UNIVERSITÄT DUISBURG ESSEN

Open-Minded

Risk, Reliability, and Uncertainty in Infrastructure Systems

(ความเสี่ยง ความน่าเชื่อถือ และความไม่แน่นอนในระบบโครงสร้างพื้นฐาน)

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Based on the doctoral dissertation "Uncertainty in Reliability Evaluation: A Framework and Practical Case Studies" of the same author

Background (ความเป็นมา)

- Fundamental changes in Thai economics
  - International fund flow
  - Infrastructure funds
  - 2 trillion Baht infrastructure investment
- Lack of risk, reliability, and uncertainty research
- Proposal of a reliability engineering framework

Infrastructure Systems (ระบบโครงสร้างพื้นฐาน)

- Guideline from Capital Market Supervisory Board (คณะกรรมการกำกับตลาดทุน) *
  1. Public Property
  2. Public Service






* http://capital.sec.or.th/webapp/nrs/nrs_search.php?chk_frm=1&ref_id=99&cat_id=1233

Failures (ความล้มเหลว)

- Public → Large-scale system
- High severity failure
- Infrastructure system reliability evaluation

Reliability (ความน่าเชื่อถือ)

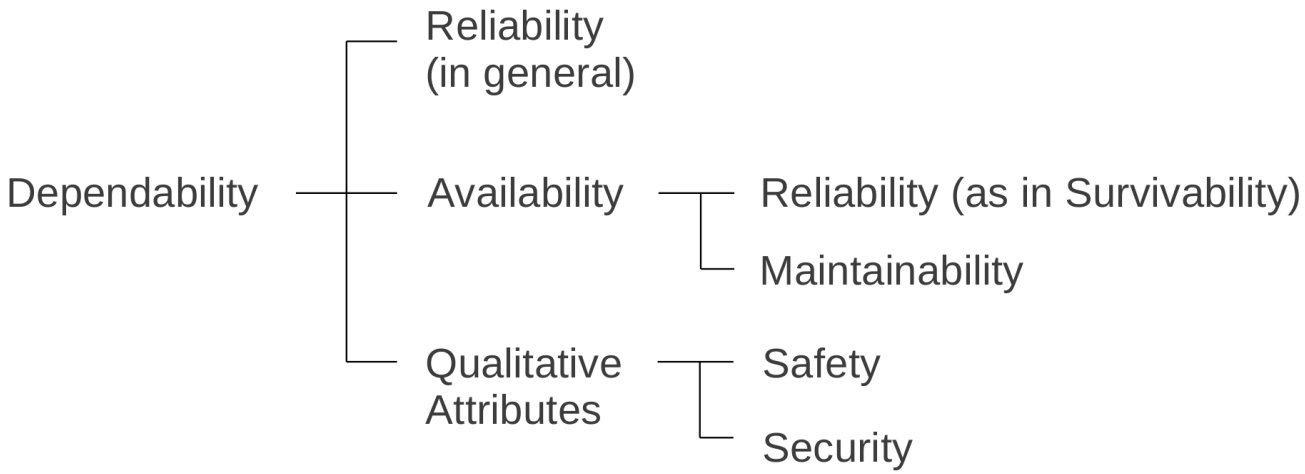
- **Reliability (ความน่าเชื่อถือ)**
  - Survivability
  - When does it fail to perform a required function?

MTTF = 12 months
Pr(Fail, 12 months)
$= 1-e^{-1} = 63\%$

- **Availability (ความพร้อมใช้งาน)**
  - Reliability + Maintainability
  - Is it available of service at a specific time?

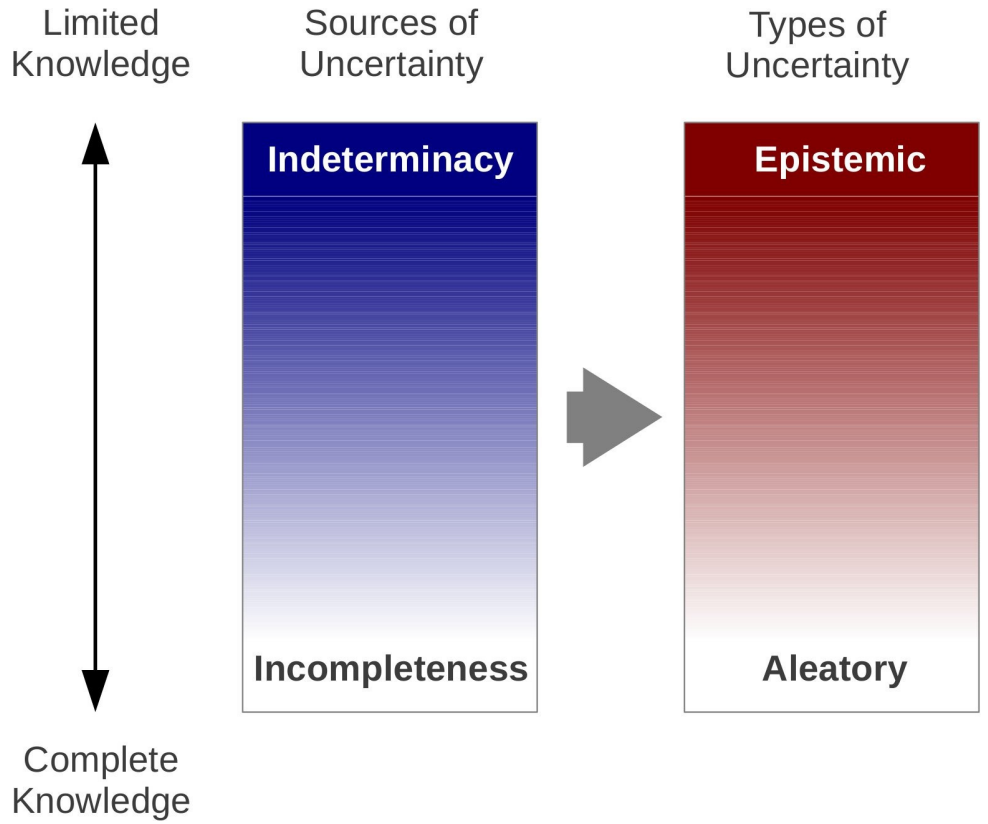
MTTF = 12 months
MTTR = 1 month
Availability = 12/13 = 92%

- **Dependability (ความวางใจได้)**
  - Reliability + Availability + Qualitative Attributes



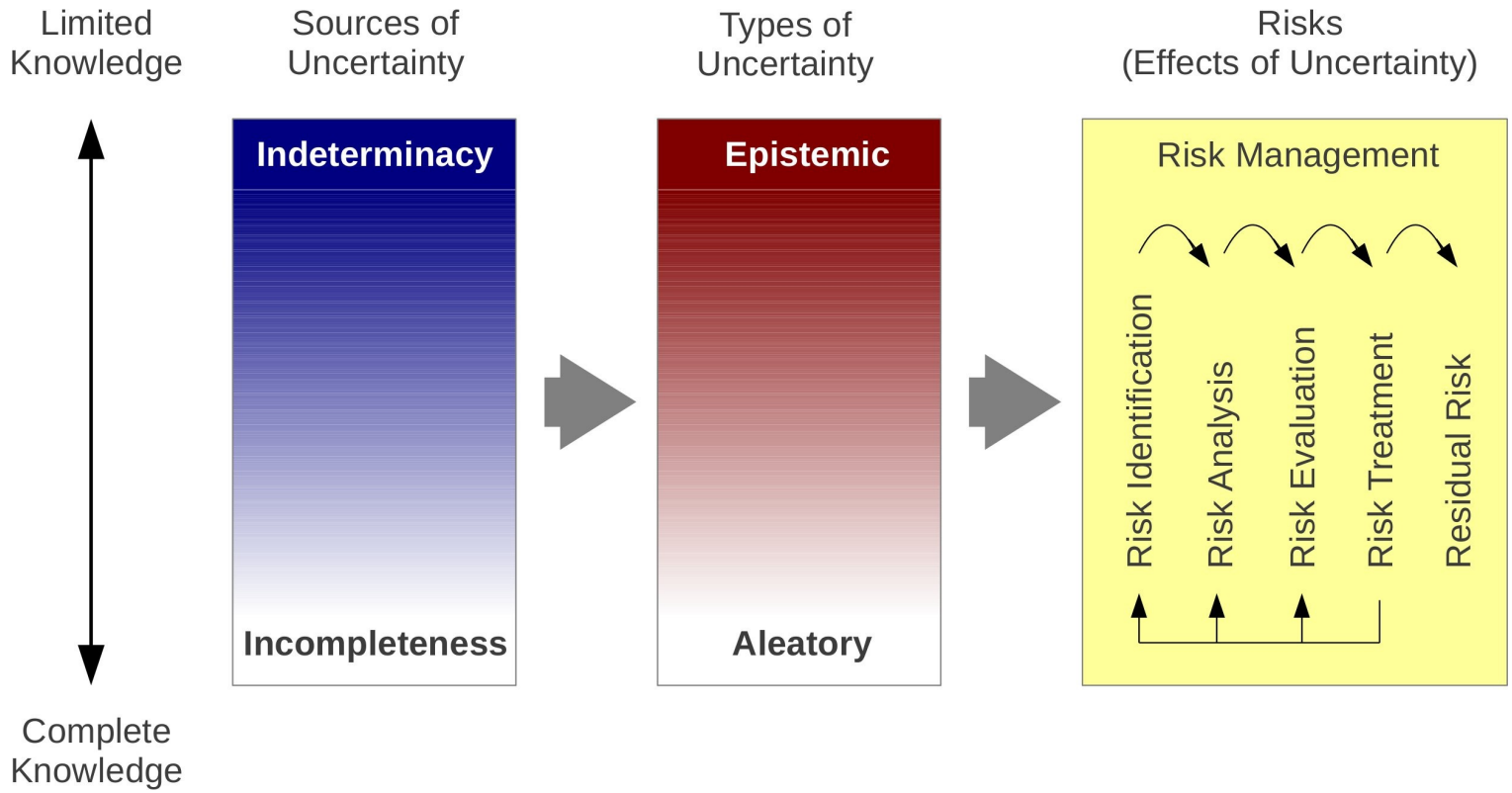
Uncertainty (ความไม่แน่นอน)

- Categorization by Types
  - Aleatory (Irreducible)
  - Epistemic (Reducible)
- Categorization by Sources [Walley 1991]
  - Indeterminacy
  - Incompleteness

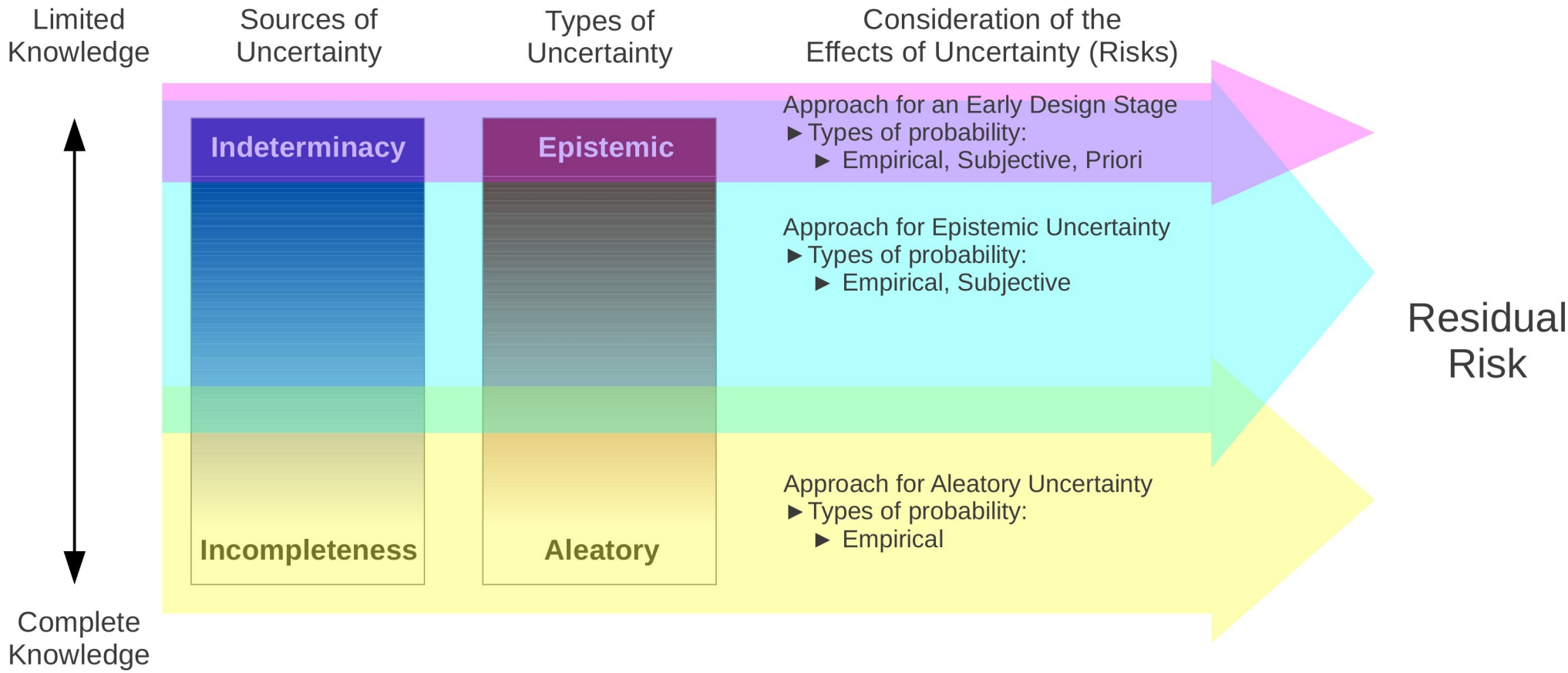


Risk (ความเสี่ยง)

- **Risk (ความเสี่ยง)**
  effect of uncertainty on objectives [ISO 31000 2009, ISO Guide 73 2009]
- **Risk management (การจัดการความเสี่ยง)**
  coordinated activities to direct and control an organization with regard to risk [ISO 31000 2009, ISO Guide 73 2009]

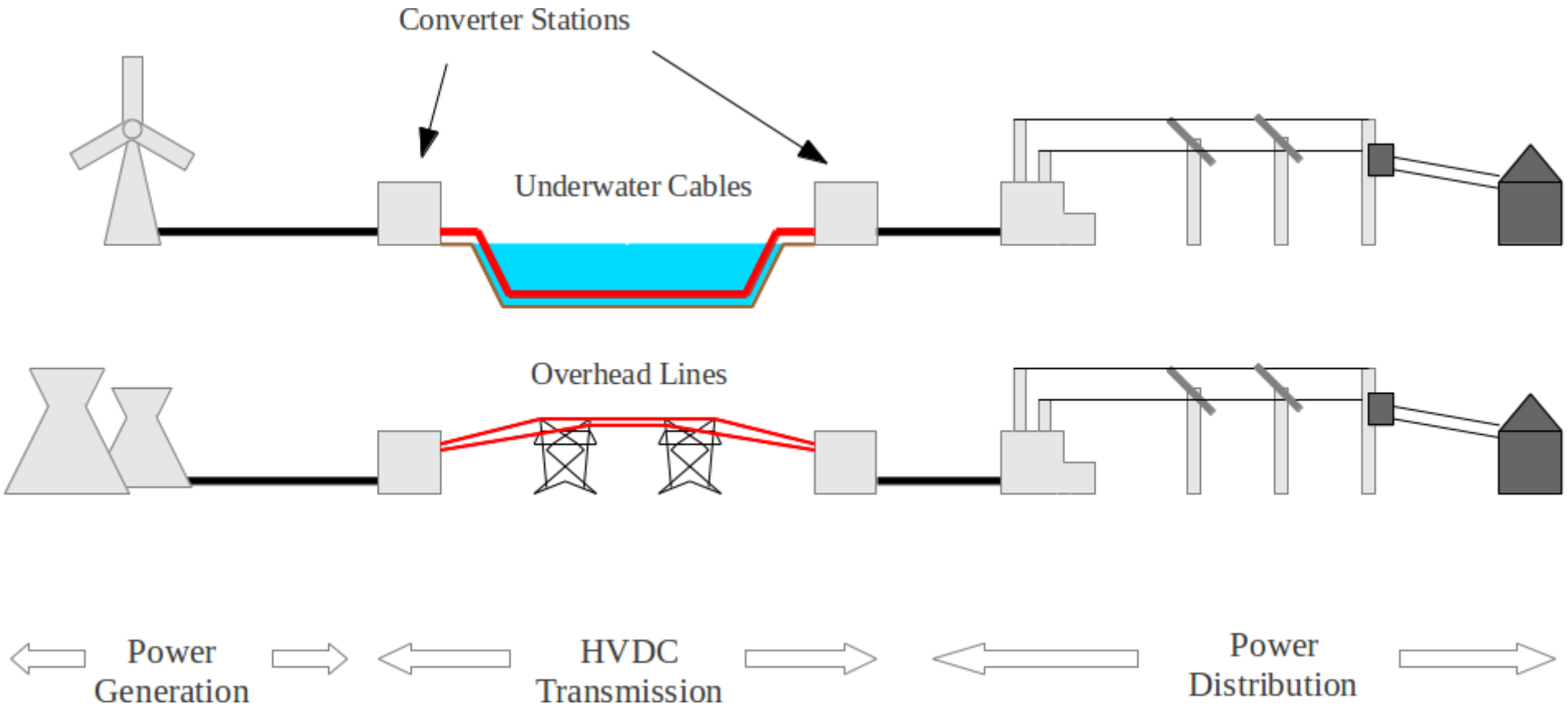


Reliability Evaluation Framework (กรอบความคิดของการประเมินความน่าเชื่อถือ)



Case Study: HVDC Converter Station

- Overview of Electrical Power System



Case Study: HVDC Converter Station

- Example of Lifetime Data: Square Butte HVDC

Data Year	AC-E		V		C&P		DC-E		O		Total Operating Time (h) *
	No. of Failures	Time to Repair (h)	No. of Failures	Time to Repair (h)	No. of Failures	Time to Repair (h)	No. of Failures	Time to Repair (h)	No. of Failures	Time to Repair (h)	
2001	5	25.6	0	0	1	0.1	3	7.8	1	5.6	8720.9
2002	5	5.9	1	13.2	1	0	1	33.9	0	0	8707
2003	2	1.7	3	5.8	4	0.1	0	0	1	0.2	8752.2
2004	9	38.7	0	0	7	6.8	3	4.3	0	0	8710.2
2005	2	23.8	3	8.6	2	2.7	0	0	1	40.3	8684.6
2006	0	0	1	0.6	1	2.5	2	5.6	1	2	8749.3
Total	23	95.7	8	28.2	16	12.2	9	51.6	4	48.1	52324.2

* 24-hour operation in 365 days minus the total of time to repair

Case Study: HVDC Converter Station

- Approach 1: Aleatory Uncertainty

β = 1.0 (exponential)	$Ti(U_S)$	$Ti(D_S)$	$Pr(U_S)$	$Pr(D_S)$	$Fr(U_S)$	$Fr(D_S)$
mean	8.72E+02	3.94E+00	9.96E-01	4.50E-03	1.14E-03	1.14E-03

conventional calculation method (approximated)

β = 1.0 (exponential)	$t(U_S)$	$t(D_S)$	$Pr(U_S)$	$Pr(D_S)$	$Fr(U_S)$	$Fr(D_S)$
$min_{10\%}$	9.21E+01	2.17E-01	9.03E-01	1.08E-04	4.97E-04	9.80E-03
mean	8.75E+02	3.94E+00	9.96E-01	4.48E-03	1.14E-03	1.14E-03
$max_{90\%}$	2.01E+03	9.94E+00	1.00E+00	9.74E-02	9.80E-03	4.97E-04

simulation | min-max calculation

Case Study: HVDC Converter Station

- ## Approach 2: Epistemic Uncertainty

System	AC-E		V		C&P		DC-E		O		Total Operating Time (h) *
	No. of Failures	Time to Repair (h)	No. of Failures	Time to Repair (h)	No. of Failures	Time to Repair (h)	No. of Failures	Time to Repair (h)	No. of Failures	Time to Repair (h)	
Square Butte	18	70.1	8	28.2	15	12.1	6	43.8	3	42.5	52324.2
Vancouver Island Pole 2	16	51.7	4	31.2	8	45.3	4	8.5	8	12.4	52410.9

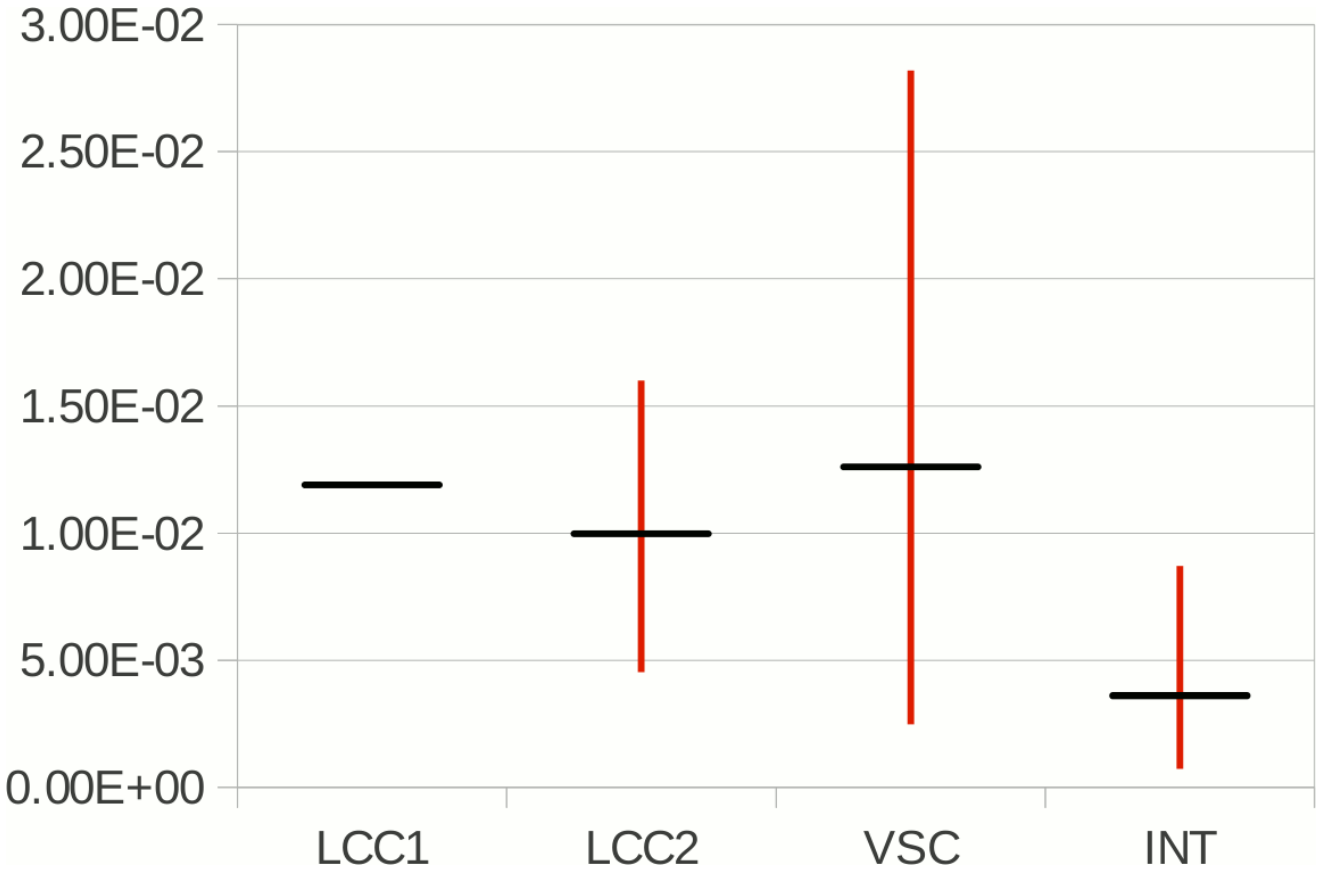
* 24-hour operation in 365 days minus the total of time to repair

Simulation Results							
Measure	Index	$Ti(U_s)$	$Ti(D_s)$	$Pr(U_s)$	$Pr(D_s)$	$Fr(U_s)$	$Fr(D_s)$
Central Tendency	Arithmetic Mean	1.23E+03	4.36E+00	9.96E-01	3.56E-03	8.16E-04	8.16E-04
	Median	1.23E+03	4.35E+00	9.96E-01	3.52E-03	8.13E-04	8.13E-04
Location	80% Confidence						
	- $Min_{10\%}$	1.12E+03	3.57E+00	9.96E-01	2.86E-03	7.49E-04	7.49E-04
	- $Max_{90\%}$	1.33E+03	5.17E+00	9.97E-01	4.31E-03	8.87E-04	8.87E-04
Dipersion	Variance	6.18E+03	3.77E-01	3.16E-07	3.18E-07	2.76E-09	2.76E-09
	S.D.	7.86E+01	6.14E-01	5.63E-04	5.64E-04	5.25E-05	5.25E-05
	Skewness	2.30E-02	1.06E-01	-3.56E-01	3.57E-01	2.79E-01	2.79E-01
	Excess Kurtosis	2.55E+00	2.69E+00	2.99E+00	2.99E+00	2.69E+00	2.69E+00

Case Study: HVDC Converter Station

- Approach 3: Early Design Stage

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety



Summary (สรุปเนื้อหาสำคัญ)

- Infrastructure Systems
- Risk, Reliability and Uncertainty
  - Practical Engineering Framework
  - Case studies from infrastructure system
- Can be applied to Thailand infrastructure developments

Q / A
คำถาม / คำตอบ