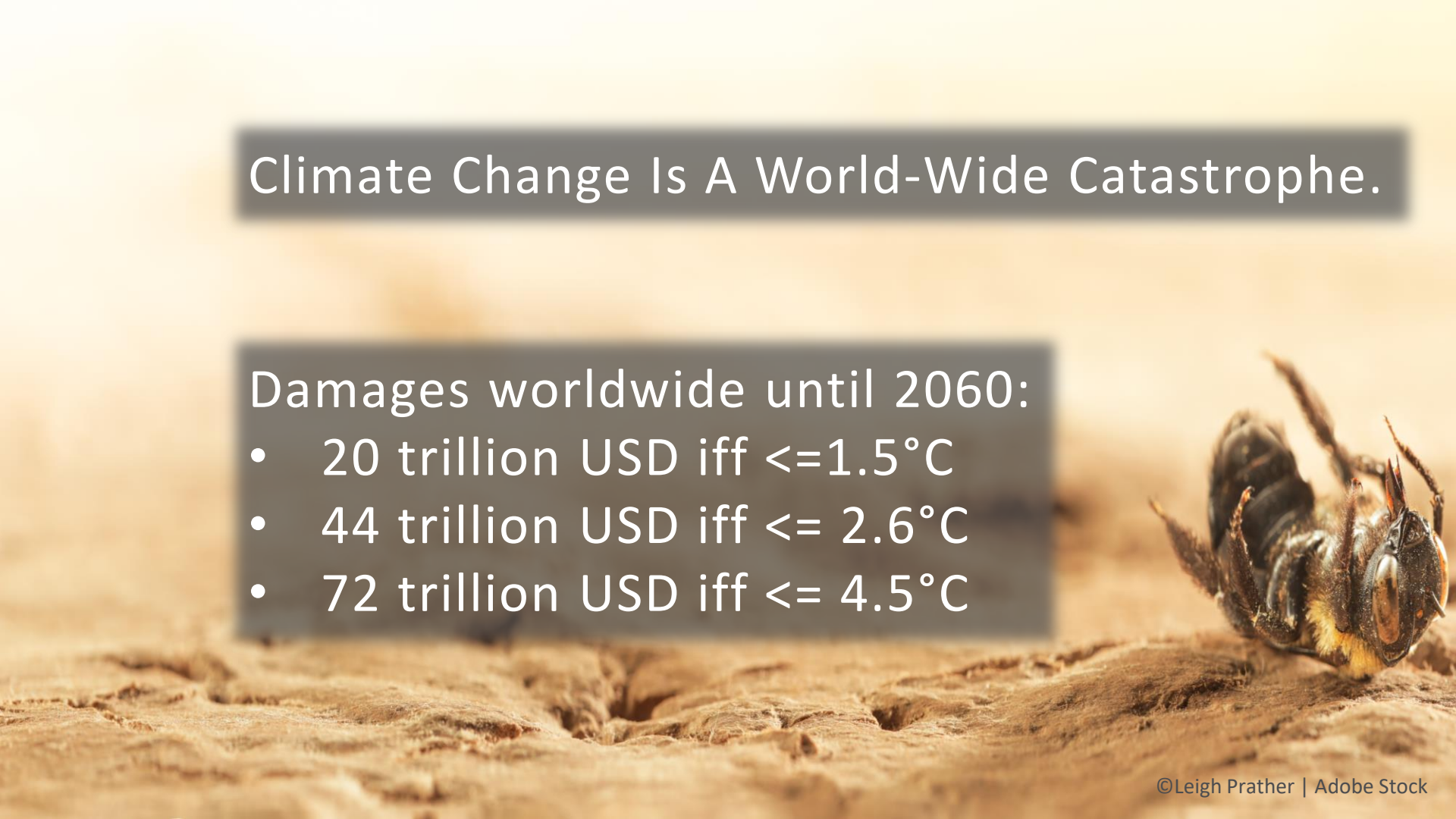
# Climate Change Is A World-Wide Catastrophe.

Damages worldwide until 2060:

- 20 trillion USD iff <=1.5°C
- 44 trillion USD iff <= 2.6°C
- 72 trillion USD iff <= 4.5°C



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# GREEN 2021 Conference
# AI vs Climate Change

## How AI Creates Resilient and Efficient Planning & Design for Green Renovation Projects

> Lasse Hammer – OFFIS e.V.

# Outline

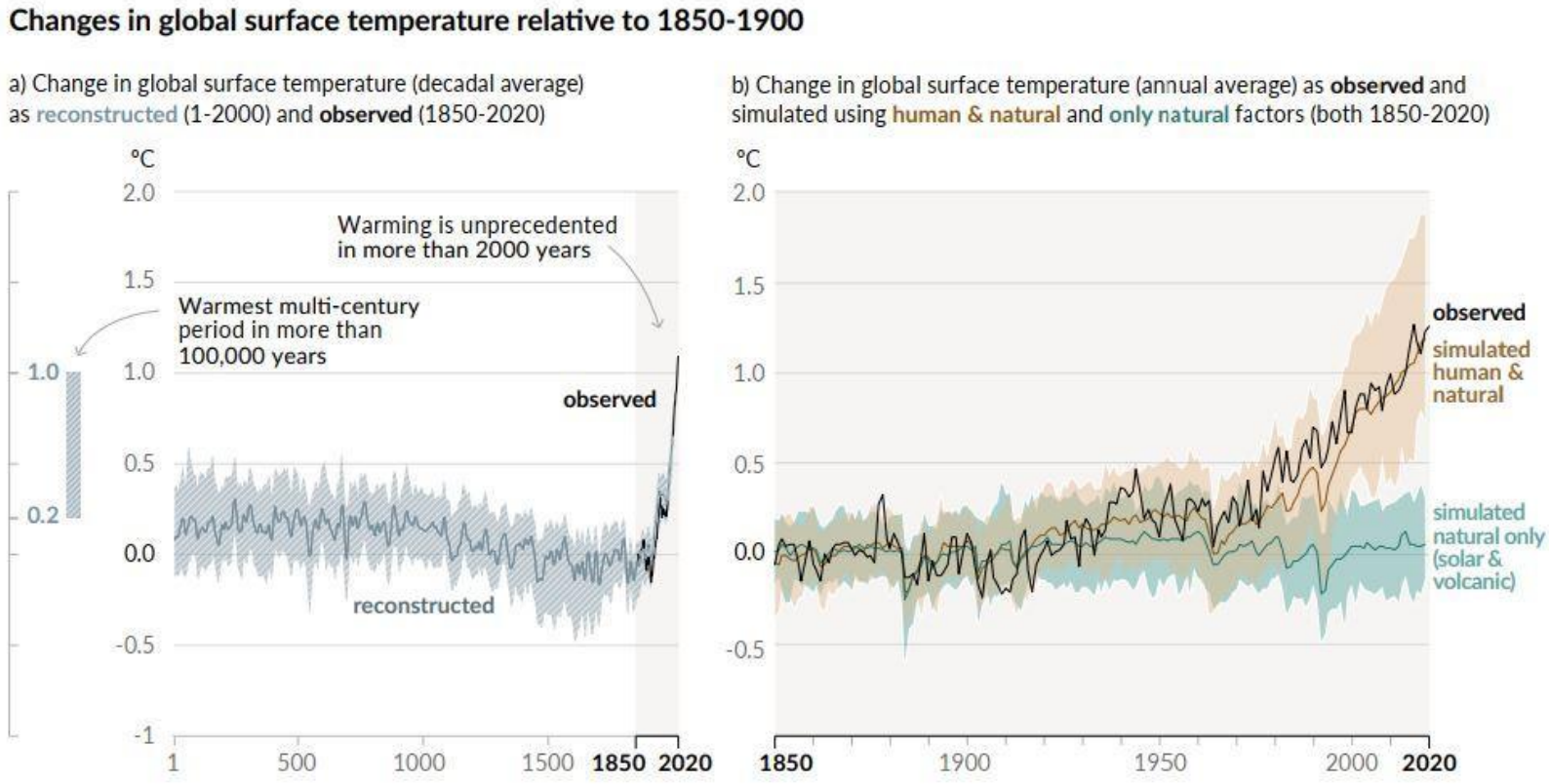
**Status Quo**

**RenovAIte Project**

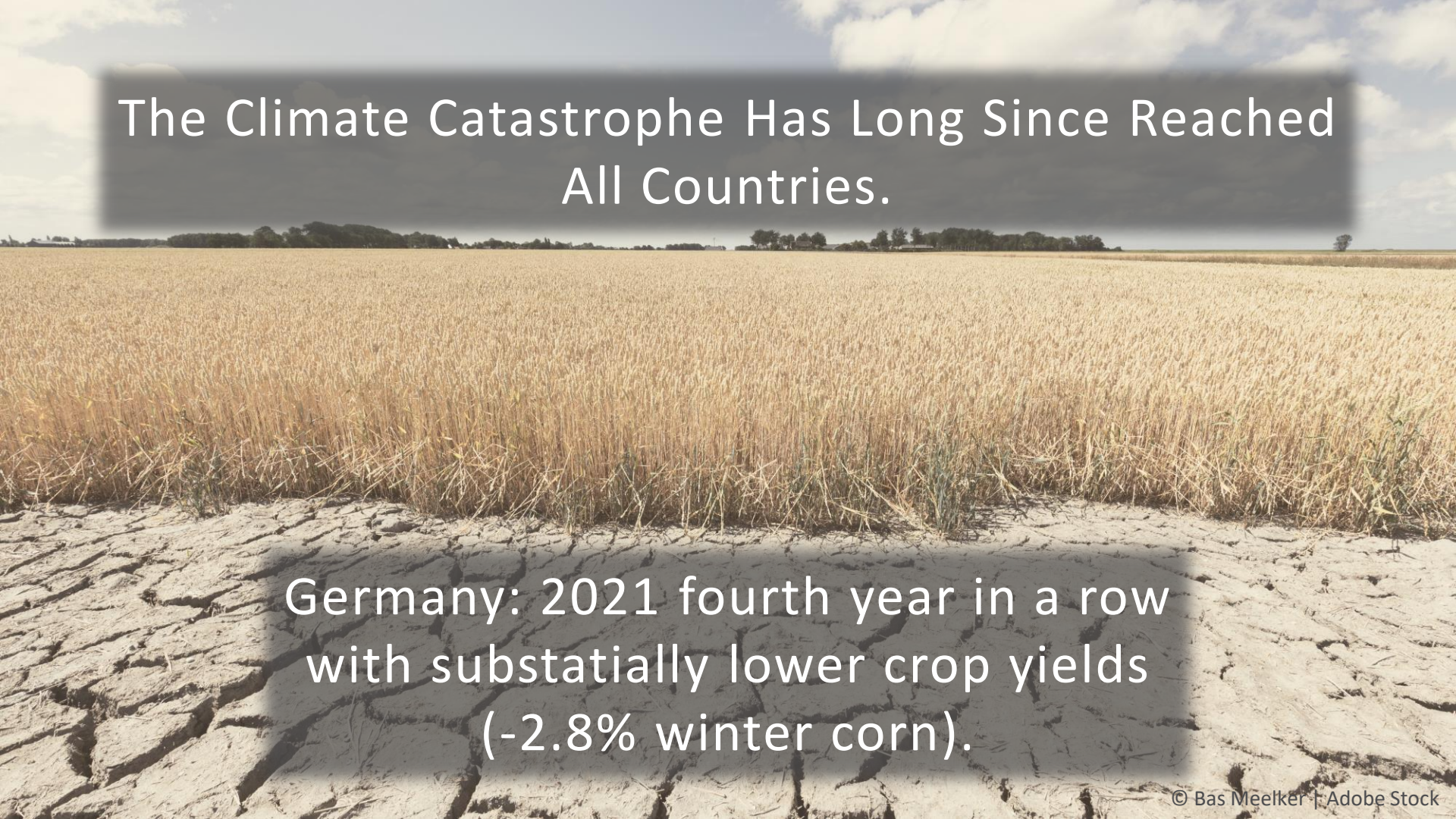
**Adversarial Resilience Learning**

# IPCC Report 2021

## A Man-Made Climate Catastrophe




IPCC Report 2021, Fig. SPM.1

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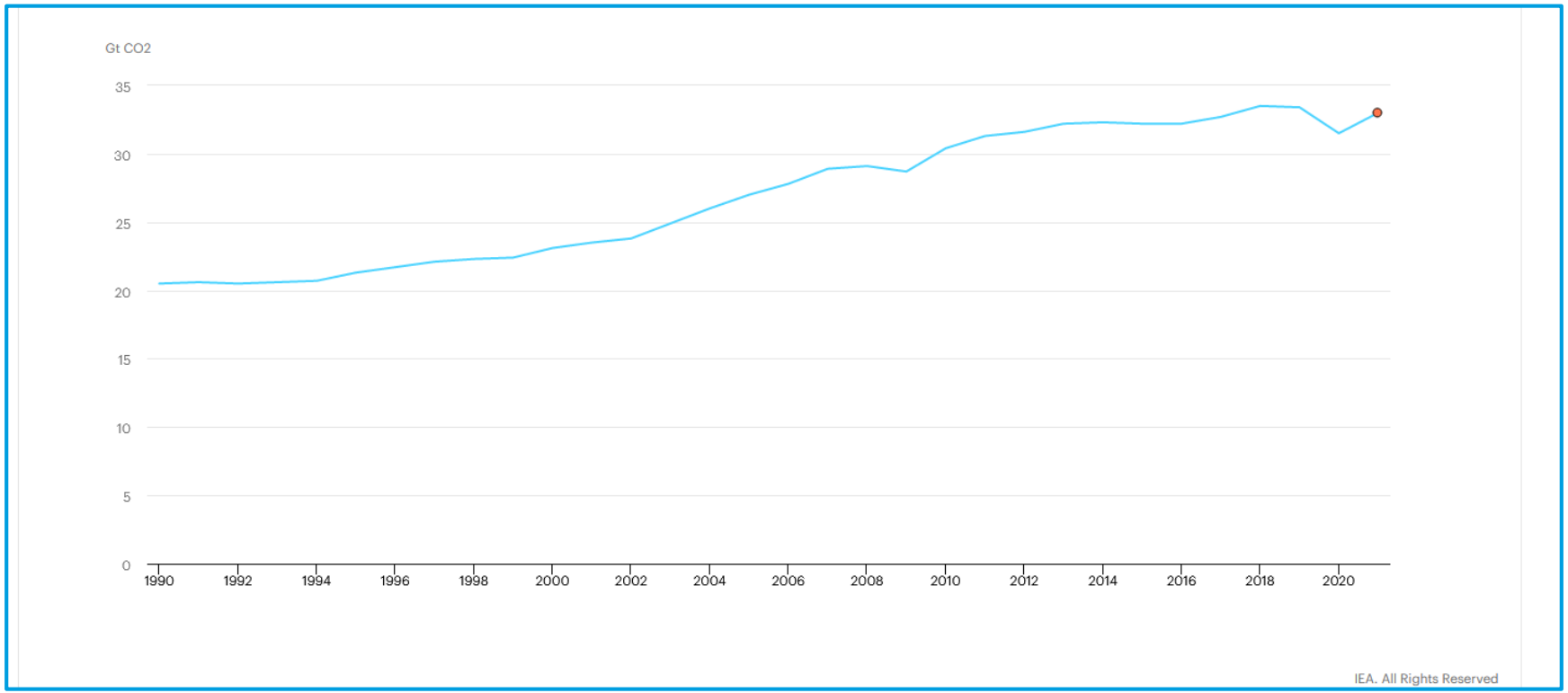
# Global $CO_2$ emissions are still rising



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Germany plans reduction by 67% until 2030.

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# Renovation and insulation of existing buildings

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# Impact of changing environment?

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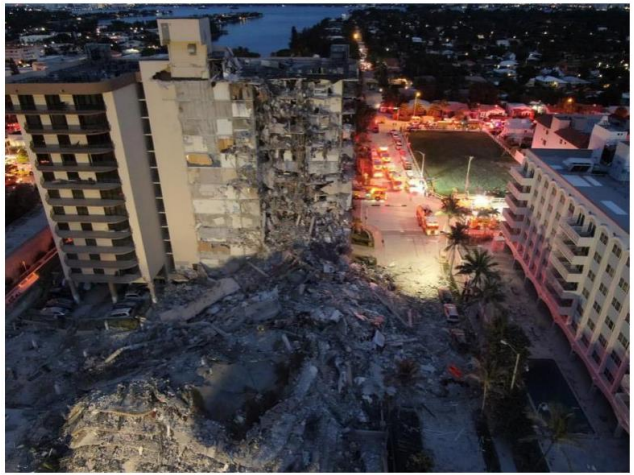
# Impacts on renovation

## Surfside Champlain Towers South Condo Collapse & the Science of Concrete [Video]

**TOPICS:** American Chemical Society Concrete

By AMERICAN CHEMICAL SOCIETY OCTOBER 22, 2021



## Shortages of materials and skills are holding builders back

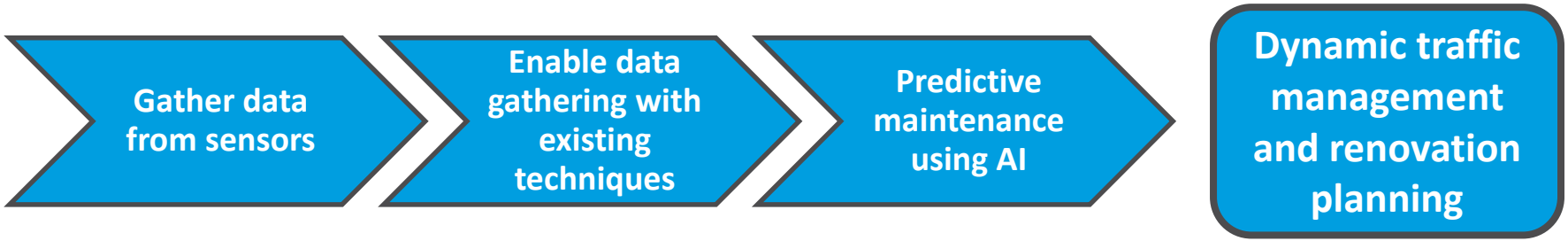
Construction output is falling as a result of material price increases and skills shortages; restricting smaller builders' ability to recover from the pandemic.

# The solution?

**Optimize renovation plans to be robust in a changing environment!**

# The RenovAIte Project

# Project goals



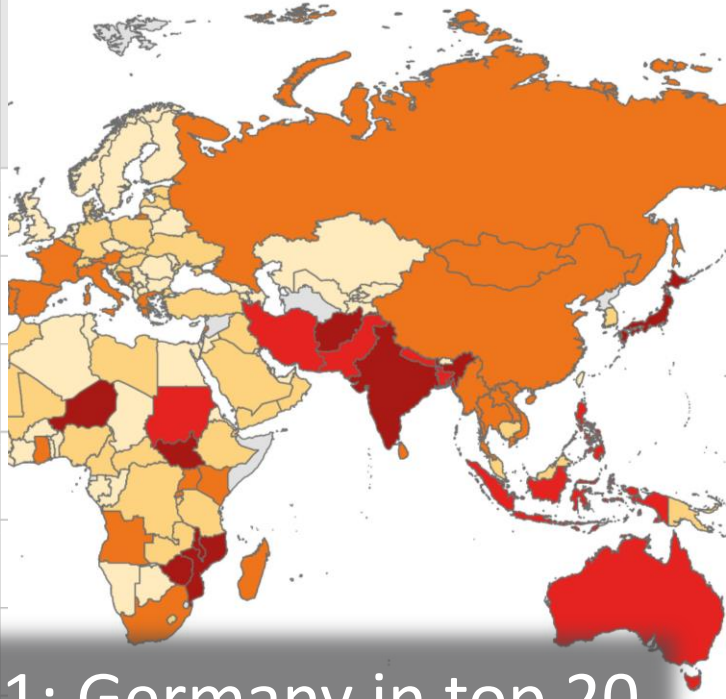
# Project goals

**Provide decision making tool**

# Climate Catastrophe Changes The Game Rapidly

Not Just The “Usual Suspects”

| Ranking 2012 (2011) | Country | CRI score | Death toll | Deaths per 100,000 inhabitants | Absolute losses (in million US$ PPP) | Losses per unit GDP in % |
|---|---|---|---|---|---|---|
| **1** (37) | Haiti | 6.83 | 128 | 1.23 | 1220.66 | 9.53 |
| **2** (4) | Philippines | 10.33 | 1408 | 1.47 | 1205.48 | 0.29 |
| **3** (3) | Pakistan | 12.67 | 662 | 0.37 | 6087.82 | 1.11 |
| **4** (22) | Madagascar | 15.67 | 113 | 0.50 | 356.98 | 1.69 |
| **5** (131) | Fiji | 17.00 | 17 | 1.89 | 135.55 | 3.18 |
| **6** (36[9]) | Serbia | 17.67 | 28 | 0.39 | 1325.06 | 1.70 |
| **7** (131) | Samoa | 18.33 | 6 | 3.28 | 220.91 | 19.57 |



Climate Risk Index 2012 … 2021: Germany in top 20

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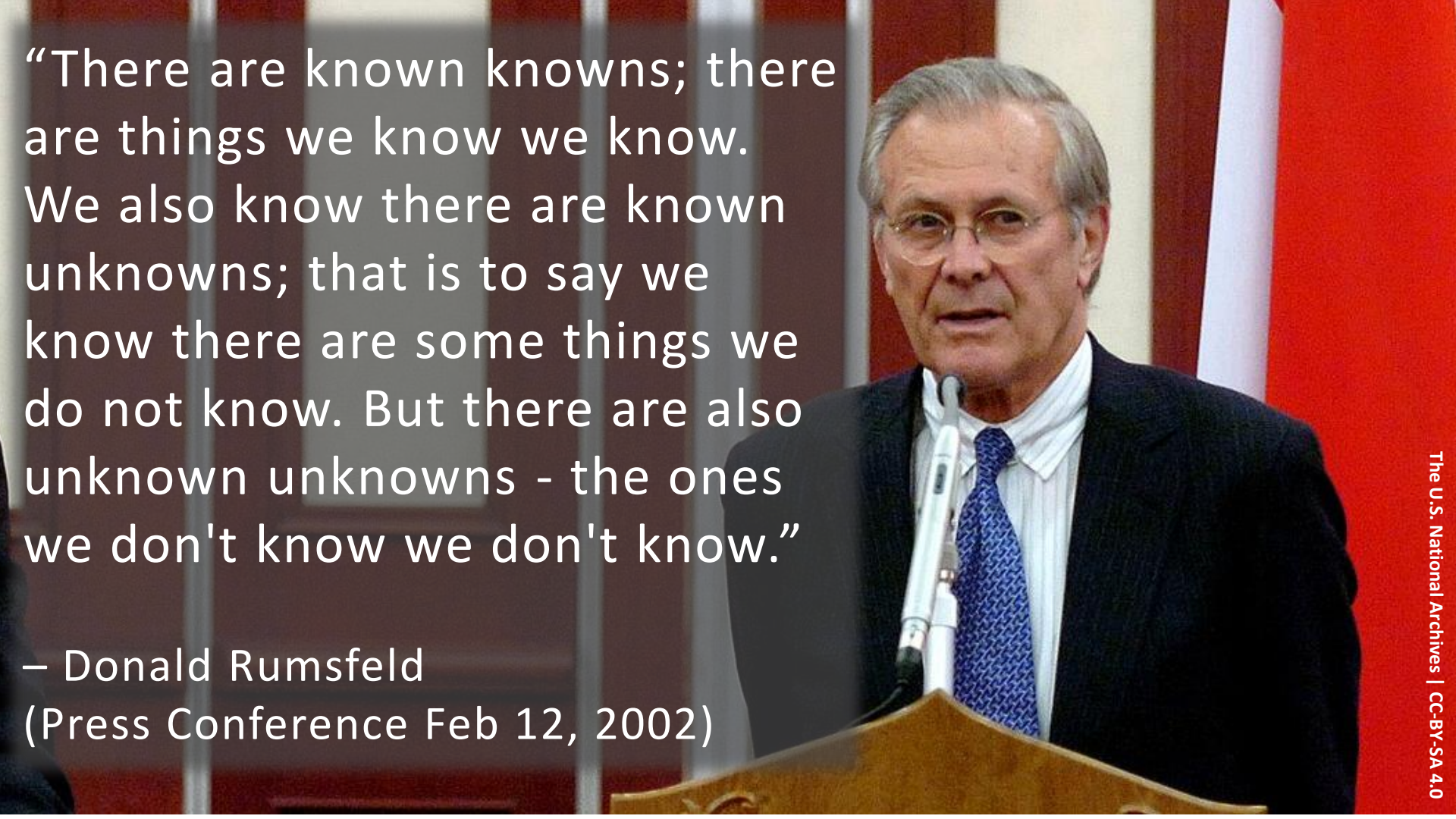


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Cyber Security for Critical National Infrastructures

Has Many Unknown Unknowns.

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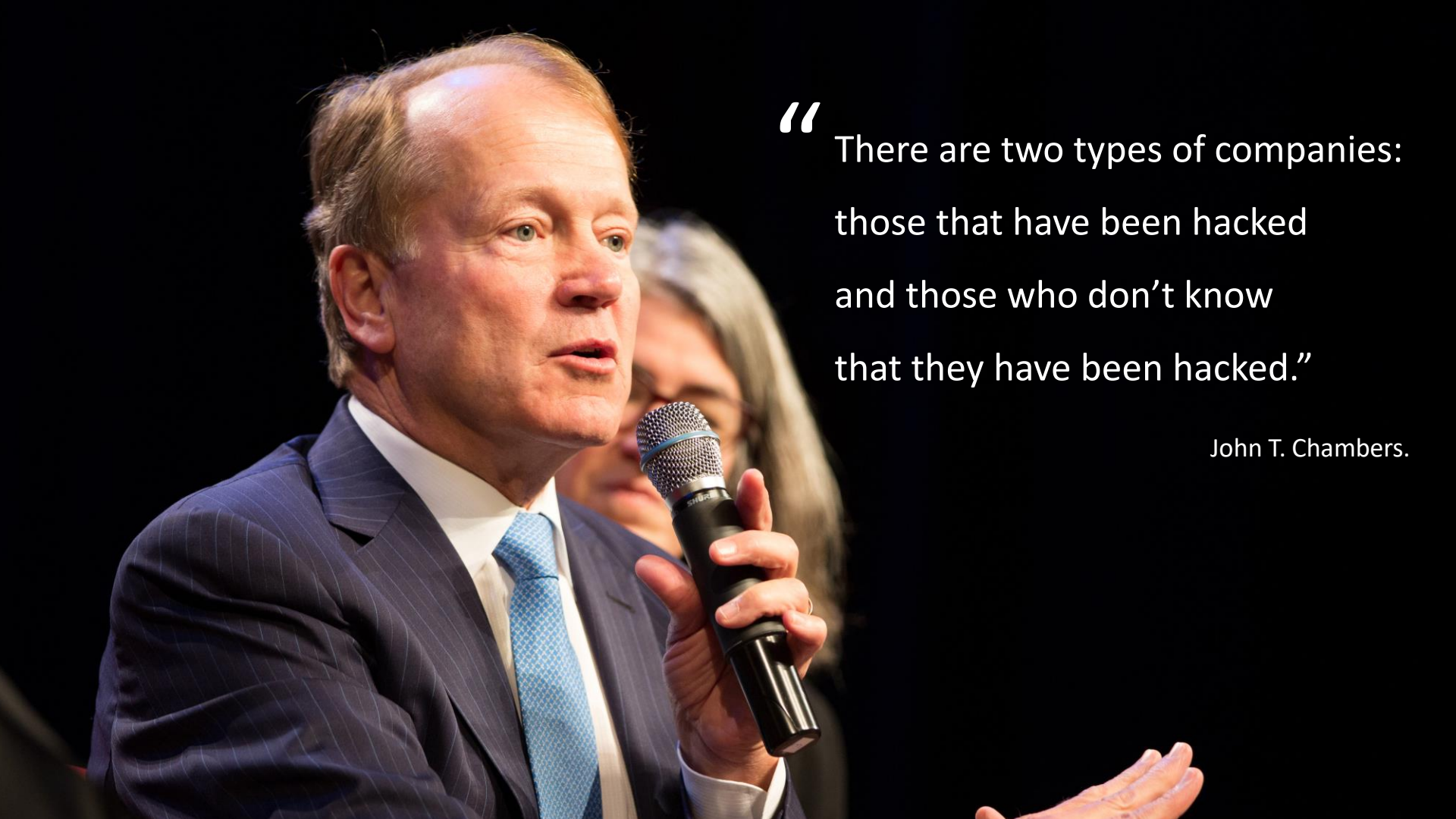
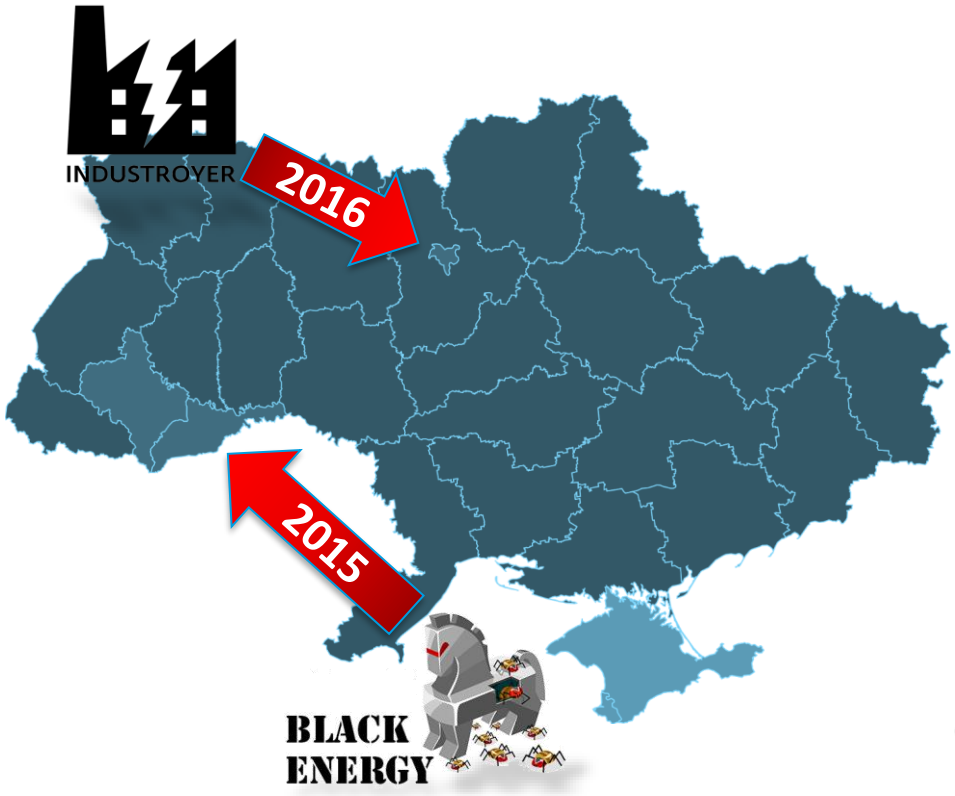

“There are two types of companies:
those that have been hacked
and those who don’t know
that they have been hacked.”
John T. Chambers.

# Applies to Critical Infrastructures, too

Attack against the Ukrainian Power Grid




**Dec 23rd, 2015**

- > Cyber Attack leads to **Blackout**
- > **3 Grid Operators** targeted
- > Operative **Intrusion into Control Systems**
- > Disconnect of **several Transformers**
- > Several Months in Preparation

**2016**

- > **Highly automated** Variant

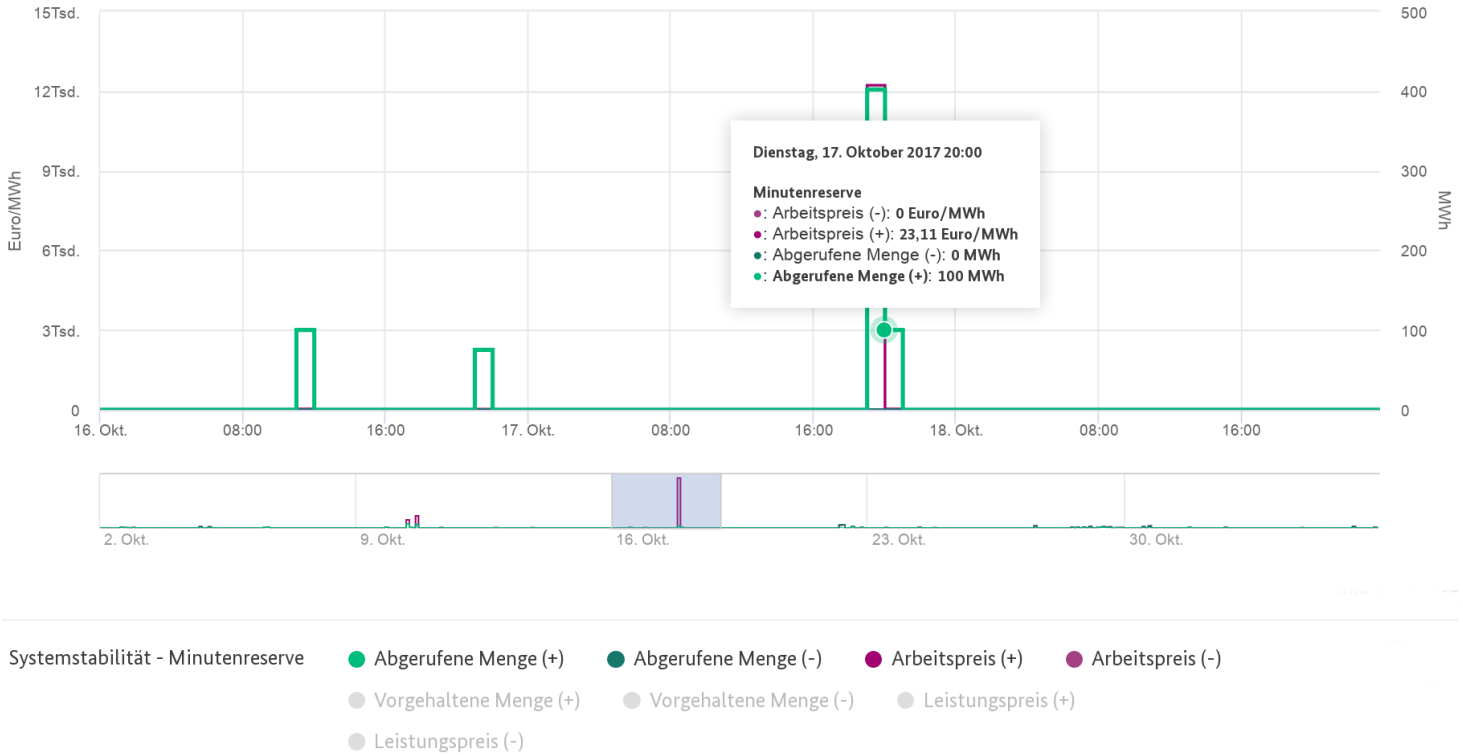
**Our infrastructures are valuable targets.**

# Digitalized Critical Infrastructures: A Threat?

Newspaper Collection

# Market can also be the Culprit

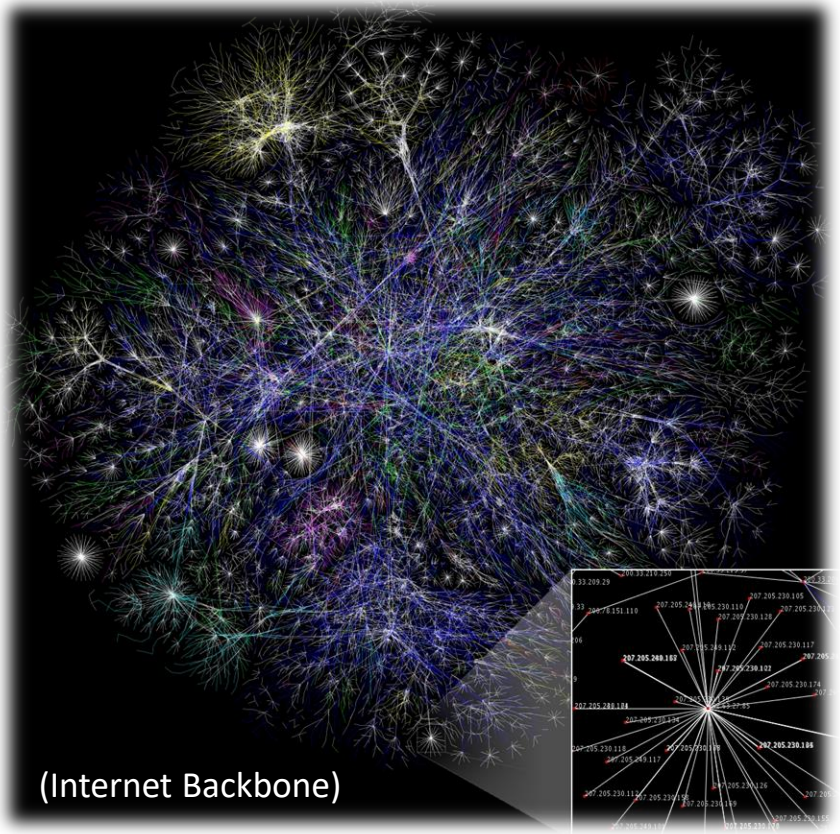
## Gaming a Critical Infrastructure?



# Learning Resilient Control

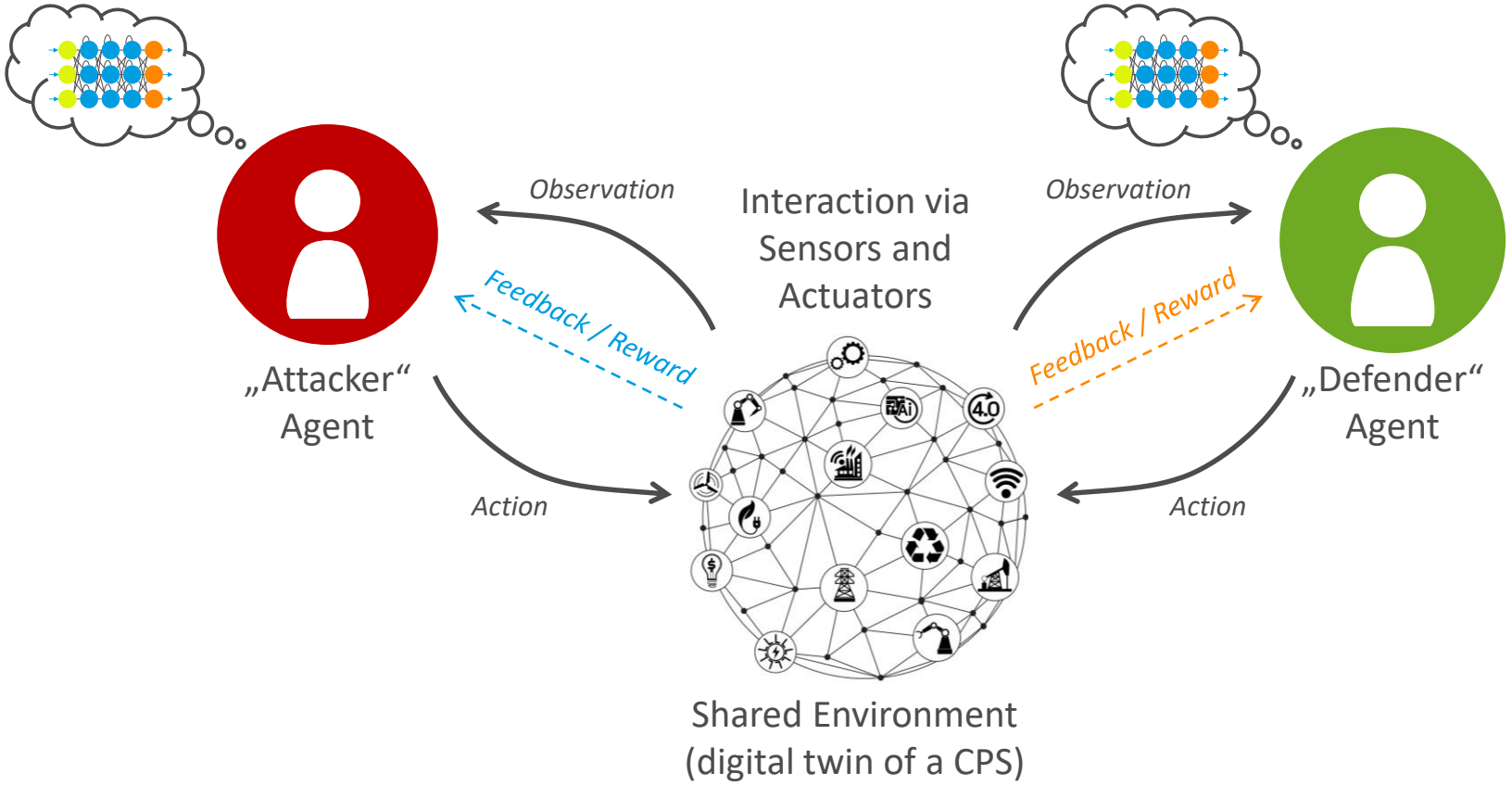
## CPS inherently vulnerable

- Interconnected CPS have always attack surface **due to their inherent complexity**
  - Low latency of ICT and OT
  - High interdependence
  - Complexity in breadth and depth
  - Cricital Services as SPOF (DNS, BGP, *SCADA, SDL*)
- Learning Stratgies for **automatic issue mangement**



# Adversarial Resilience Learning Concept

## Competing Agents Learn in a Shared Environment



# Adversarial Learning

ARL != AL

- Attempt to modify input data slightly in order to yield extremely different output from ANN
- Modification of data not or only slightly visible to humans
- Ex: RGB noise on a picture, small textual changes in spam messages
- AL: Finding mechanisms against these attacks

# Generative Adversarial Networks

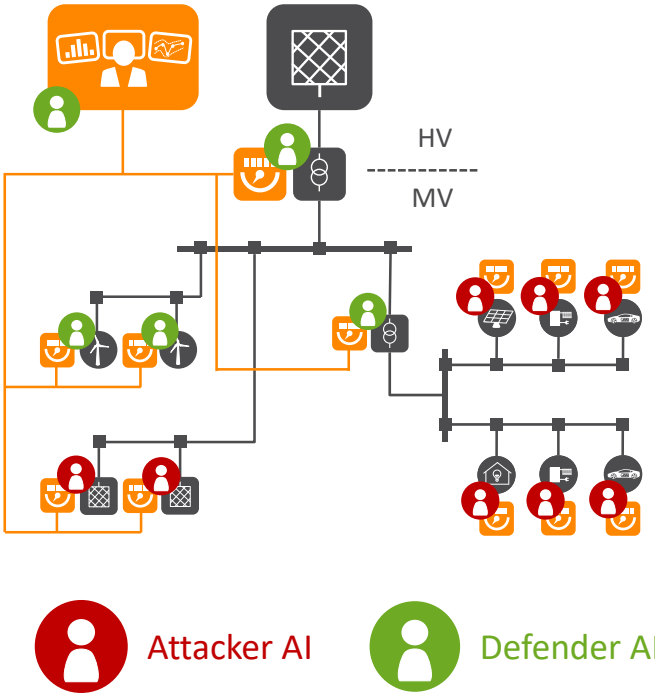
ARL != GAN

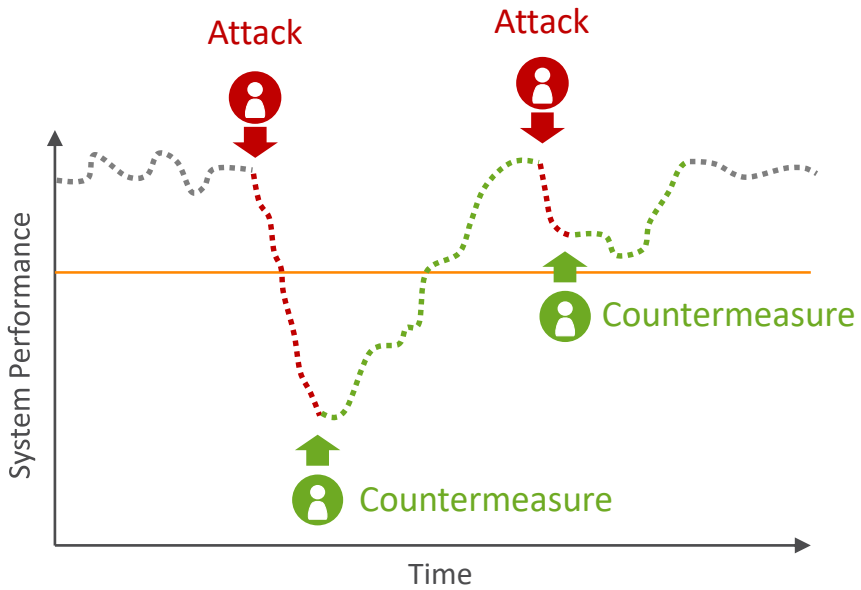
- Two ANNs with **different roles**: Generator and Discriminator
- Zero-sum game
- Generator maps vector of latent variables to feature space; Discriminator evaluates the result
- Error measure: Ability of the Discriminator to differentiate between real and generated data's distribution

# Demo: Attack on a Power System

Prevention of (sub-)system takeover as a secondary problem

Smart Grid
Cyber-Resilience Lab

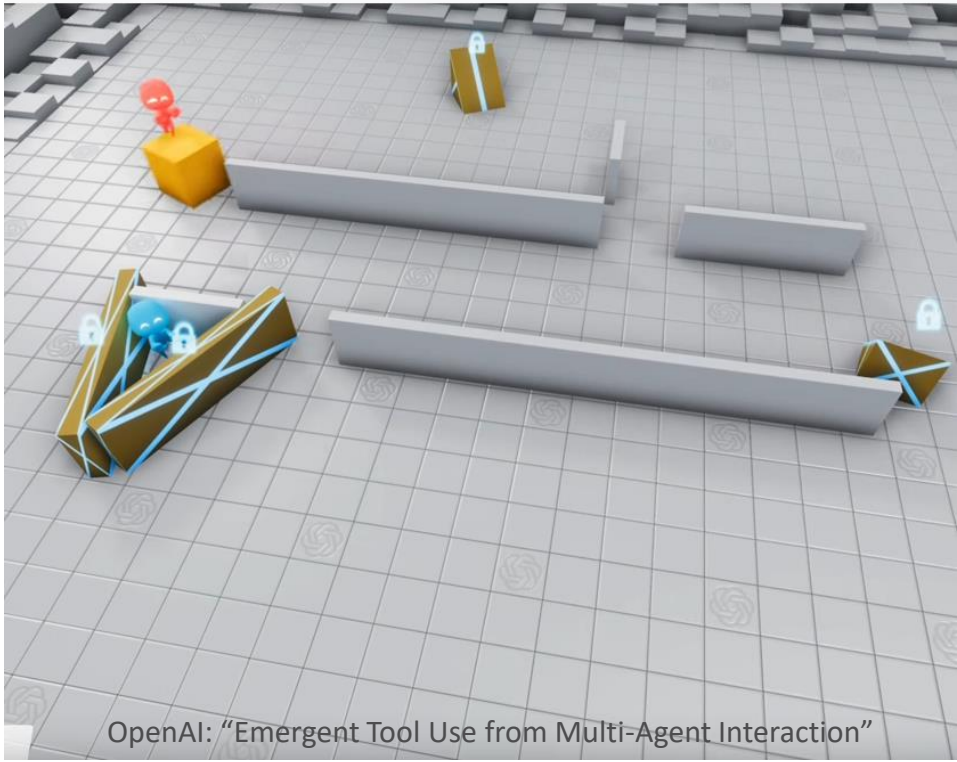


# Why does it work?

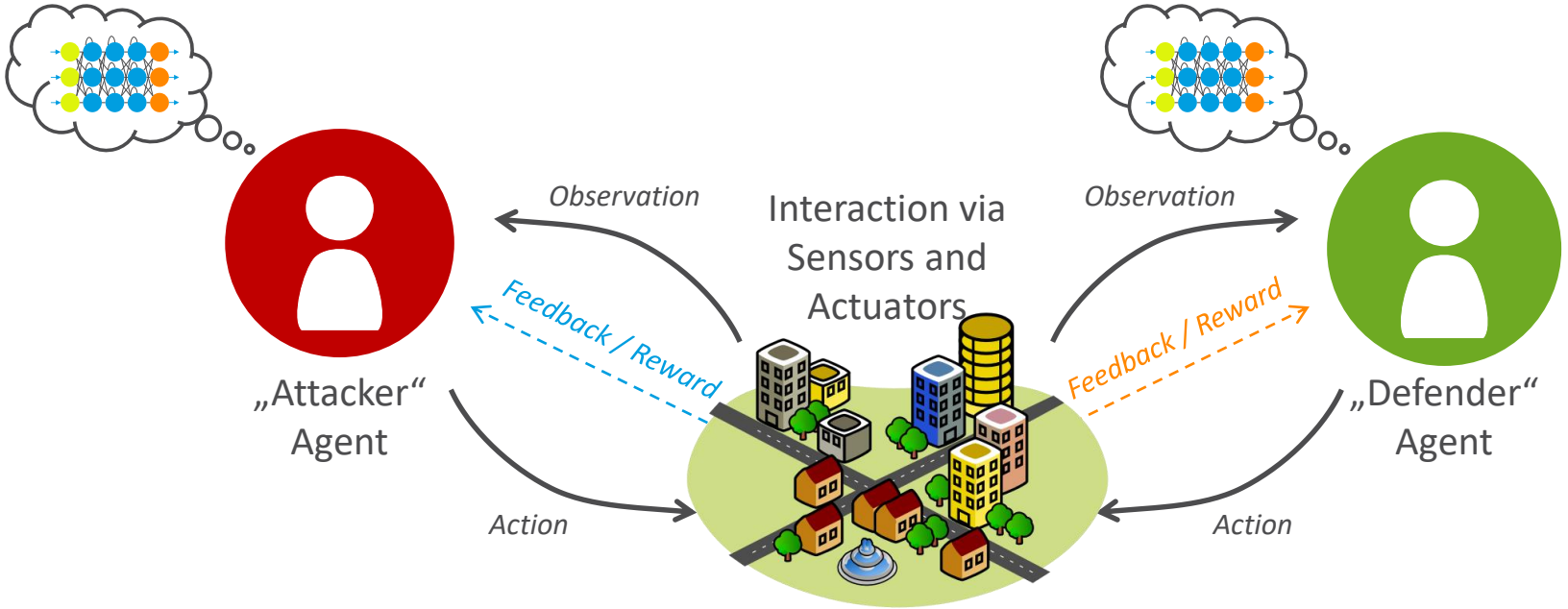
RL Agents discover bugs in the engine

- Setup: Two groups of agents play *hide and seek*
- No domain information; agents learn strategies and tool use independently
- Result: Agents learn to exploit bugs in the underlying game engine
  - Holes in walls
  - Sliding boxes
  - Edge/corner jumps



OpenAI: “Emergent Tool Use from Multi-Agent Interaction”

# ARL in RenovAIte

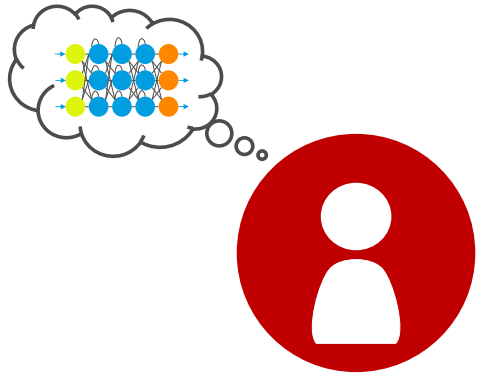



Shared Environment (simulation models)

# ARL in RenovAIte: Attacker

**Learns to model realistic threats:**

- Climate change
- Natural disasters
- Shortage of workforce
- Material shortages
- Etc.

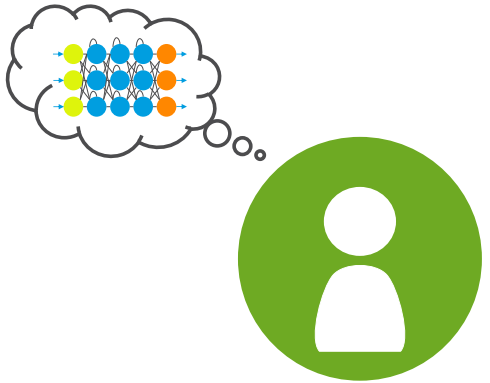


„Attacker“
Agent

# ARL in RenovAIte: Defender

**Creates resilient renovation strategies:**

- > Choice of measures
- > Choice of material
- > Creation of work schedules



„Defender“
Agent

# ARL in RenovAIte: Environment

**Is changed continuously:**

> Defender changes renovation plan to simulate

> Attacker changes simulation properteis dynamically

Shared Environment
(simulation models)

# Conclusion

**Goals:**

> Improve long term resilience of renovations

> Provide decision making tool for optimized housing renovation

> Automated monitoring and predictive maintenance for road renovation

**Reduce impact of changing environments on renovation planning and execution**

# Contact us!


Lasse Hammer
OFFIS e.V. - Workgroup PSI

> lasse.hammer@offis.de

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