Lessons Learned from large disturbances and operational challenges ahead

Danny Klaar
TenneT TSO B.V.

25 March 2021

Main events outlook from 2018 till today!

REUTERS

WORLD NEWS MARCH 22, 2018 / 12:38 AM / 2 YEARS AGO

Tens of millions in northern Brazil hit by massive power outage

March 2018

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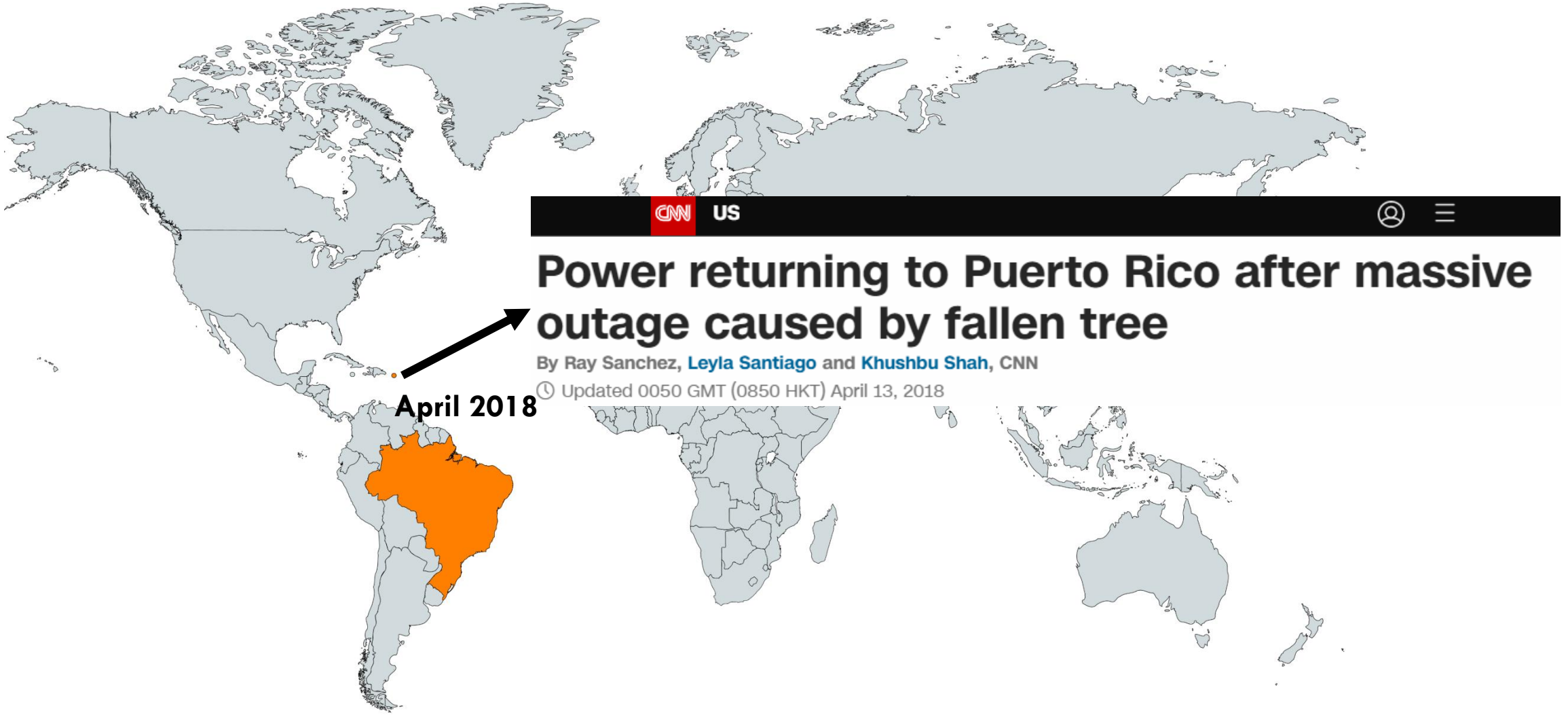

CNN US

Power returning to Puerto Rico after massive outage caused by fallen tree

By Ray Sanchez, Leyla Santiago and Khushbu Shah, CNN

Updated 0050 GMT (0850 HKT) April 13, 2018

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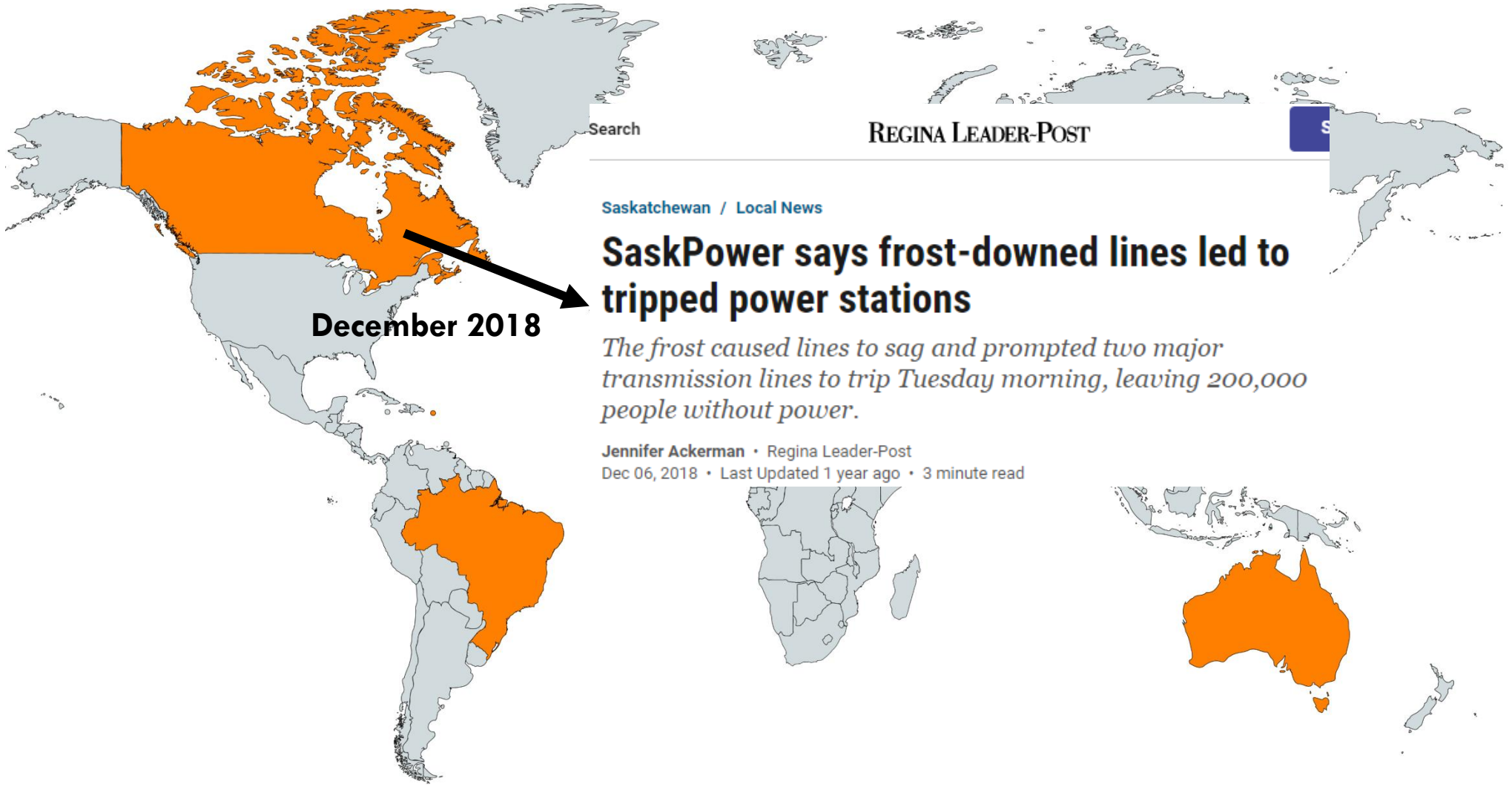

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REGINA LEADER-POST

Saskatchewan / Local News

SaskPower says frost-downed lines led to tripped power stations

The frost caused lines to sag and prompted two major transmission lines to trip Tuesday morning, leaving 200,000 people without power.

Jennifer Ackerman • Regina Leader-Post
Dec 06, 2018 • Last Updated 1 year ago • 3 minute read

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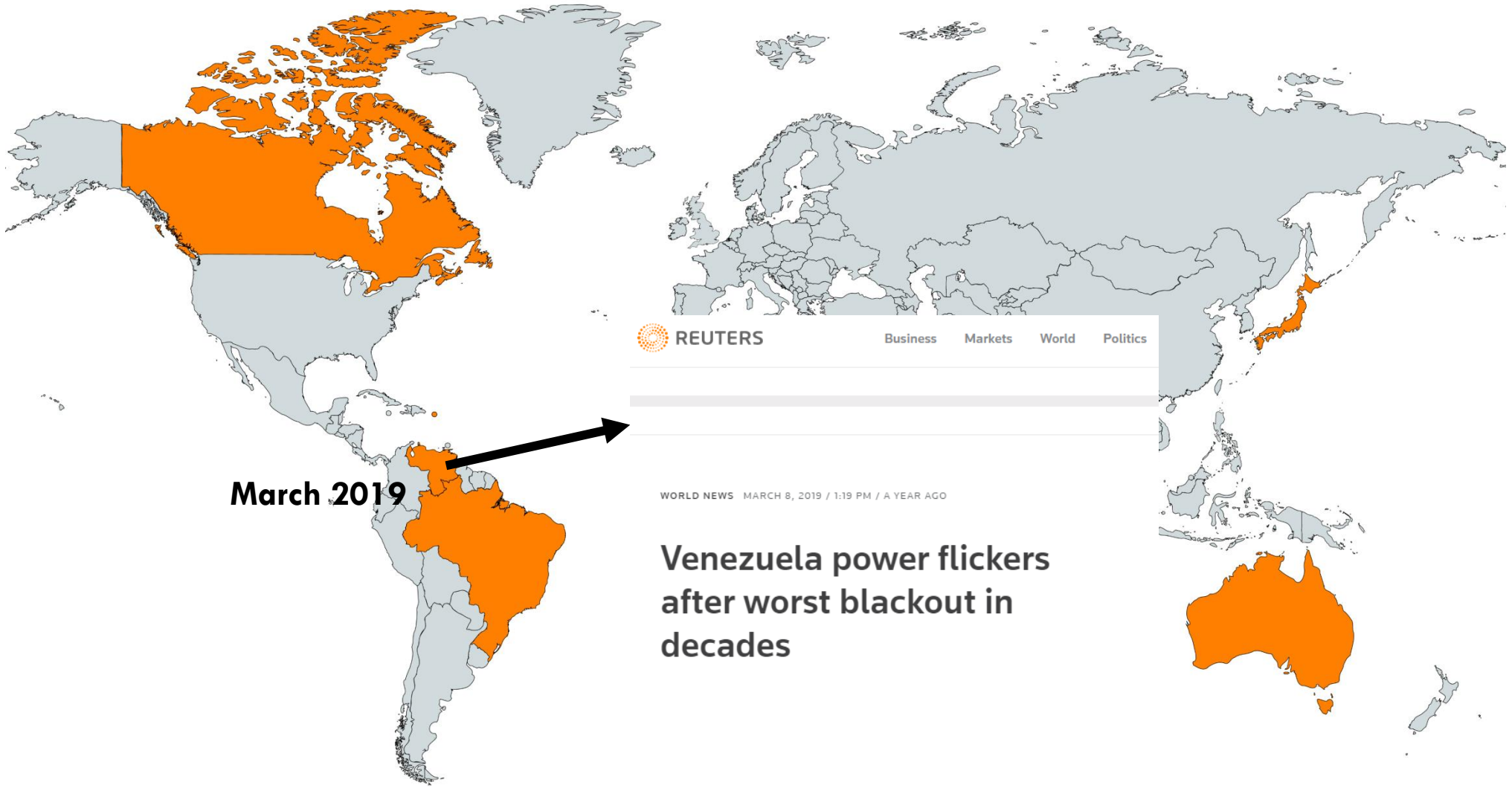

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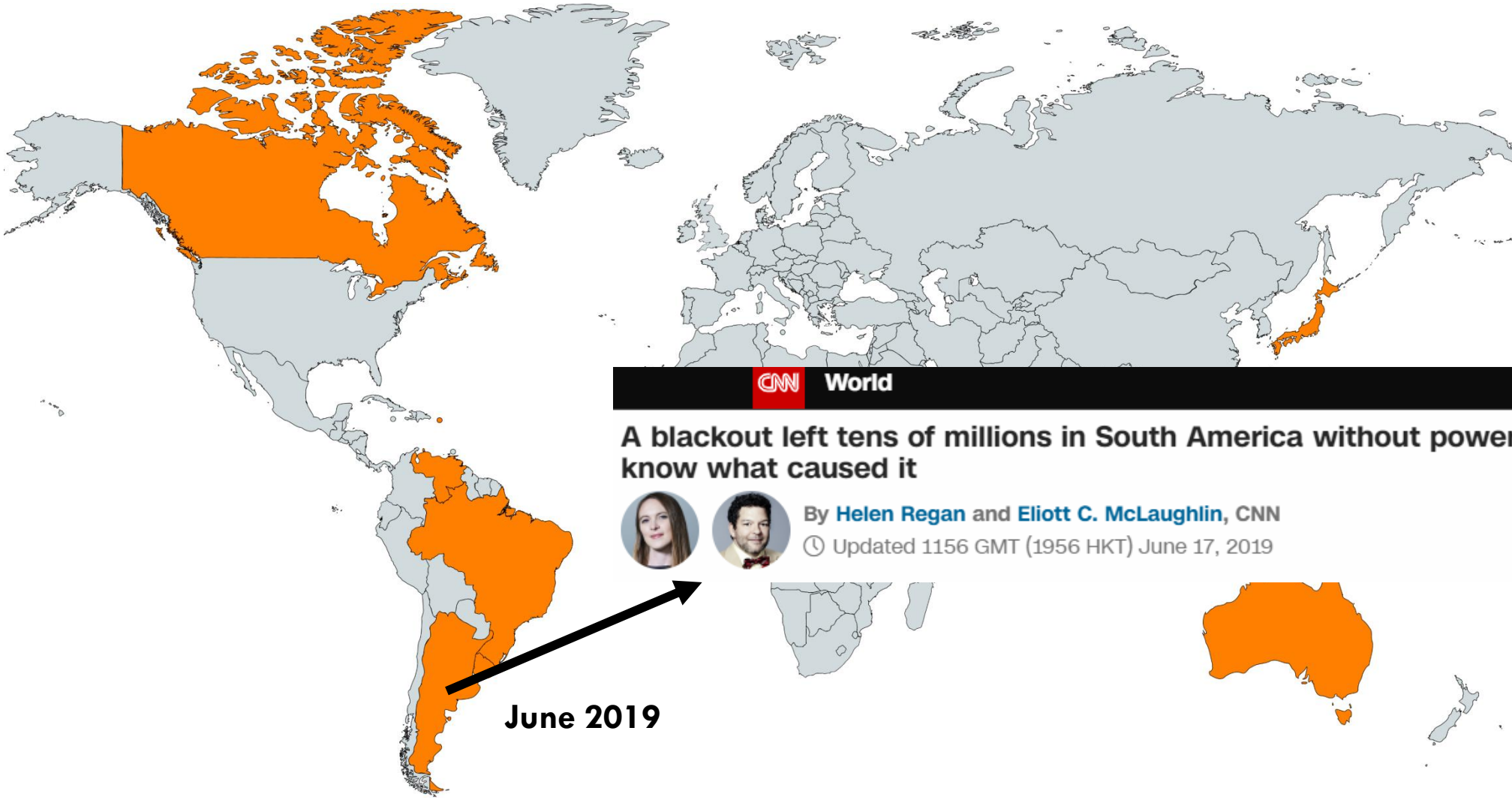

CNN World

A blackout left tens of millions in South America without power. Officials still don't know what caused it

By Helen Regan and Eliott C. McLaughlin, CNN

Updated 1156 GMT (1956 HKT) June 17, 2019

June 2019

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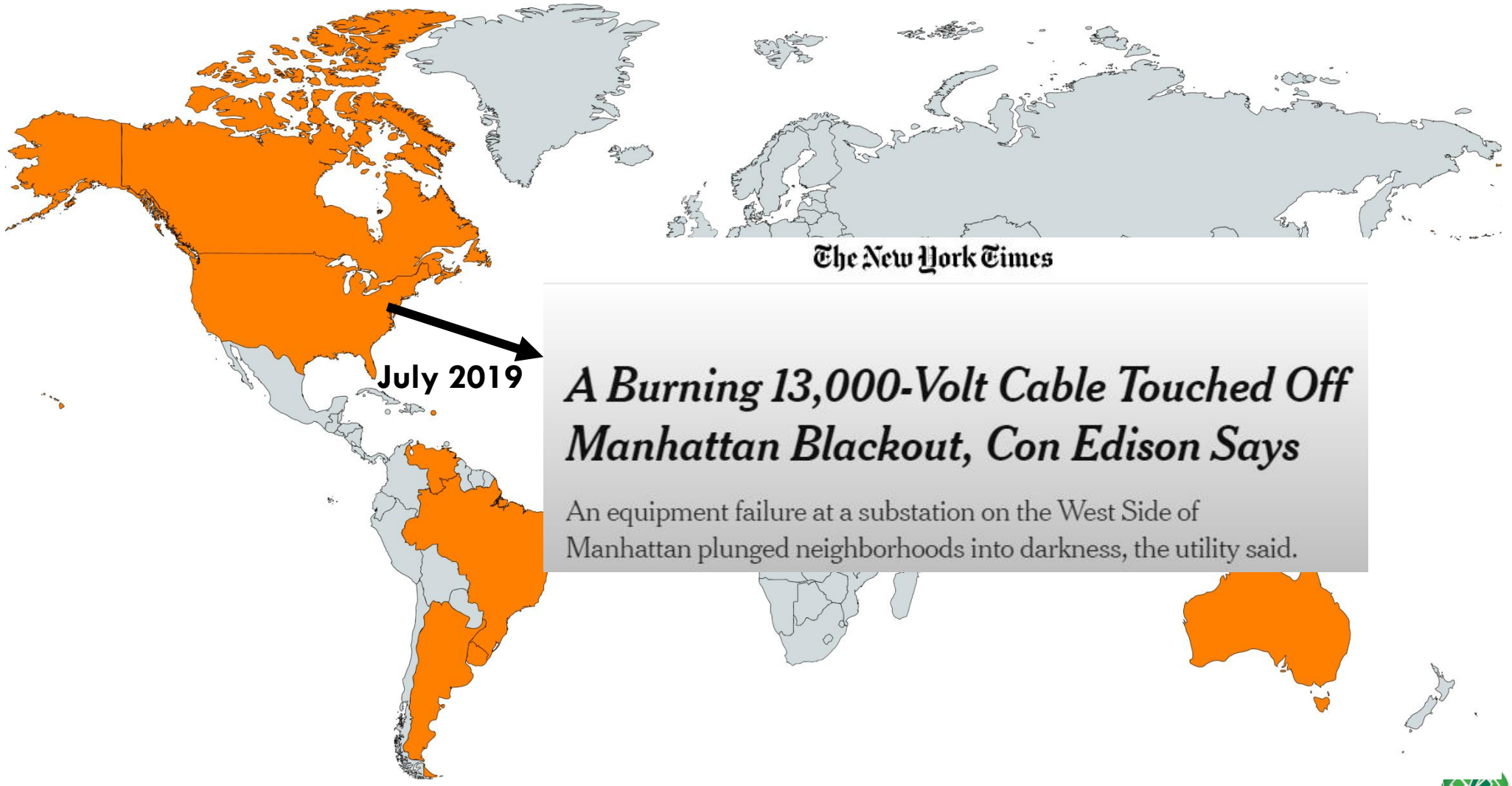

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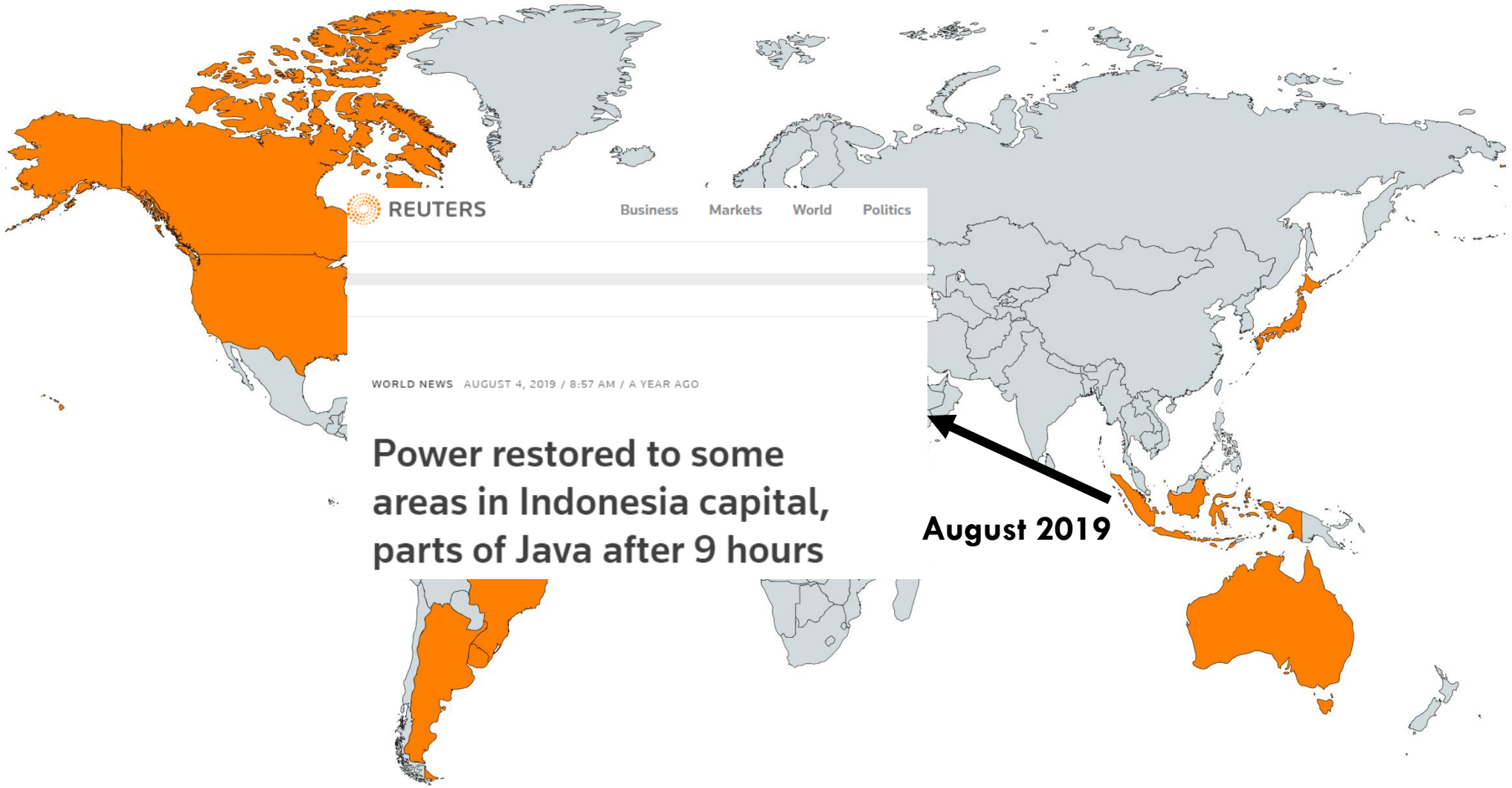

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UK power cut: National Grid promises to learn lessons from blackout

10 August 2019 Share

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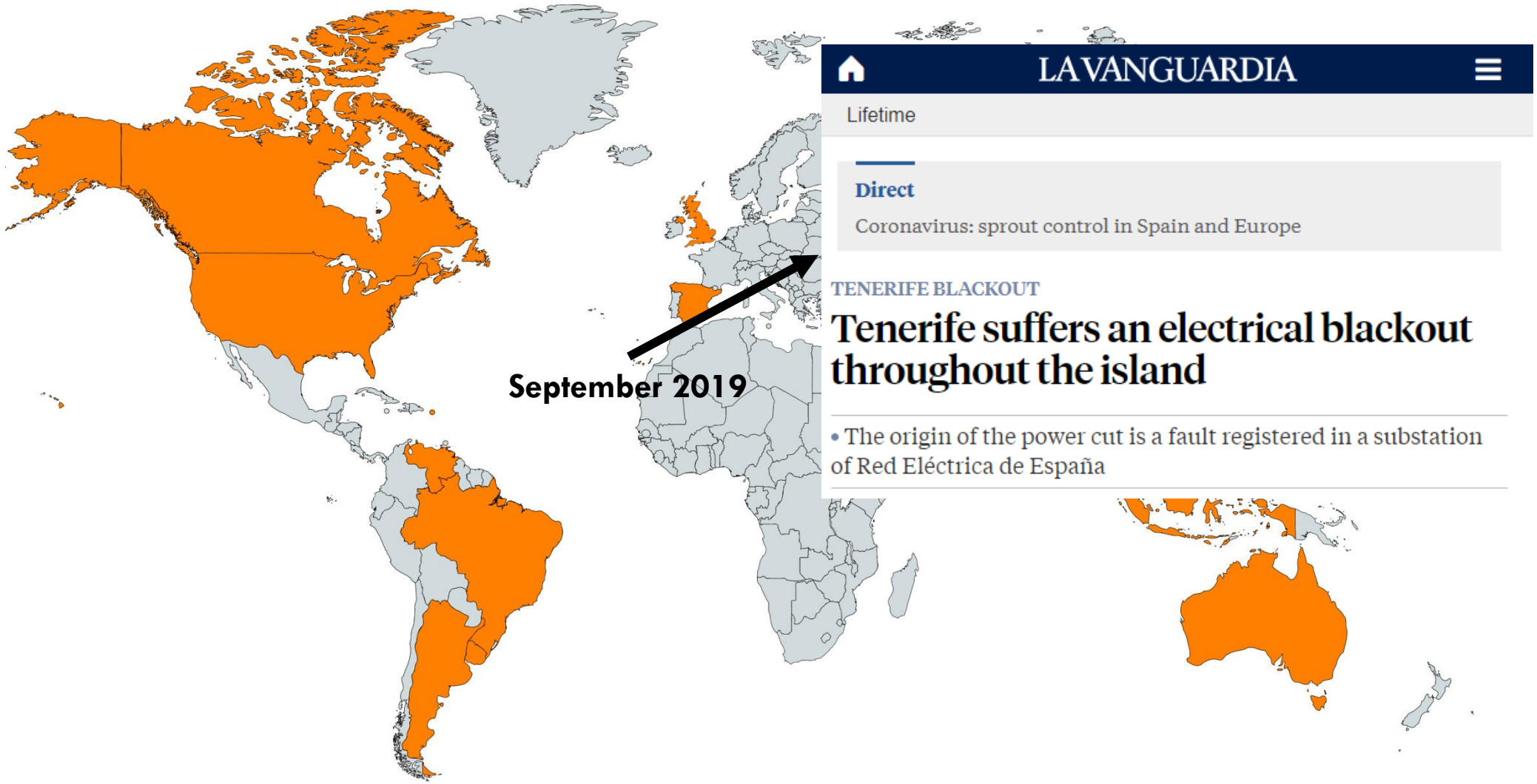

LA VANGUARDIA

Lifetime

Direct

Coronavirus: sprout control in Spain and Europe

TENERIFE BLACKOUT

Tenerife suffers an electrical blackout throughout the island

- The origin of the power cut is a fault registered in a substation of Red Eléctrica de España

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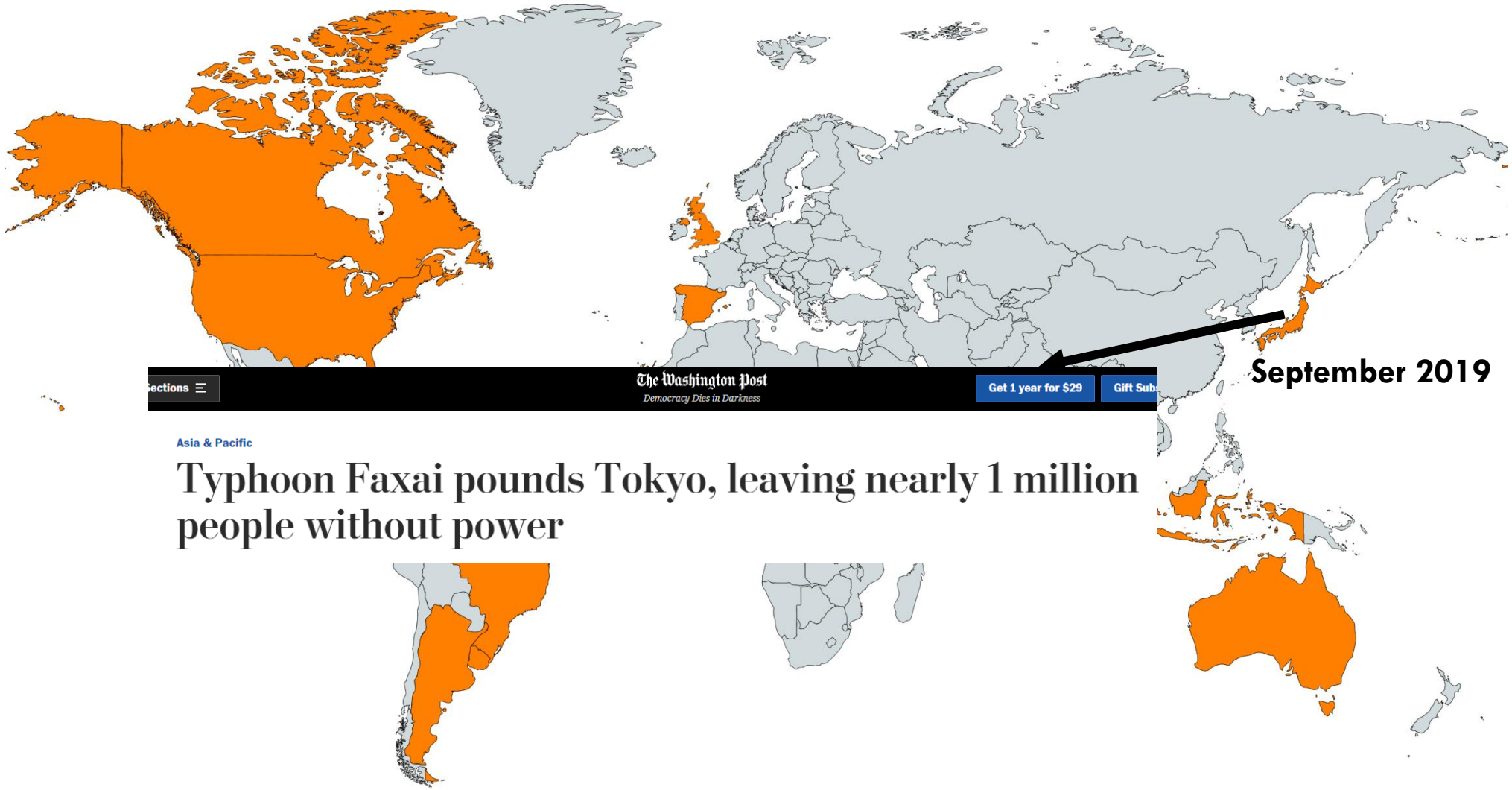

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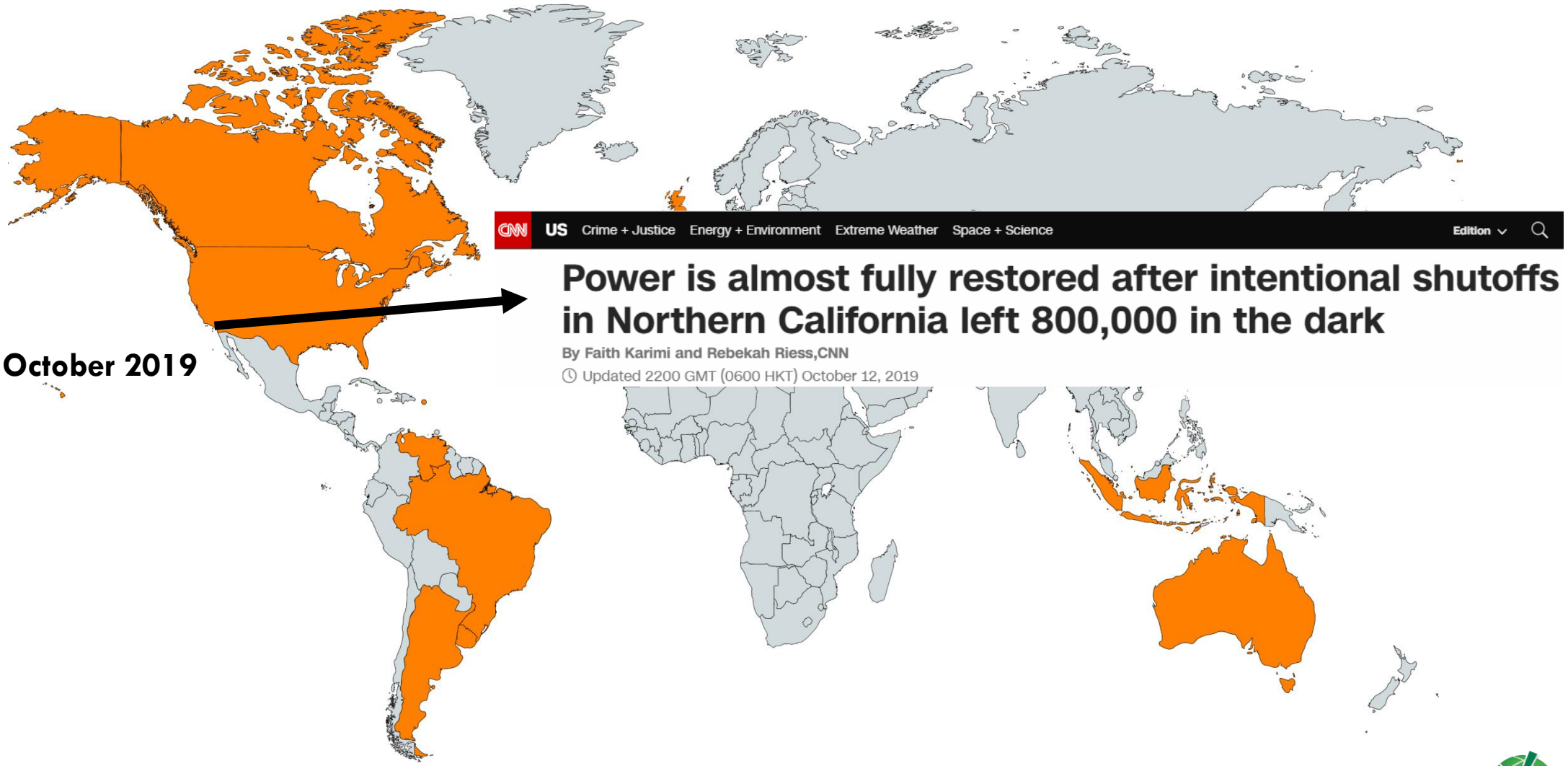

October 2019

CNN US Crime + Justice Energy + Environment Extreme Weather Space + Science Edition

Power is almost fully restored after intentional shutoffs in Northern California left 800,000 in the dark

By Faith Karimi and Rebekah Riess,CNN

Updated 2200 GMT (0600 HKT) October 12, 2019

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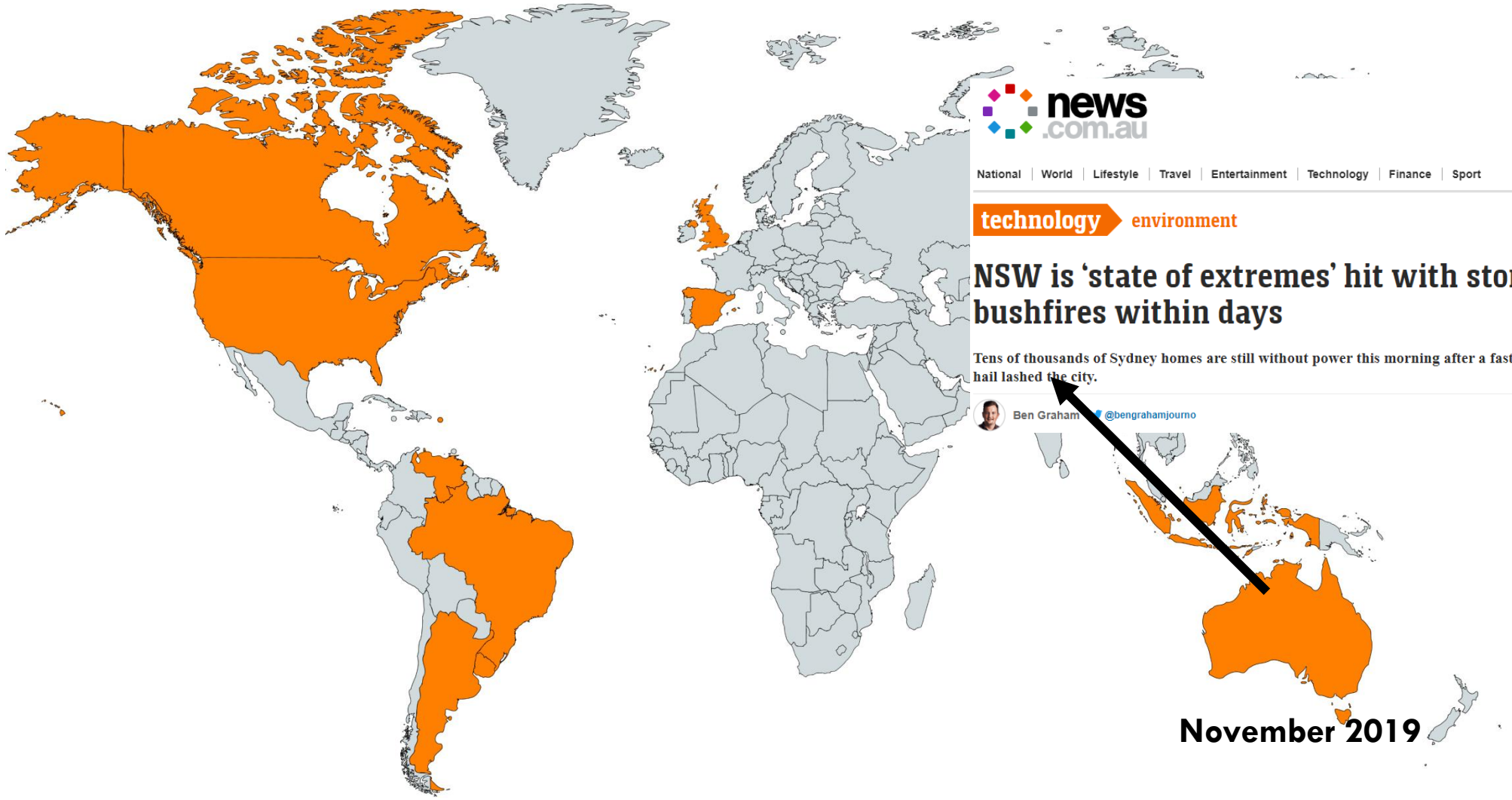

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National | World | Lifestyle | Travel | Entertainment | Technology | Finance | Sport

technology environment

NSW is 'state of extremes' hit with storms, snow and bushfires within days

Tens of thousands of Sydney homes are still without power this morning after a fast-moving storm of strong winds and hail lashed the city.

Ben Graham @bengrahamjourno news.com.au NOVEMBER 27, 2019 6:30AM

November 2019

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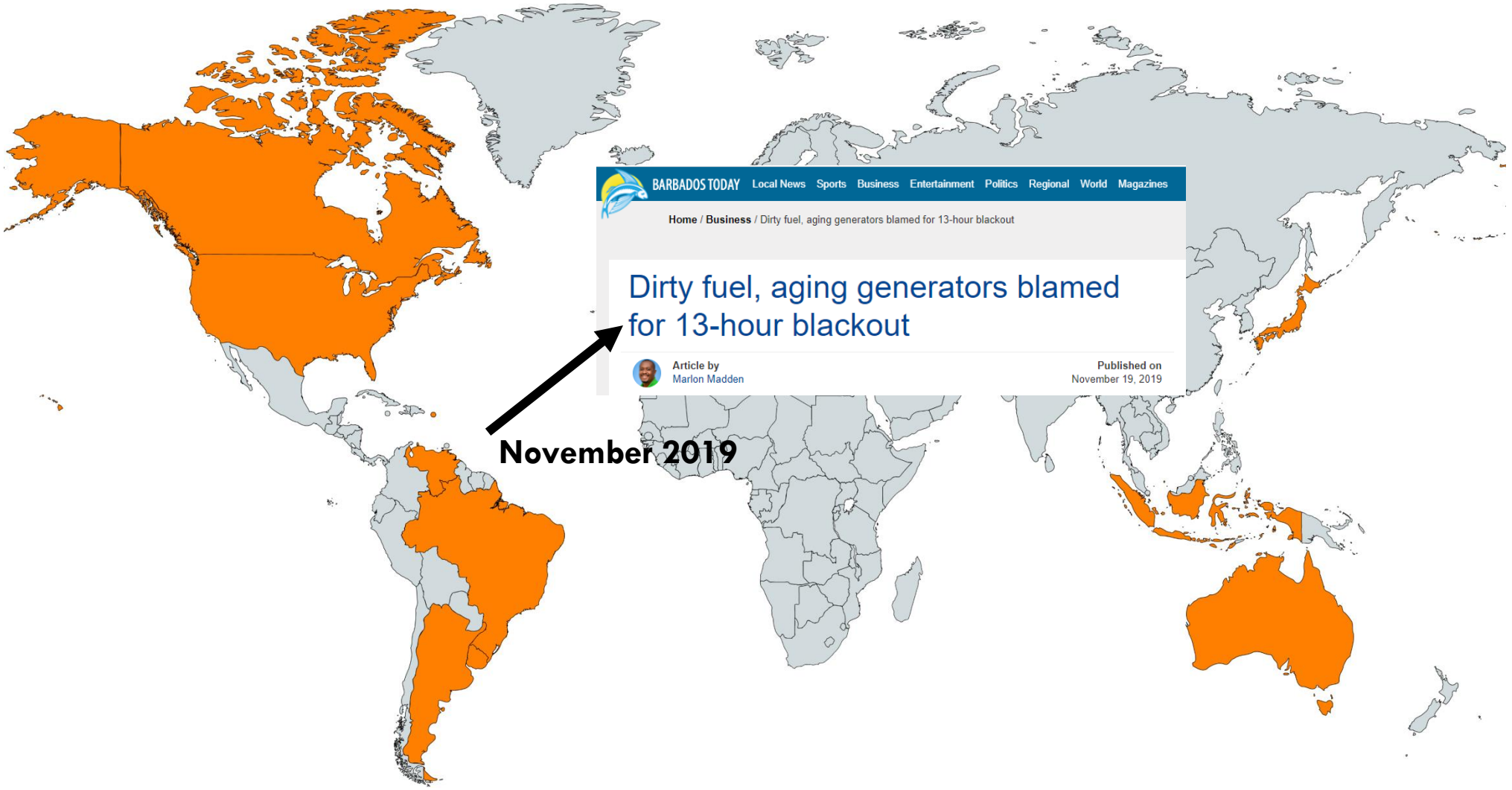

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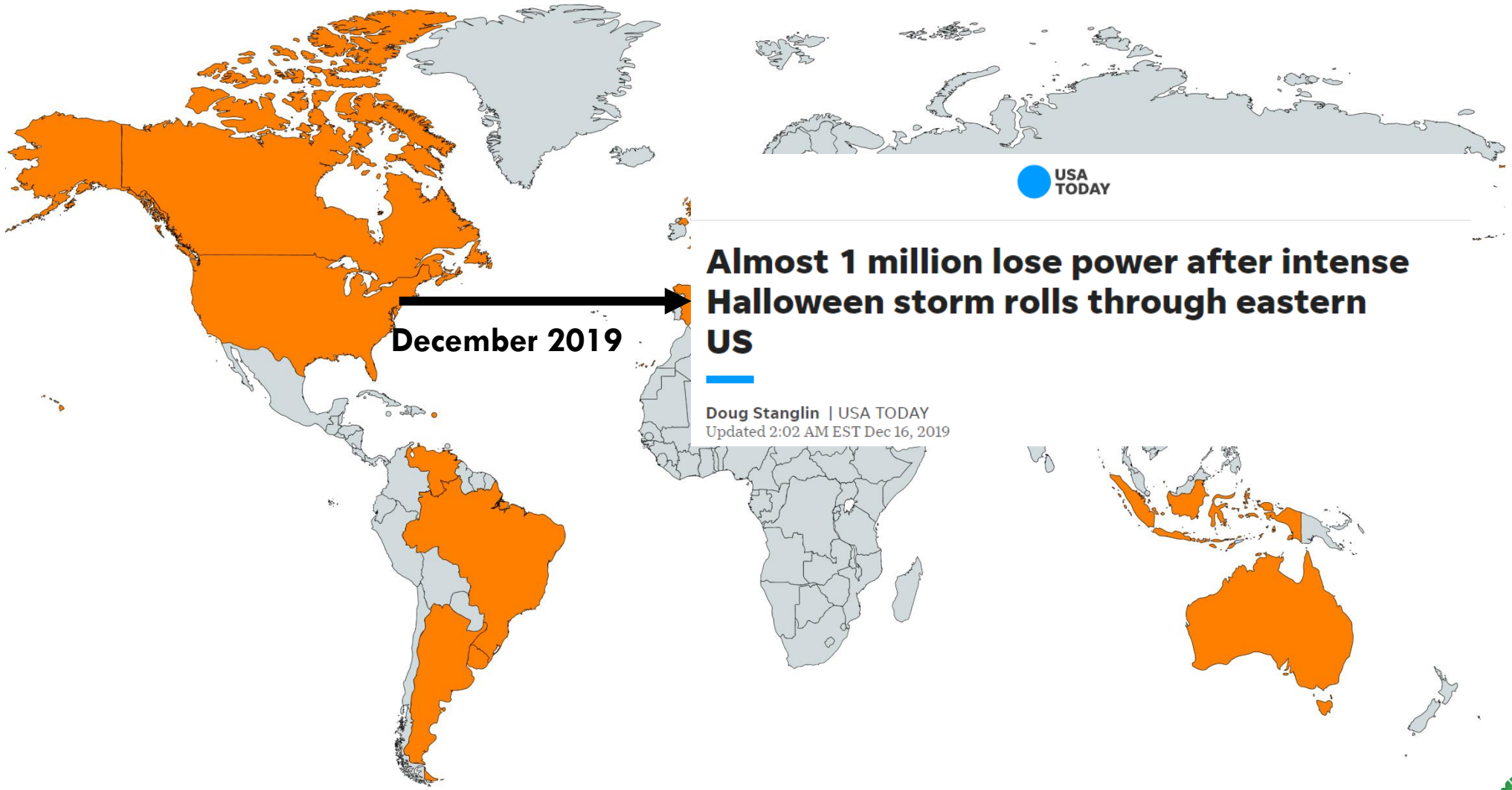

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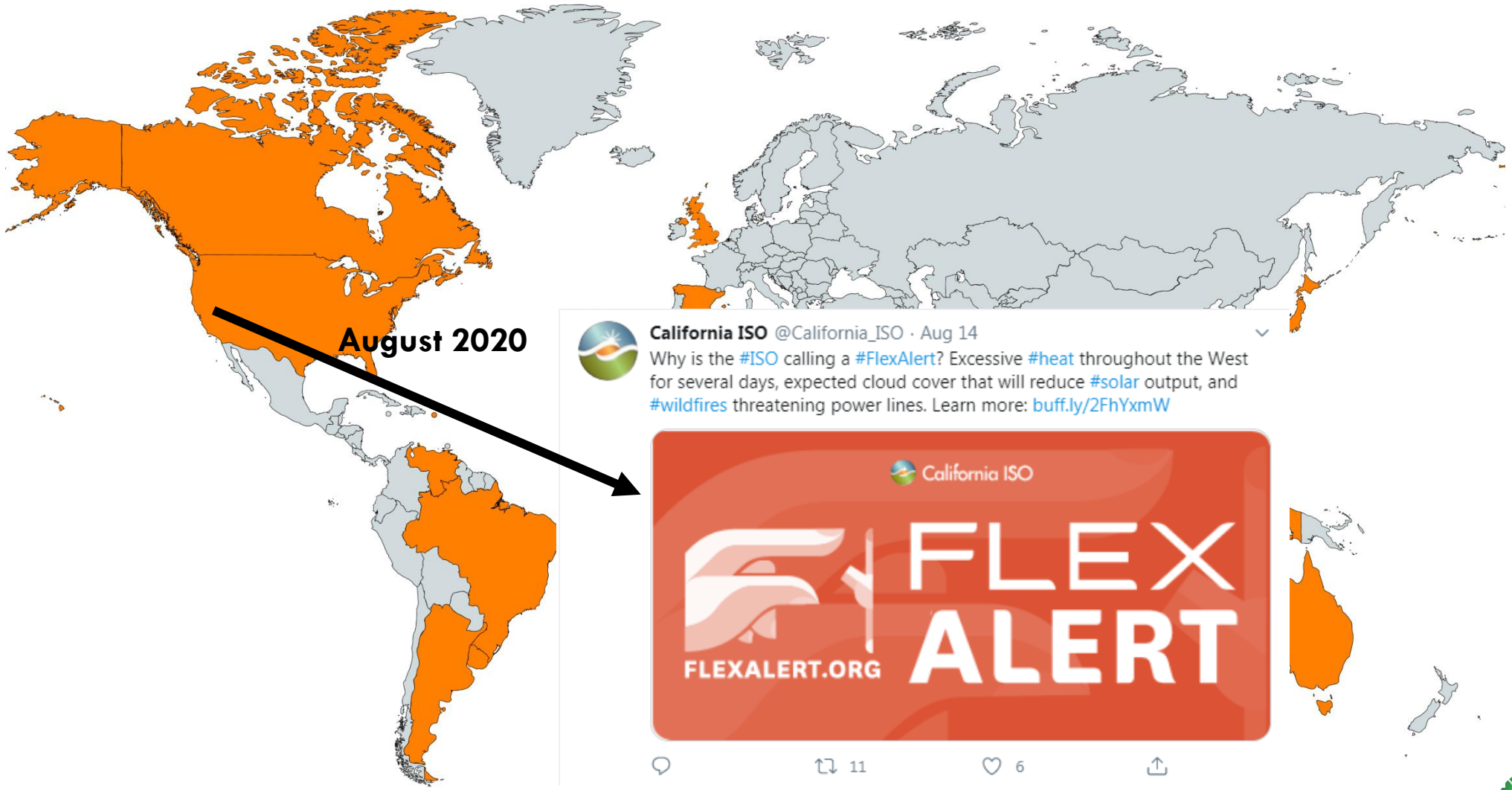

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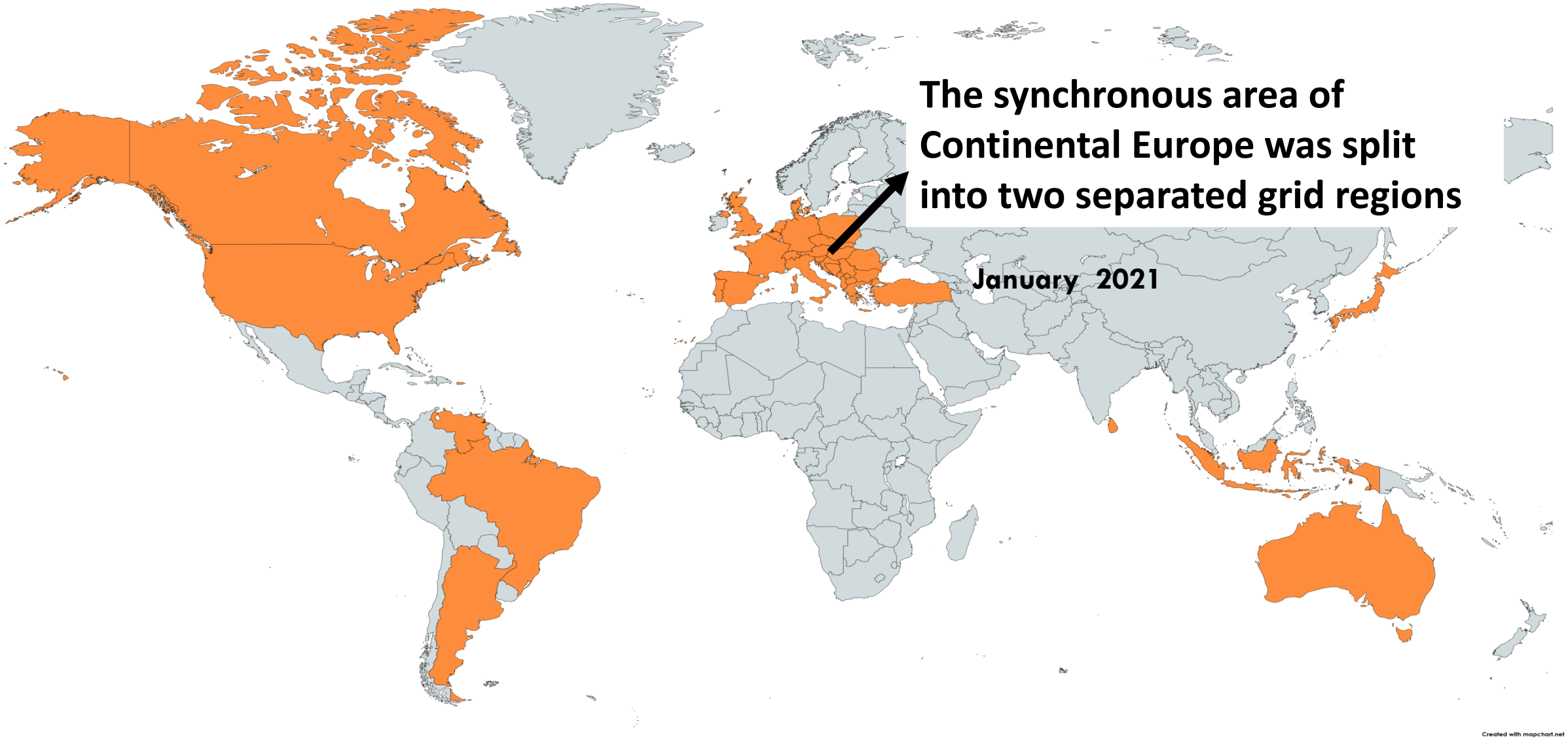

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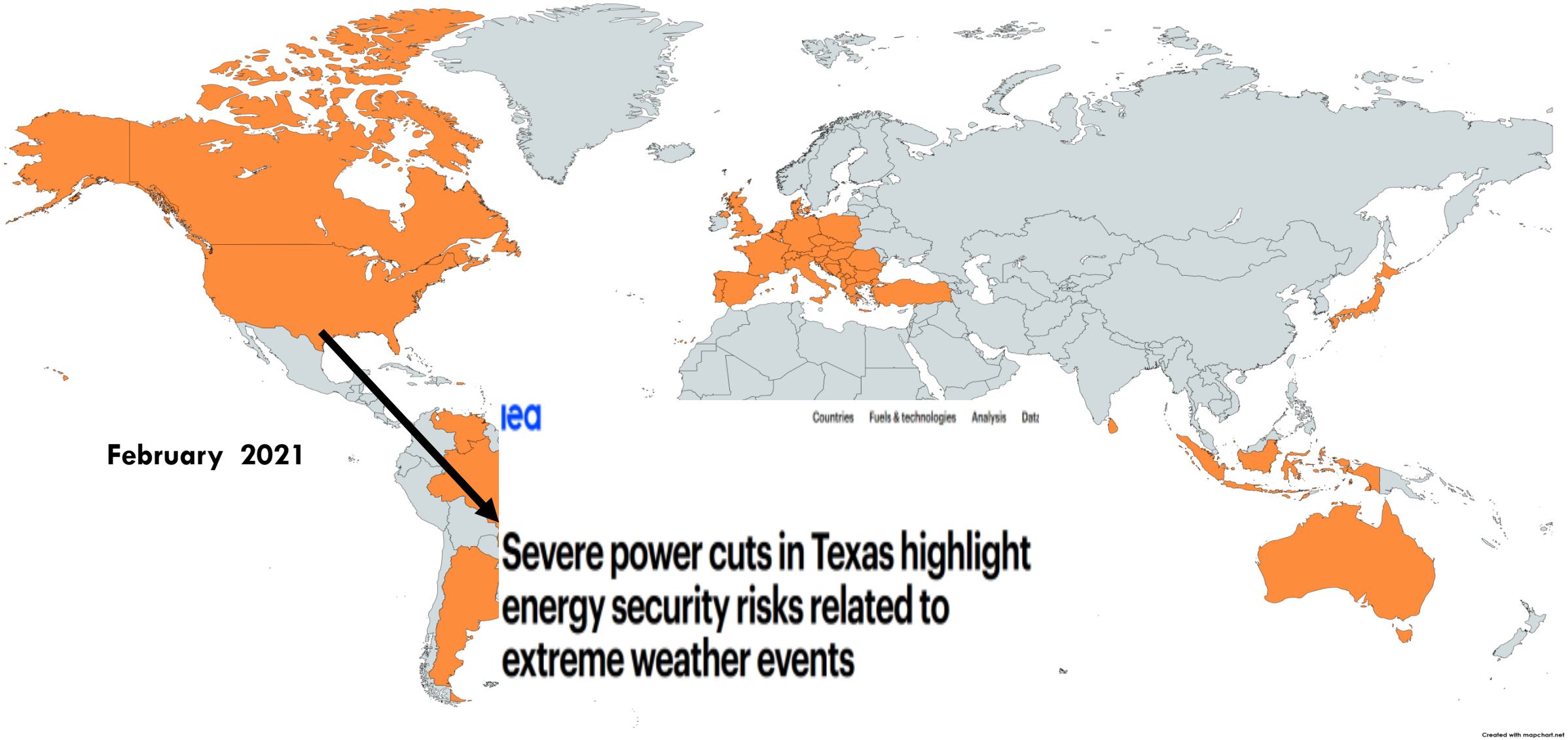

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Every blackout is different and also their impact on society

An **adequacy situation**, e.g. as occurred in California, is different from a **tornado, an earthquake or bush fires** that will cause permanent damage to the infrastructure.

The consequences of a blackout are also strictly connected to **correct operation protection and control systems**. E.g. during emergency situations that cause Under Frequency Load Shedding (UFLS) is crucial to keep critical loads in service.

Critical situations e.g. caused by severe weather conditions, **that turned into success stories**, and the lights stayed on:

- **Cold weather operation at MISO (USA)** in January 2019 (MISO operated with extreme cold, with unplanned generation outages. The emergency operational procedures were activated and MISO reliably met all obligations)
- **Separation of South Australia January-February 2020**, the islanding event lasted for 17 days (crucial support also from available flexibility which includes BESS installed and VPP in SA). This occurred during an extremely hot summer in Australia full of many other operational challenges.

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Every blackout is different

09/08/2019: UK disturbances conclusions from the Large Disturbances workshop (By R. Jameson and K. Bell)

- **Particular challenges in provision of frequency containment response**
  - How much is needed in a system with reducing inertia?
  - Opening up the market to new response providers and reducing dependency on fossil fueled plant
- **The impact of DG**
  - On August 9th, the behaviour of DG made a bad situation much worse
  - DG could play an active part in energy markets and provide system services
  - Generators' compliance with the Grid Code is not sufficiently considered proactively given the increased complexity of the system
- **Inverter connected resources**
  - Can offer flexibility but represent a threat if not properly understood and coordinated
- **More decision support and system awareness**
  - A better appreciation of risks and the costs and benefits of different interventions when operating the system requires much better collection of data

Disclaimer: overview of events according to our best knowledge, it may not be complete

Every blackout is different

16/06/2019: Argentina Blackout conclusions from the Large Disturbances workshop (By F. Gallego)

- **Combination of several causes**
  - Human Error (no action of the SPS, the adaption required was incomplete)
  - Generators' protections (wrong UF settings)
  - Demand's UFLS scheme (shed less load than expected)
- **Measures under development**
  - Consideration of more severe contingencies (for example, single fault followed by SPS failure)
  - Measures to speed up the restoration process:
    Improve operators training for islanded operation;
    Increase the number of power plants with black start capability.
  - New special protection schemes for automatic islanding, including backup system's, such as Automatic generation disconnection schemes based on PMUs, as back up for primary special protection schemes.

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Adequacy situation & Need for flexibility

15/08/2020: California USA (source: Preliminary Root Cause Analysis Rotating Outages August 2020)

- **Rolling blackouts in CAISO (Flex Alert)**
  - **Extreme heat across Western US, expected cloud cover that will reduce PV output, and wildfires threatening power lines**
  - **Electricity demand exceeding the existing electricity resource planning targets, amplified by the extreme heat.**

- **Lessons learned**
  - Update the resource and reliability planning targets
  - Ensure that the generation and storage projects are completed by their targeted dates
  - Increase flexibility: expedite the regulatory and procurement processes to develop additional resources that can be online by 2021
  - Enhance market practices to ensure they accurately reflect the actual balance of supply and demand during stressed operating conditions

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Adequacy situation & Need for flexibility

15-17/02/2021: Texas USA (source: IEA report 18-02-2021)

- **Rolling blackouts in Electricity Reliability Council of Texas (ERCOT) area**
  - **Exceptionally cold weather hitting the United States has provoked an electricity shortage in Texas, with extensive power cuts affecting over 4 million customers.**
  - **The cold weather drove up electricity heating demand and hampered supply from the gas system and from power plants. Market wholesale electricity prices rose to the cap of 9000 USD per MWh.**
  - **The outages were far larger and much longer lasting than the rotating cuts during the exceptionally hot weather in California last August 2020.**
- **Lessons learned**
  - A resilient electricity system requires a resilient natural gas system.
  - System planners need to ensure that power systems are resilient to increasing weather extremes.
  - High dependence on electricity in space heating can result in strong market volatility when the energy system faces exceptionally cold temperatures.

Changing Operational Conditions

- **High penetration of RES** (requiring an observable and flexible power system)
- **Integration of new technologies** (power electronics based with higher controllability, but also with controller interaction risks)
- **Higher dependency digital technologies** (where cybersecurity is central)
- **More dynamic energy markets** (which will evolve depending on the generation mix and available transmission capacity)

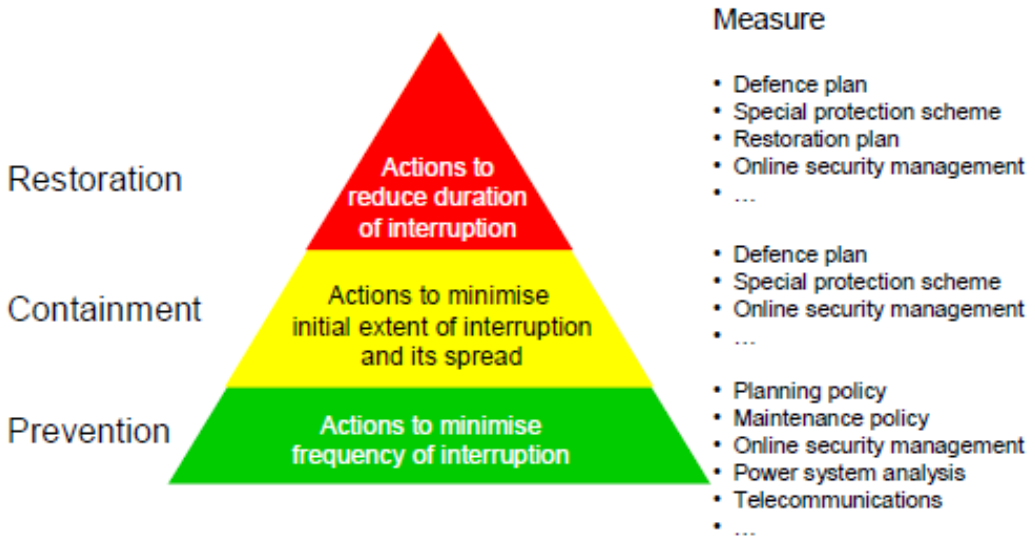
Conclusions

The dependencies and complexity of a cyber-physical system are of crucial importance for system operators, where **network security and security of supply remain their goal**.

In addition, the **frequency and severity of natural phenomena** has also increased, increasing the likelihood of severe blackouts with longer restoration times due to infrastructure damage. **System Resilience** and **Restoration** are crucial to recover High Impact Low Probability (HILP) events and restore the system as soon as possible.

All together there are two certainties:

1. We need to design and operate a **more complex, resilient and stable power system**:
   increasing **flexibility, controllability and observability**
2. There will be many interesting events
   to share in the future workshops to come



Technical management of major unreliability events[6]