

# ADAPTATION & RESILIENCE

What do we mean by these concepts and why are they of particular relevance today?

RGI ENTSO-E conference  
Brussels/online, March 14, 2023

Malin Göteman  
Dept. of Electrical Engineering, Uppsala University, Sweden



**STandUP**  
*for*  
**ENERGY**

**CNDS**



UPPSALA  
UNIVERSITET

# RESILIENCE

“The capacity of the energy system and its components to cope with a hazardous event or trend, to respond in ways that maintain its essential functions, identity and structure as well as its capacity for adaptation, learning and transformation. It encompasses the following concepts: robustness, resourcefulness, recovery.”

International Energy Agency (IEA), 2015

# RESILIENCE

“The capacity of the energy system and its components to **cope** with a hazardous event or trend, to respond in ways that **maintain its essential functions**, identity and structure as well as its capacity for **adaptation, learning** and **transformation**. It encompasses the following concepts: **robustness, resourcefulness, recovery.**”

International Energy Agency (IEA), 2015



# RESILIENCE vs



## Energy security

Reliable, affordable access to all fuels and energy sources

## Stability

Invariant under perturbations

## Reliability

High probability events, average disruption indices

## Robustness

Ability to withstand stress without losing its system functionality

## Sustainability

Capability of being maintained (ecologically, for future generations)

## Vulnerability

Exposure to hazards

## Resistance

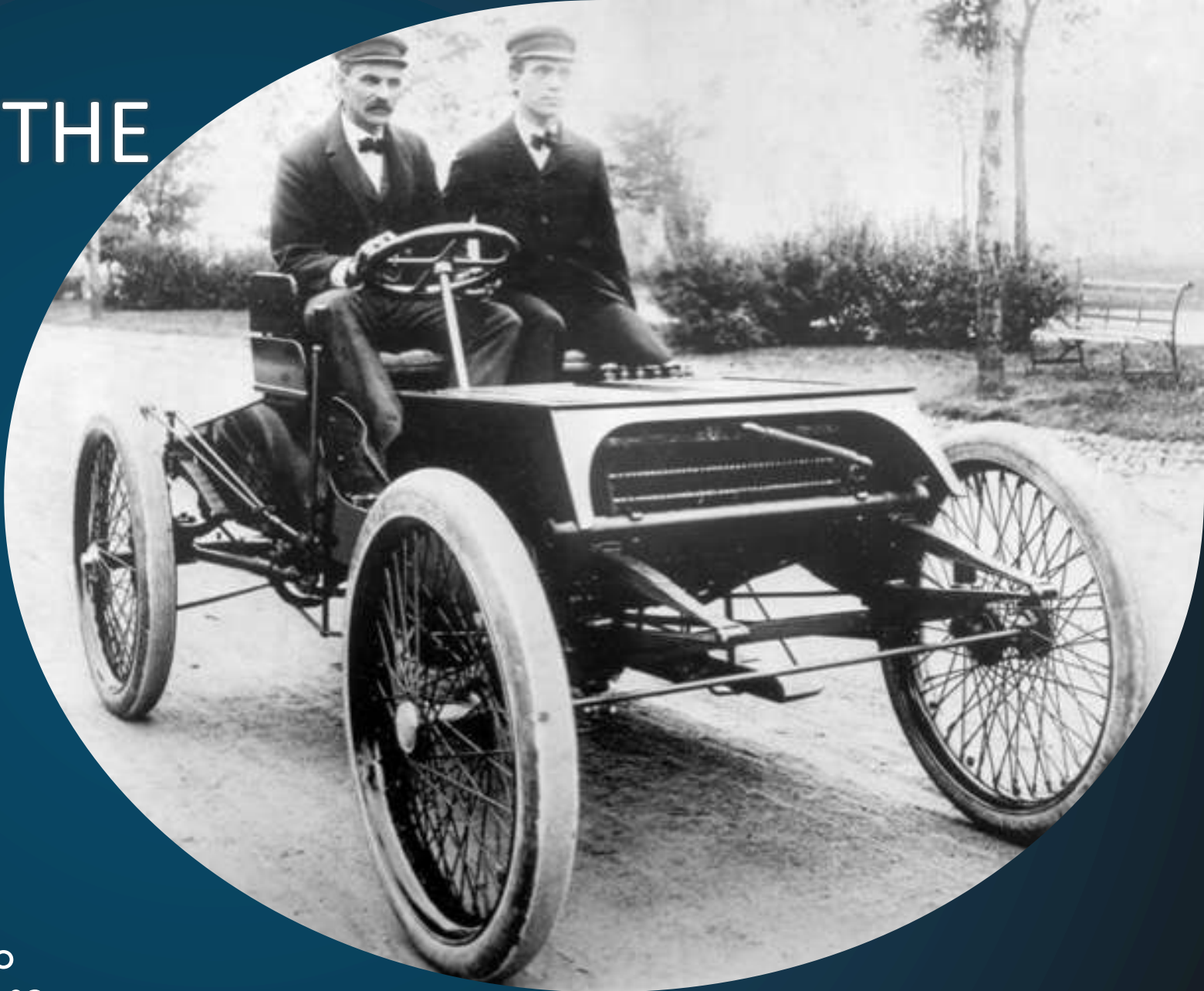
Ability to stay functional

WHY RESILIENCE?

# CAN WE PREDICT THE FUTURE?

“The horse is here to stay but the automobile is only a novelty—a fad”

The president of Michigan Savings Bank to Henry Ford's lawyer Horace Rackham, 1903



# CAN WE PREDICT THE FUTURE?

“Electricity is just a fad.”



Junios Morgan to his son J.P. Morgan, who had hired Thomas Edison to install electricity in his mansion, 1881



# CAN WE PREDICT THE FUTURE?

“There is not the slightest indication that nuclear energy will ever be obtainable. It would mean that the atom would have to be shattered at will.”

Albert Einstein, 1932





# CAN WE PREDICT THE FUTURE?

“I think there is a world market for maybe five computers.”



Thomas Watson, chairman of IBM, 1943

# CAN WE PREDICT THE FUTURE?

“There is no reason for any individual to have a computer in his home.”



Ken Olson, president, chairman and founder of Digital Equipment Corporation (DEC), 1977



# CAN WE PREDICT THE FUTURE?

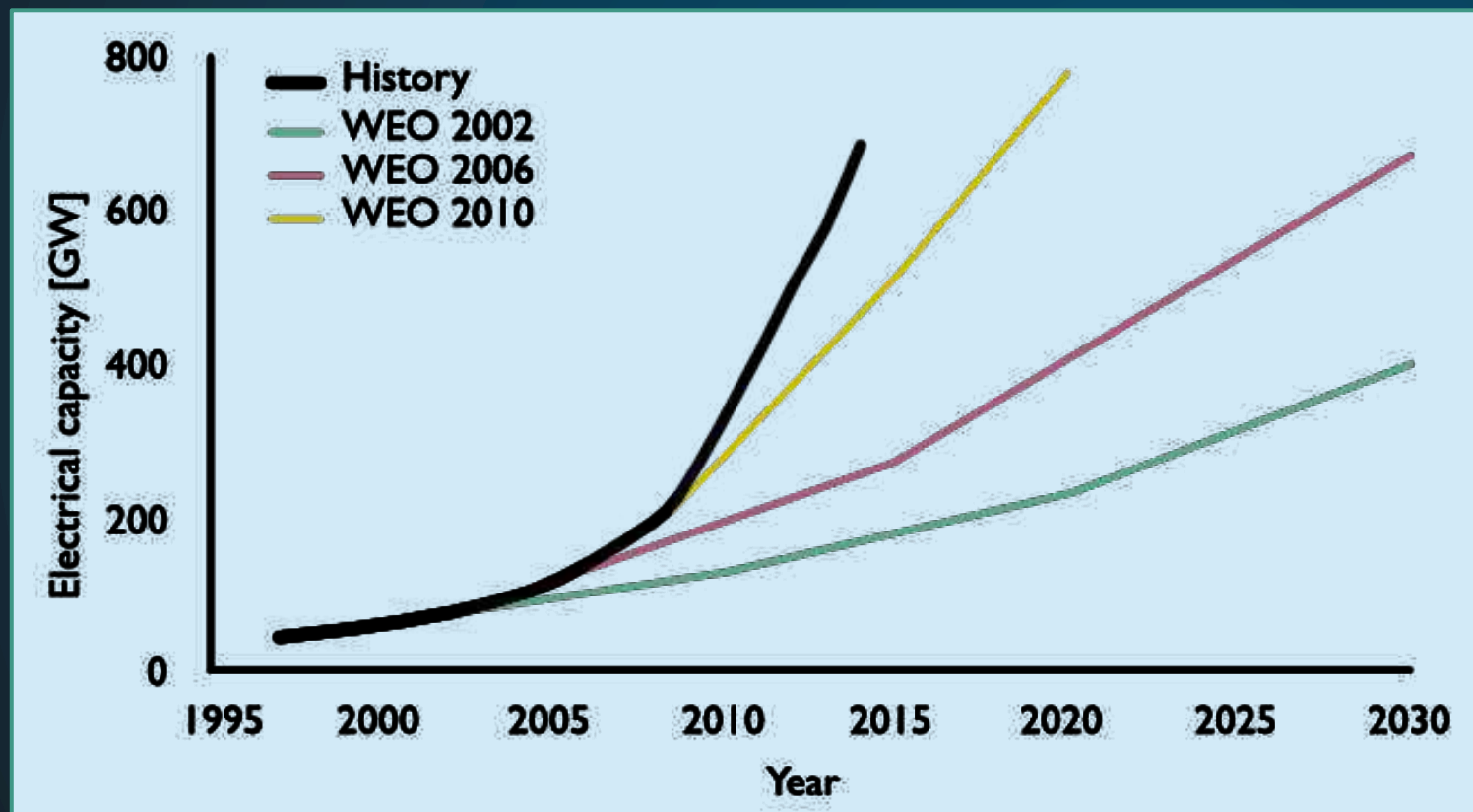


“There’s no chance that the iPhone is going to get any significant market share. No chance.”

Steve Ballmer, the CEO of Microsoft, 2007



# CAN WE PREDICT THE FUTURE?



Projections by World Energy Outlook (IEA) on installed capacity of renewables

# WHY RESILIENCE AND WHY TODAY

- Society and the energy system are changing
- Dependency on a secure energy supply increasing





# WHY RESILIENCE AND WHY TODAY

“The point is to build systems that will be safe when they fail, not to try to build fail-safe systems.”

Brian Walker, CSIRO and Stockholm Resilience Centre





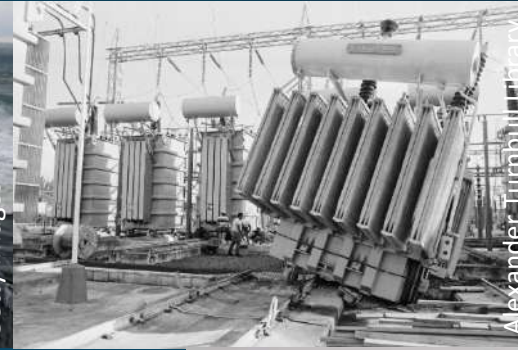
RESILIENT... TO WHAT?

# THREATS

- Natural (weather, geological, space)



Getty Images



Alexander Turnbull Library



AP file photo



Zhang et al. (2023)



Canadian History Ehx

# THREATS

- Natural (weather, geological, space)
- Malicious (hostile attacks, geopolitical events)



Getty Images



Alexander Turnbull Library



AP file photo



Zhang et al. (2023)



Canadian History Ehx



NPR



Reuters



# THREATS

- Natural (weather, geological, space)
- Malicious (hostile attacks, geopolitical events)
- Accidental (equipment failure, human factor)
- Systemic (system transformations, interdependencies)



Getty Images



Alexander Turnbull Library



AP file photo



Zhang et al. (2023)



Canadian History Ehx



NPR




Reuters



Anders Nilsson, NyTeknik

# THREATS

- Natural (weather, geological, space)
- Malicious (hostile attacks, geopolitical events)
- Accidental (equipment failure, human factor)
- Systemic (system transformations, interdependencies)



Threat  
landscape  
is *changing*

Energy systems  
Societal dependencies  
Threat landscapes

are changing → Increased  
*frequency* and/or  
*severity* of  
disruptions?





# FUTURE DIRECTIONS



**RESILIENCE.** The capacity of the energy system and its components to **cope** with a hazardous event or trend, to respond in ways that **maintain its essential functions**, identity and structure as well as its capacity for **adaptation, learning** and **transformation**. It encompasses the following concepts: **robustness, resourcefulness, recovery**.

# THANK YOU!



UPPSALA  
UNIVERSITET

CNDS

STandUP  
for  
ENERGY

