions for operation (LCO) for the preventive maintenance of the safety system is allowed during the power operation in Korea
- **System:** Emergency diesel generator (EDG)
- **Target:** OPR 1000 standard OH schedule

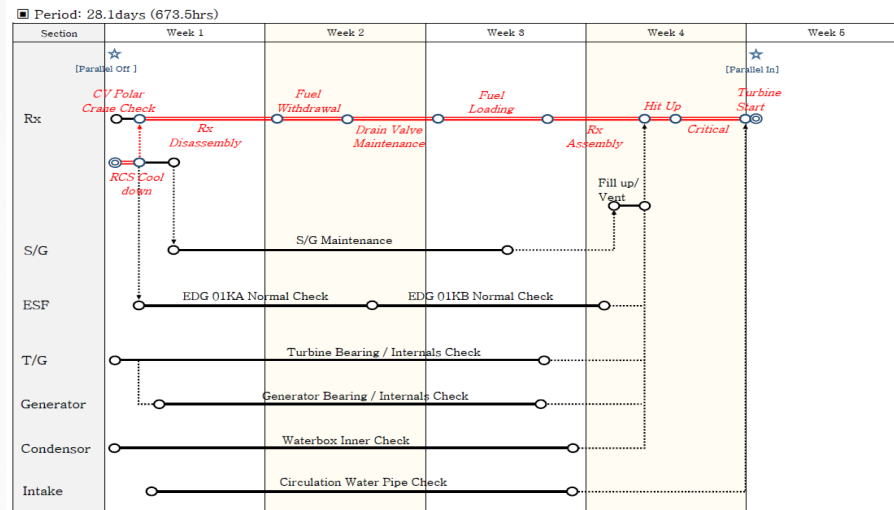
1. Evaluation of On-Line Maintenance Effect on Outage Schedule
2. Evaluation of additional equipment effect to satisfy N+2 requirements

2. EDG Maintenance in Outage

□ Standard OH Schedule for OPR 1000

Standard Maintenance Procedure (Standard Maintenance-9680A) for OH schedule development in Korea

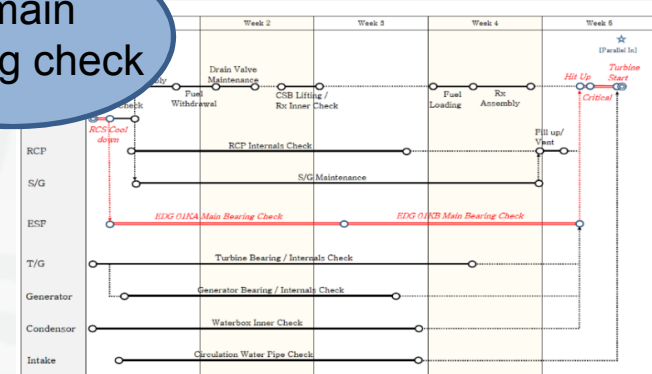
No.	Basic Unit Process
1	RCS Cool Down / Drainage
2	Rx Accessory Disassembly
3	Rx Disassembly
4



Standard OH schedule

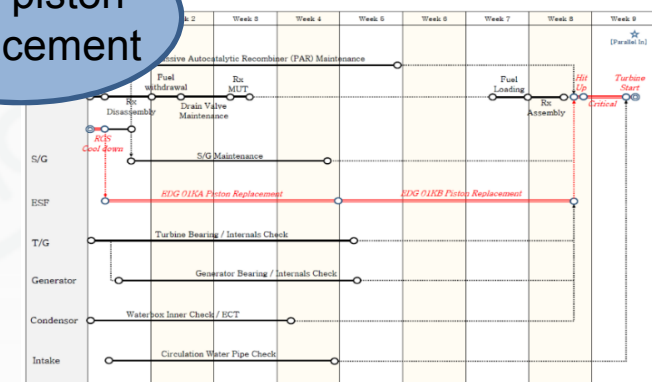
□ Effect of EDG for OH Schedule

EDG main bearing check



OH schedule in 2010

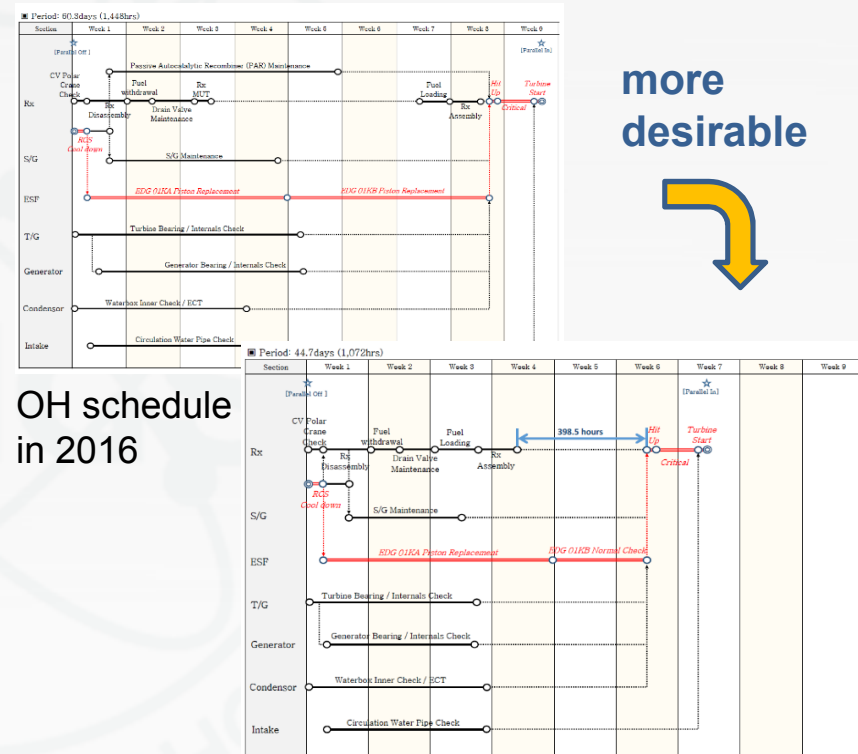
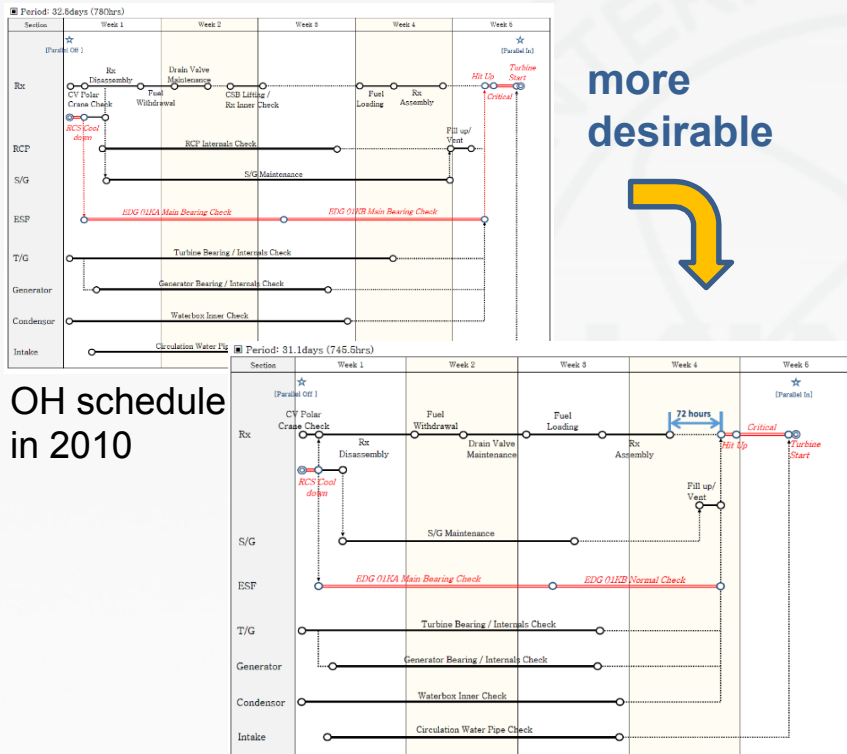
EDG piston replacement



OH schedule in 2016

2. EDG Maintenance in Outage

□ Baseline OH Schedules with EDG Maintenance



- More desirable to perform OH for one item at a time both from safety and efficiency perspective.

3. Implementation of OLM

□ OLM Implemented based on Risk-informed regulation (RIR)

- If we assume that EDG outage is performed online to domestic NPPs, the time added to the baseline OH schedule could be saved.

- OH period for EDG main bearing check: **72 hours saved**

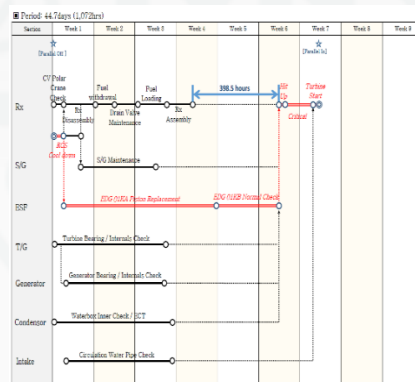
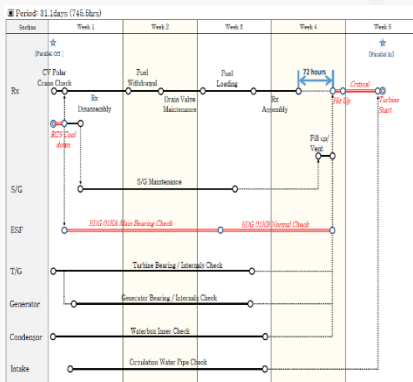
- OH period for EDG piston replacement: **398.5 hours saved**

- Target Period: 2019~2038 (20 years)

- EDG main bearing check will be performed: one train in 2024 and the other train in 2026



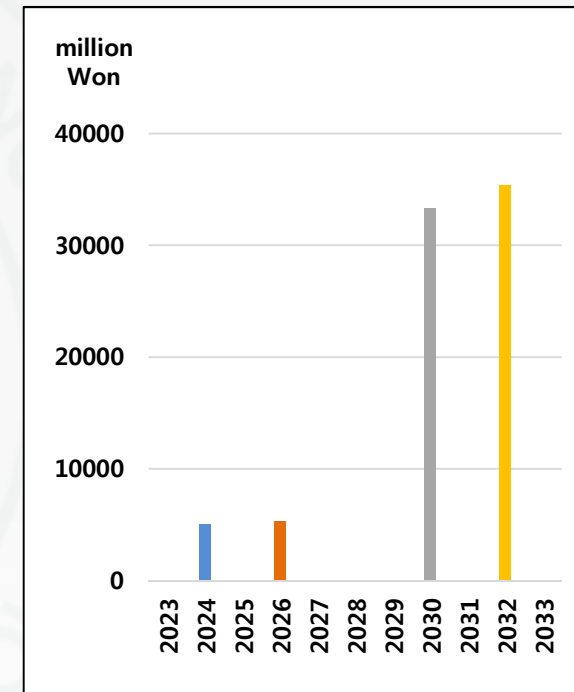
- EDG piston replacement will be performed: one train in 2030 and the other train in 2032



3. Implementation of OLM

□ The economic effect of OLM implementation based on RIR

Year	Saved time by OLM (hours)	Electricity Production per hour (MW/h)	Electricity unit price in the relevant year (Won/kW)	Economic benefit based on RIR	
				In the relevant year (million Won)	In 2018 (million Won)
2024	72	1,050	66.71	5,043	3,360
2026	72	1,050	70.77	5,350	3,114
2030	398.5	1,050	79.66	33,332	14,800
2032	398.5	1,050	84.50	35,357	13,712
-	941	-	-	79,082	34,986



- Assumptions used are,

Electricity unit price in relevant year is estimated by applying annual inflation rate of 3.0% on electricity unit price (55.87 Won/kW) in 2018.

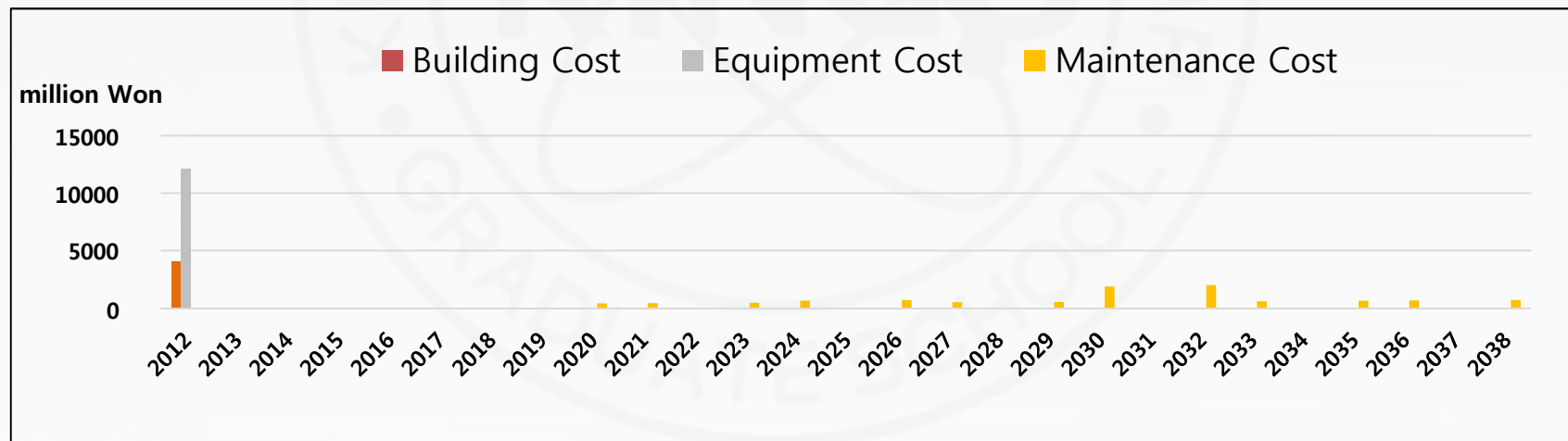
Annual discount rate of 7.0% is applied based on economic effect in the relevant year.

3. Implementation of OLM

□ OLM Implemented based on N+2 criterion

- In some European countries such as Finland and UK, the N+2 criterion is required to safety systems for mew plants.
- The economic benefit while satisfying the N+2 criterion can be calculated as below

$$\text{Economic benefit based on N+2} = \text{Economic effect by OLM in 2018} - \text{Building cost in 2018} - \text{Equipment cost in 2018} - \text{Maintenance costs in 2018 (13 times OH)}$$



* The maintenance costs include material costs such as main bearings and pistons.

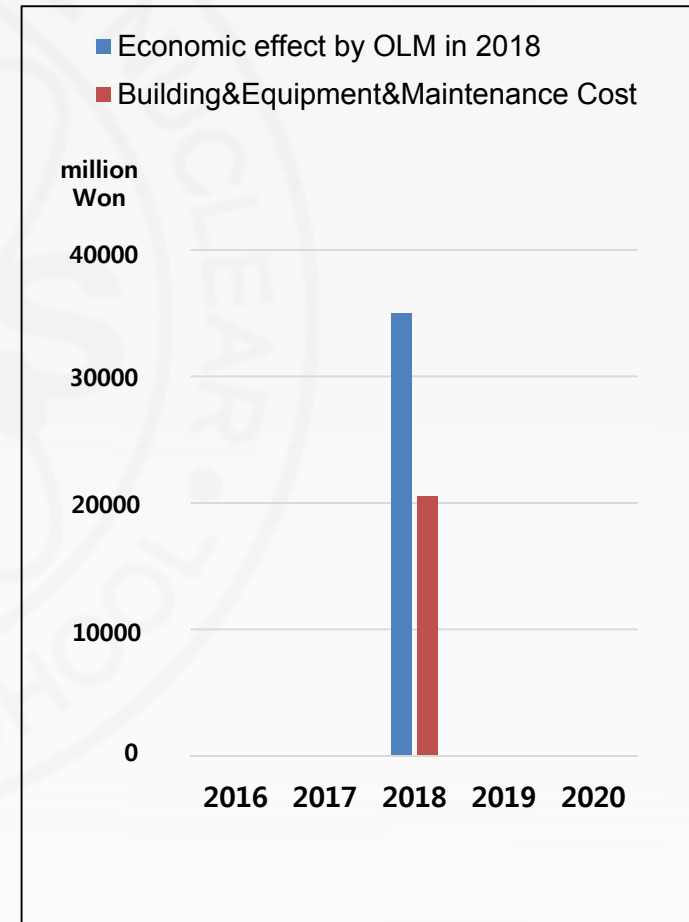
3. Implementation of OLM

□ The economic effect of OLM implementation based on N+2 criterion

(Unit: million Won)

Economic effect by OLM in 2018	Building Cost in 2018	Equipment Cost in 2018	Maintenance Costs in 2018 (13 times OH)	Economic benefit based on N+2
34,986	4,818	14,440	3,833	11,895

- Assumptions in the NPV calculation are,
 - 1) **Building and equipment costs:** the inflation rate of 3.0% was applied to EDG building and equipment costs.
 - 2) **Maintenance costs:** the inflation rate of 3.0% was applied to one OH maintenance cost of year 2016 to calculate the amount of 13 OH maintenance cost from 2019 to 2038. And, discount rate (3.0%) is applied based on the 13 OH maintenance cost from 2019 to 2038 in order to calculate the amount in 2018.



4. Summary

□ The benefit of performing OLM on EDG was analyzed for OPR 1000

1. Application of AOT extension assuming it is allowed based on RIR, similar to the U.S. regulation.

- there are 941 hours time saved and more than 5 billion Won benefits in 2024 and 2026, and over 33 billion Won in 2030 and 2032, respectively.
- When convert into the net present value (NPV) of 2018, the total benefit is 35 billion Won.

2. Effect of N+2 criterion being used for new NPPs in Finland and UK.

- N+2 criterion can be calculated by excluding the building, equipment and maintenance costs from the economic benefit of the RIR based OLM.
- The benefit is 11.9 billion Won (NPV in 2018).

- ✓ The result shows that OLM is useful in reducing OH period.
- ✓ The evaluation was based on 28 day standard OH schedule. In the U.S., the OH period is about 20 days. If we reduce the main critical path such as reactor, the impact would be greater.
- ✓ For NPPs with four EDGs, there would be substantial benefit of having OLM for the major EDG tasks.

Thank you for your attention

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