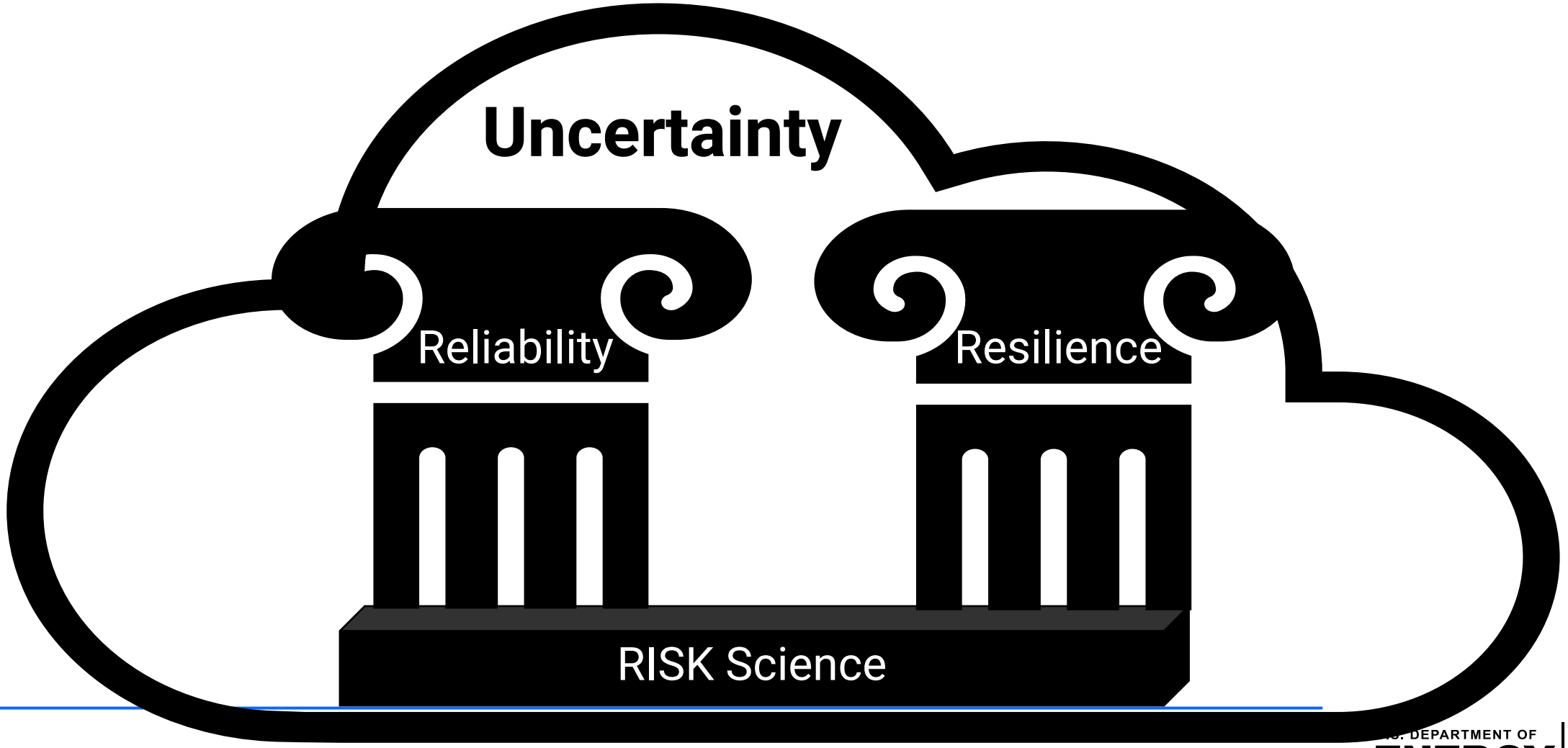
U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

THE FRONTIERS OF DECISION MAKING UNDER UNCERTAINTY IN GRID MODERNIZATION

02.13.24

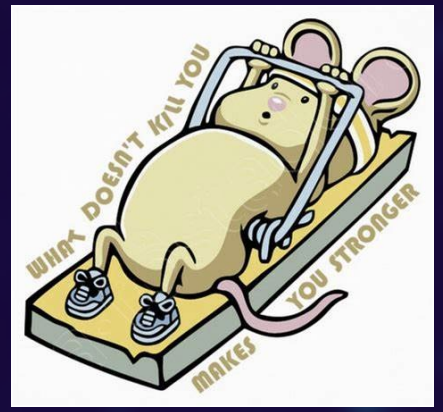
NEXT-GEN GRID



U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

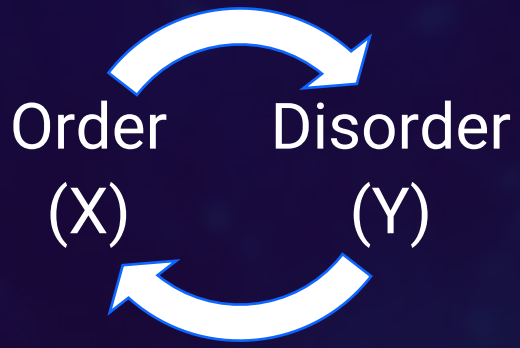
Déja vu: → Vuja Dé:

RESILIENCE

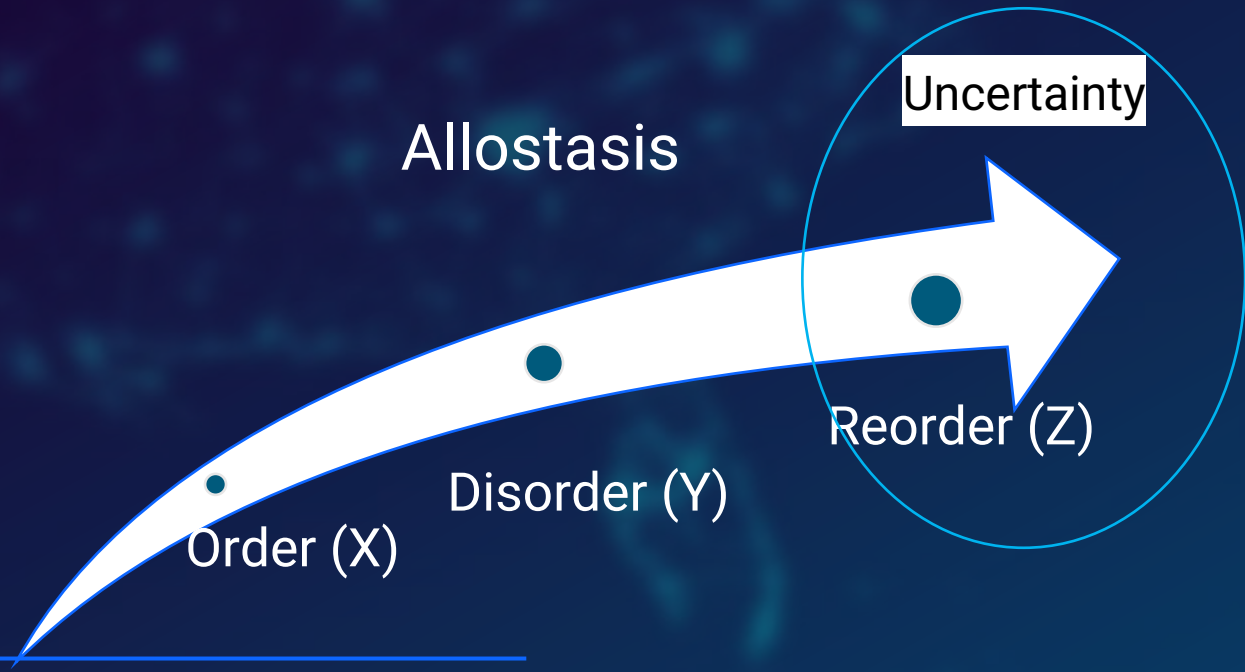


- There's no avoiding of failure
- Possibility of 'transformation'

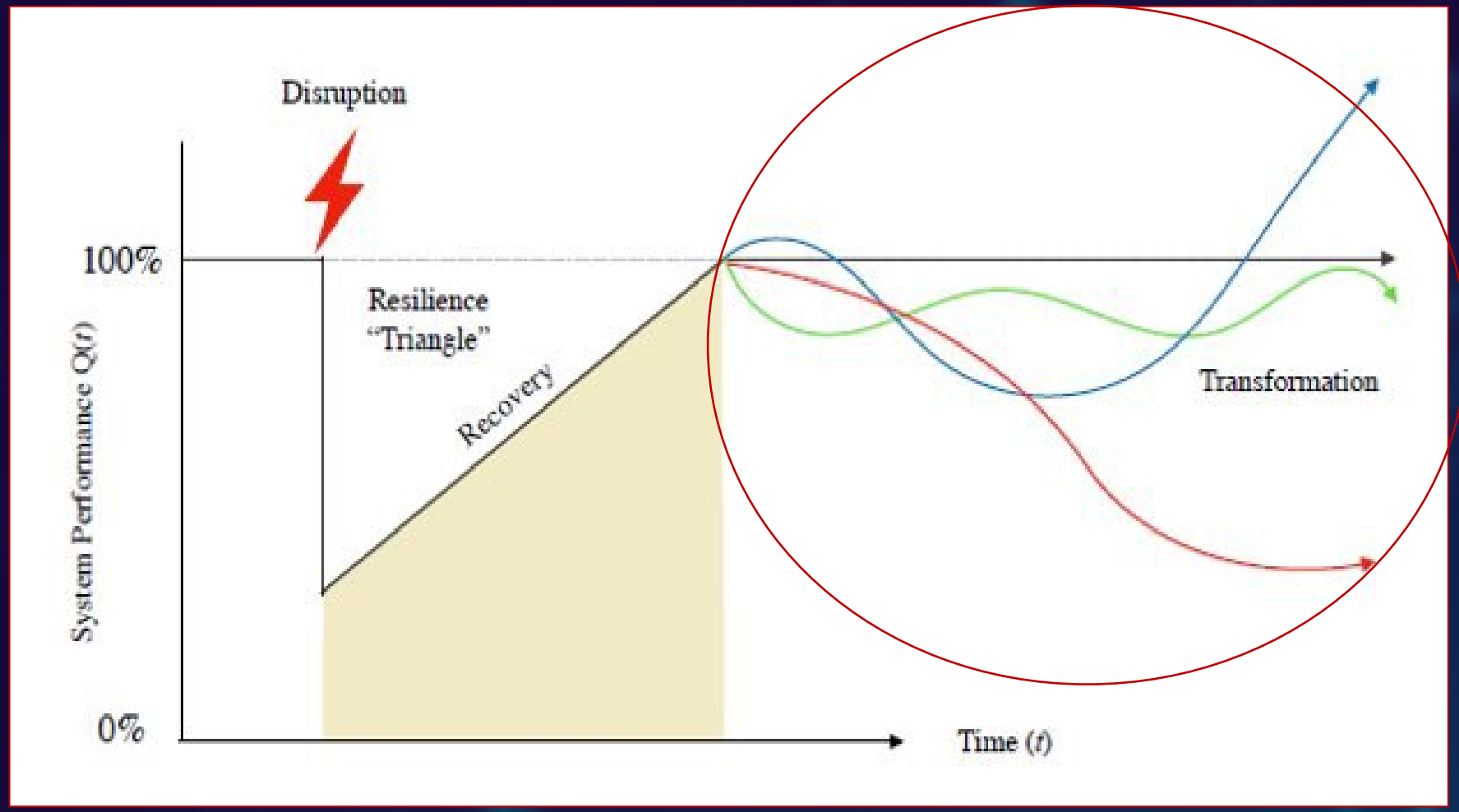
Homeostasis



Allostasis



RESILIENCE


Disruption
100%
0%
System Performance Q(t)
Resilience
"Triangle"
Recovery
Transformation
Time (t)

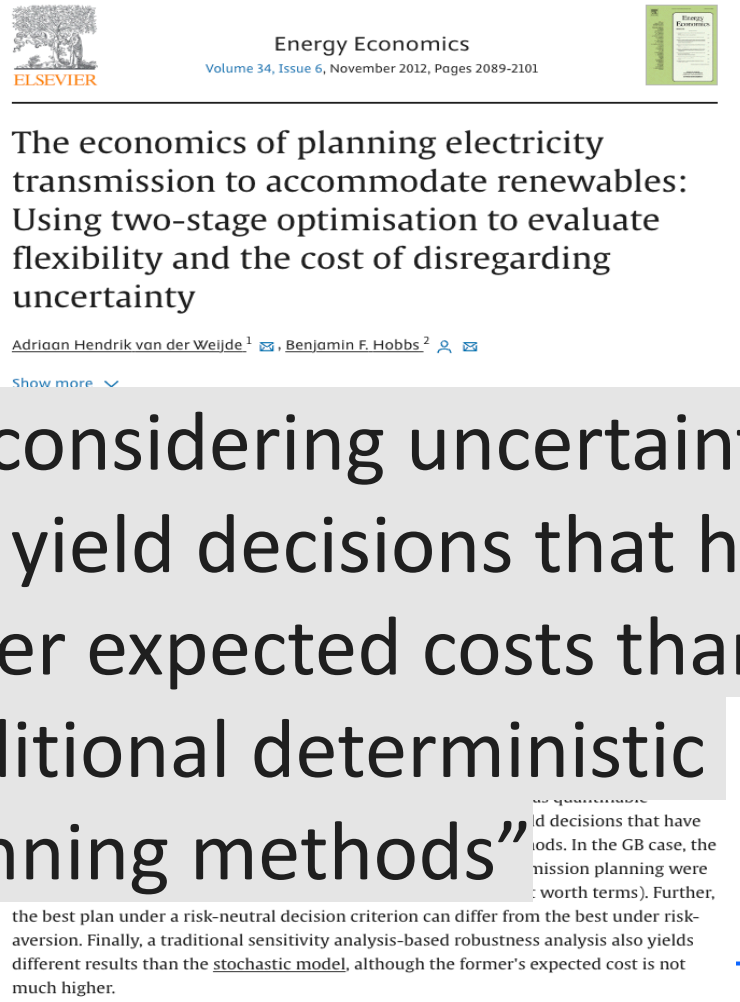
RISK ANALYSIS:

- What can go wrong?
- What are the consequences? Over what time frame?
- What is the *likelihood*?

Risk Description=

(Hazard Scenarios, Consequences, Uncertainties)$_t$

UNCERTAINTY IS NOT THE ENEMY!



ELSEVIER

Energy Economics

Volume 34, Issue 6, November 2012, Pages 2089-2101

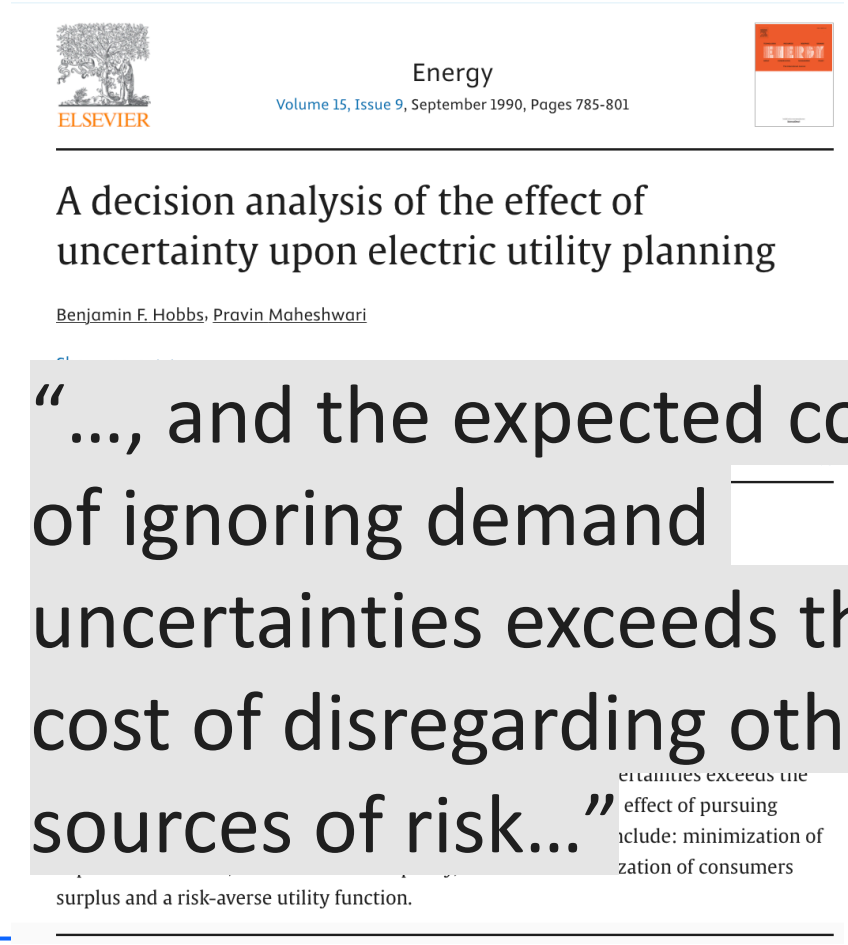
The economics of planning electricity transmission to accommodate renewables: Using two-stage optimisation to evaluate flexibility and the cost of disregarding uncertainty

Adriaan Hendrik van der Weijde [1], Benjamin F. Hobbs [2]

Show more

d decisions that have
ods. In the GB case, the
nission planning were
worth terms). Further,
the best plan under a risk-neutral decision criterion can differ from the best under risk-aversion. Finally, a traditional sensitivity analysis-based robustness analysis also yields different results than the stochastic model, although the former's expected cost is not much higher.

"....considering uncertainty can yield decisions that have lower expected costs than traditional deterministic planning methods"



ELSEVIER

Energy

Volume 15, Issue 9, September 1990, Pages 785-801

A decision analysis of the effect of uncertainty upon electric utility planning

Benjamin F. Hobbs, Pravin Maheshwari

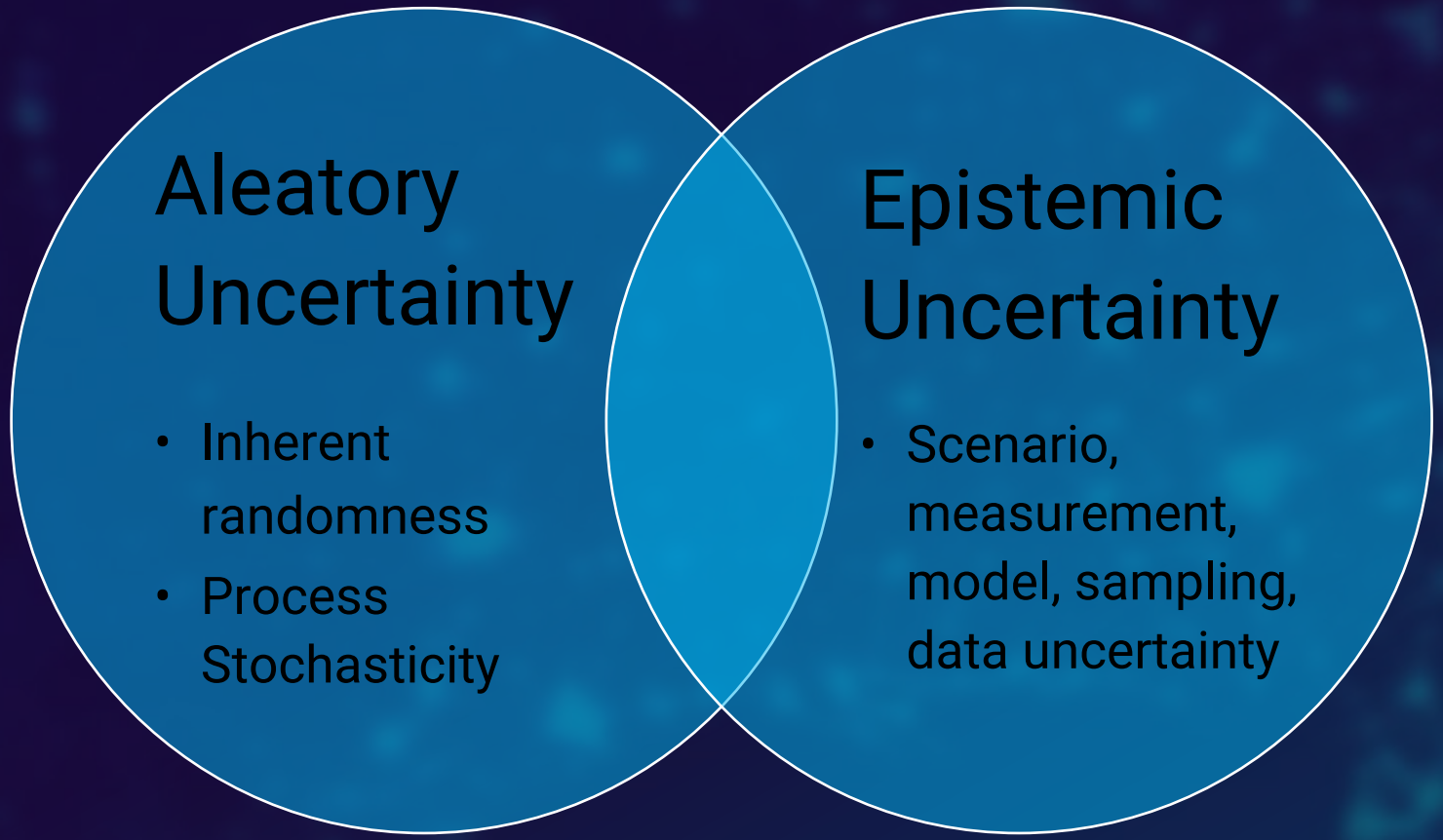
ertainties exceeds the
effect of pursuing
nclude: minimization of
zation of consumers
surplus and a risk-averse utility function.

"..., and the expected cost of ignoring demand uncertainties exceeds the cost of disregarding other sources of risk..."

WHAT IS UNCERTAINTY?

- We view uncertainty through a narrow lens!
  - Uncertainties ≠ Probabilities 
- What often don't distinguish between the sources of uncertainty?
- Lack of clarity about uncertainty (types/source, etc.) is not conducive to characterizing and bounding uncertainties…

SOURCES OF UNCERTAINTY

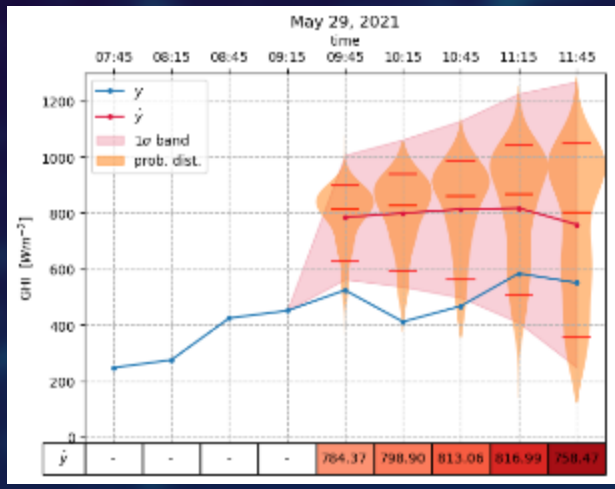


We often fail to distinguish between the types of uncertainty

SOURCES OF UNCERTAINTY

Induction Principle

Learning Algorithm



Background Knowledge

Training Data

Model

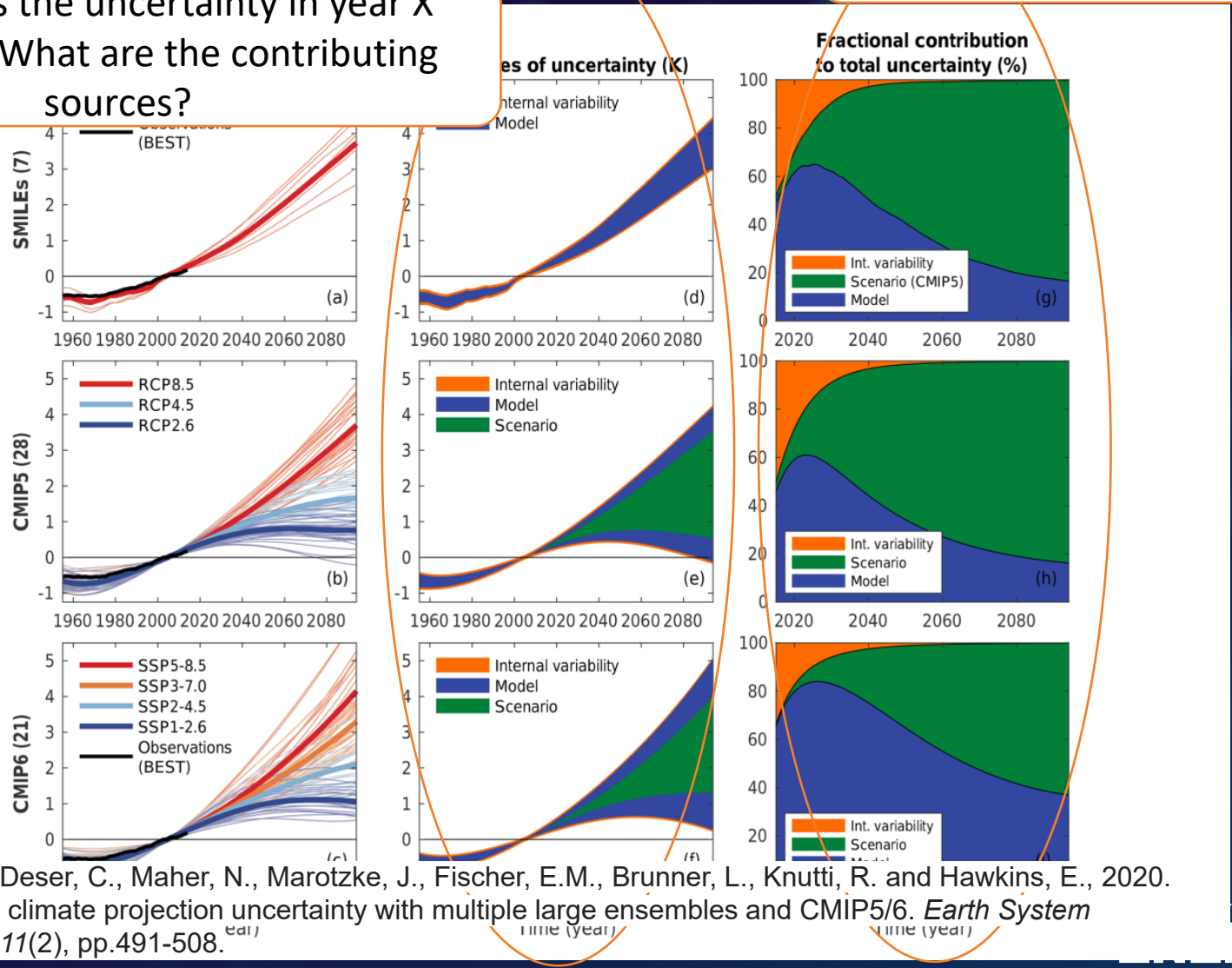
Prediction

$$Y = f(X) + \varepsilon$$

$Total\ U = Model\ U + Internal\ U + Scen$

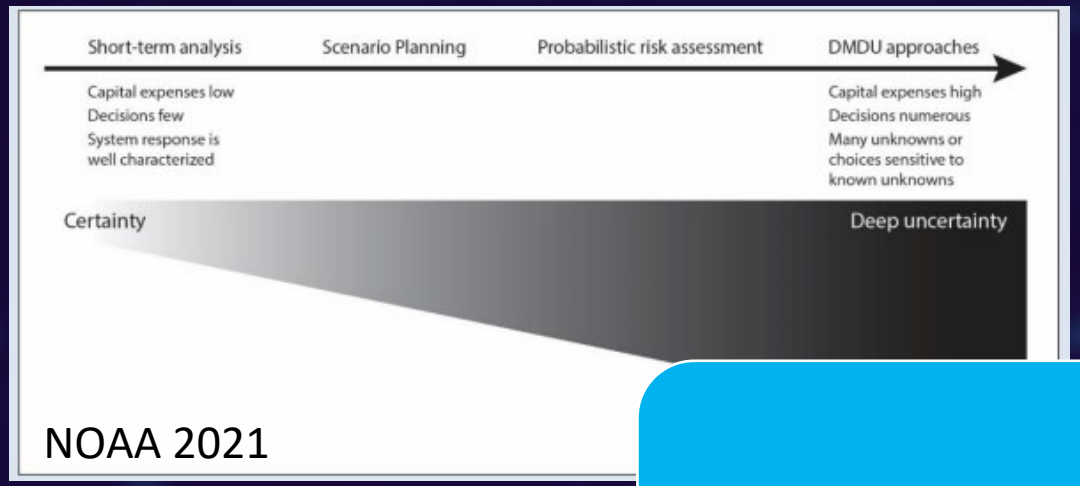
How large is the uncertainty in year X (absolute)? What are the contributing sources?

Which sources of uncertainty are critical from now until year X (relative)?



Lehner, F., Deser, C., Maher, N., Marotzke, J., Fischer, E.M., Brunner, L., Knutti, R. and Hawkins, E., 2020. Partitioning climate projection uncertainty with multiple large ensembles and CMIP5/6. *Earth System Dynamics*, *11*(2), pp.491-508.

DECISION-MAKING UNDER *DEEP* UNCERTAINTY



NOAA 2021

Decision Structuring

Analytics on 'Plausible Futures'

Scenario Discovery/Vulnerability Analytics

Tradeoff Analytics

Robust Strategy

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

CHALLENGES AND OPPORTUNITIES

Lowering long-term costs;
Conducive to more robust decisions

Fragmented & siloed academic research

Opening the floor for feedback

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

Thank you!