

Challenges for Electricity Distribution Networks

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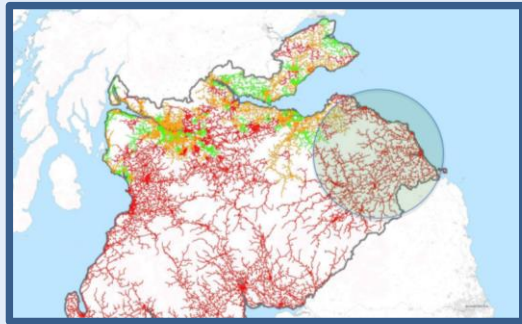
Introduction



- What is the electricity distribution network?
- What impact does DG have on the distribution network?
- Why are some distribution networks 'Full' of DG?
- How can other **distributed energy resources** mitigate the limitations on DG?

WHAT IS THE ELECTRICITY DISTRIBUTION NETWORK?

The World of Distribution Infrastructure



- large number of medium and low voltage, lower value assets
- Radial Systems predominate

Scotland it is $\leq 33\text{kV}$

England and Wales it is $\leq 132\text{kV}$

The World of Distribution Infrastructure



- Small transformer
- Limited redundancy
- Hard to automate
- Little real-time control actions

The World of Distribution

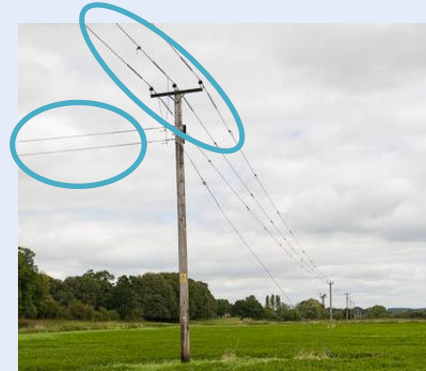
Monitoring and visibility



- Limited real time visibility
- Limited options for remote control
- Some automatic control actions
- *No visibility / control* of lower voltage levels (11kV and below)

The World of Distribution

Electrical characteristics



- Highly resistive
- Can have significant imbalance on three phase components and ...
- large single phase sections
- Often 'radial'

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The World of Distribution

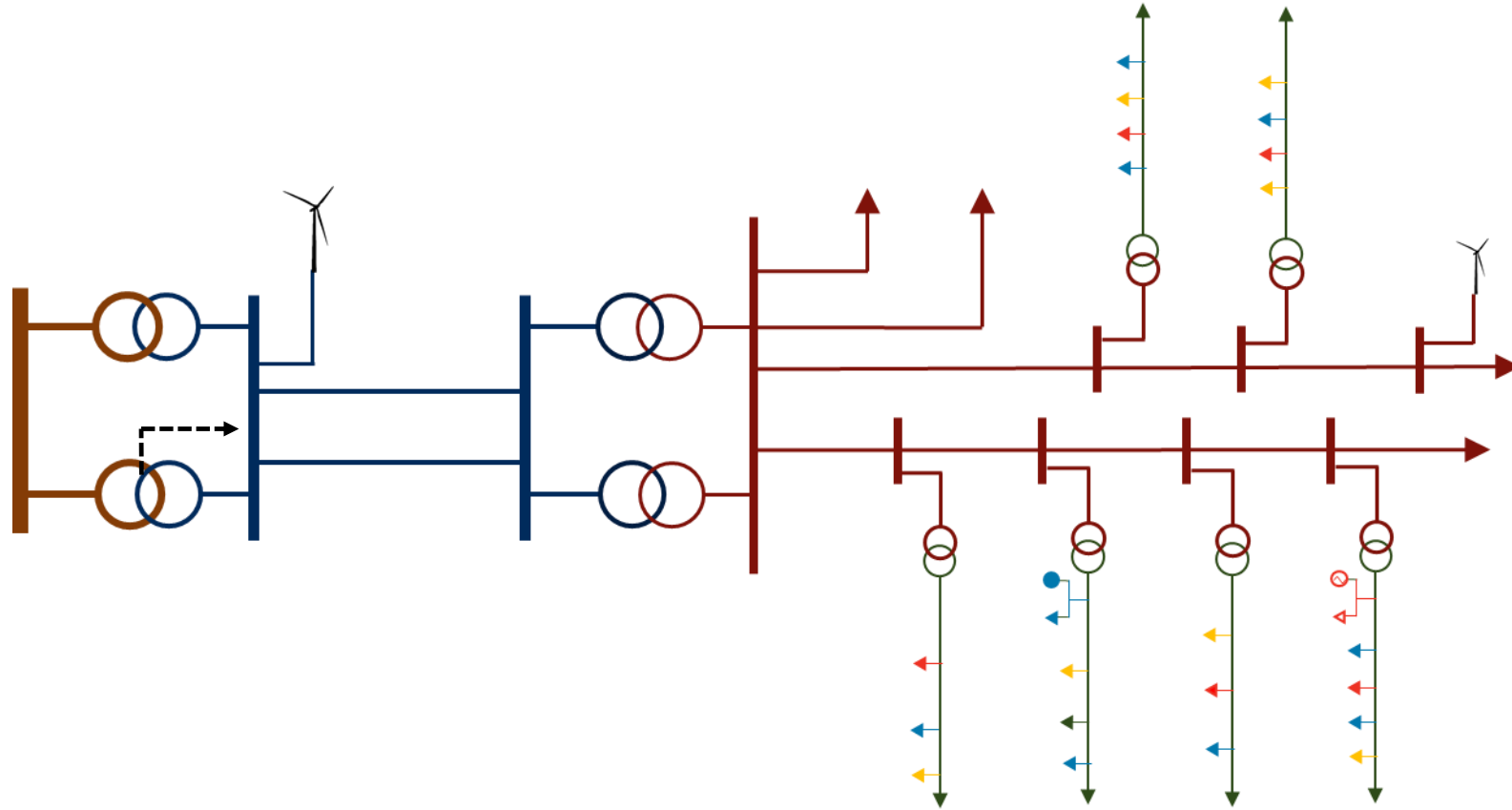
Summary

The network, particularly at lower voltage levels, has little or no real time monitoring to the point to that it relies on customers phoning up to report a fault.

Some automated control actions exist, but very limited remote control is possible.

At lower voltage levels, 'automatic' response is likely to involve simply disconnecting a load / generator / network section, until an engineer can attend

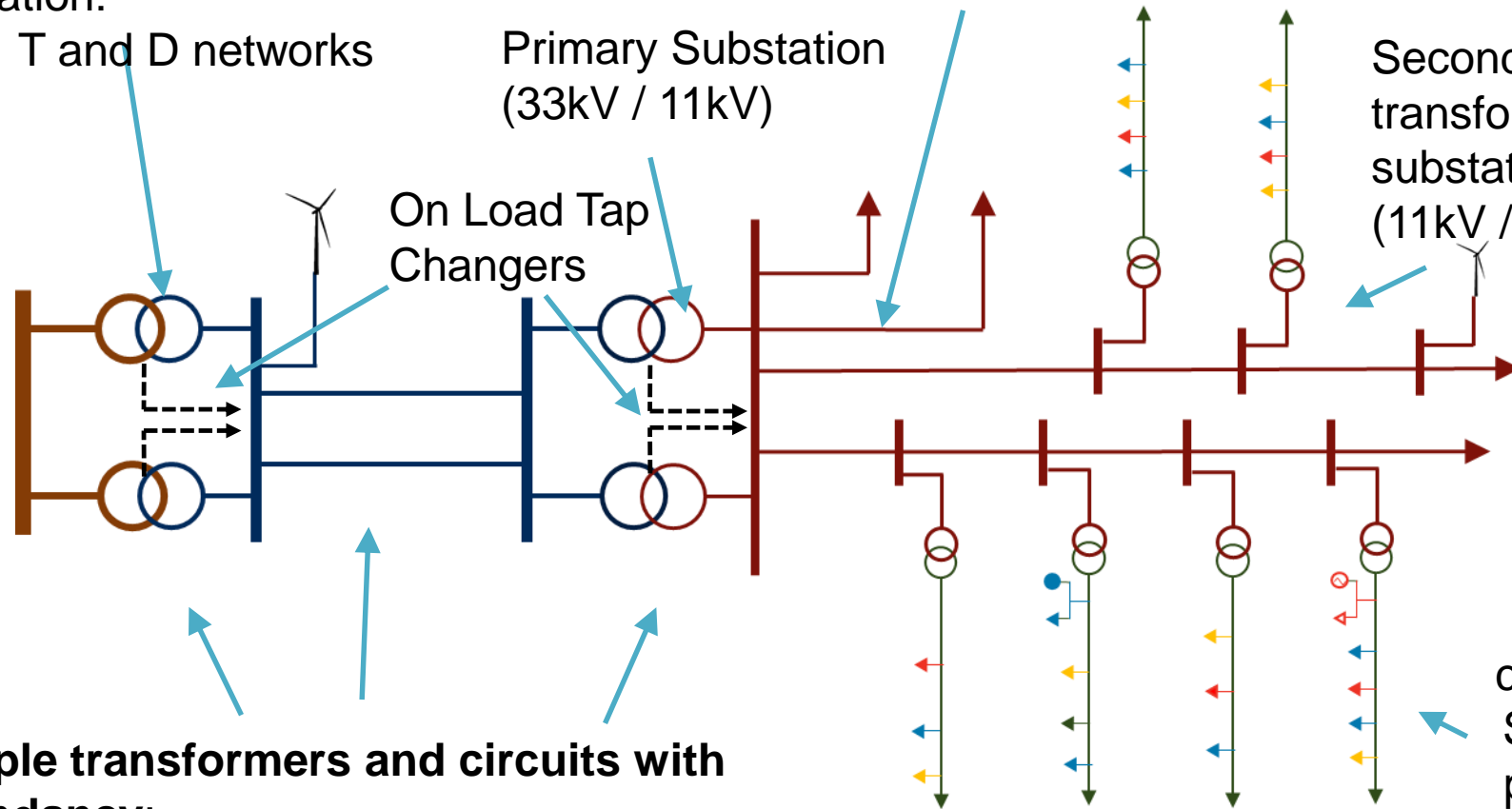
Components of a Distribution Network



Components of a Distribution Network

Grid Supply Point (GSP) substation:

Joins T and D networks



Multiple transformers and circuits with redundancy:

If one is off due to fault, the other is not overloaded

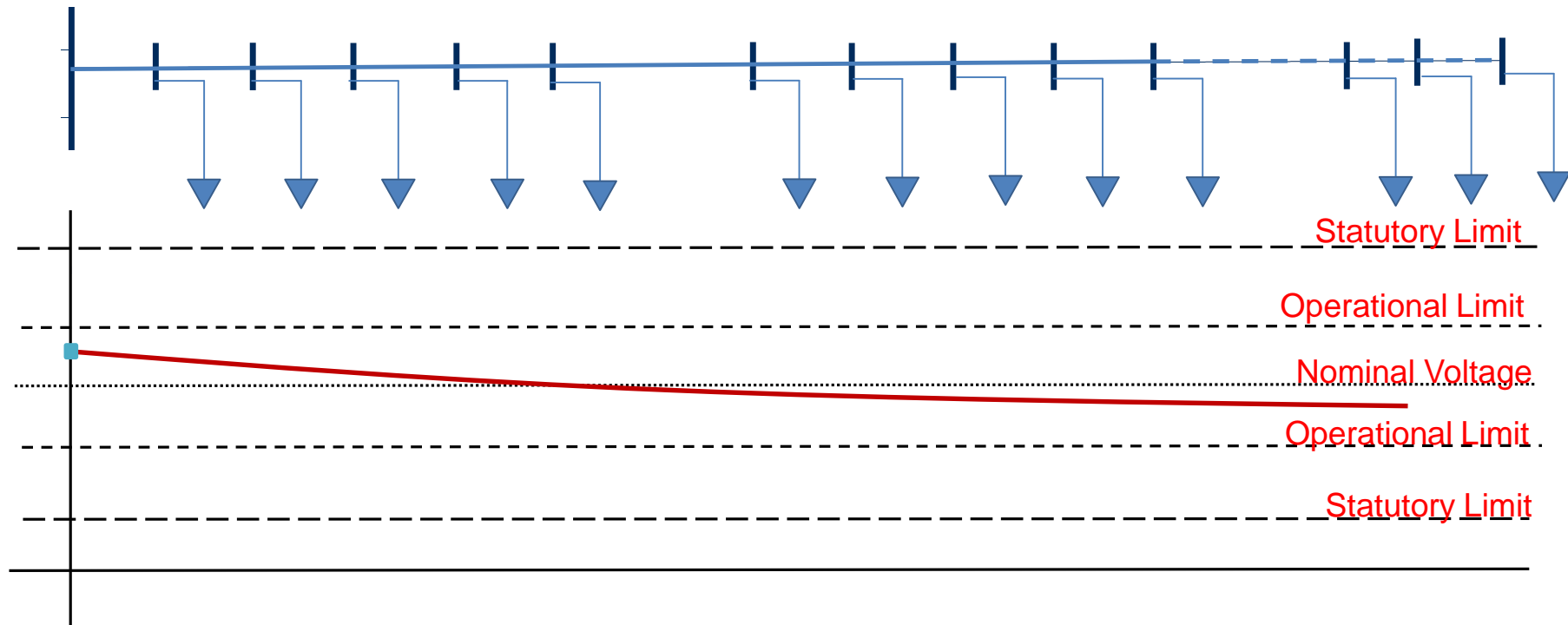
Secondary transformers / substations (11kV / 400 V)

LV circuits
Single phase Loads
(e.g. Your house)

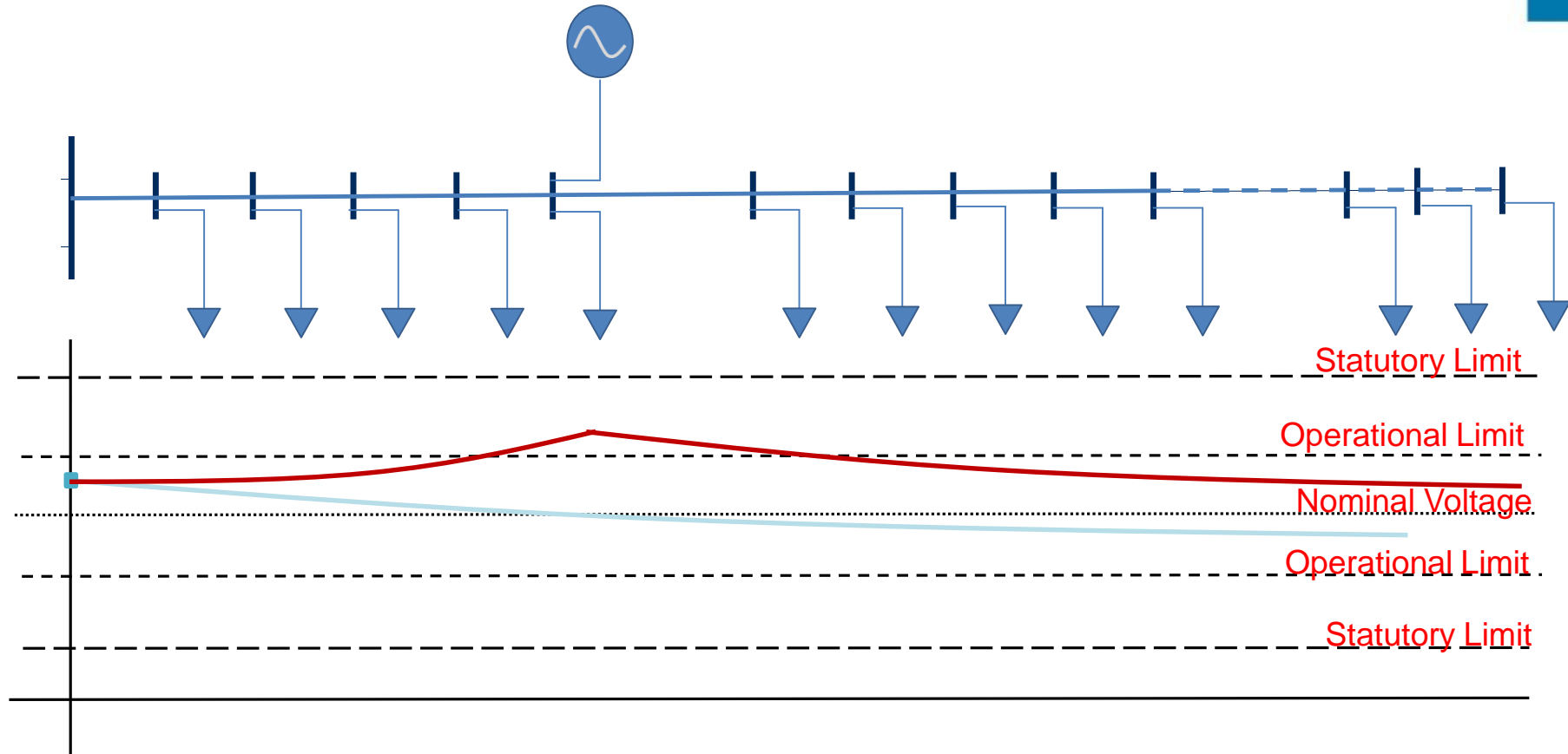
WHAT IMPACT DOES DISTRIBUTED GENERATION HAVE ON THE DISTRIBUTION NETWORK?

- It affects the system power flow by providing a source of energy that can be consumed locally
- Adding DG can improve reliability (helps meet local demand)
- Adding DG can also decrease reliability if there is excess power (flexible demand becomes useful).
- It affects the voltage profile of a distribution feeder

11kV Feeder



11kV Feeder



WHY ARE SOME DISTRIBUTION NETWORKS 'FULL' OF DISTRIBUTED GENERATION?

What is Firm capacity?

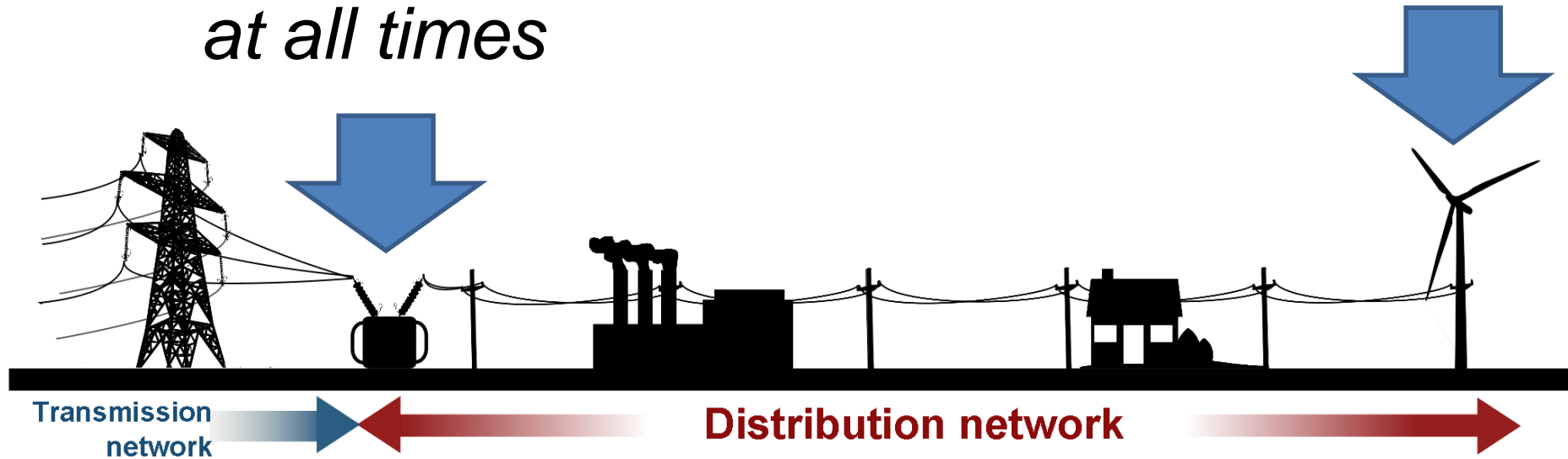
- *the capacity of installed generation that can be operated whilst keeping the system within operating limits under the **worst case conditions***
- ***Worst case conditions are usually Minimum demand, Maximum generation e.g. 3AM on a windy, warm summers night.***

Beyond the Firm Limit

$$|P| < P_{max}^{network}$$

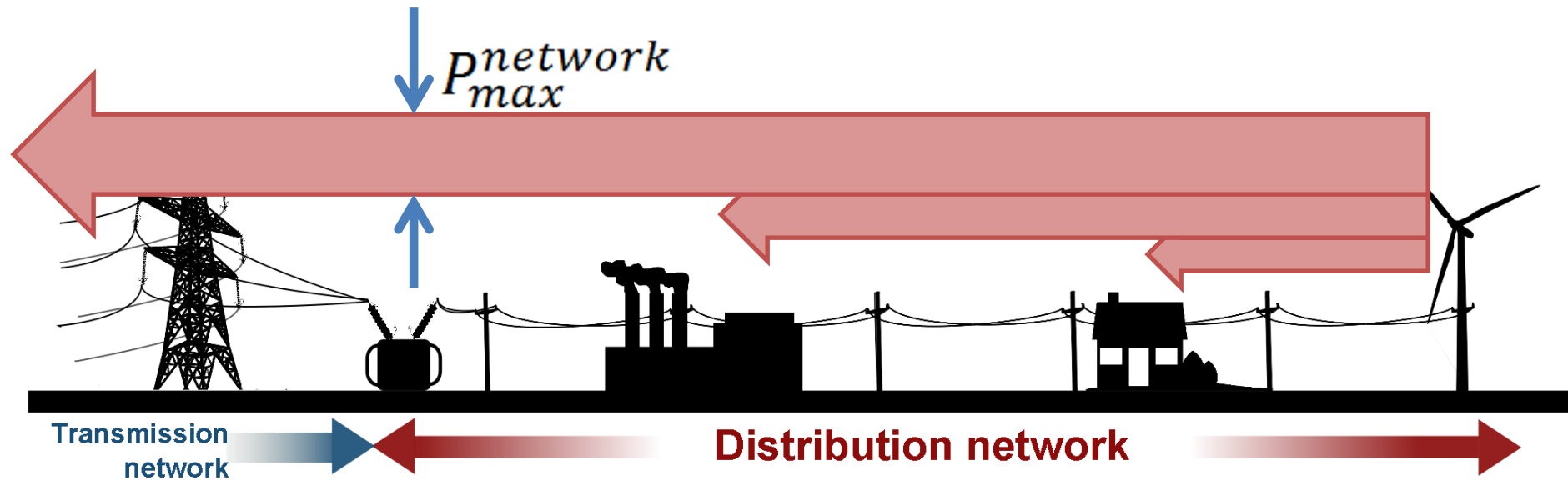
at all times

$$P_{capacity}^{DG} < P_{max}^{network} + P_{min}^{demand}$$



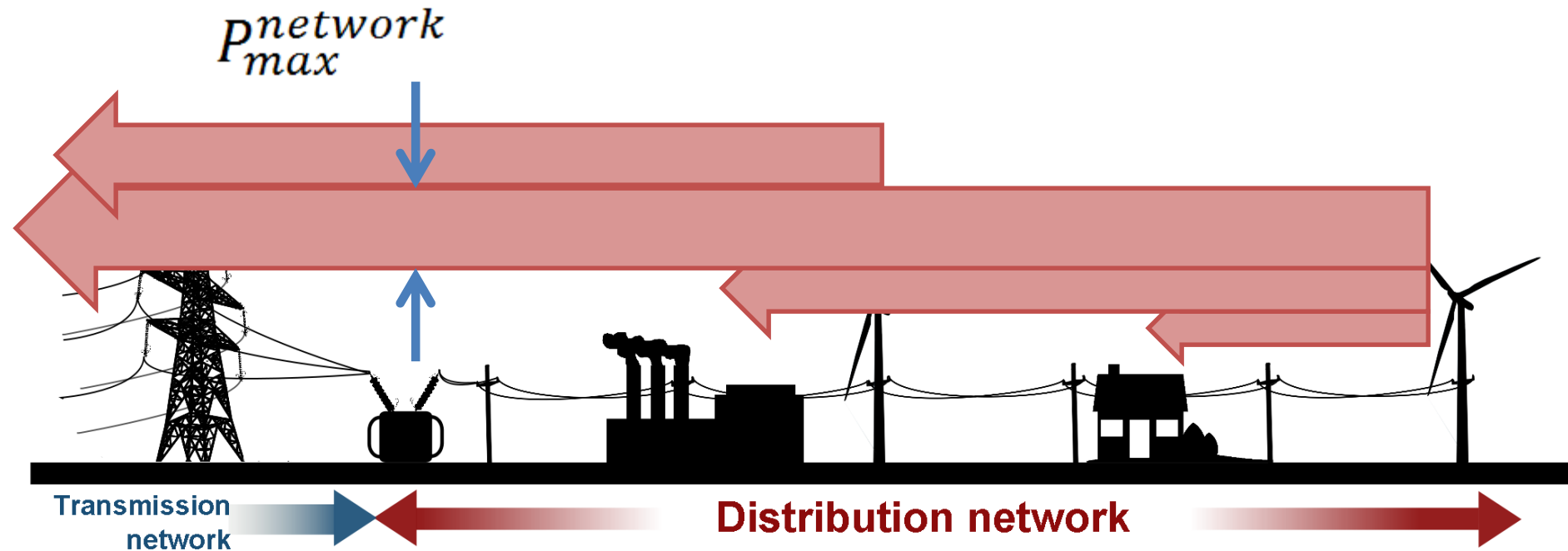
**Traditional + Distributed
Generation**

Beyond the Firm Limit



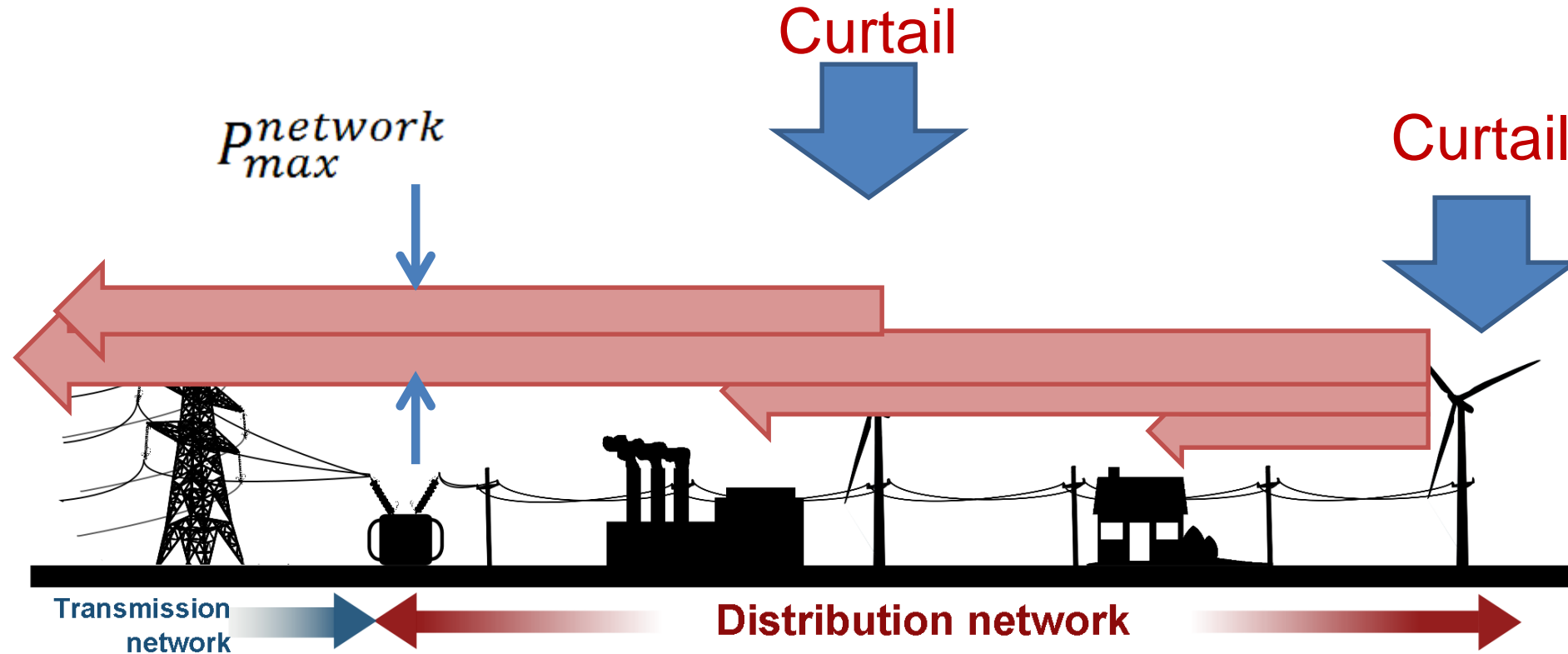
**Traditional + Distributed
Generation**

Beyond the Firm Limit



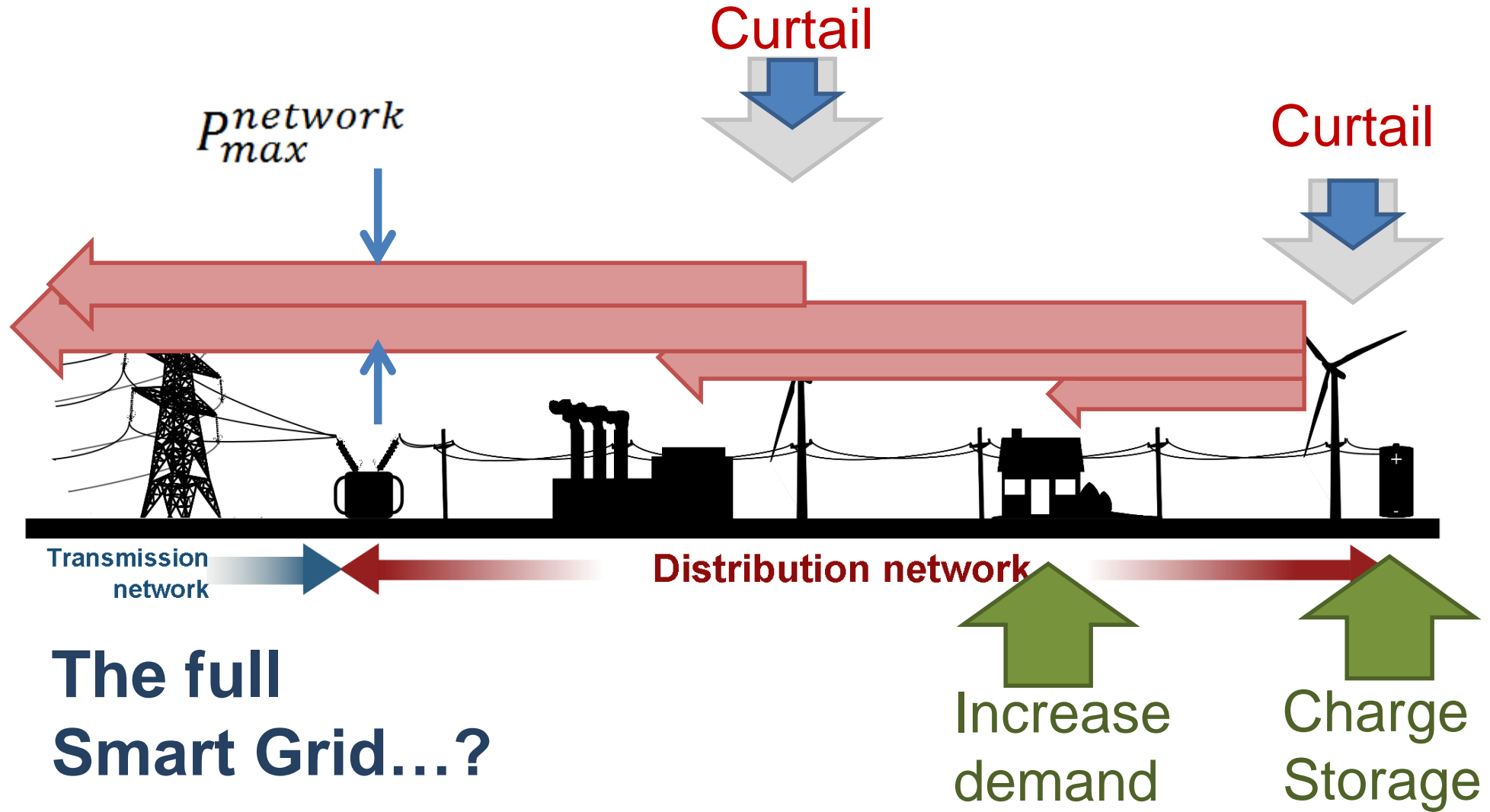
**Traditional + Distributed
Generation**

Beyond the Firm Limit



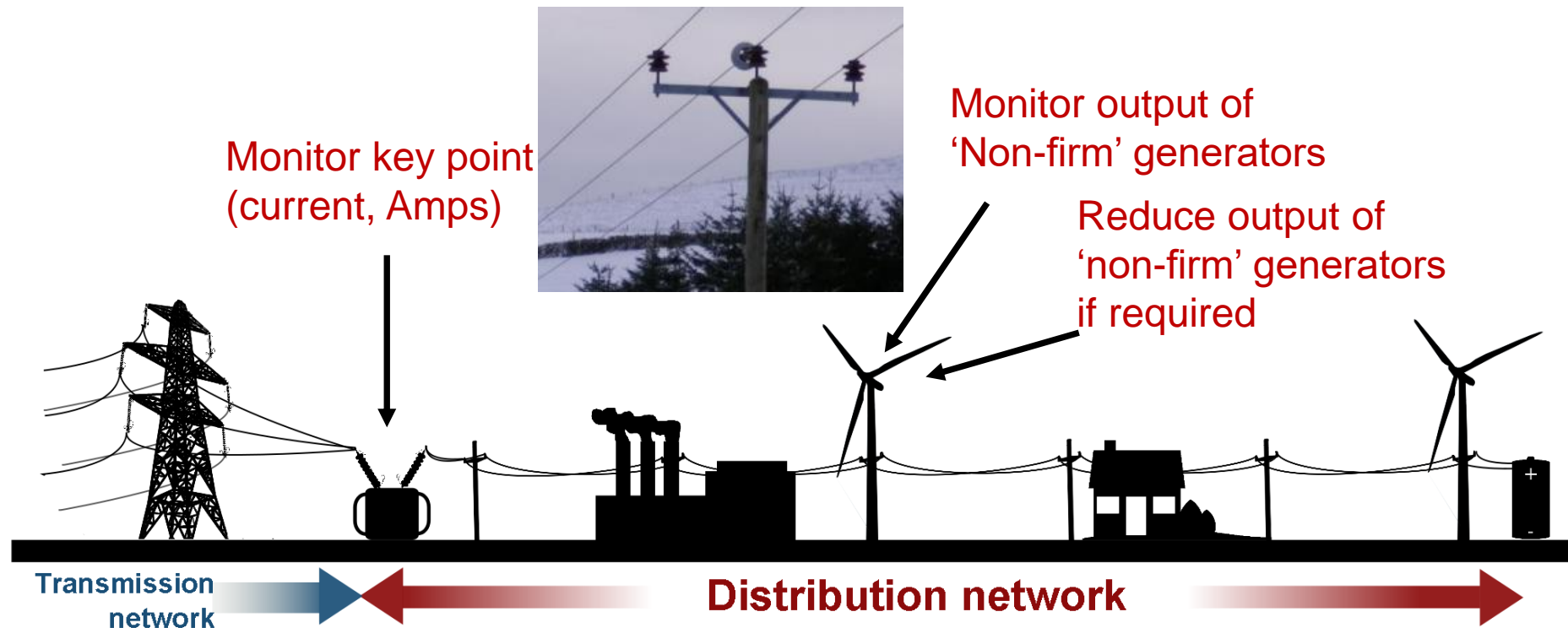
**Active
Network Management**

Beyond the Firm Limit



The Active Network Management Philosophy

- Firm limit means, by definition, there is additional network capacity the vast majority of the time. But no monitoring and control available to access it securely
- ANM aims to use minimal monitoring and controllability of *new* generation to access that network capacity



**HOW CAN OTHER
DISTRIBUTED ENERGY
RESOURCES MITIGATE THE
LIMITATIONS ON DG?**

- Energy Storage
- Connection of New Demand
 - Commercial
 - EV
- Smart metering
- Network visibility
- Complementary Energy Carriers
- Whole systems approach
- Market/Policy Solutions





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