nationalgrid

Vector Shift

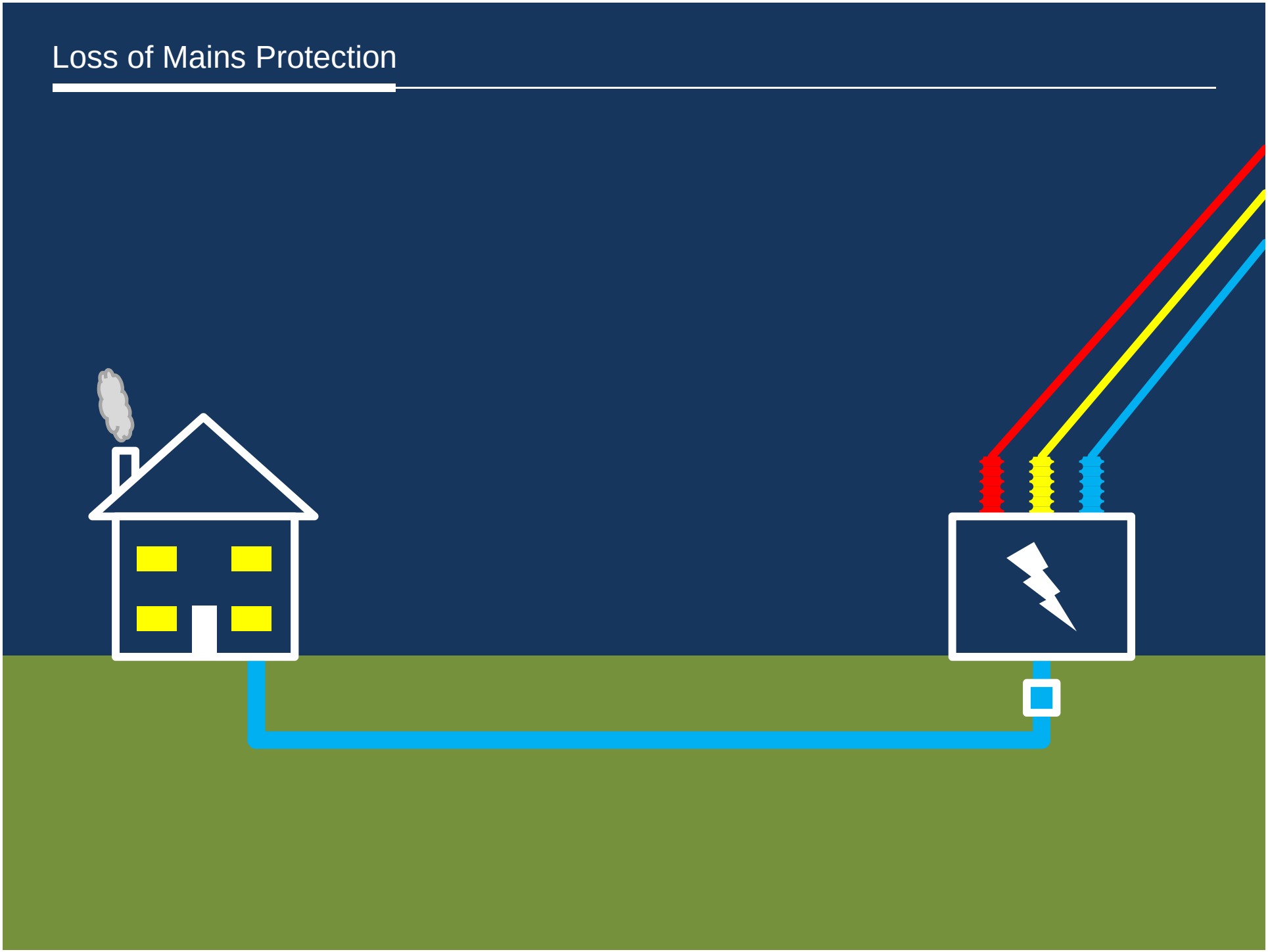
Robert Westmancoat

Overview

Loss of Mains Protection	why do we need it?
Detecting a fault	what methods are used?
What's the risk?	changing power system
Observations & Analysis	real-life events and forecasts
Risk mitigation	what have we been doing?

Loss of Mains Protection

Loss of Mains Protection



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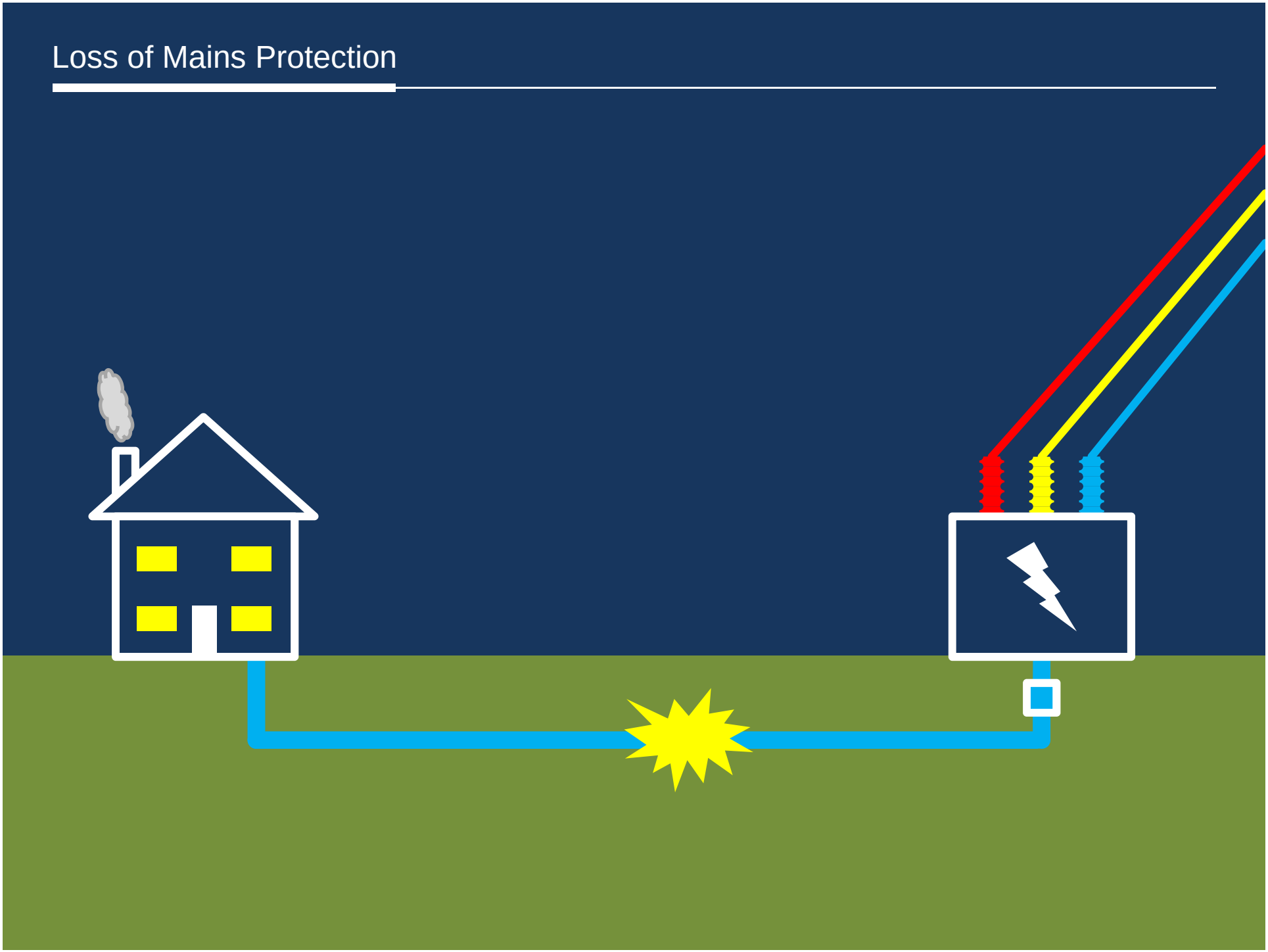

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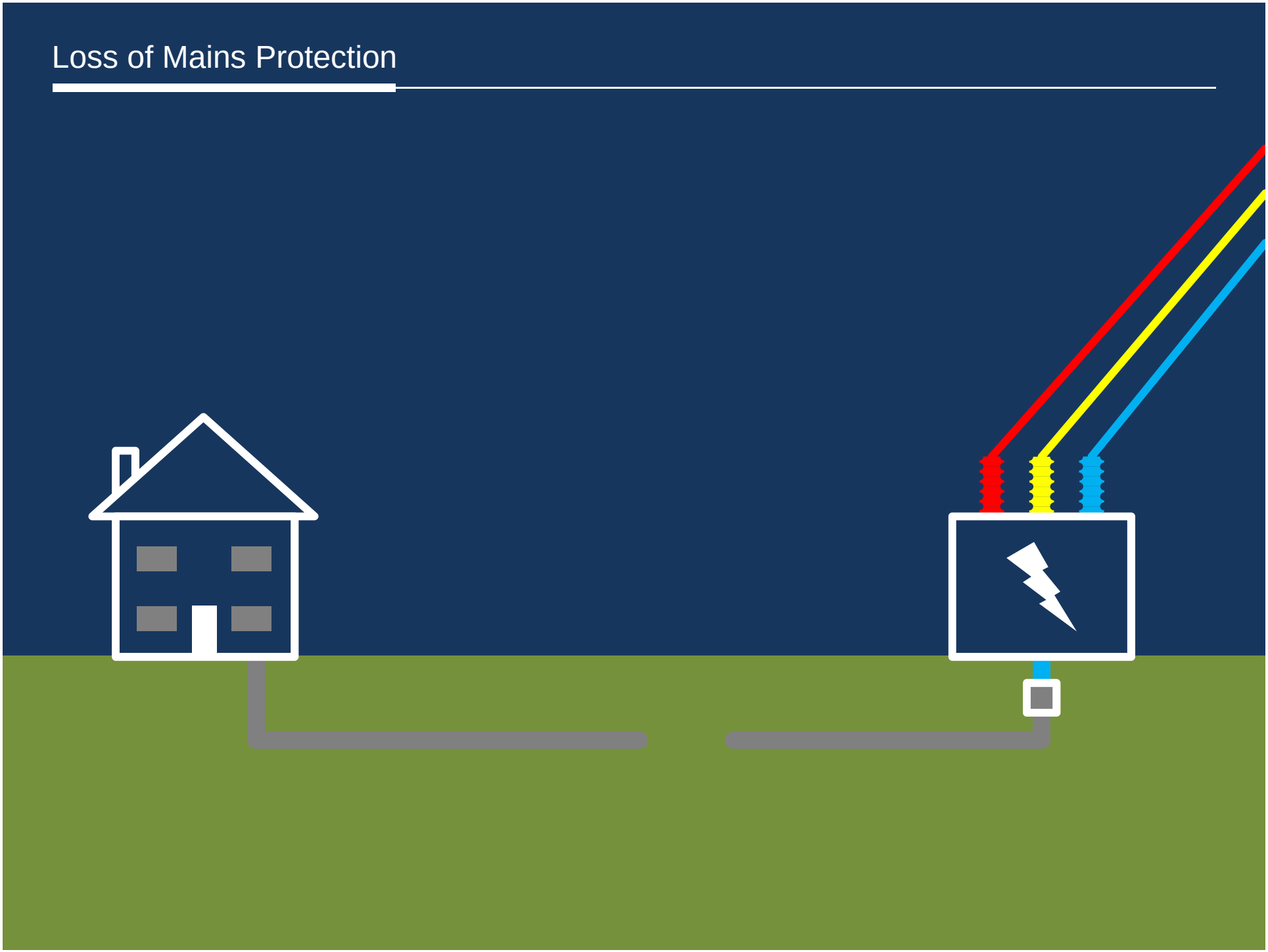

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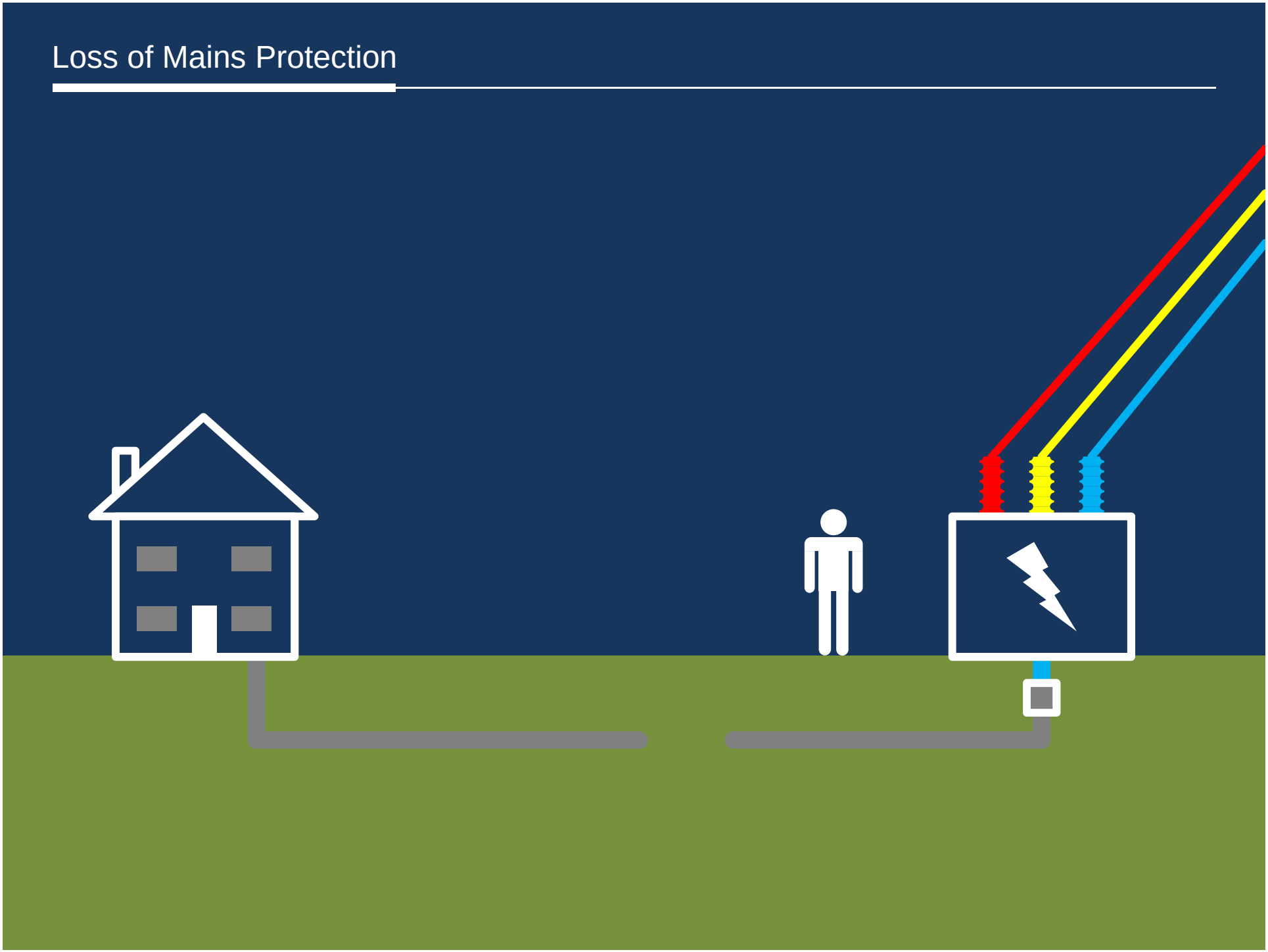

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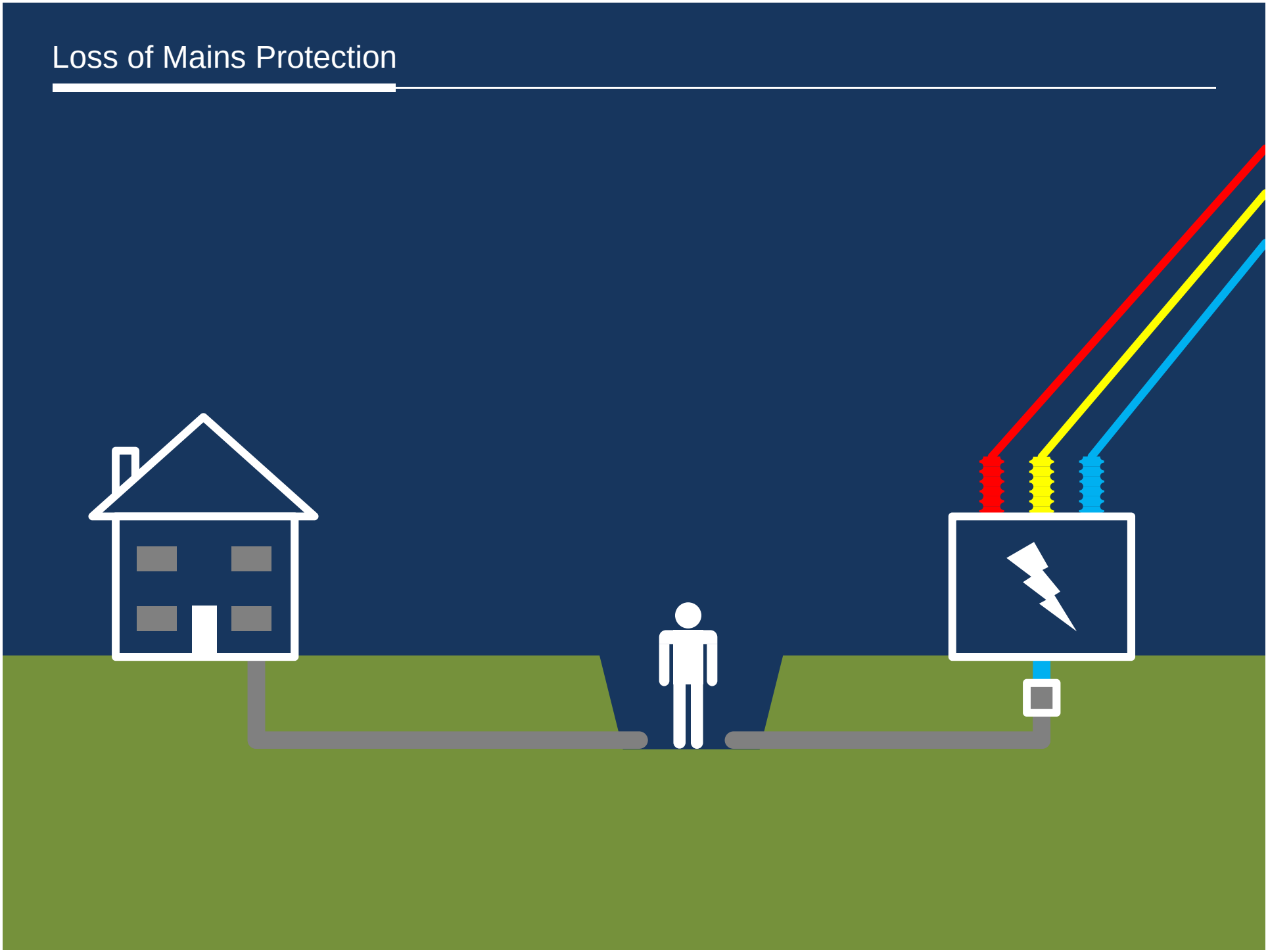

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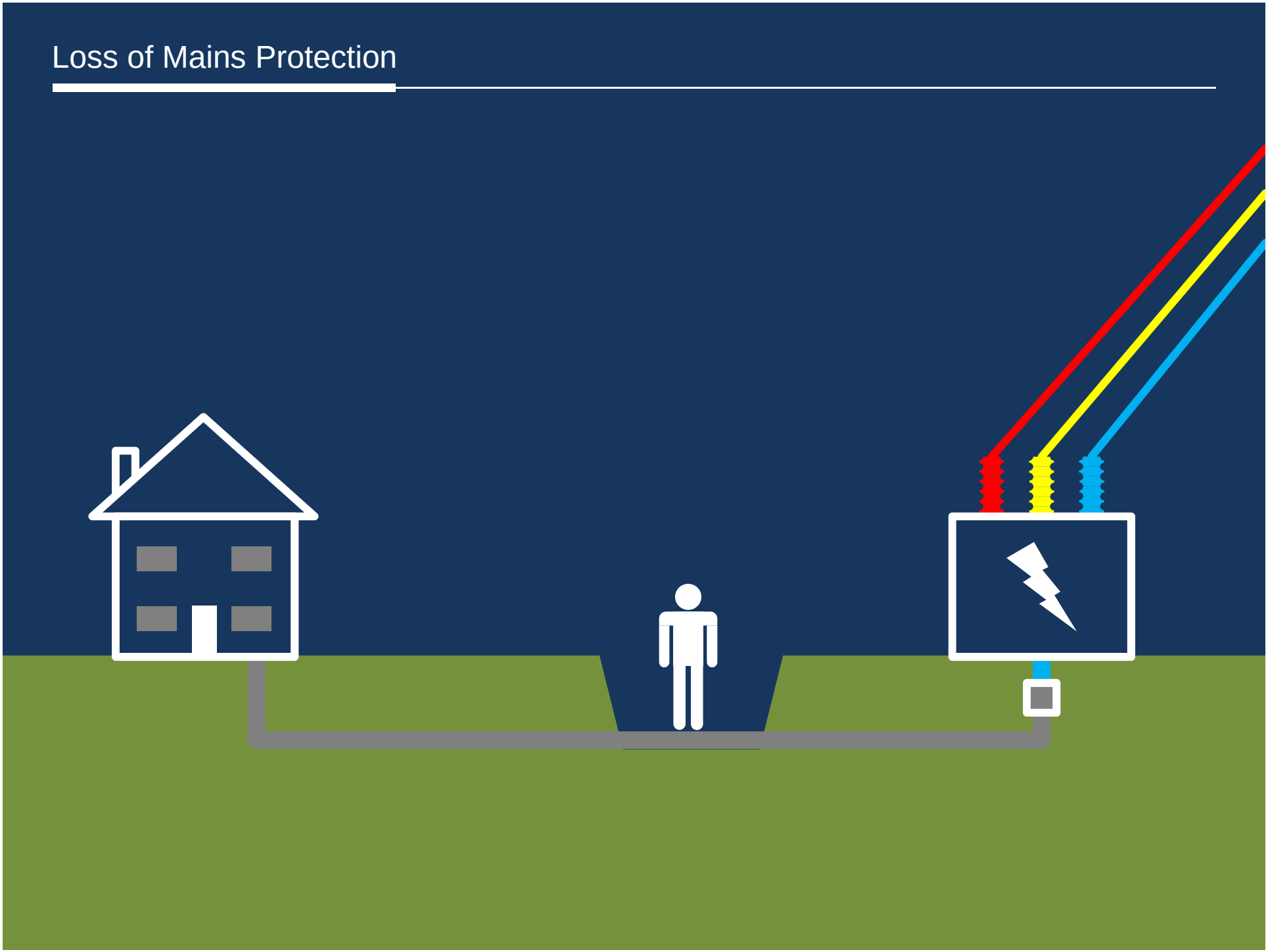

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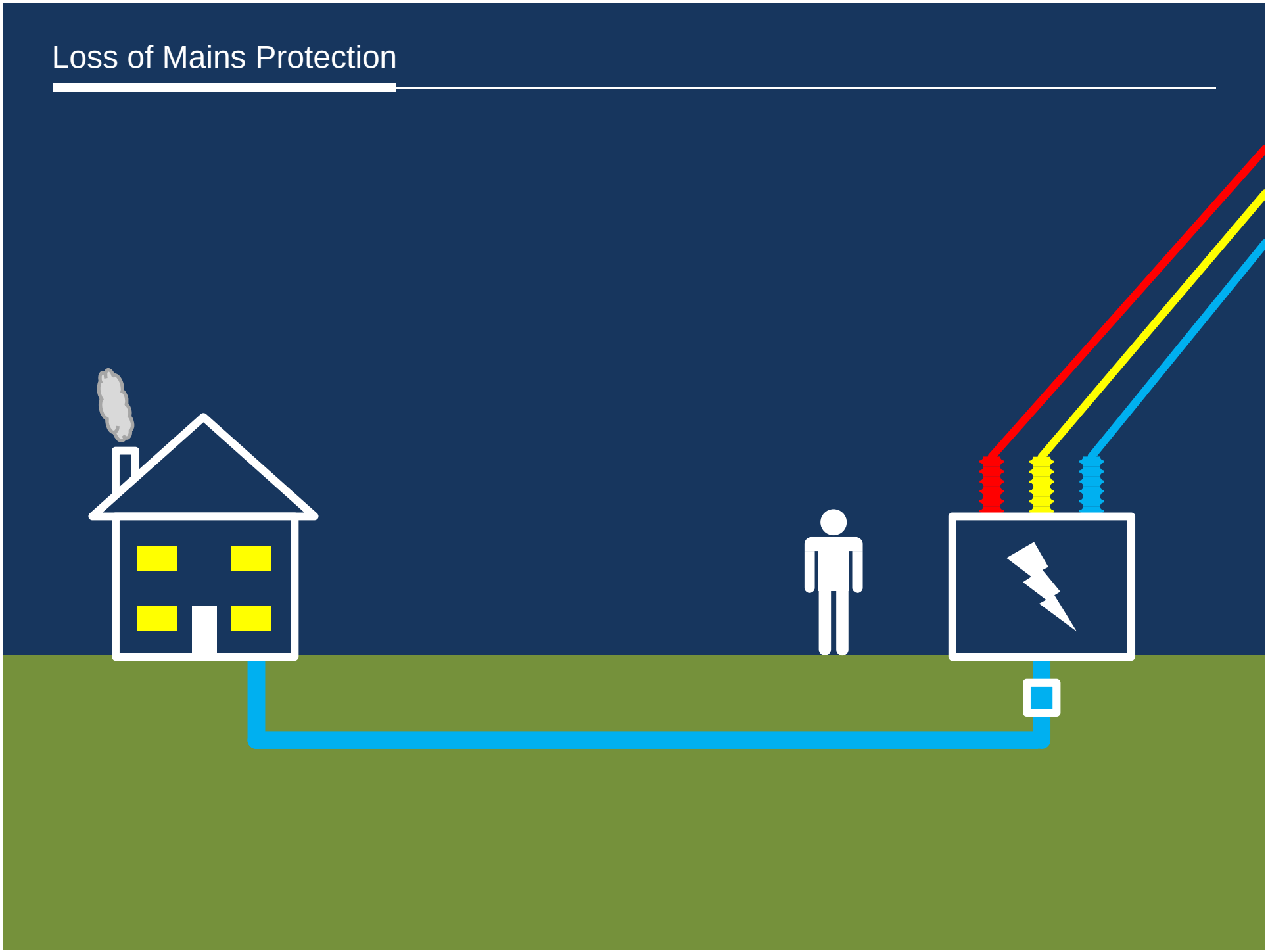

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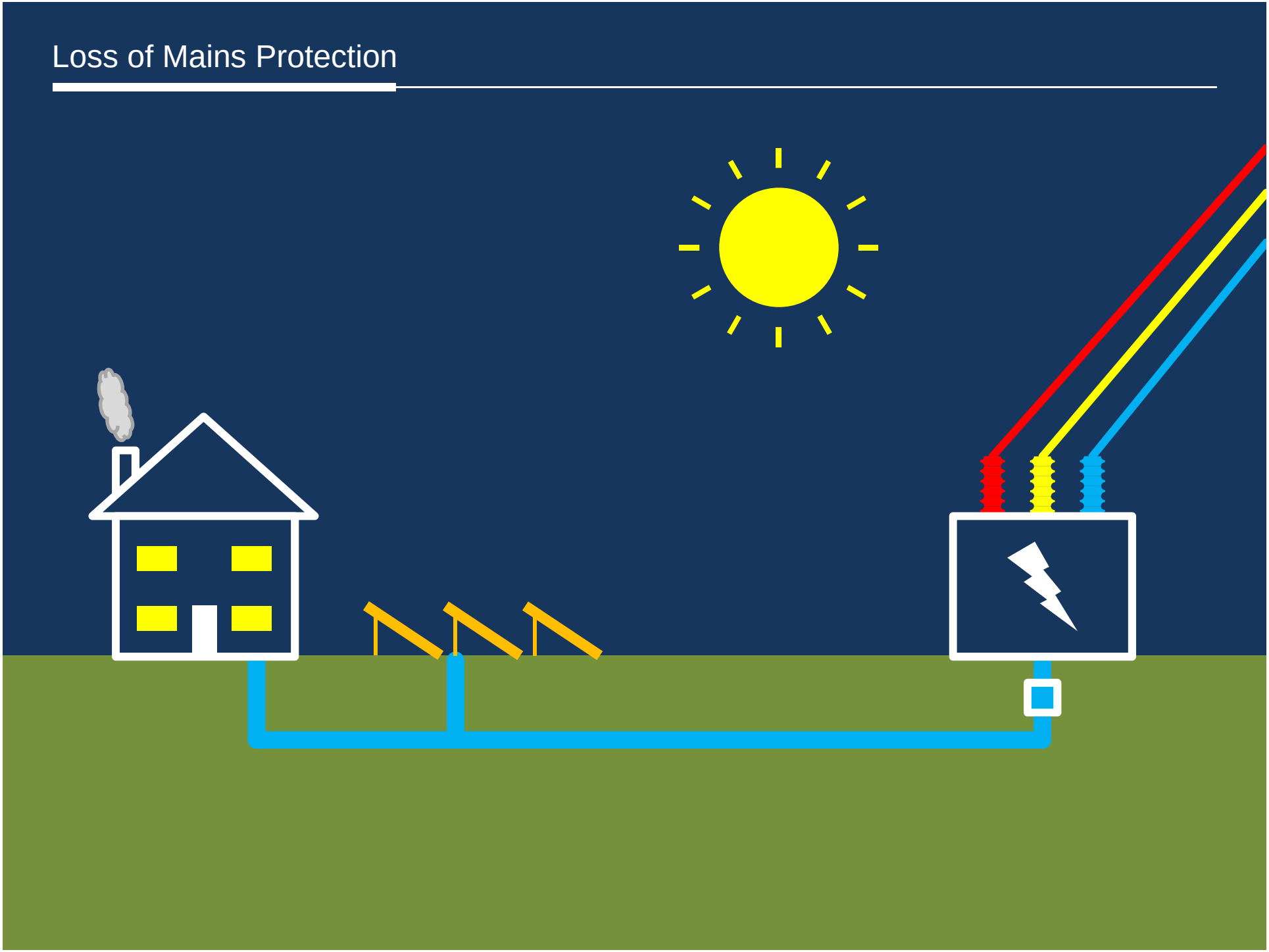

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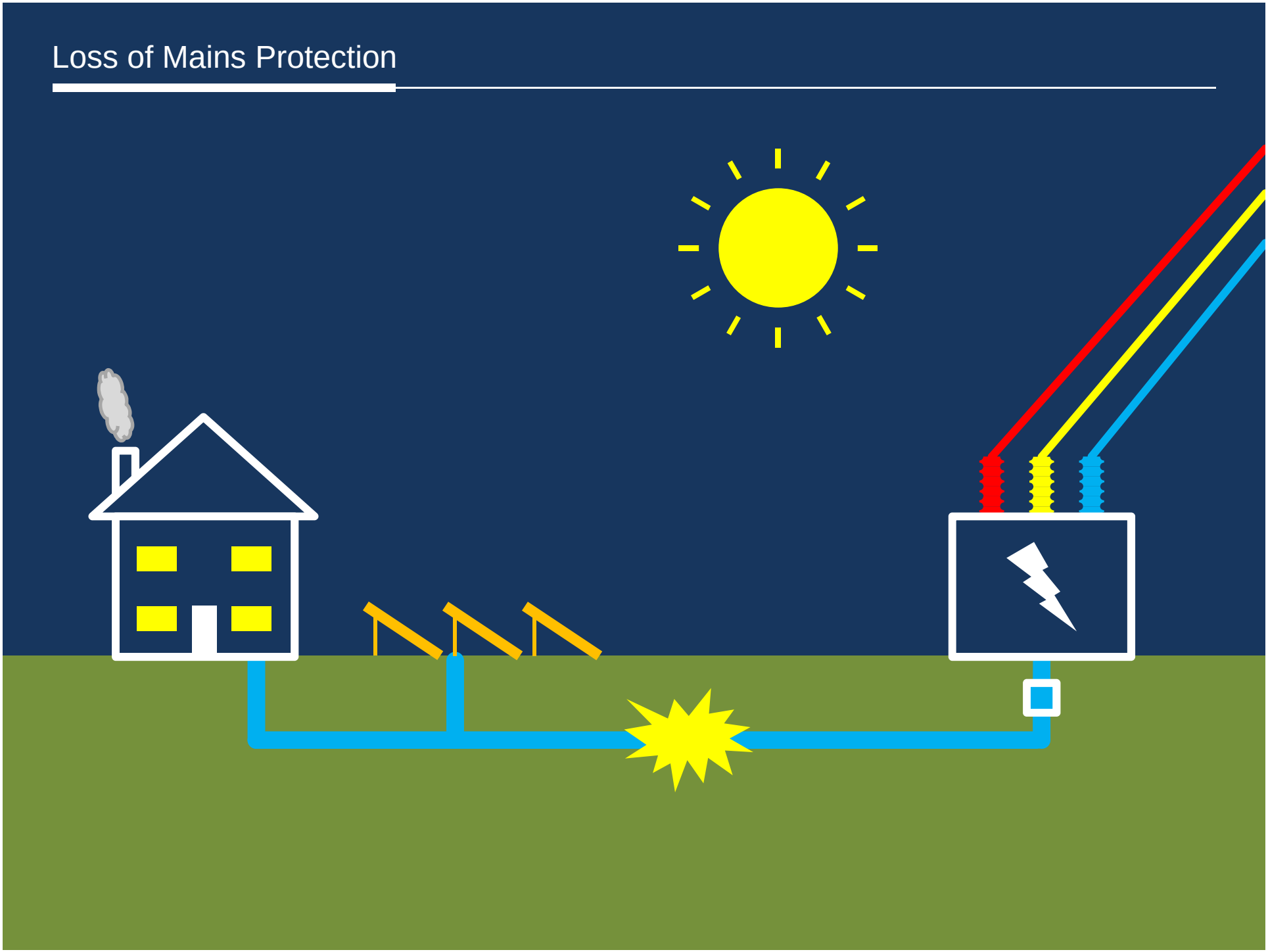

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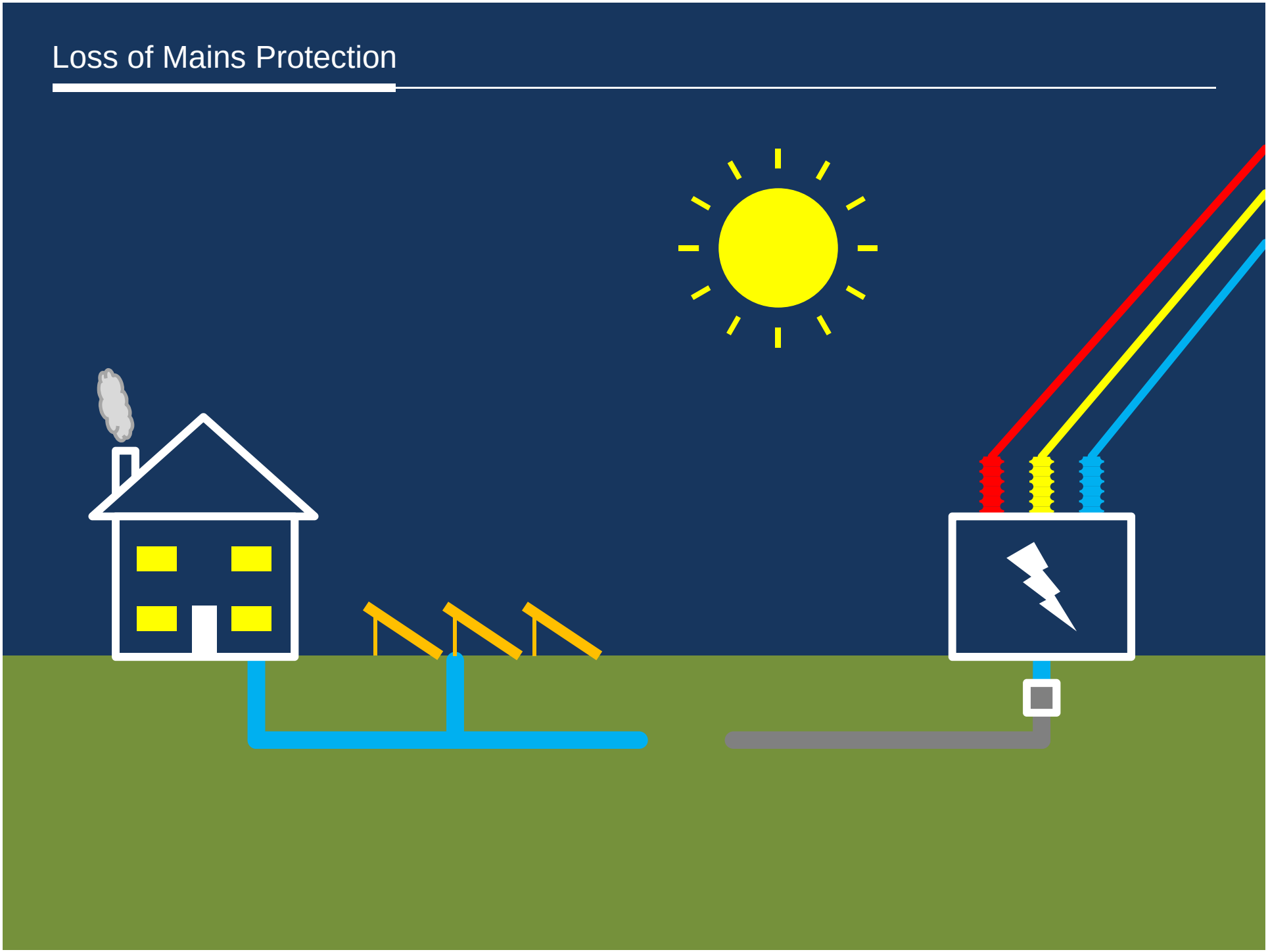

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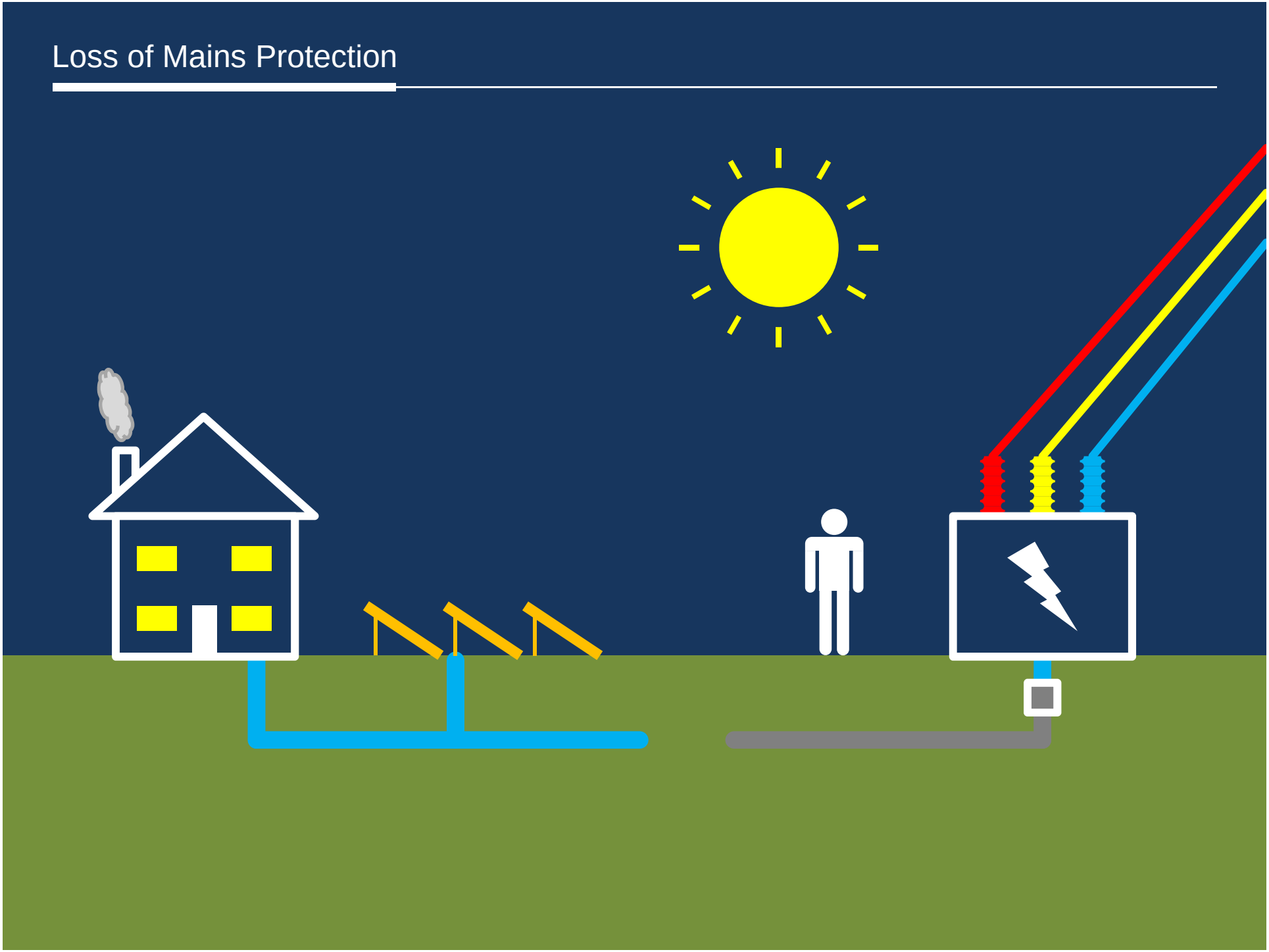

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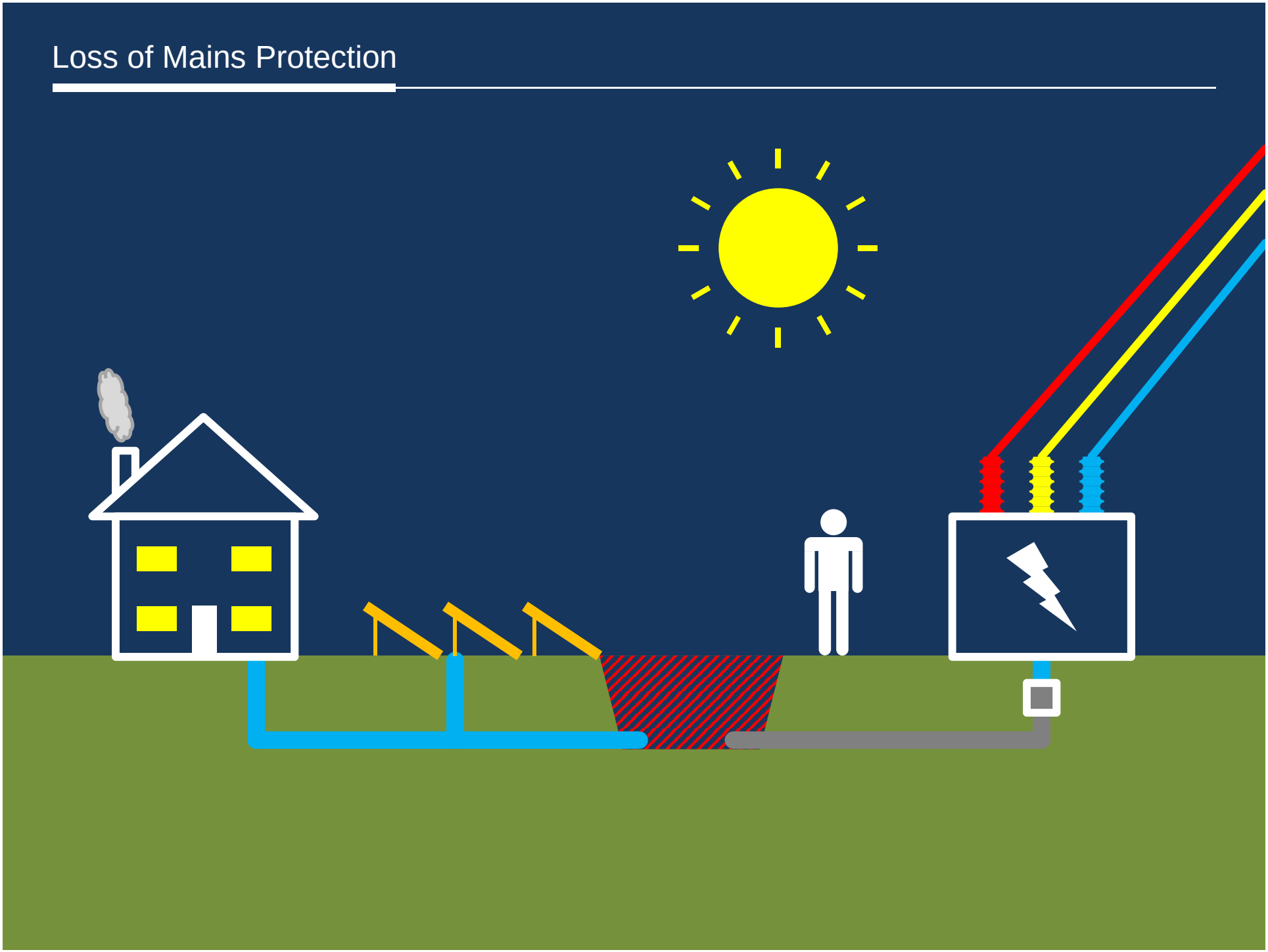

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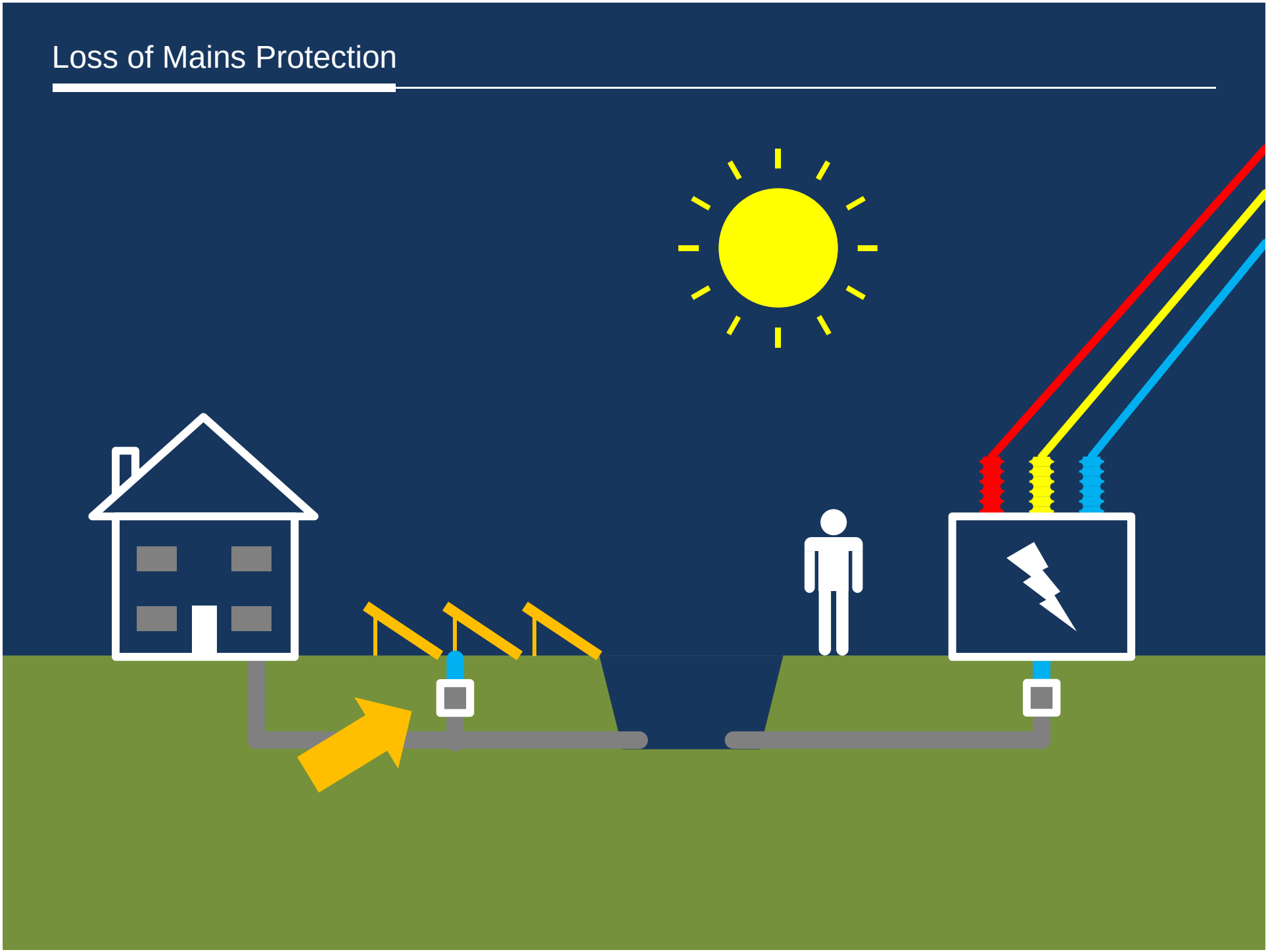


I FELT A GREAT DISTURBANCE
IN THE NETWORK

Image courtesy of "thelastamericanvagabond.com"

Inertia

/ɪˈnəːʃə/
noun

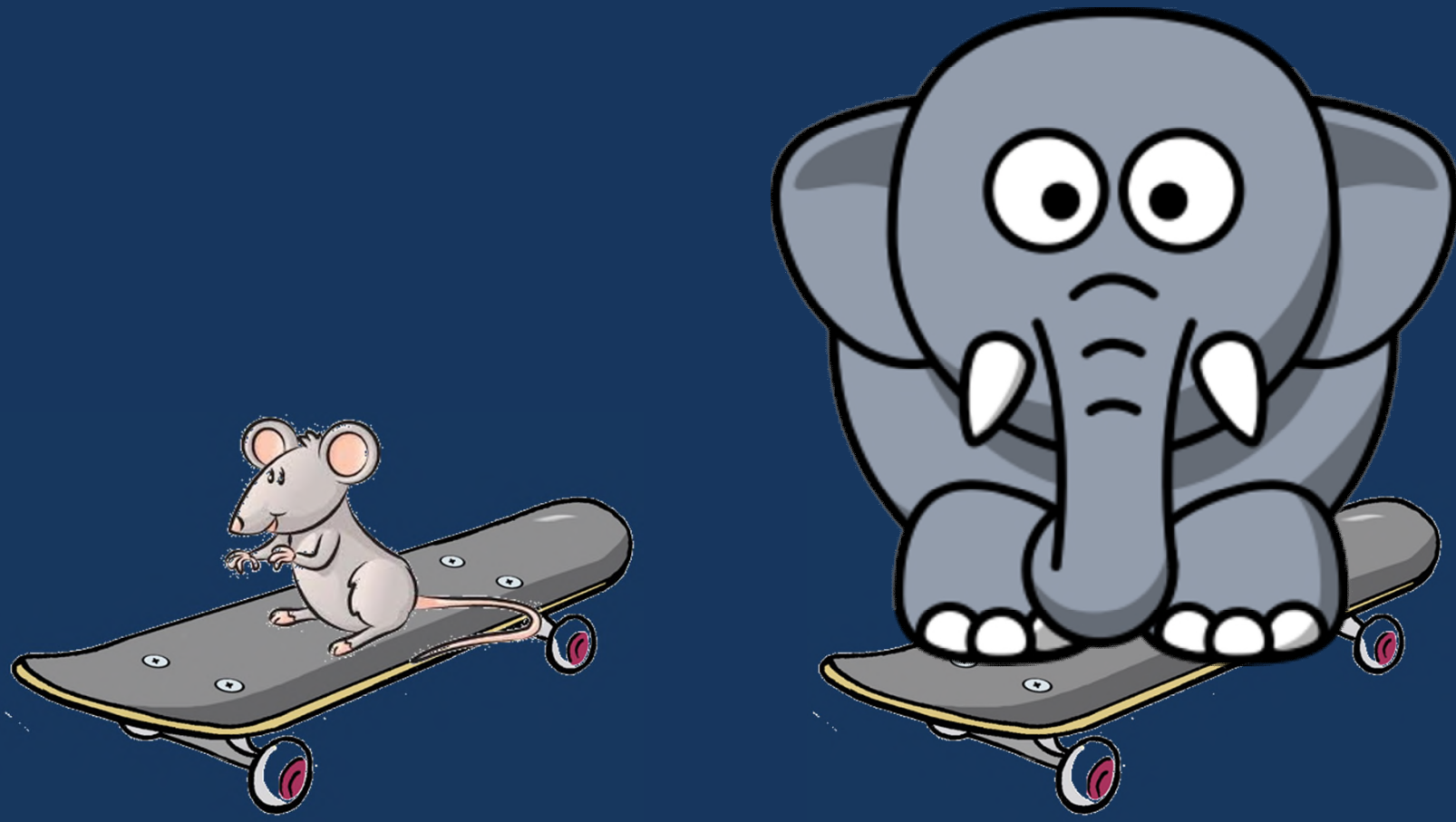
“a tendency to do nothing or to remain unchanged”

Inertia

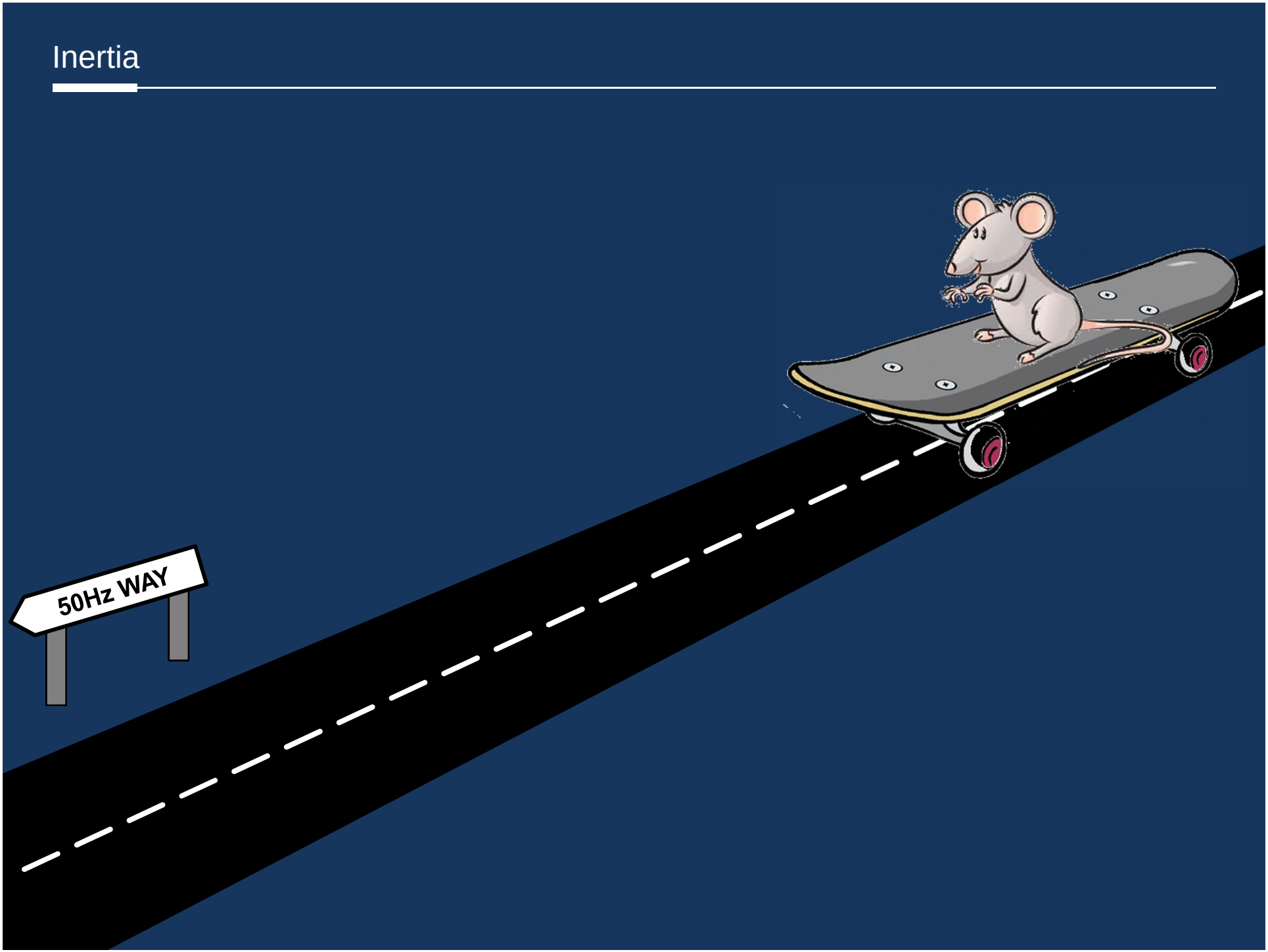
/ɪˈnəːʃə/
noun

“a property of matter by which it continues in its existing state of rest or uniform motion in a straight line, unless that state is changed by an external force”

Inertia



Inertia



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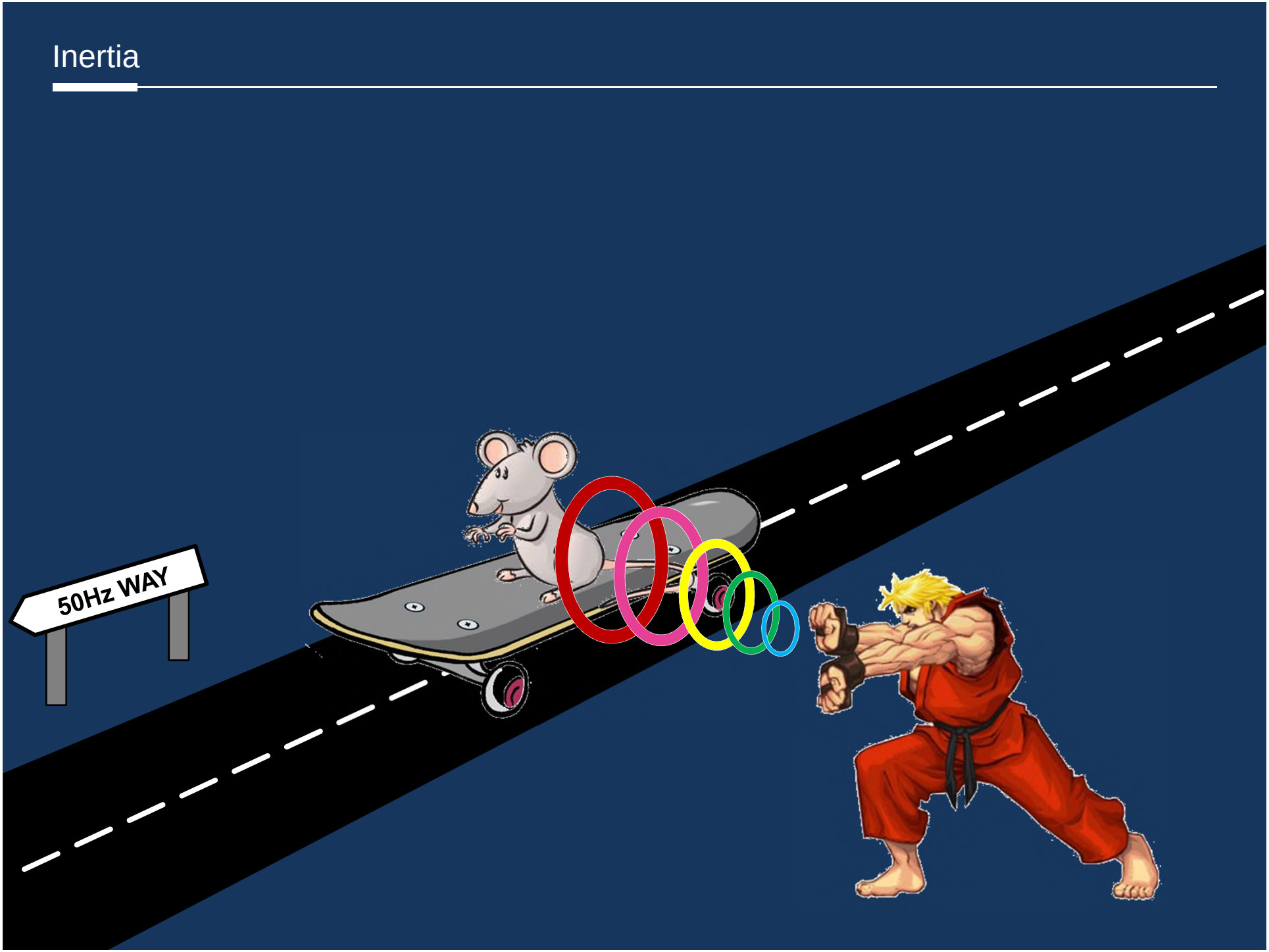

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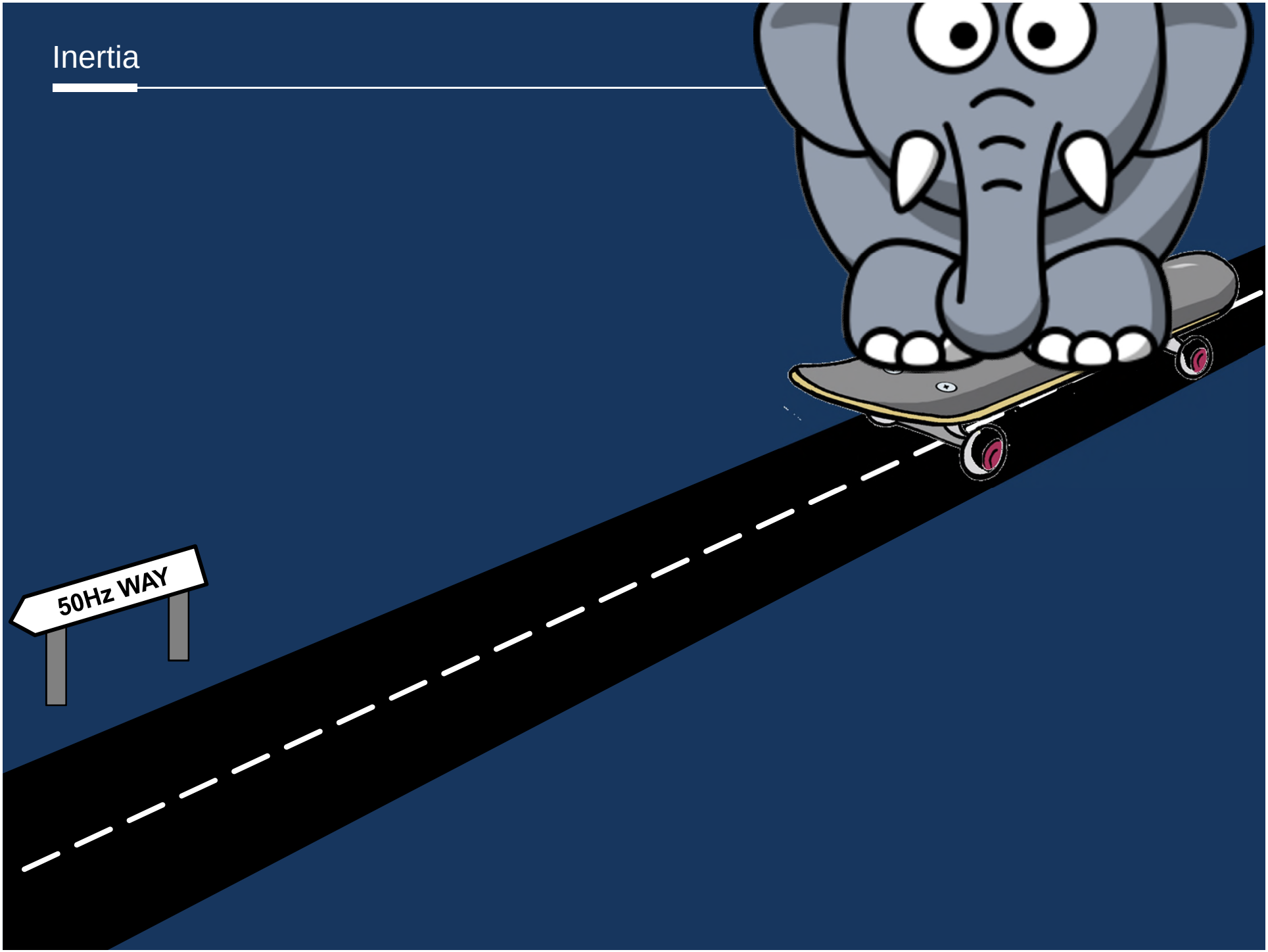

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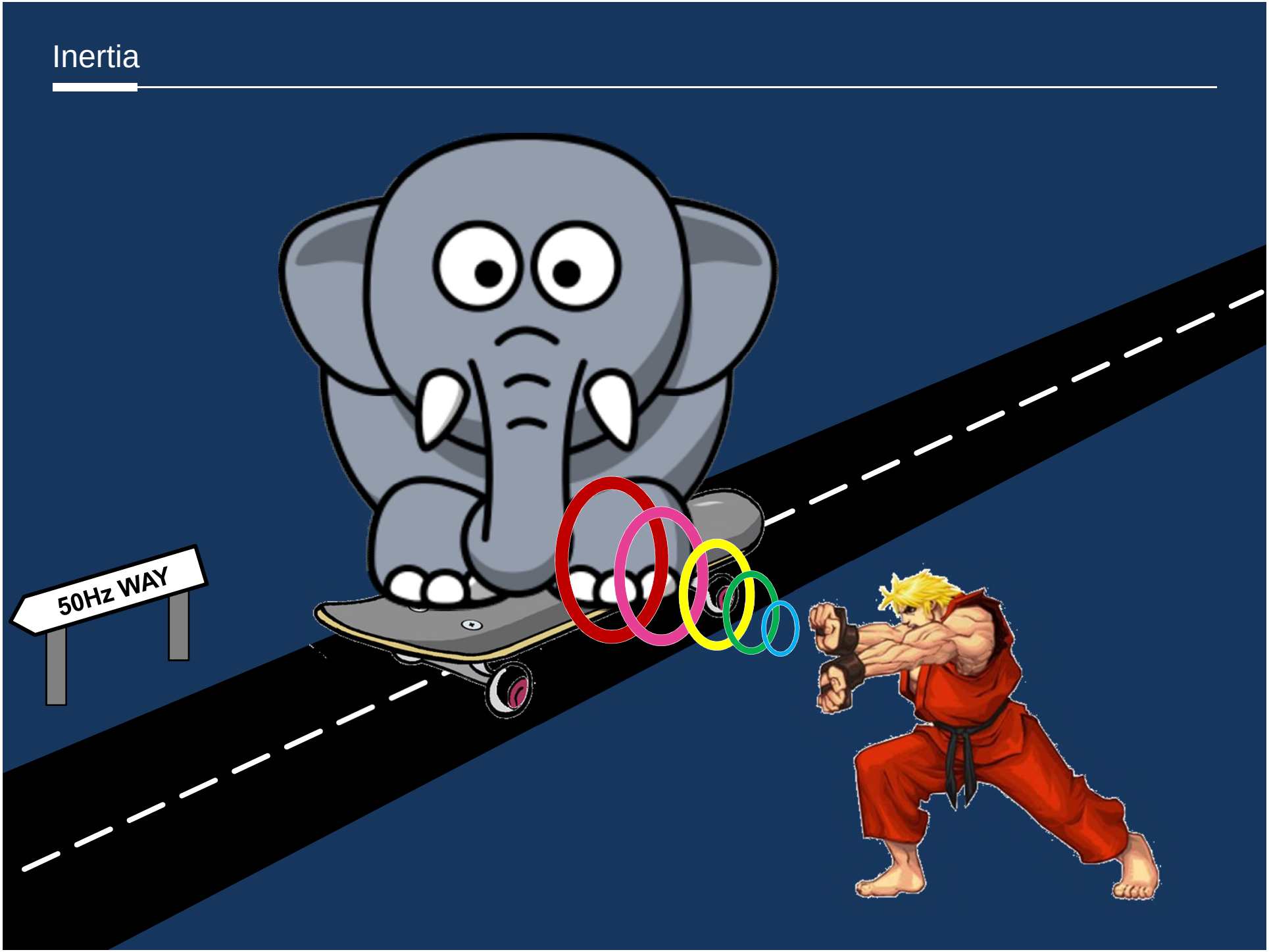
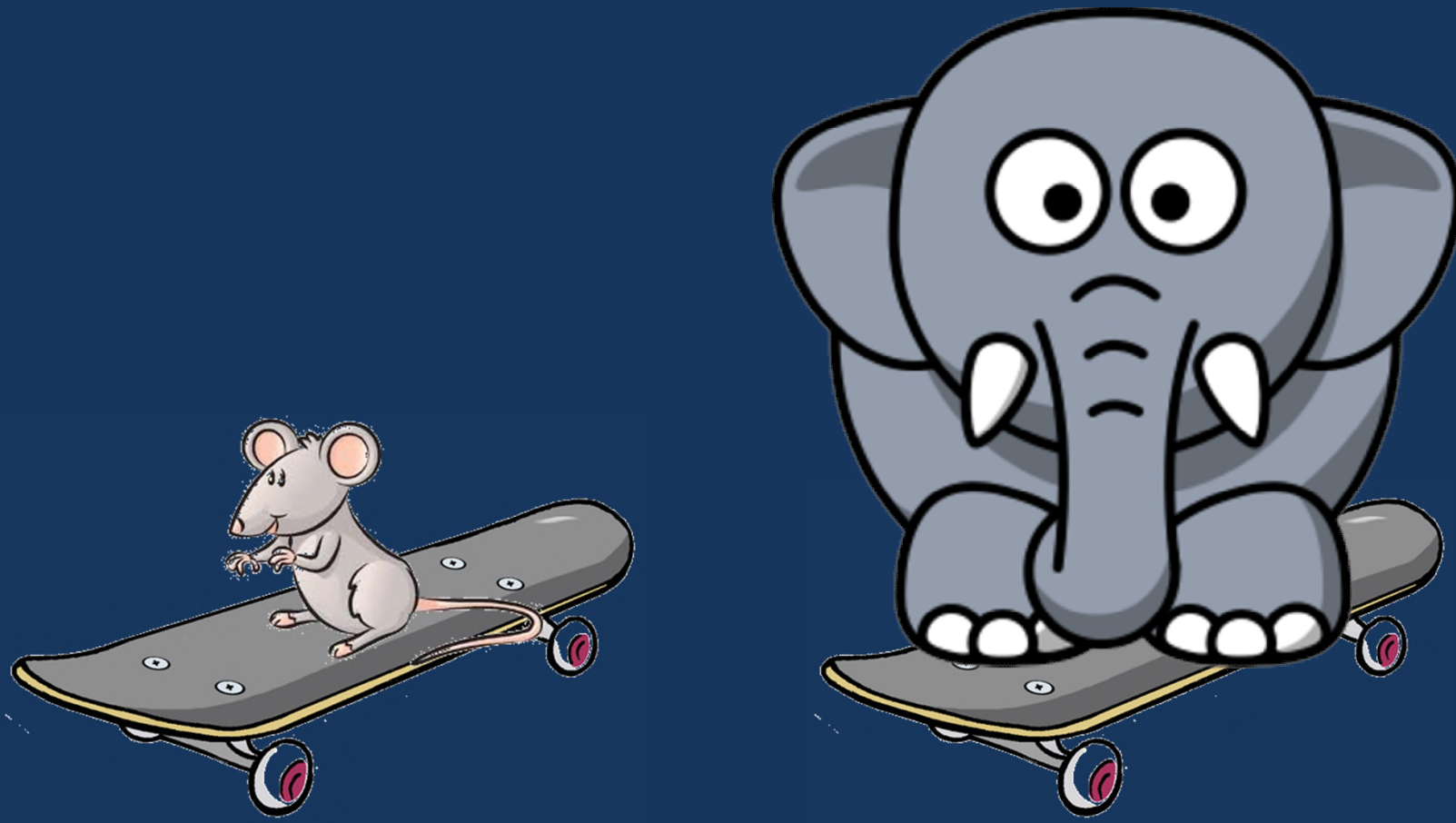


LoM: RoCoF



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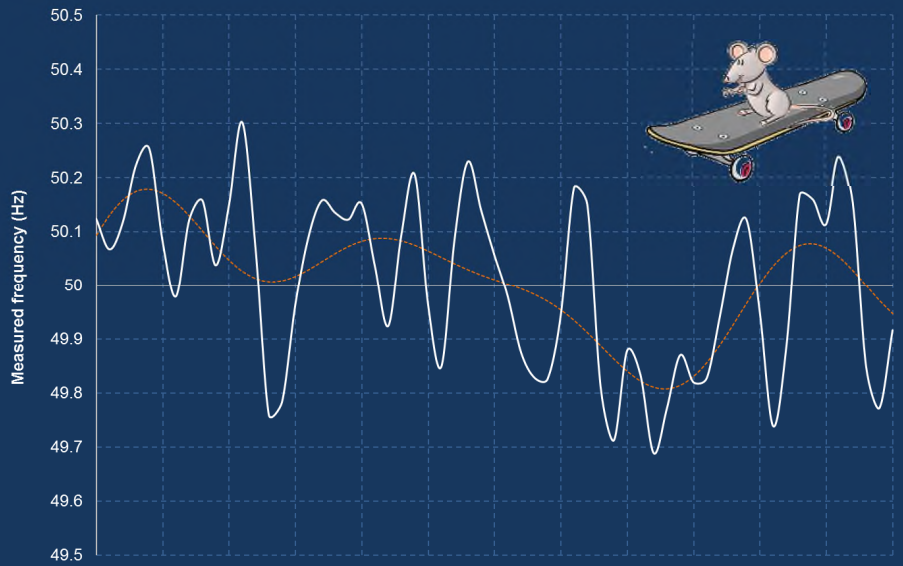
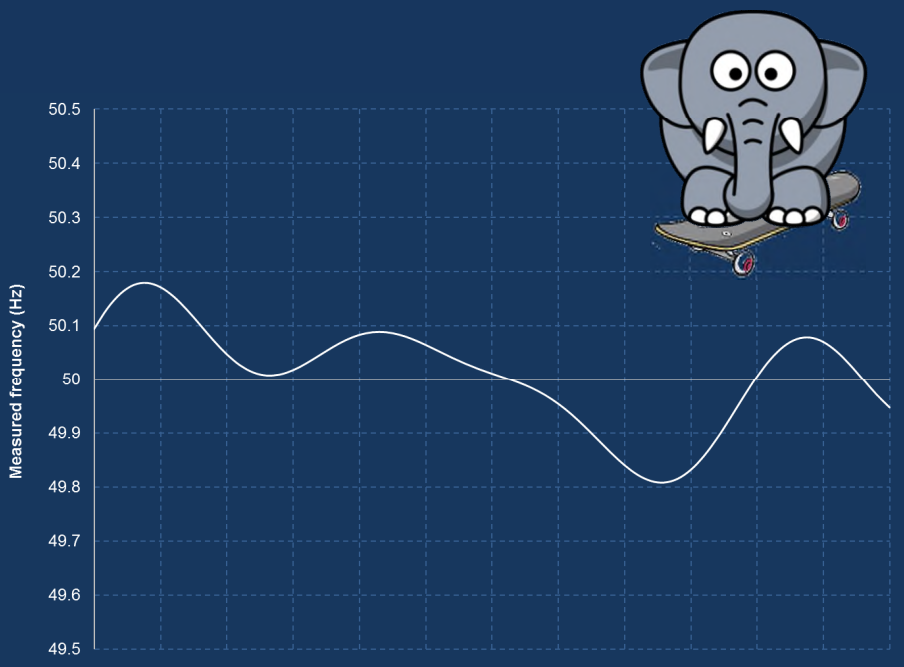




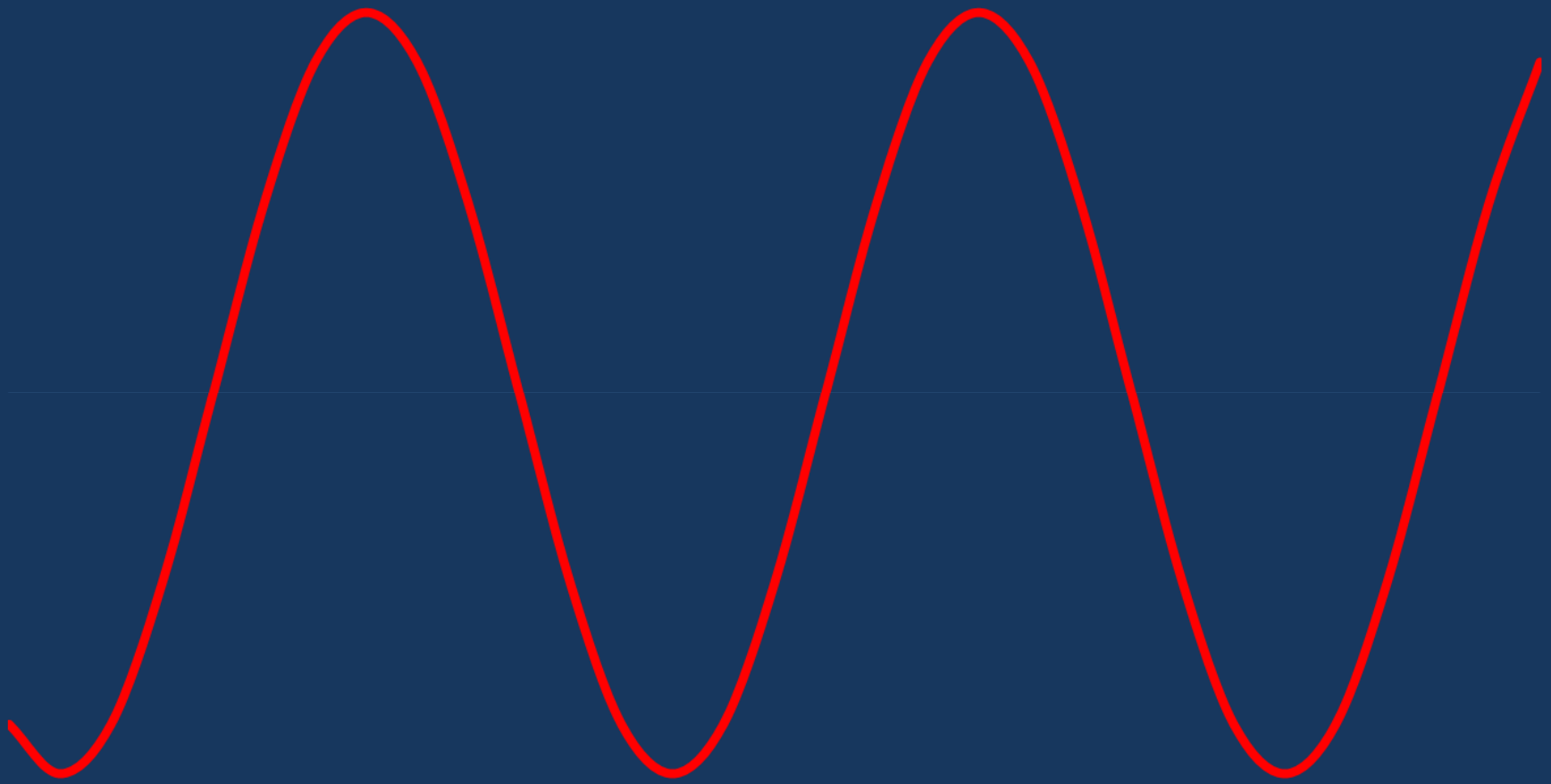
High rate of change
→ Small system
→ Islanded

Low rate of change
→ Large system
→ Connected

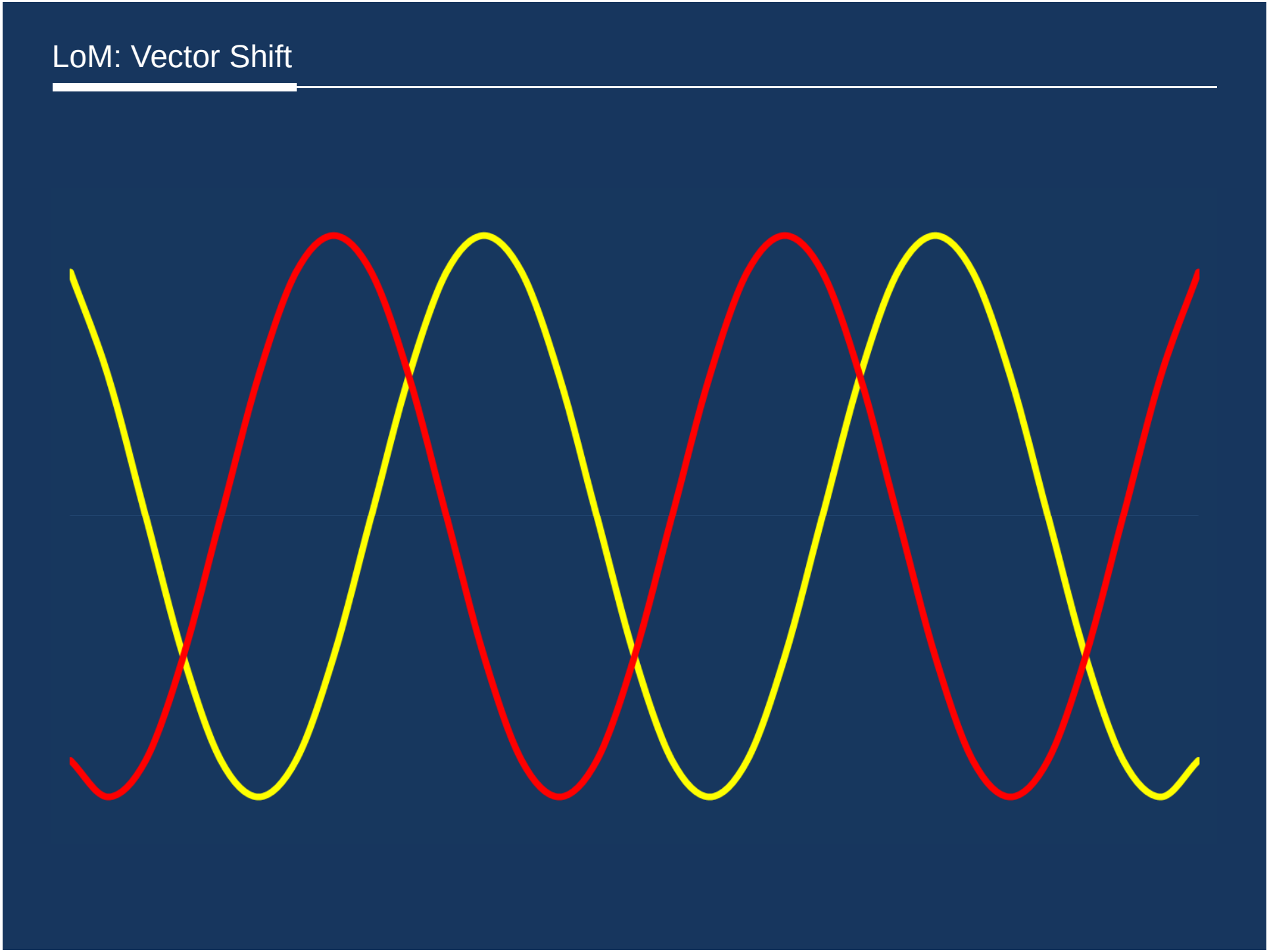
LoM: Vector Shift

Image credit: Les Bossinas (Cortez III Service Corp.) for NASA

LoM: Vector Shift



LoM: Vector Shift



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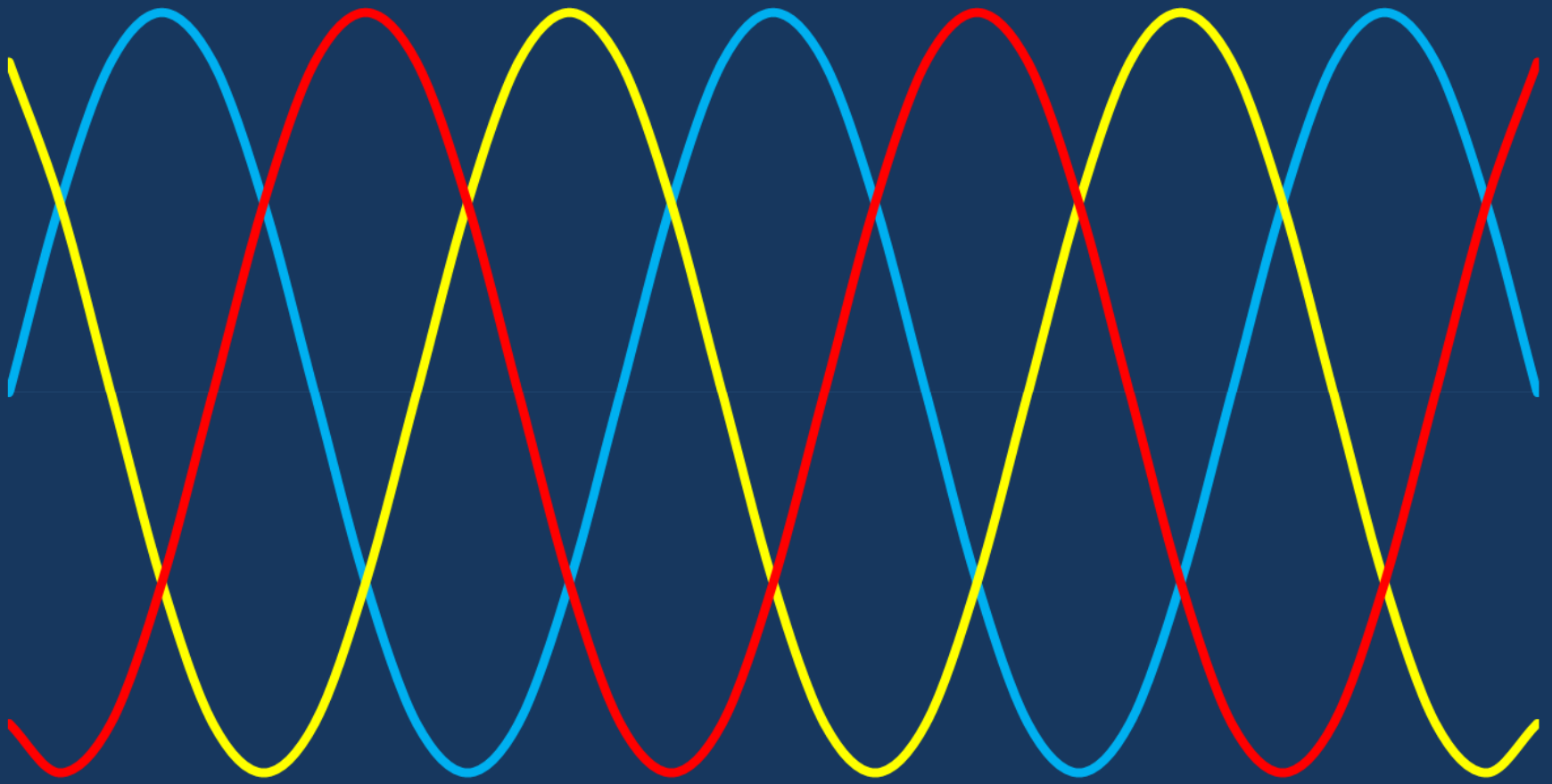

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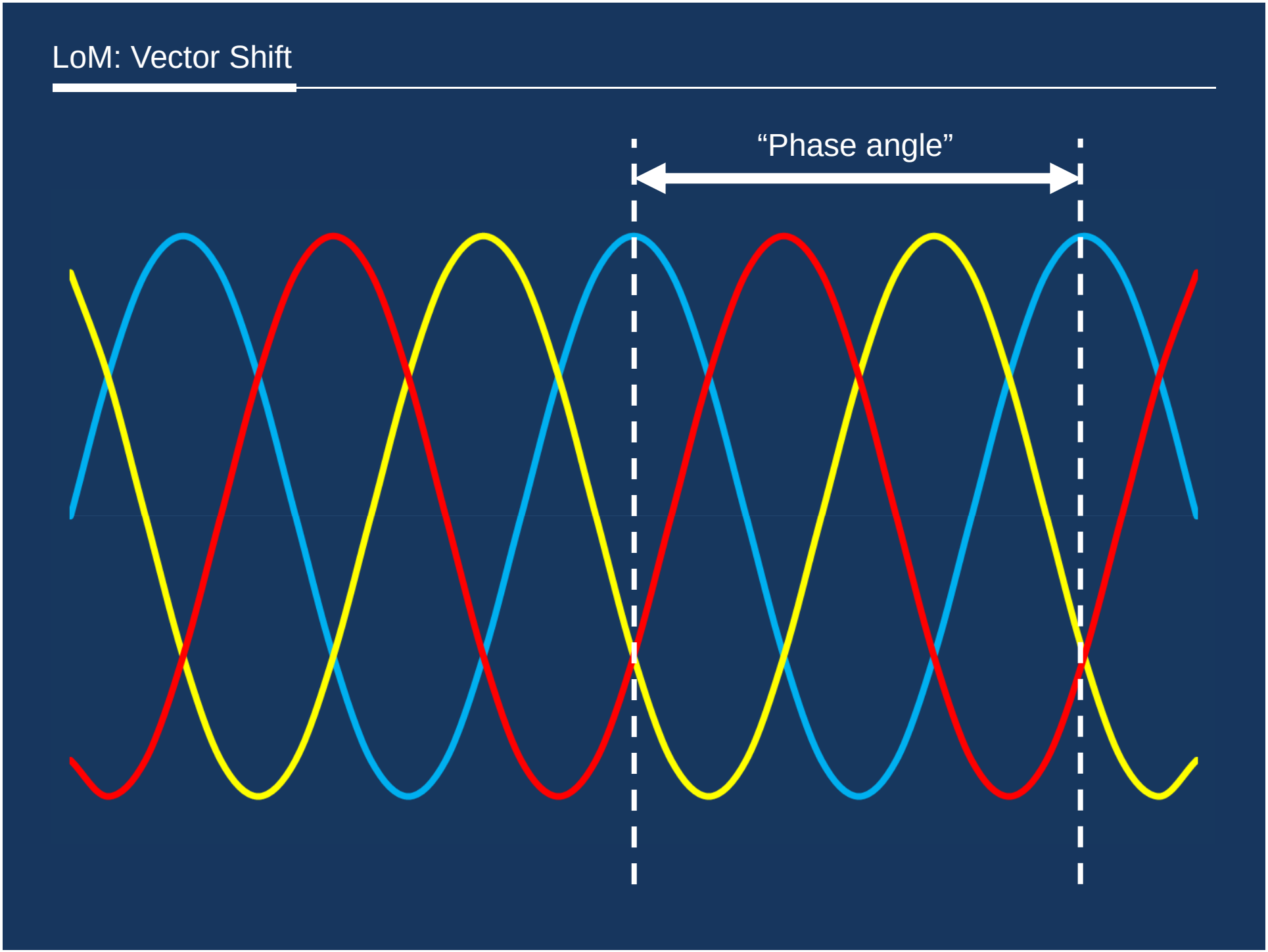

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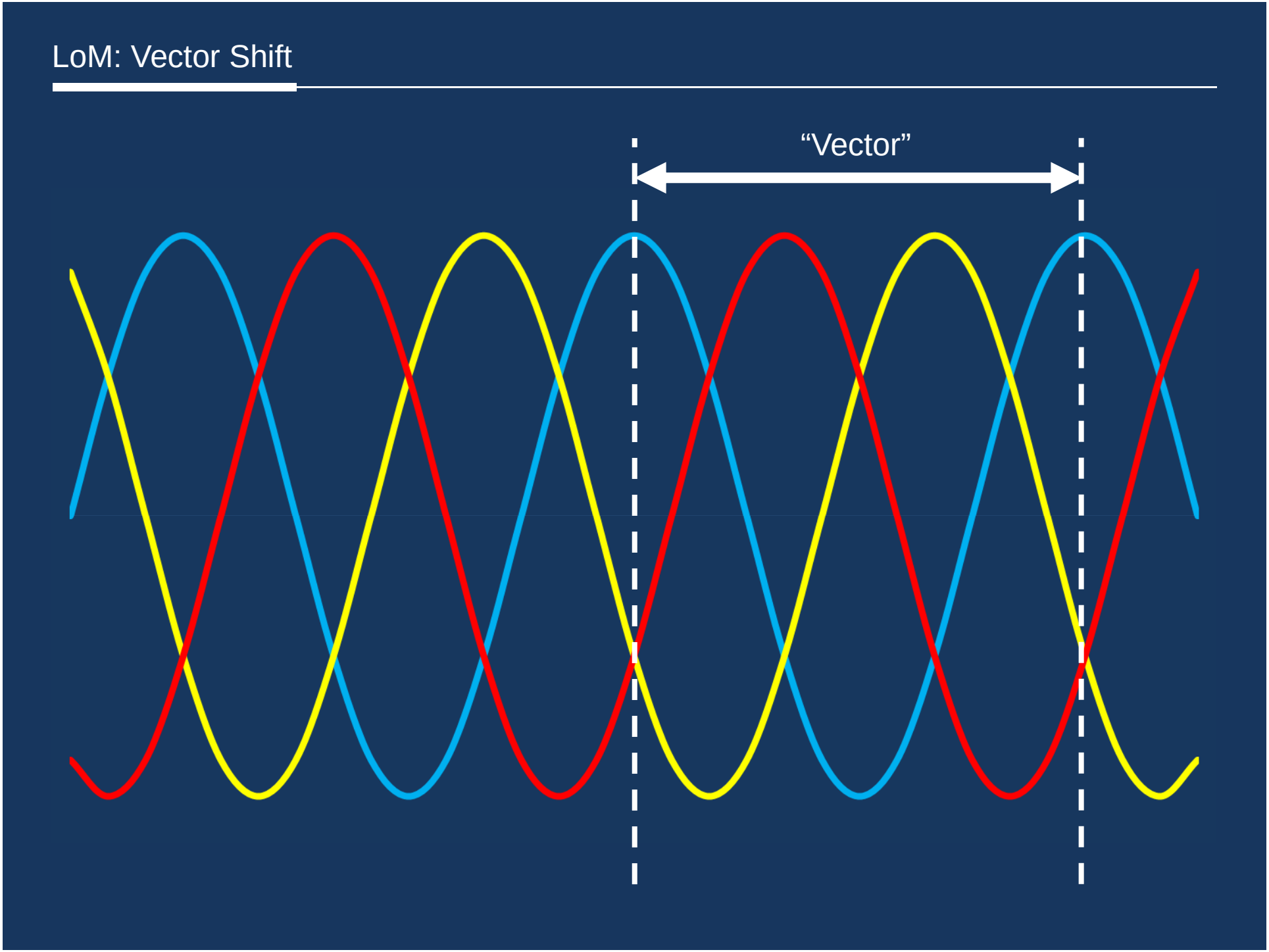

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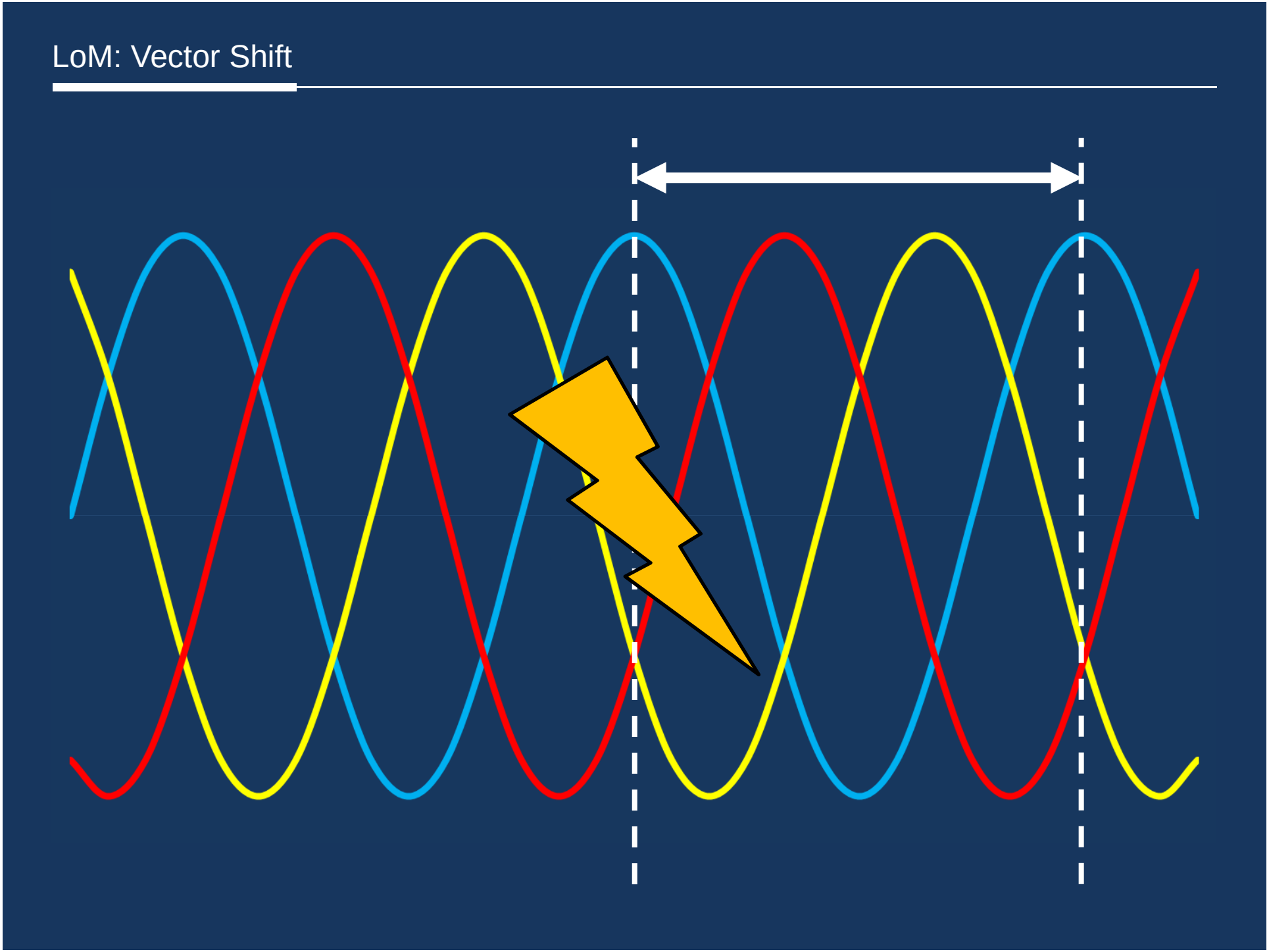

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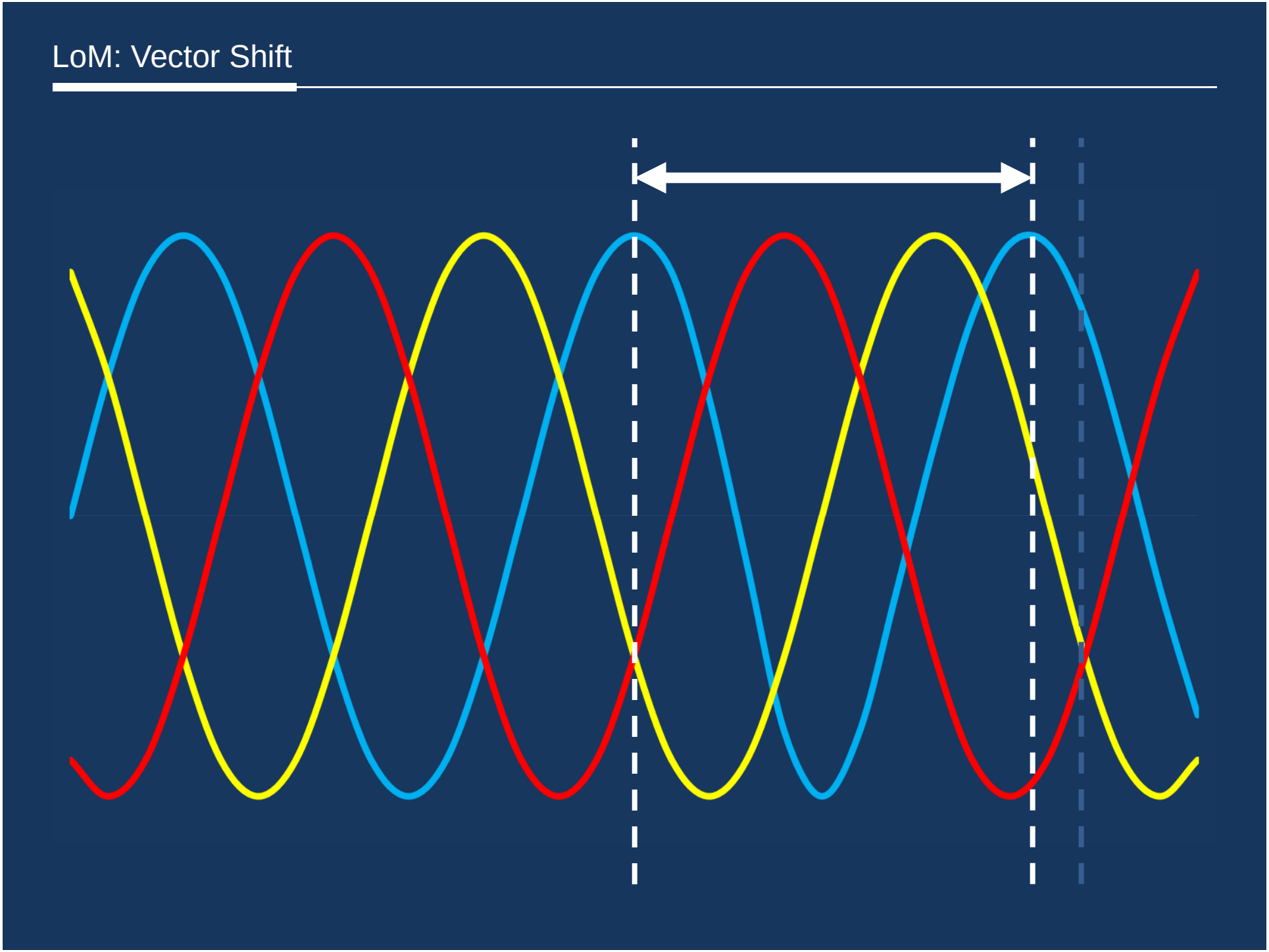

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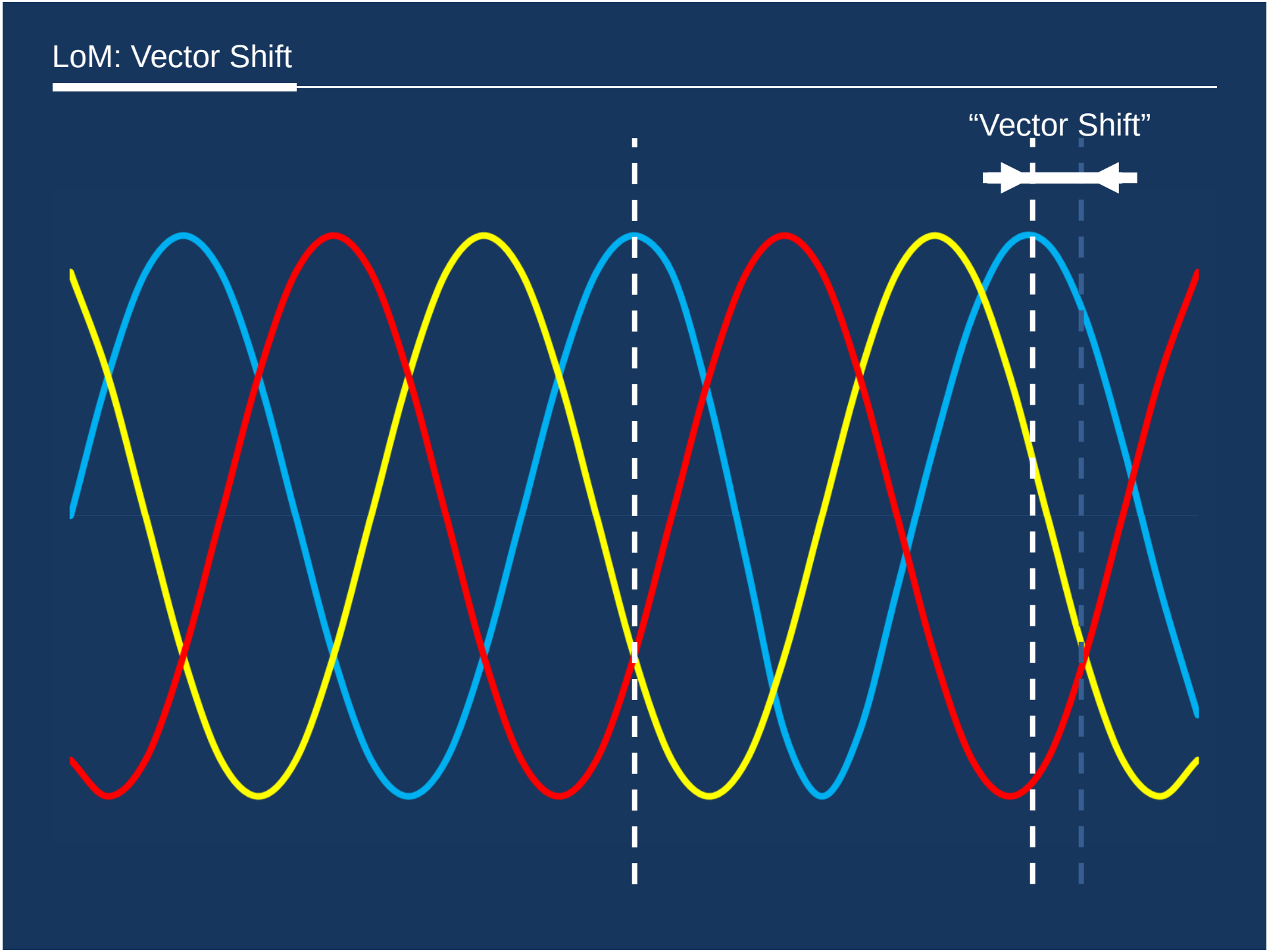
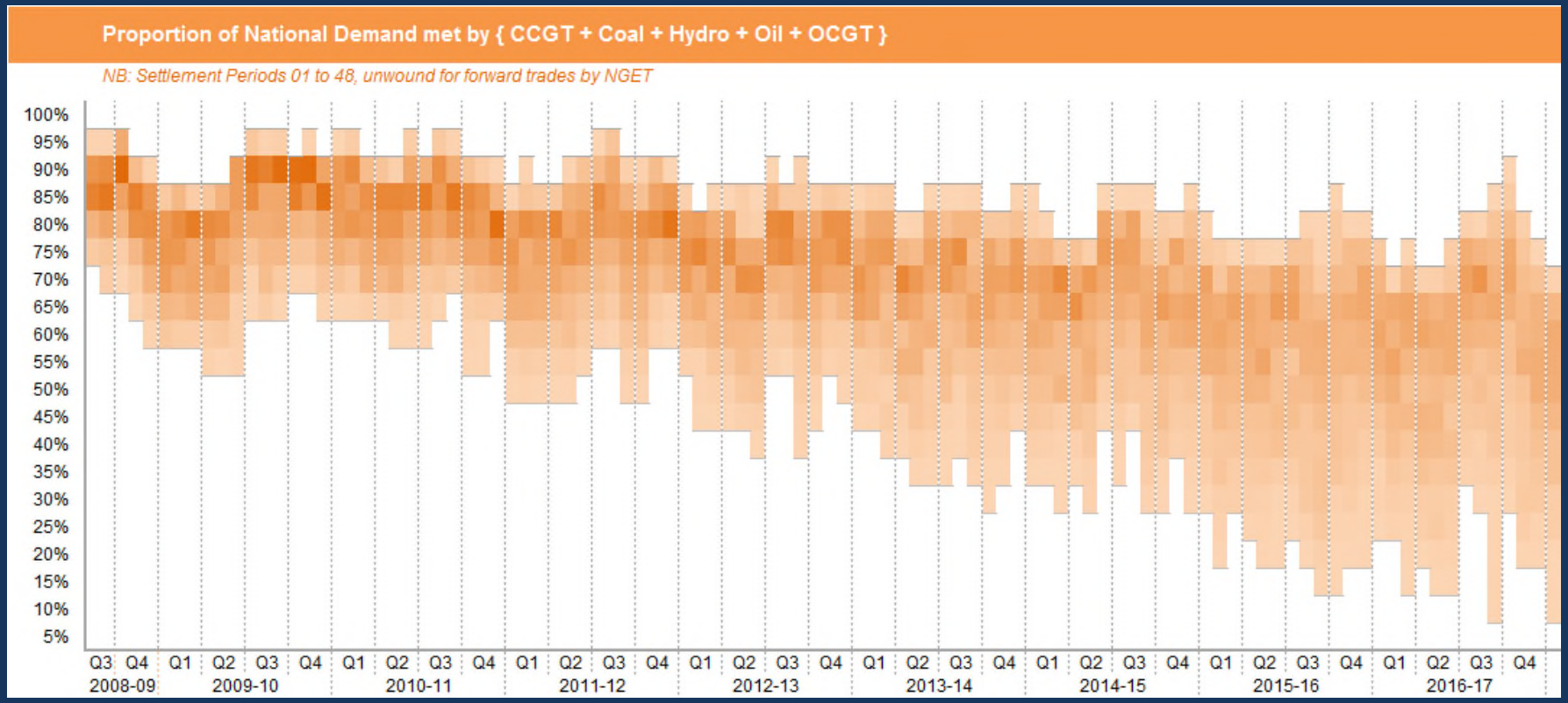
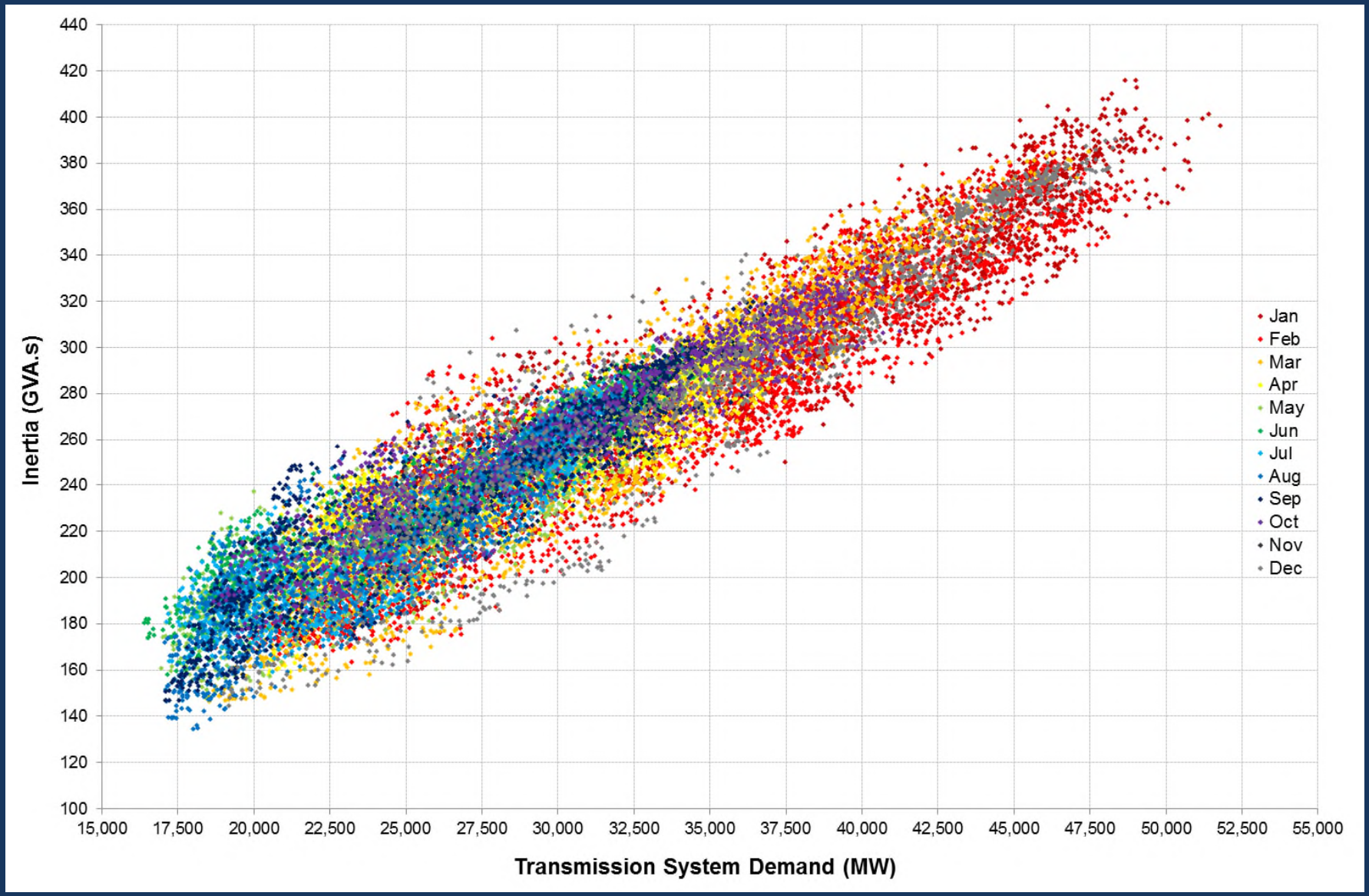


Loss of Mains:
What’s the risk?

Evolution of the Generation Mix

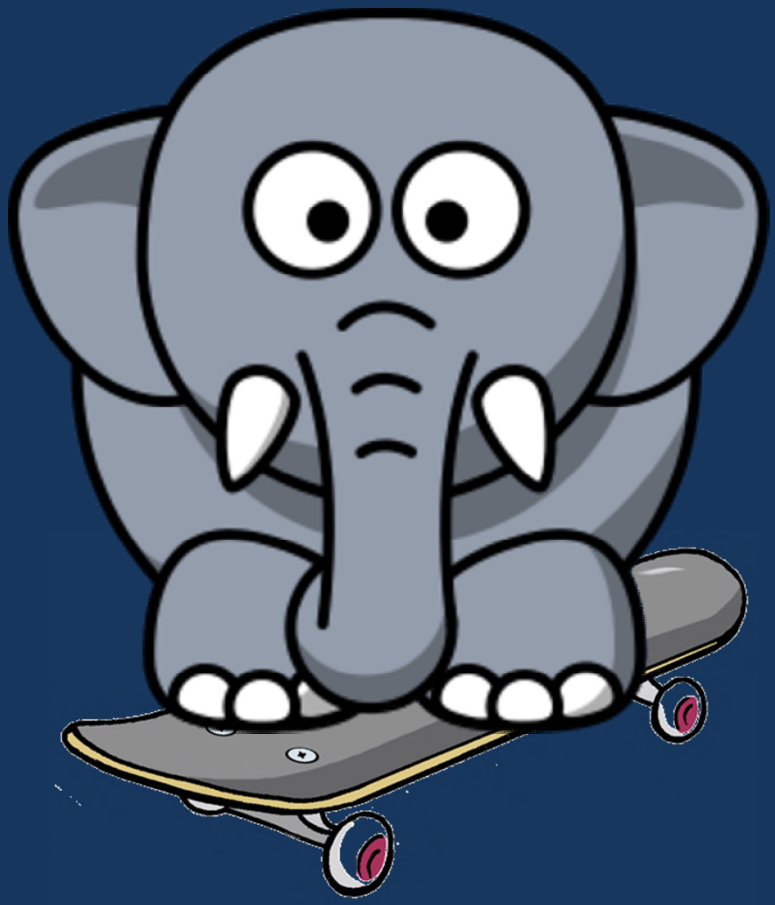


Inertia vs. Demand



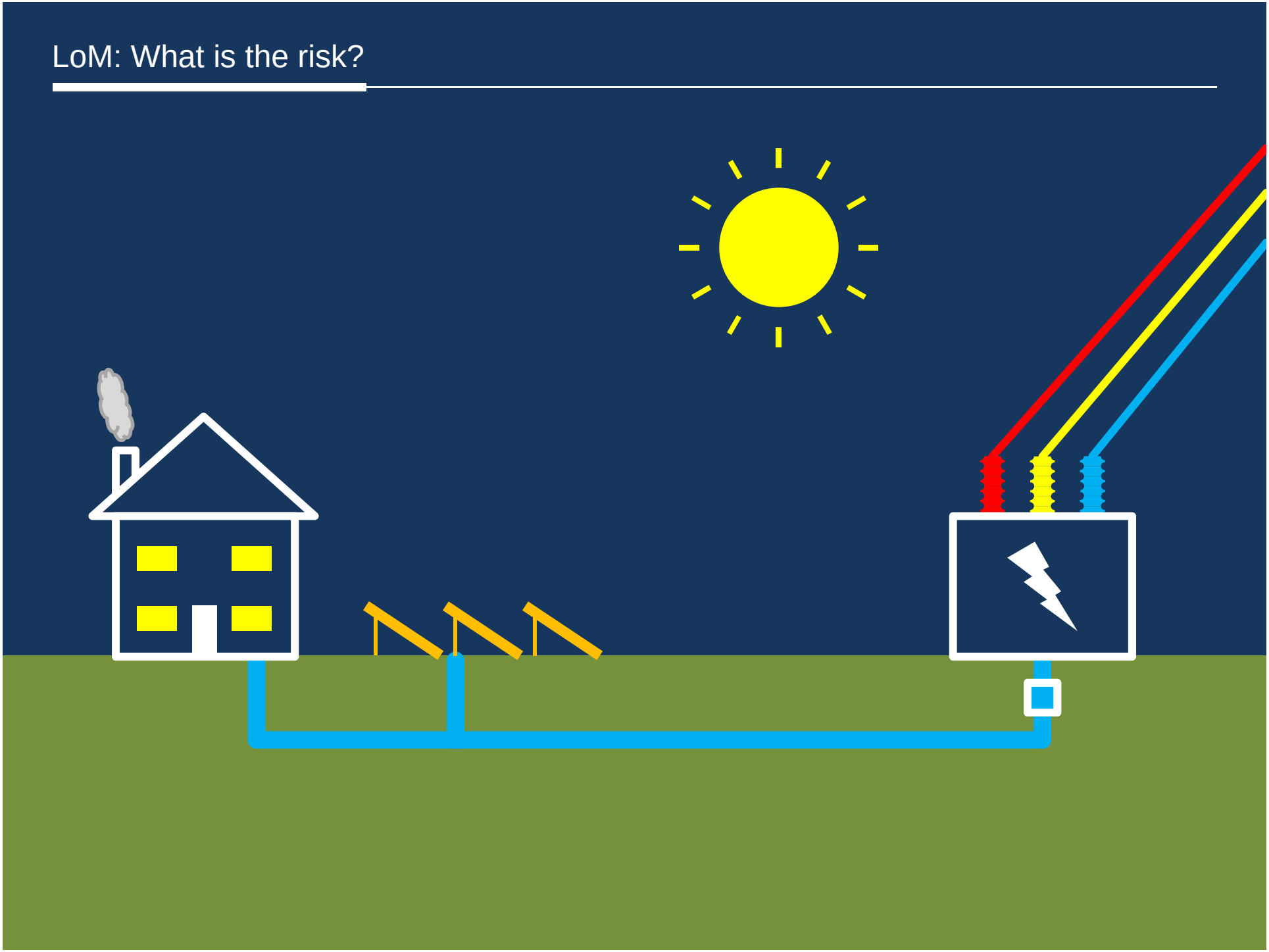
LoM: What is the risk?

RoCoF high / VS large
→ Small system
→ Islanded



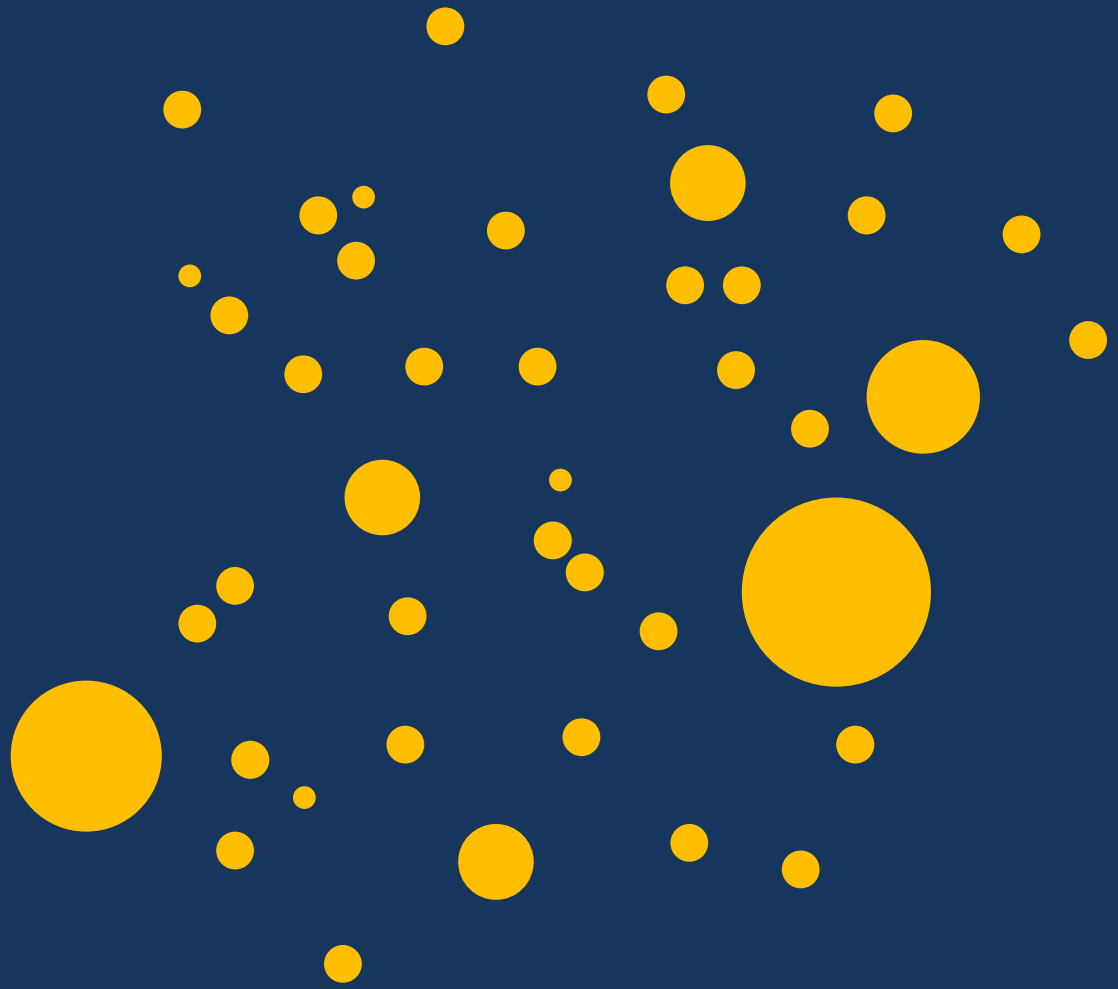
RoCoF low / VS small
→ Large system
→ Connected

LoM: What is the risk?



LoM: What is the risk?

LoM: What is the risk?



RoCoF:
1,500 MW

Vector Shift:
1,200 MW

Loss of Mains: Observations & Analysis

LoM: Real-life events

May 2016						
M	T	W	T	F	S	S
25	26	27	28	29	30	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	1	2	3	4	5

Vector Shift

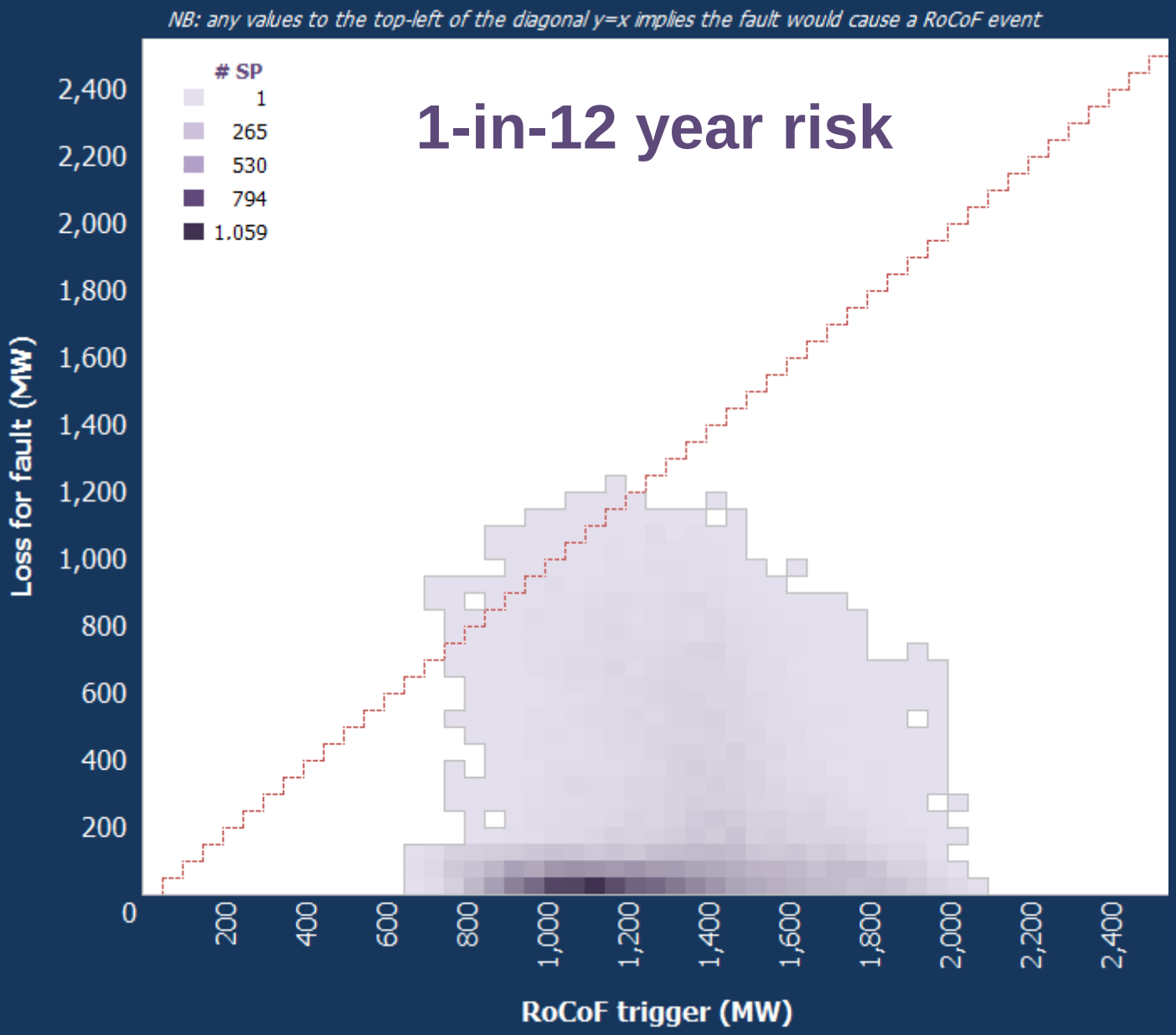
380MW

Langage – Landulph 400kV

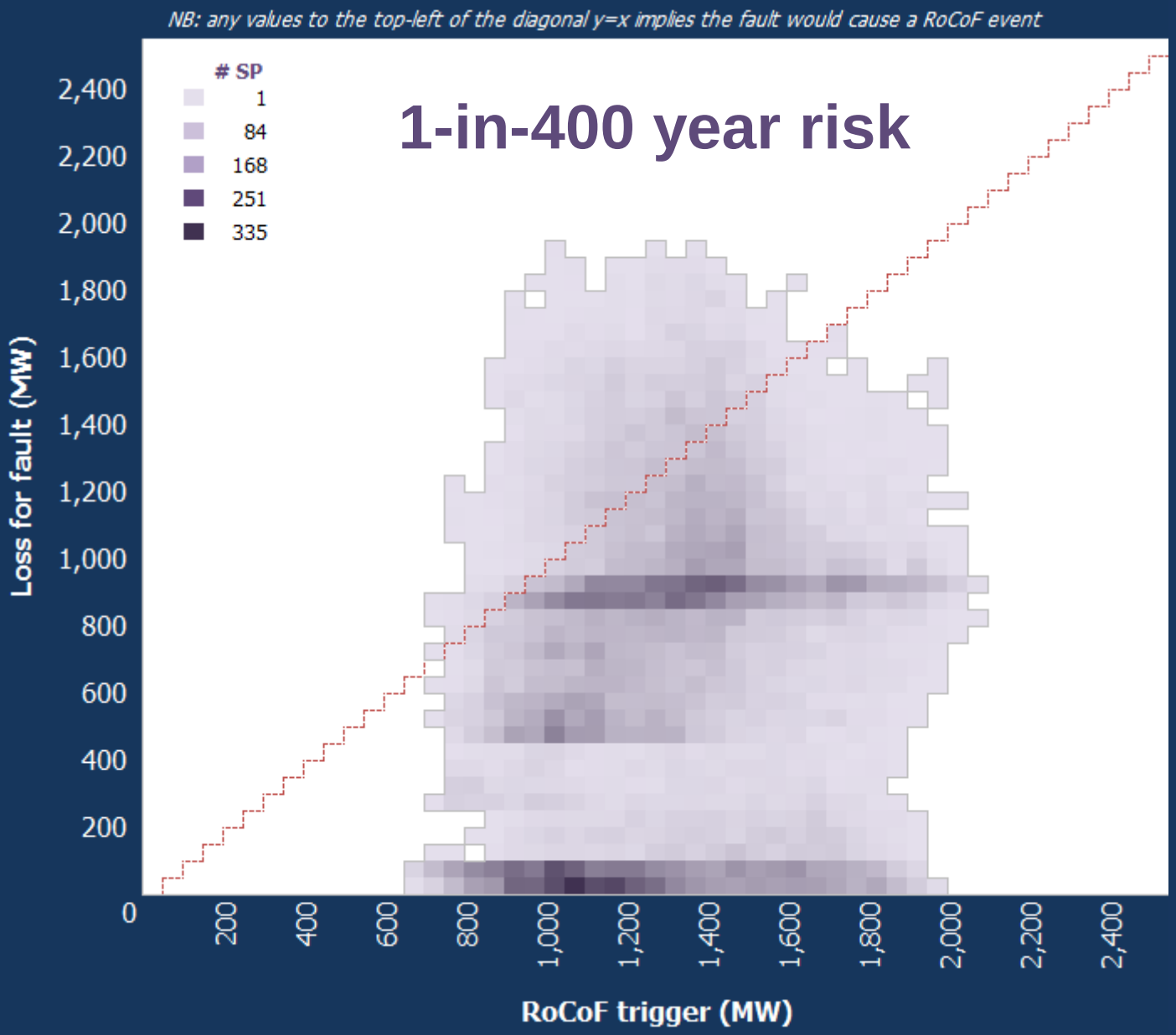
LoM: Real-life events

Date	Fault	Loss (MW)
17 Mar ‘16 12:27	Grain Bus Coupler	470
20 Mar ‘16 16:13	Grain – Kingsnorth	200
22 May ‘16 11:15	Langage – Landulph	380
07 Jun ‘16 17:04	Cowley – Leighton Buzzard – Sundon	145
21 May ‘17 18:20	Littlebrook Reserve Bar	200
08 Jun ’17 16:47	Cottam – Eaton Socon – Rye House	240
10 July ‘17 14:19	Bramford – Sizewell	300
17 July ‘17 15:26	Kensal Green Reserve Bar	400
27 Dec ‘17 02:44	Hinckley Point – Melksham	205
16 Jan ‘18 14:28	Alverdiscott – Indian Queens – Taunton	290
18 Jan ‘18 04:59	Burwell – Walpole	315

LoM: Credible events



LoM: Credible events



LoM: Credible events

"Depending on the location and nature of a fault that may trigger a VS event, **the SO is potentially unable to protect against such a large loss of infeed**.

An example could be a fault that results in the loss of a major generator or interconnector triggering a further loss of distributed generation due to VS."

Ofgem Decision: Distribution Code DC0079
Frequency Changes during Large Disturbances and their Impact on the Total System

https://www.ofgem.gov.uk/system/files/docs/2017/12/dc0079_d.pdf

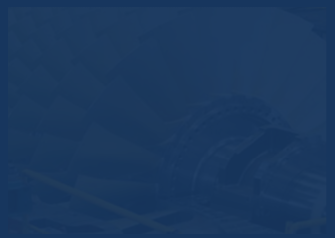
Loss of Mains: Risk mitigation

LoM: Risk mitigation

Reduce loss size

Hold more response

Increase inertia



Reduce capacity at risk

Photo credits:
Battersea Power Station - Alberto Pascual
Gas turbine - Mitsubishi Heavy Industries

LoM: Risk mitigation - RoCoF

Reduce loss size	✓	bids on large units (BOA, trading)
Hold more response	✗	not enough to secure loss size
Increase inertia	✓	synchronise high inertia units
Reduce capacity at risk	✓	D-code mod

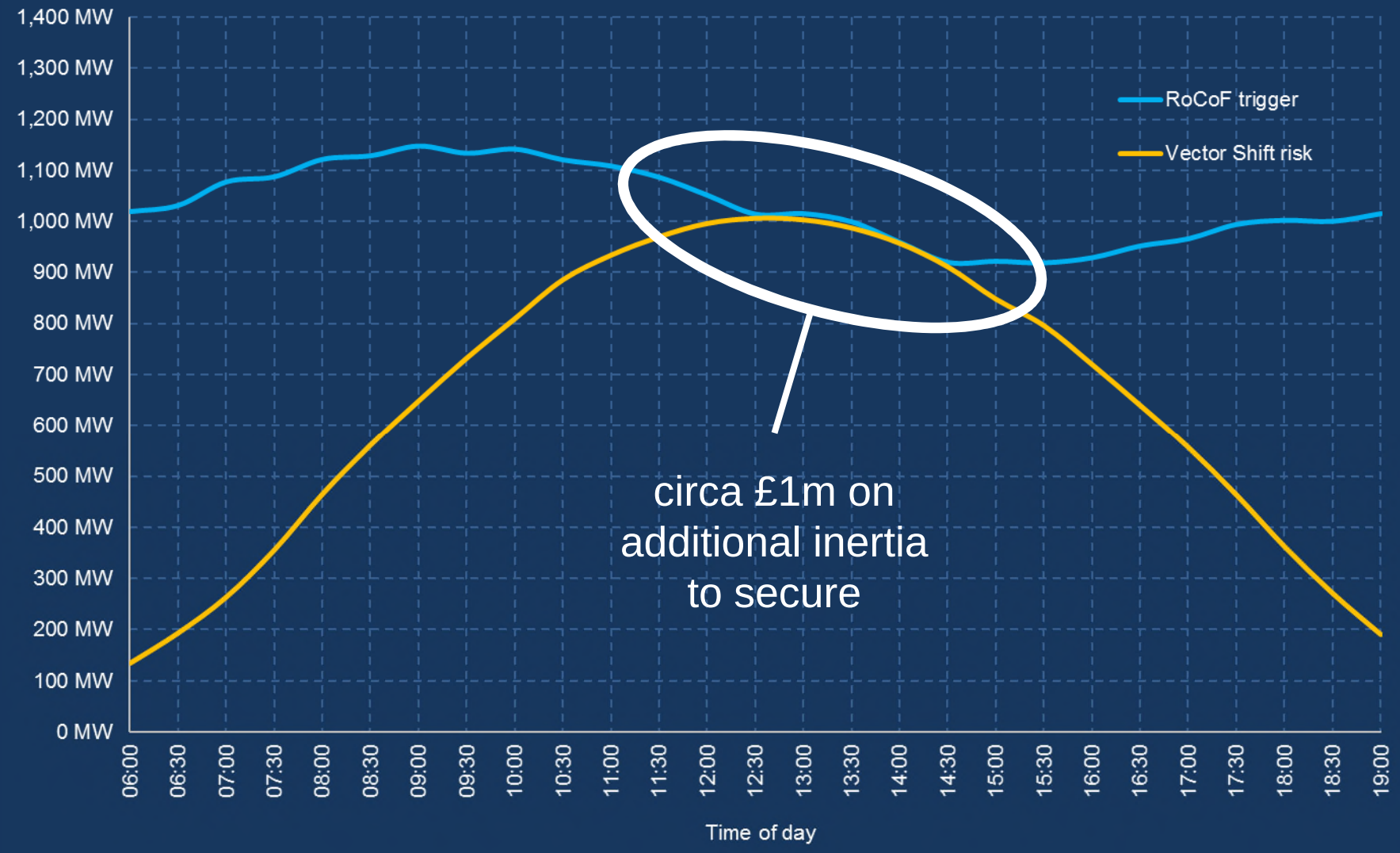
GC0035 changing setting of all sites >5MW capacity
to 0.5Hz/s or 1.0Hz/s, measured over 500ms
(effective from 01 Aug 2014)

LoM: Risk mitigation - Vector Shift

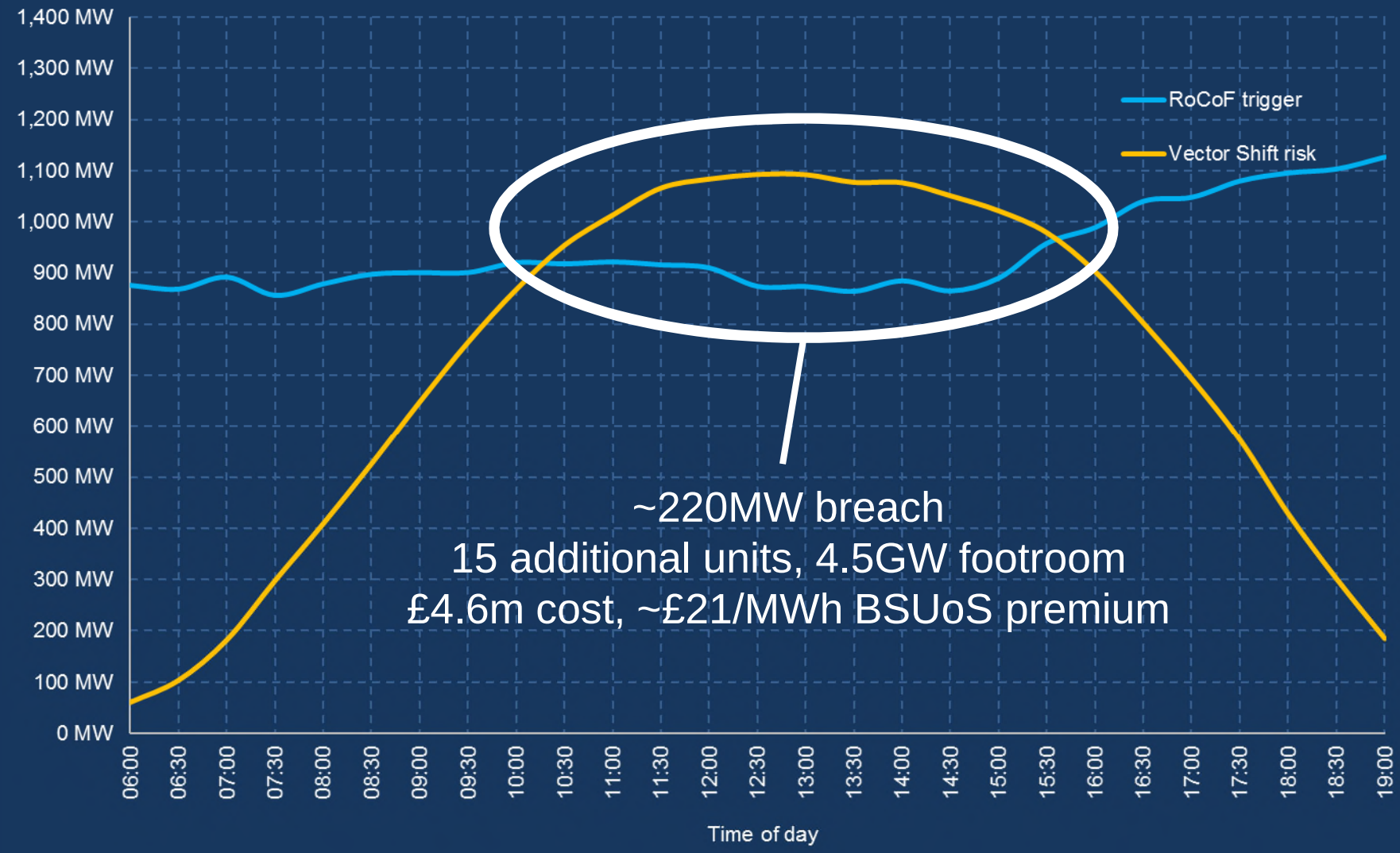
Reduce loss size	✗	no real-time control
Hold more response	✗	not enough to secure loss size
Increase inertia	◔	not always feasible
Reduce capacity at risk	✓	D-code mod

LoM: Risk mitigation - Vector Shift

Sat 19 May 2018: Royal Wedding



LoM: Risk mitigation - Vector Shift



LoM: Risk mitigation - Vector Shift

Reduce loss size	✗	no real-time control
Hold more response	✗	not enough to secure loss size
Increase inertia	✗	not always feasible
Reduce capacity at risk	✓	D-code mod

LoM: Risk mitigation - Vector Shift

DC0079 summary of recommendations:

- RoCoF settings changed to 1Hz/s, measured over 500ms

- not allowed to use Vector Shift

- demonstrate stability for appropriate RoCoF and Vector Shift disturbances

DC0079 decisions:

01 Feb 2018: new non-type tested generators

01 July 2018: new type tested generators

In progress: all existing type tested and non-type tested generators

↳ GC0035 took over 3 years to implement

LoM: Risk mitigation - Vector Shift

Reduce loss size ✗ no real-time control

Hold more response ✗ not enough to secure loss size

Increase inertia ✗ not always feasible

Reduce capacity at risk ✗ 1-in-12 year risk for 3+ years

LoM: Risk mitigation - Vector Shift

Photo credit: http://i.dailymail.co.uk/i/pix/2013/05/11/article-2323142-19BAEF99000005DC-232_634x352.jpg

LoM: Risk mitigation - Vector Shift

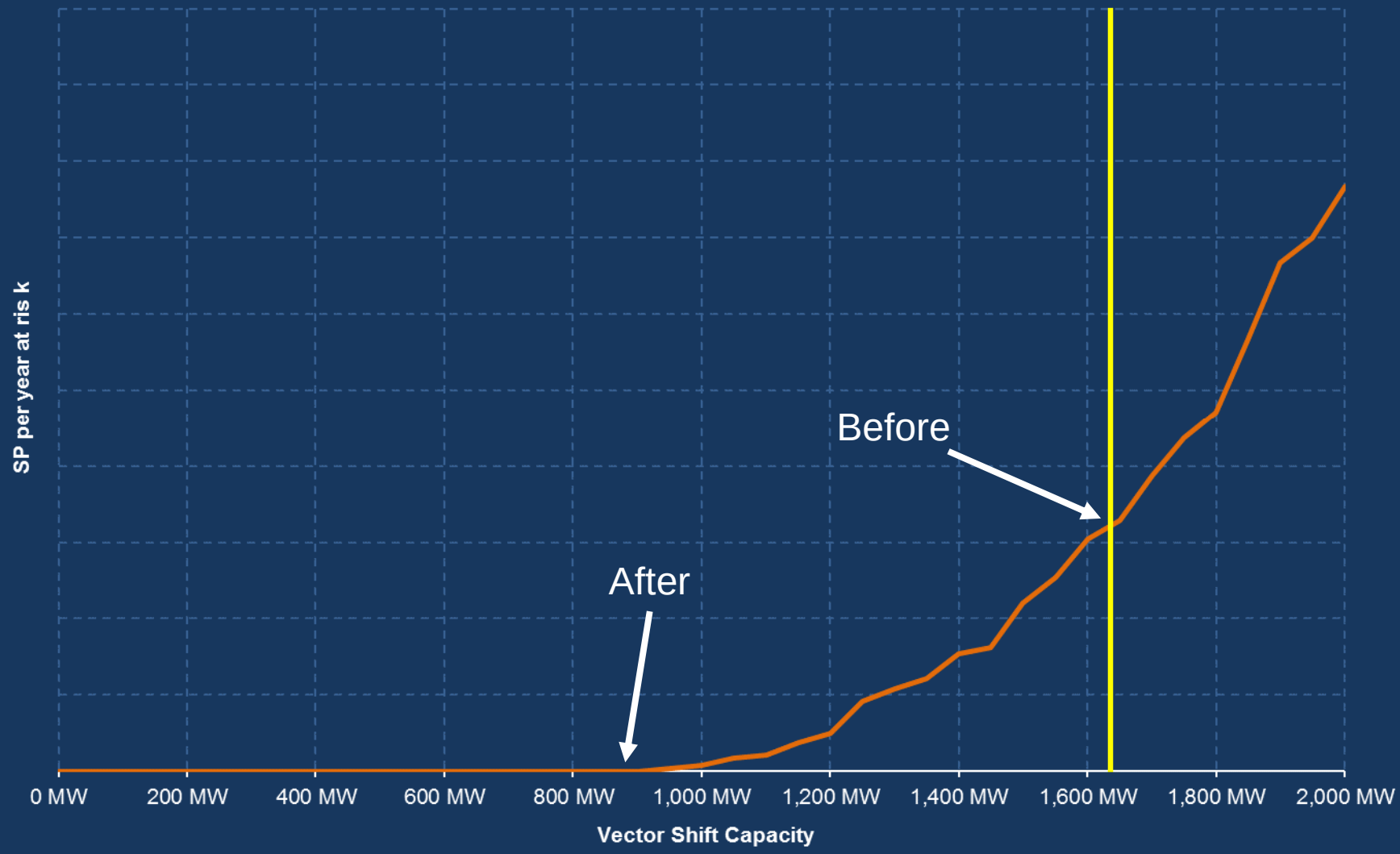
Reduce loss size ✗ no real-time control

Hold more response ✗ not enough to secure loss size

Increase inertia ✗ not always feasible

Reduce capacity at risk ✓ tender for fault resilience capability

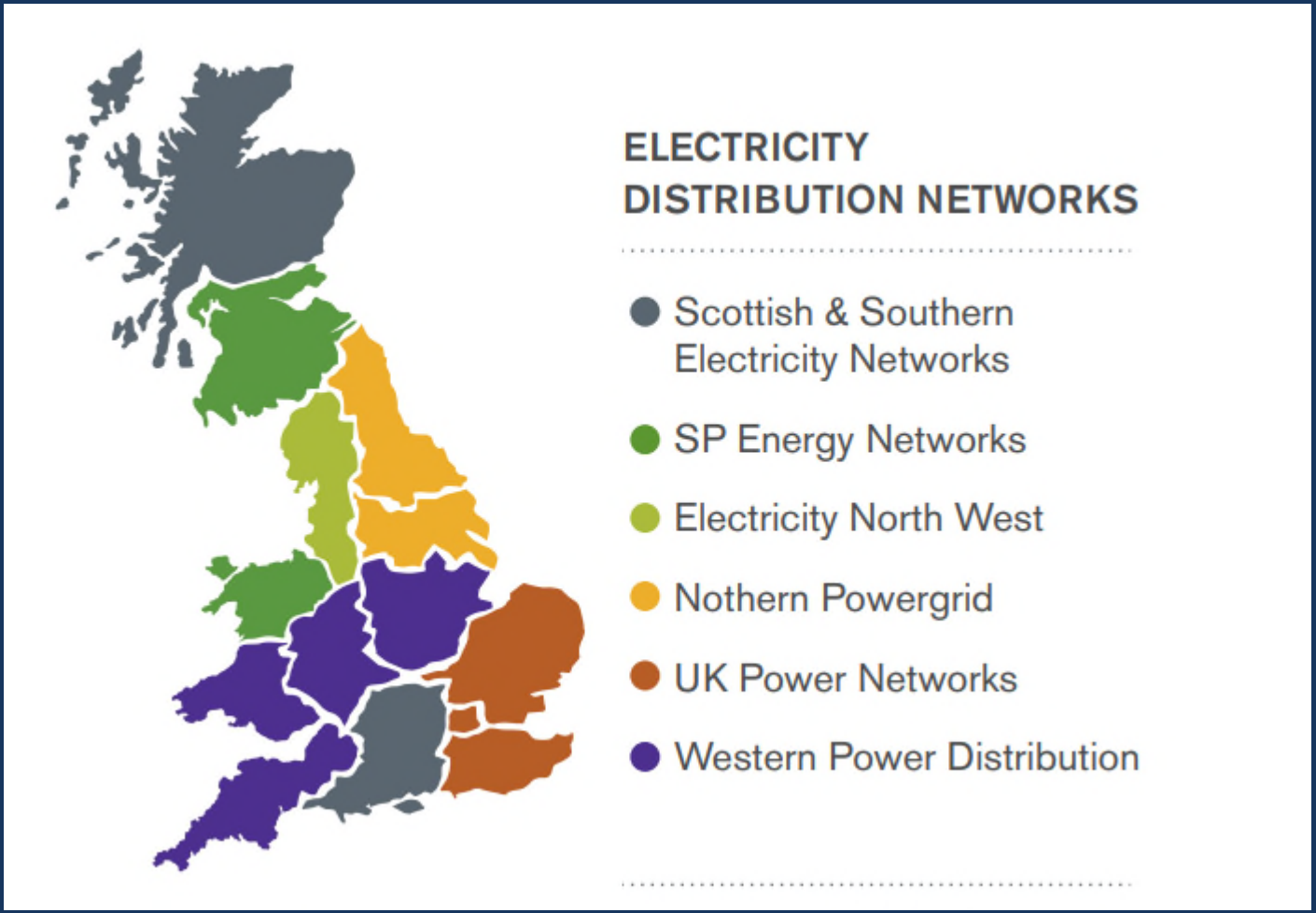
LoM: Risk mitigation - Vector Shift



LoM: Risk mitigation - Vector Shift

Photo credit: directindustry.com via http://electrical-engineering-portal.com/commissioning-protection-relays

LoM: Risk mitigation - Vector Shift



https://www.ofgem.gov.uk/key-term-explained/map-who-operates-electricity-distribution-network

LoM: Risk mitigation - Vector Shift

212 sites / 3 DNO areas / 1,450 MW capacity

Cost / Location / Capacity / Load factor

71 sites / 3 DNO areas / 811MW capacity

£200k sanctioned in w/c 14 May

500MW delivered by 25 May, remainder by 01 June

LoM: Risk mitigation

Reduce loss size ✗ no real-time control

Hold more response ✗ not enough to secure loss size

Increase inertia ✗ not always feasible

Reduce capacity at risk ✓ D-Code mod for remaining capacity

Covering both RoCoF and Vector Shift

Please engage with consultation
under Distribution Code governance