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Using STPA to Analyze Human Interactions with Engineered Systems

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Applications on

- **Elevator,**
- Fluid Flow Lab Unit,
- Headwork of Wastewater Treatment Plant,
- Input System of Incinerator

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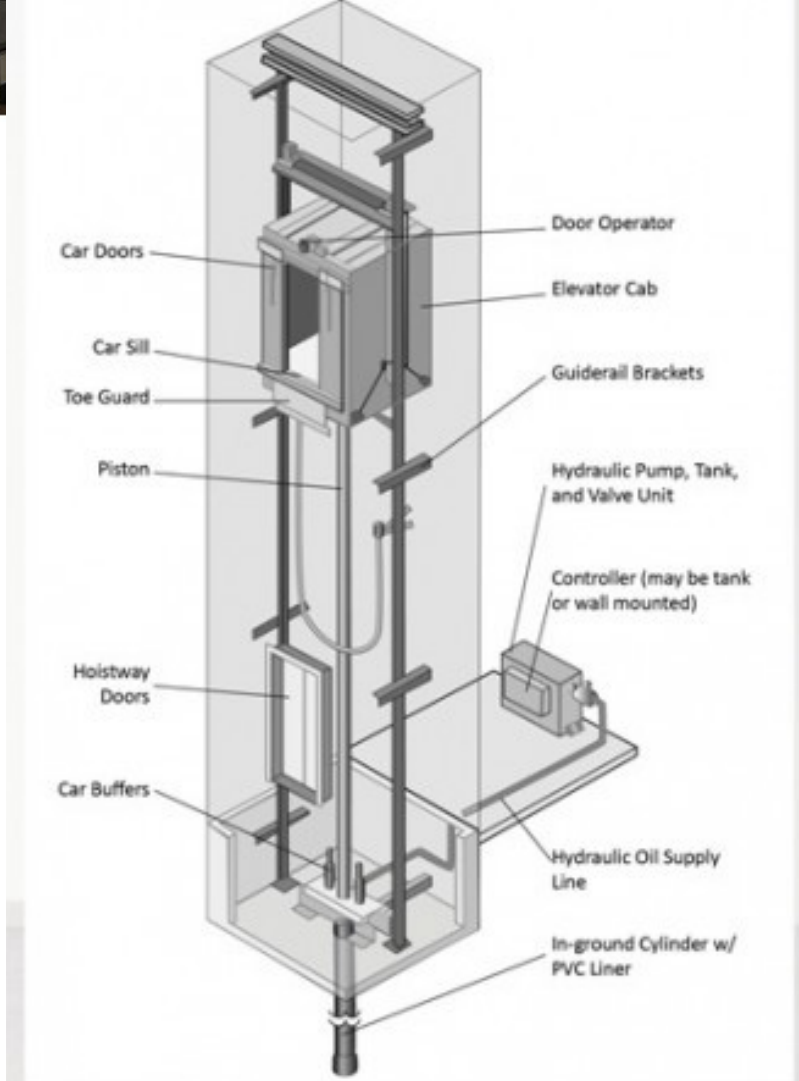
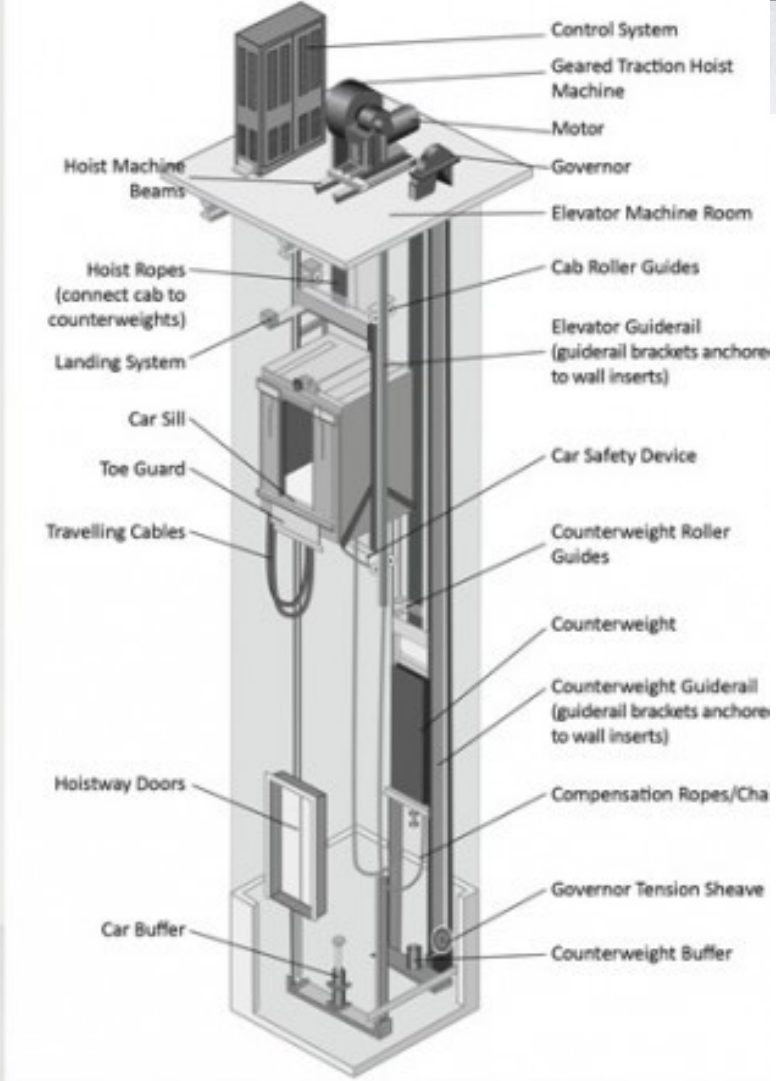
Elevator facts

- London, 1823 for tour attraction
- 6 Million units in 2002, now ??
- In 1998, estimated 1 in 12 million of elevator rides with an anomaly, vast majority minor -- doors failing to open.
- 2012 In Thailand, a woman killed in free falling elevator --"first legally recognized death caused by a falling lift“.https://en.wikipedia.org/wiki/Elevator
- Many falling accidents happened from 2008 to 2013, in Hong Kong, Taiwan and China



Hydraulic Elevators - a configuration where hydraulic cylinder(s) are used to raise and lower the car. Hydraulic systems are typically limited to buildings that are three stories tall or shorter.



Traction Elevators - a motor driven configuration where cables are attached to the car and looped over a drive sheave to a counterweight. The counterweight is located in the hoistway and rides a separate rail system.

- http://www.robsonforensic.com/articles/elevator-anatomy-schematic-of-traction-hydraulic-elevator-systems

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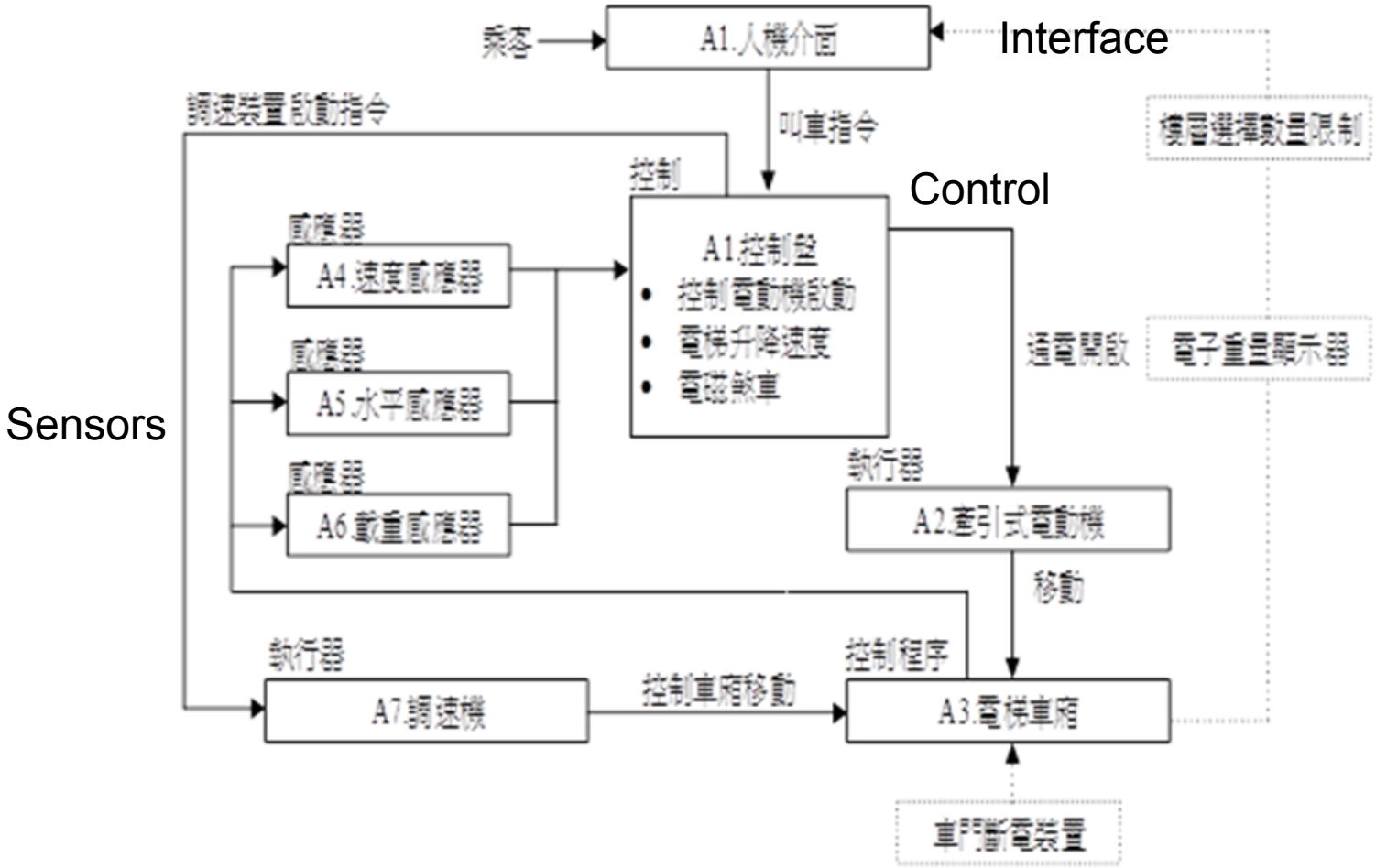
Simplified model



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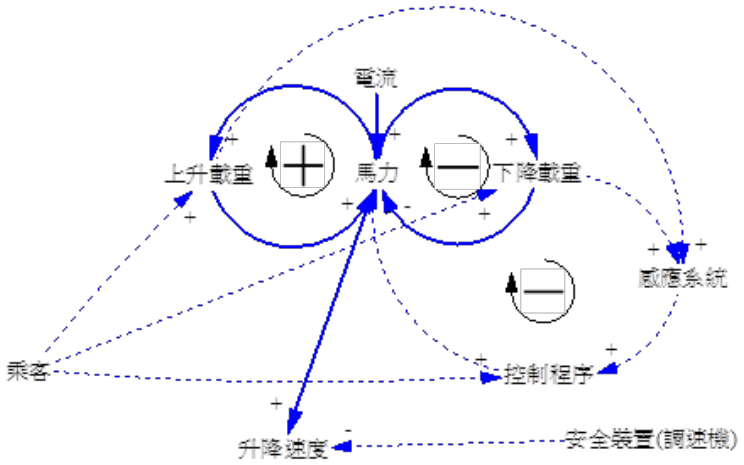
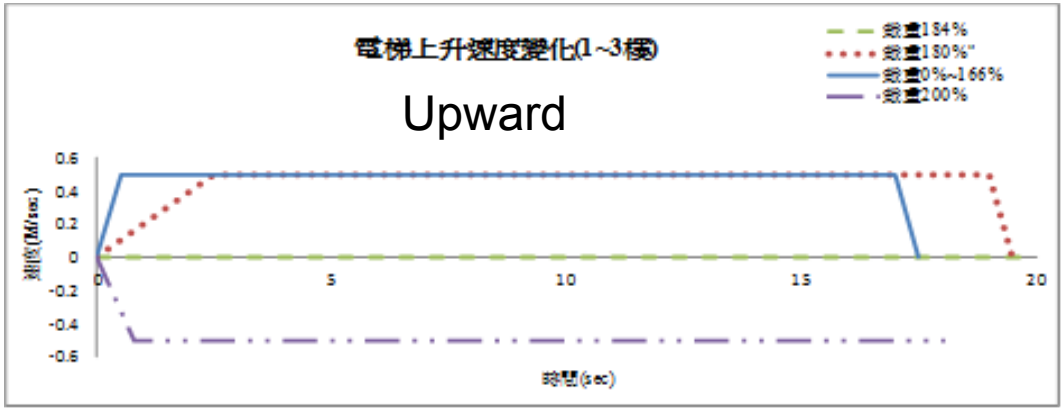
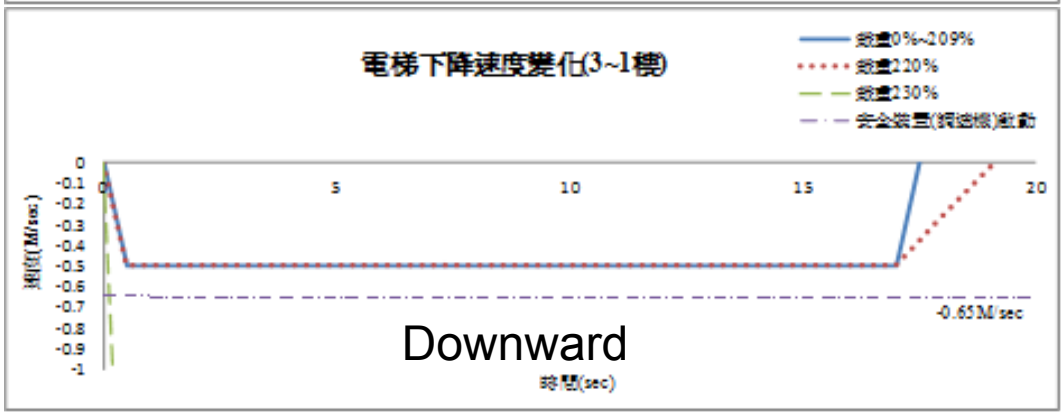
Causal Loops and Vensim Simulation







Regulation: First Brake (Electronic) on 130% designed operation speed
Second Brake (Mechanic) on 140 %

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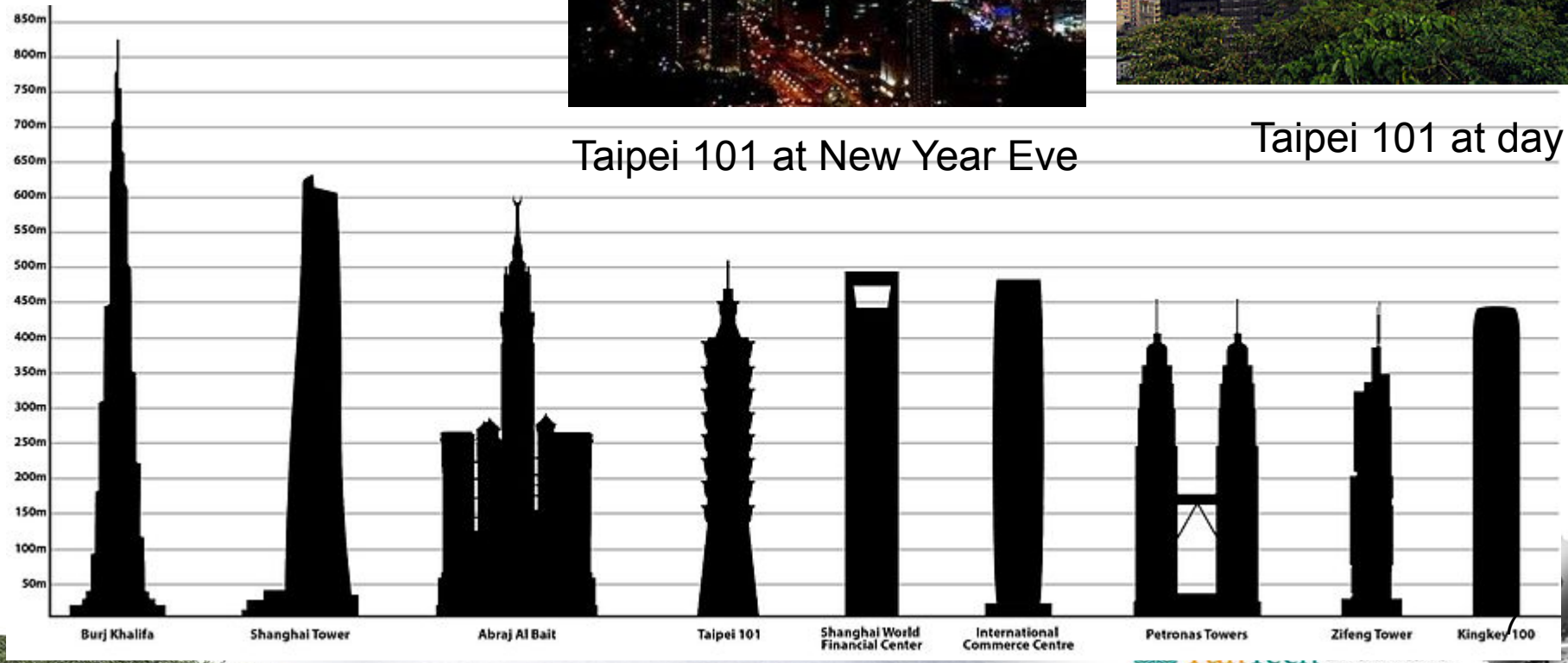
Taller Building



Taipei 101 at New Year Eve



Taipei 101 at day



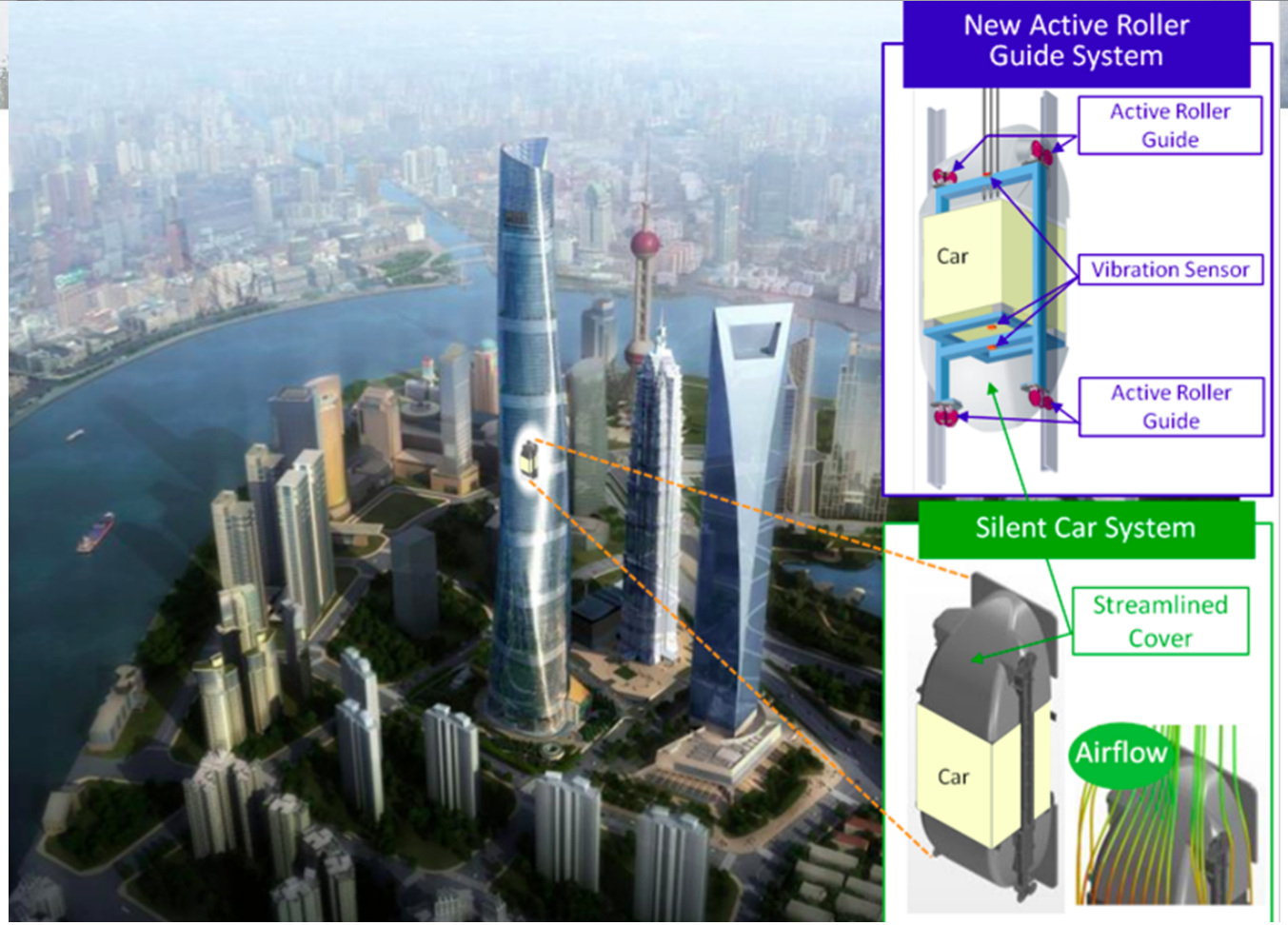
Fastest Elevators?

- 5 to 89 th floor at 37.7mph (60.3 km/h).
- http://gizmodo.com/322557/taipei-101-elevator-fastest-in-the-world









- Shanghai Tower by Mitsubishi's new elevator
- maximum speed of 1,080 m/s (64 km/h)
- Other high speed elevators from Halifa Tower (64 km/h) and Guangzhou CTF Finance Center (72 km/h)

Future Development

- Use STPA to analyze high speed elevators.
- Develop more scenarios on elevator hazards
- Relate sensors to leading indicators and regulations
- Provide the criteria for maintenance and part replacement
- Apply to more engineering examples, such as Wastewater Treatment Plants (100s in Taiwan, 1000s in China in the future)