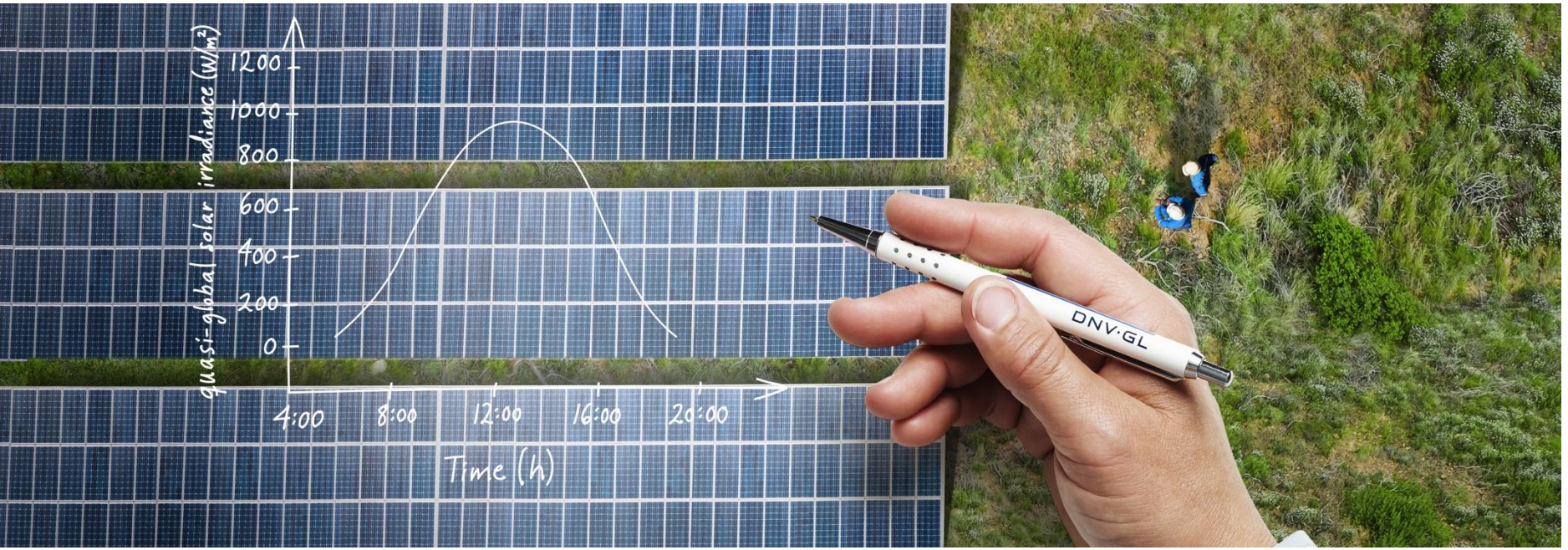


Risk-based Asset Management for Solar Farm

Loc Nguyen, Daniel Liang, Kelvin Tan

Why Asset Management System?

Organization's Goals: Performance, cost & risk management

Big Gap

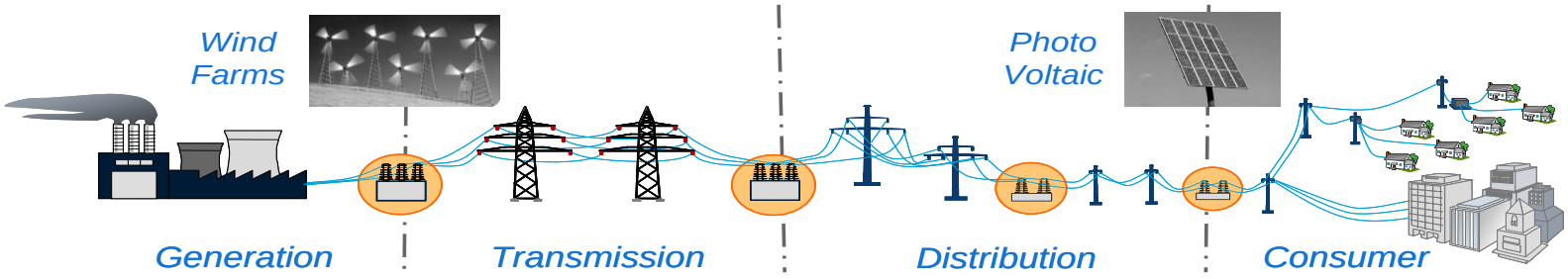
Top-down and Bottom-up Gaps:

- Top managers mainly care about organization's KPI
- Site operators only care about equipment's performance
- Mid-level managers struggling on how to fulfil the gaps & justify top management

Lack of structure system & process

- Structure system to fulfill gaps between ground level and high level (asset health, risk, cost, etc.)
- Process: no feedback loop for AM activities and improvements

AM activities: Maintenance, Refurbishment, Replacement



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Asset Management Solution

Organization's Goals: Performance, cost & risk management

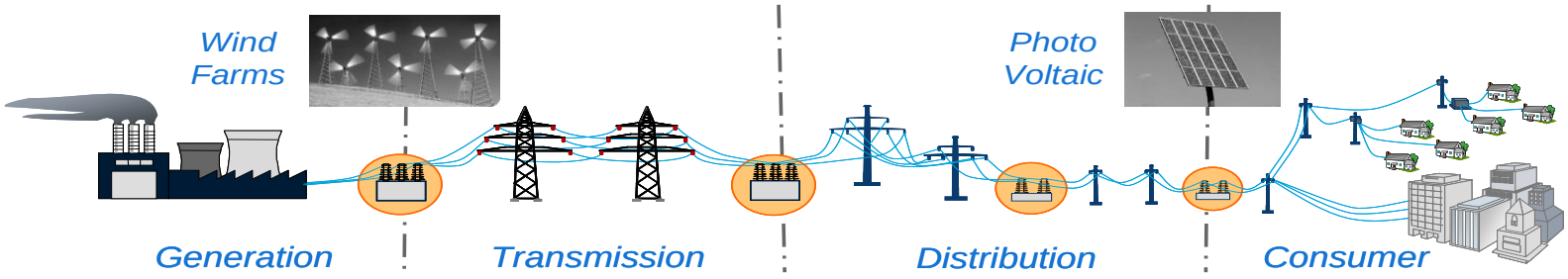
Identify KPI & Build Organization's Risk Framework & Appetize

- Finance, Reliability (e.g. SAIDI, SAIFI), Quality, Environment, etc.

Asset management Software

- Assess asset performance/health: remaining lifetime, maintenance time, failure probability
- Assess failure impact & risk on different KPI's
- Control performance, cost, and risk

AM activities: Maintenance, Refurbishment, Replacement



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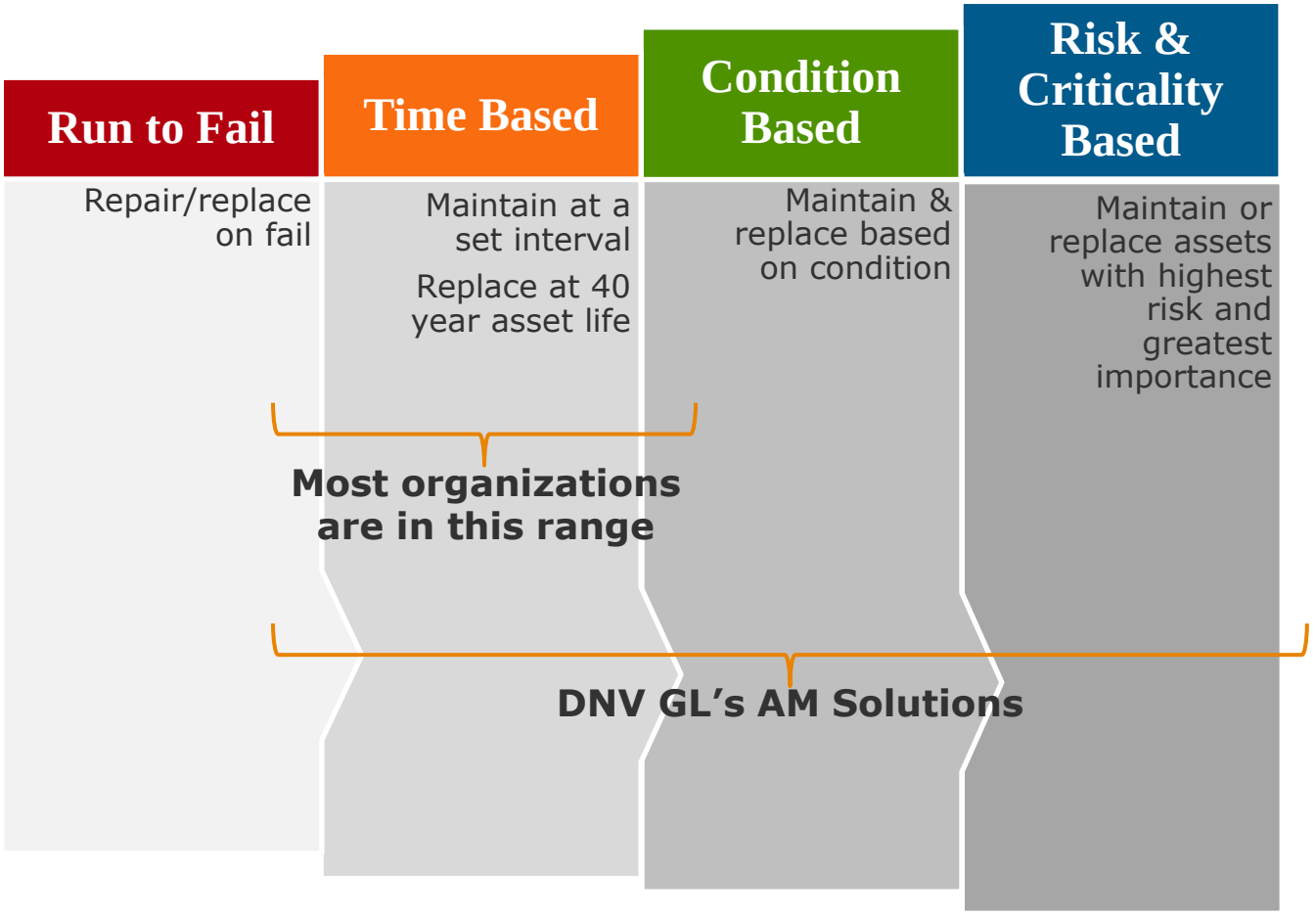
DNV GL's AM Solutions

DNV GL's Asset Management Solution



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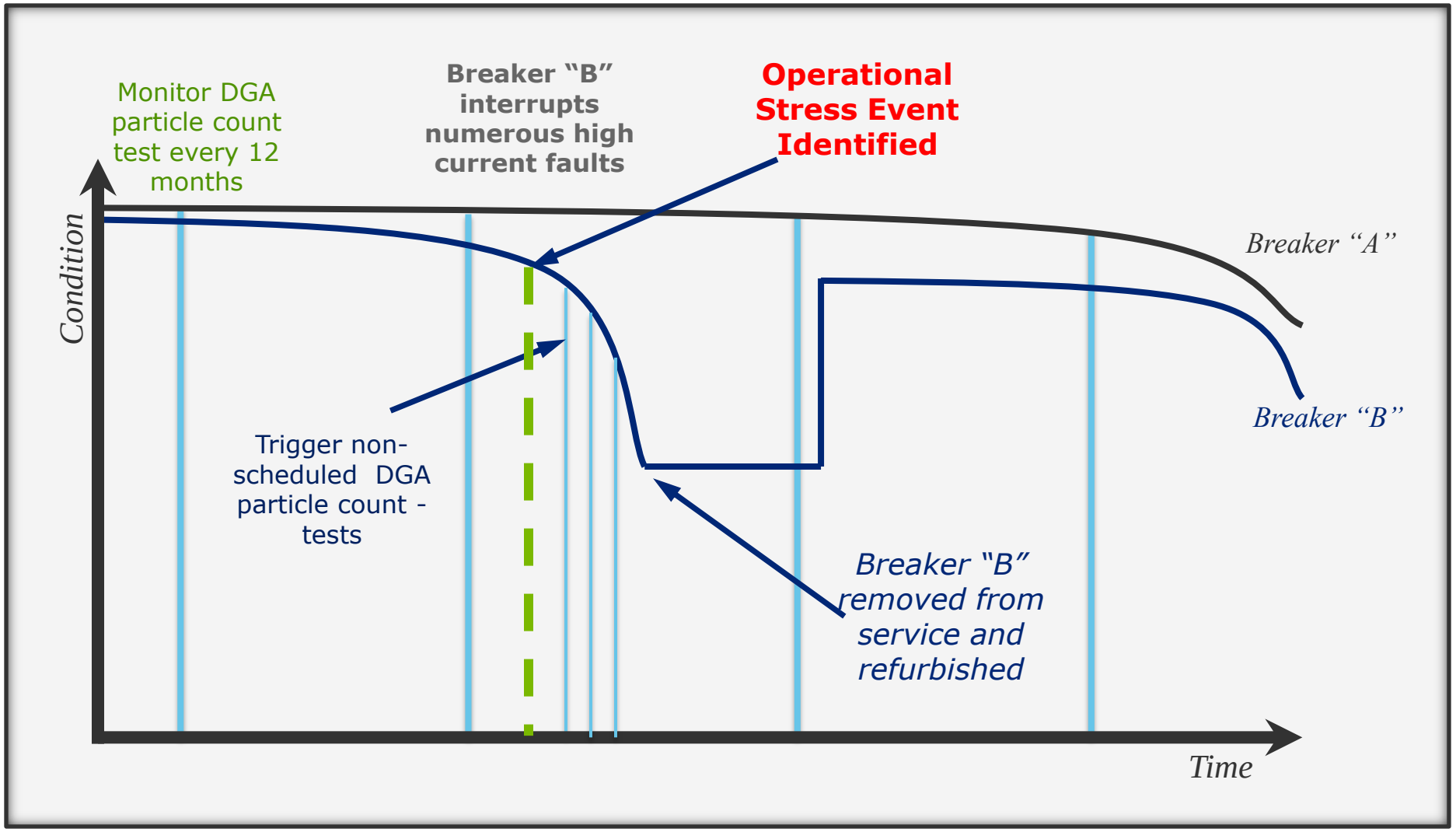
Condition-based Maintenance
Monitors Operational Stress to Find Potential Failures



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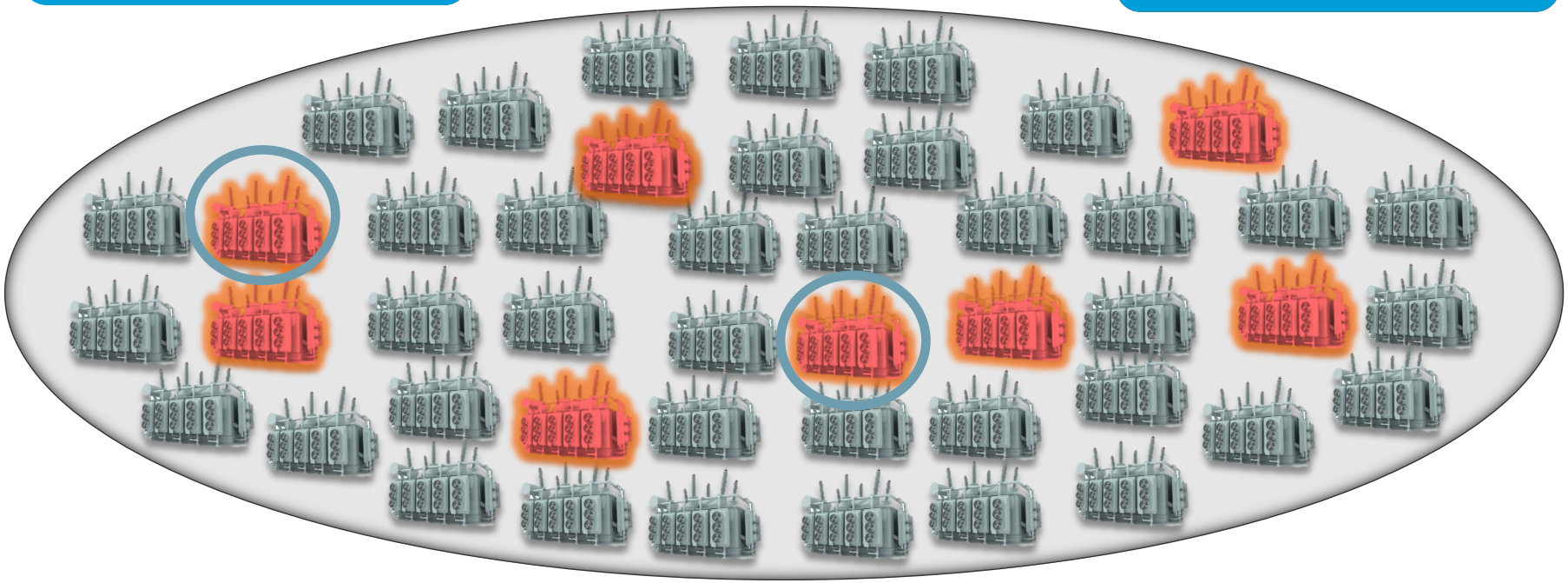
Risk-based Maintenance

Which equipment should be **replaced** and how to justify to regulators?

Which equipment is at the **greatest risk** of failure?

How can we spend our **maintenance** dollars more efficiently?



Health | **Criticality** | **Risk**

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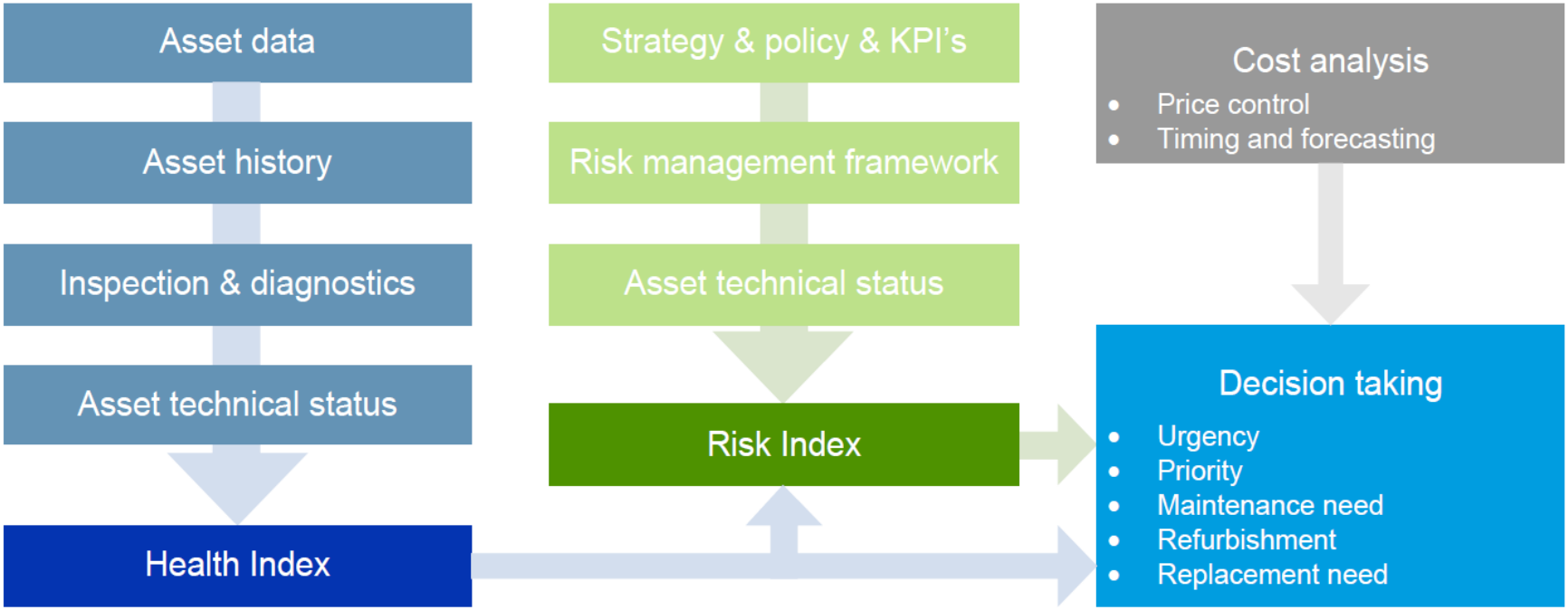
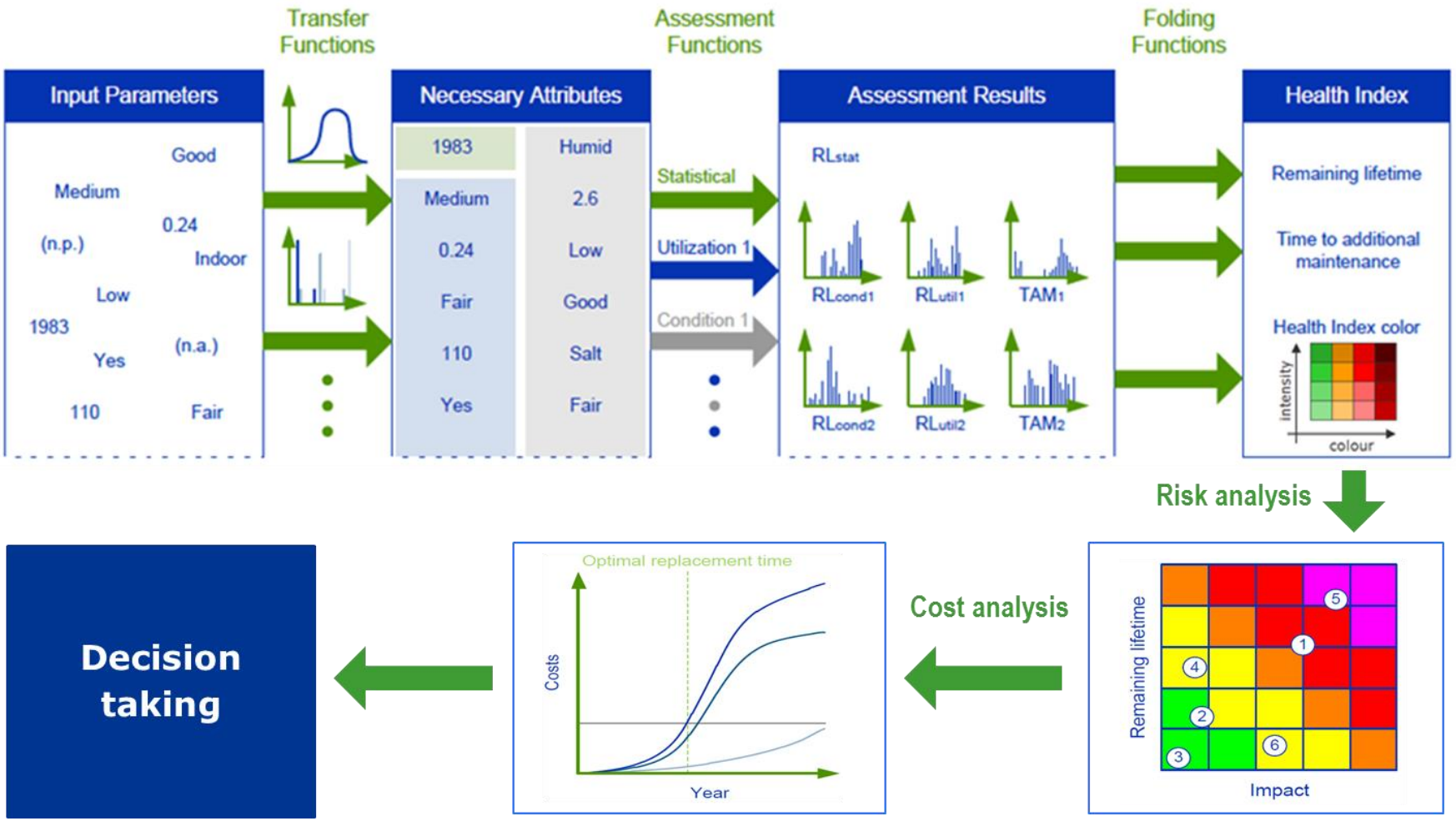
Risk-based Maintenance



Risk-based Maintenance



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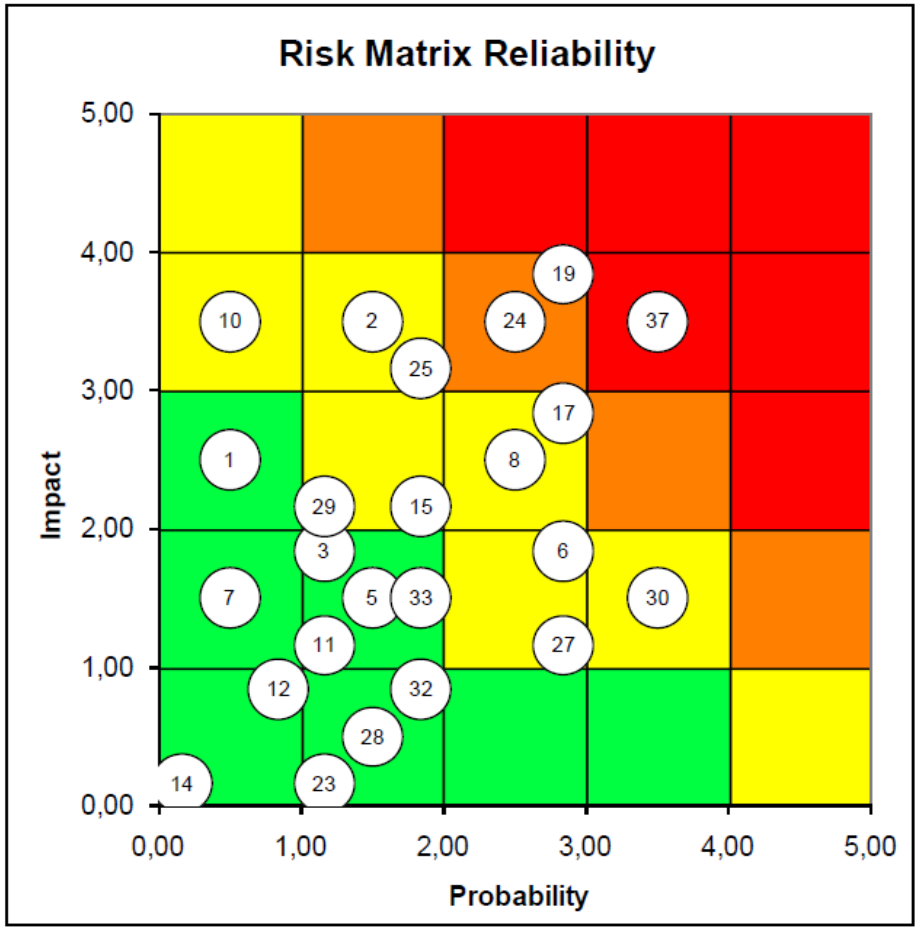
Risk-based Maintenance - Example of Risk bubble graph



- Plotting the estimated asset risks
  - Each individual asset
- Selecting the top priority assets
  - Based upon remnant life
  - Failure impact
- Enabling strong decision support

Probability	Impact	Reliability impact
1=> RL >15 years	1=negligible	1 client without power
2=> RL 7-15 years	2=small	10 clients without power (1 LV feeder)
3=> RL 3-7 years	3=average	100 clients without power (1 MV cabinet)
4=> RL 2-3 years	4=severe	1000 clients without power (1 MV feeder)
5=> RL ≤ 1 year	5=major	10.000 clients without power (1 HV transformer)

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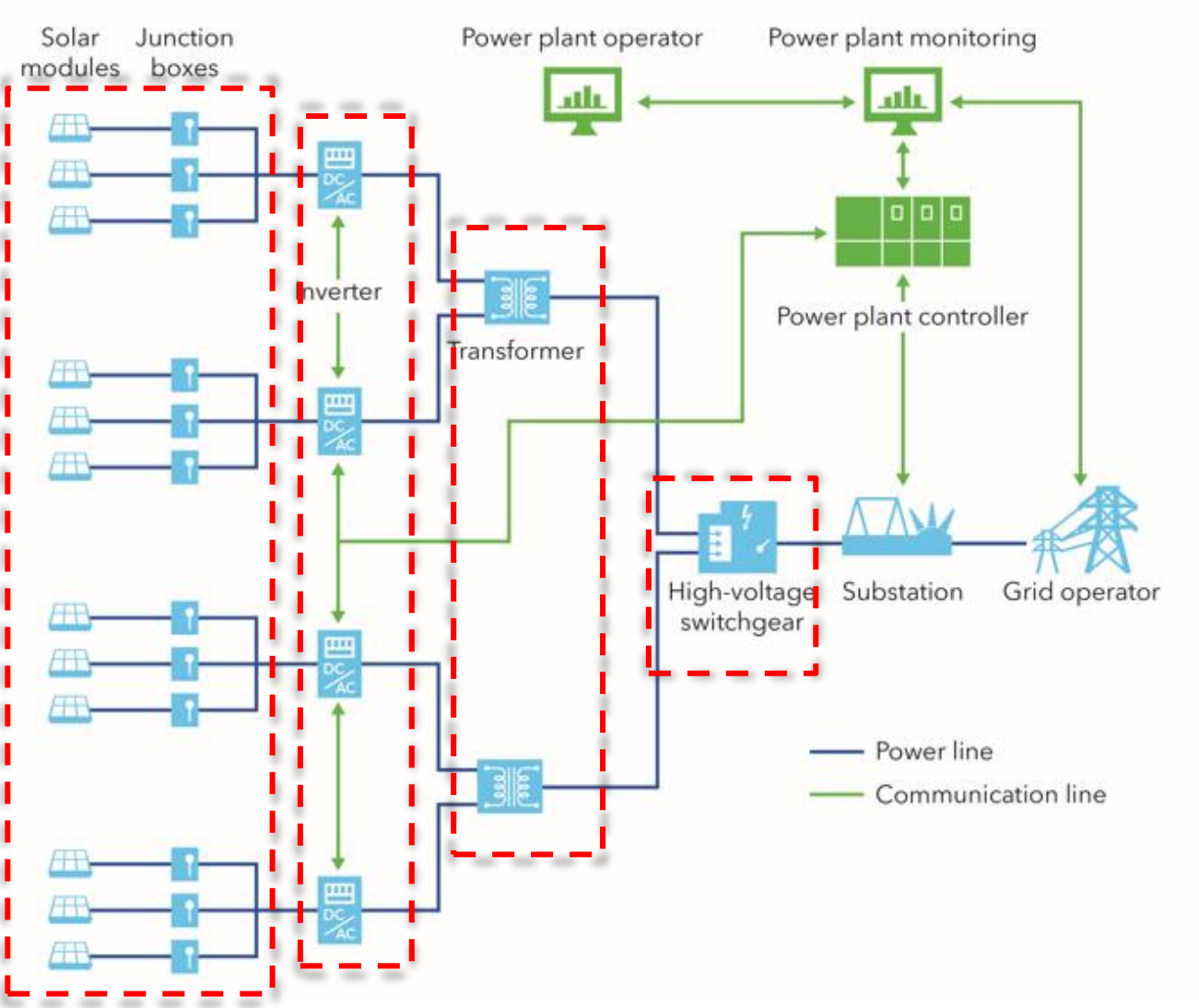
Assessment of Health and Risk of PV Plant



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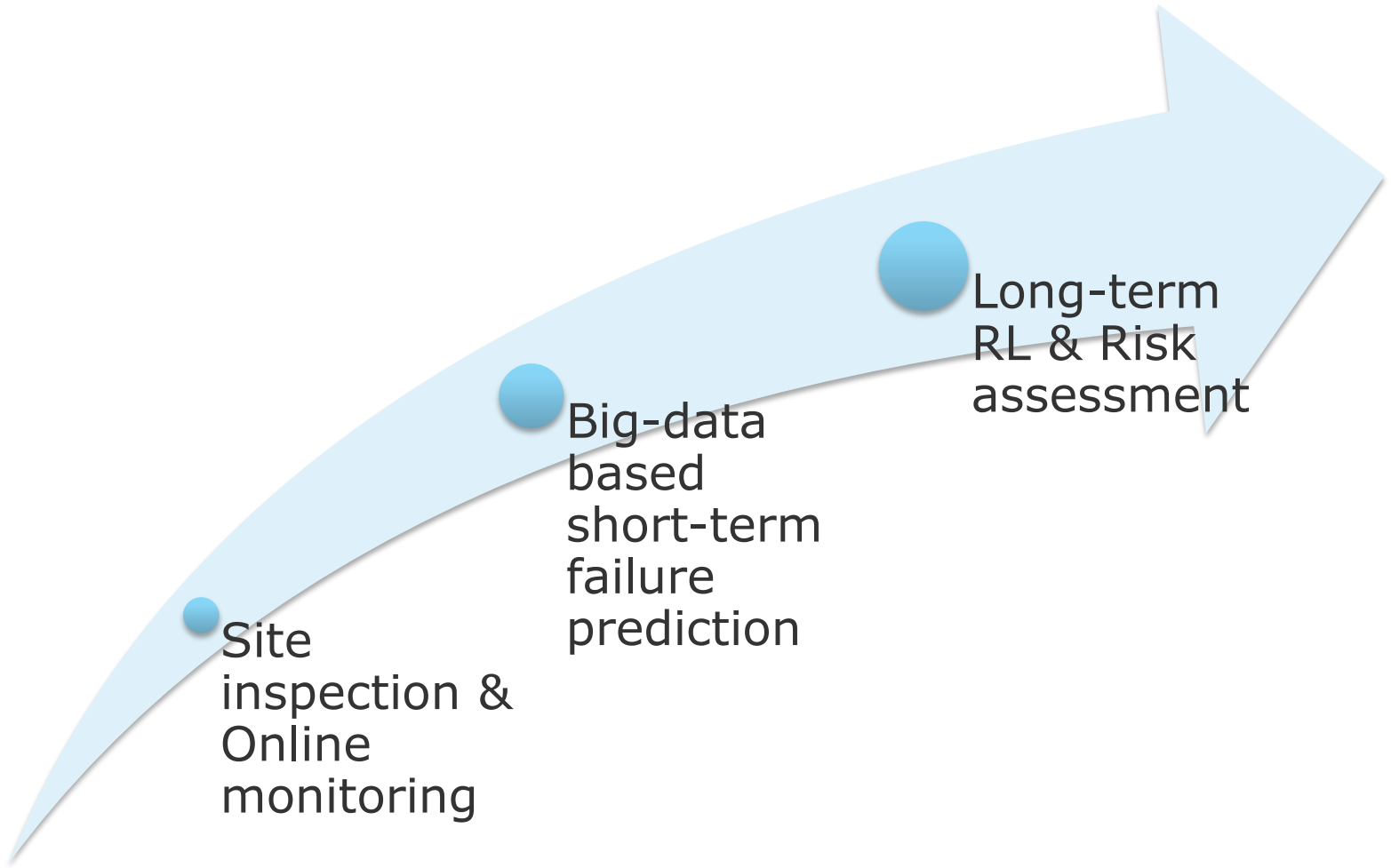
DNV GL's AM solution for solar



Online monitoring & inspection

Online monitoring by SunHelm

Site inspection

Check monitoring data for consistency

- Datasheets and certificates of sensors
- Maintenance of sensors

Analyze PV plant production

- Detection of local or temporary defects
- Identification of steadily decreasing of constant underperformance

Generation of action list

- Recommendation of immediate actions or on-site inspection
- IR imaging and IV curve (IEC 60904-1, IEC 60891)
- Visual inspection (IEC 61215)
- Insulation and Earth resistance (IEC 62446)
- Drone inspection & image analysis

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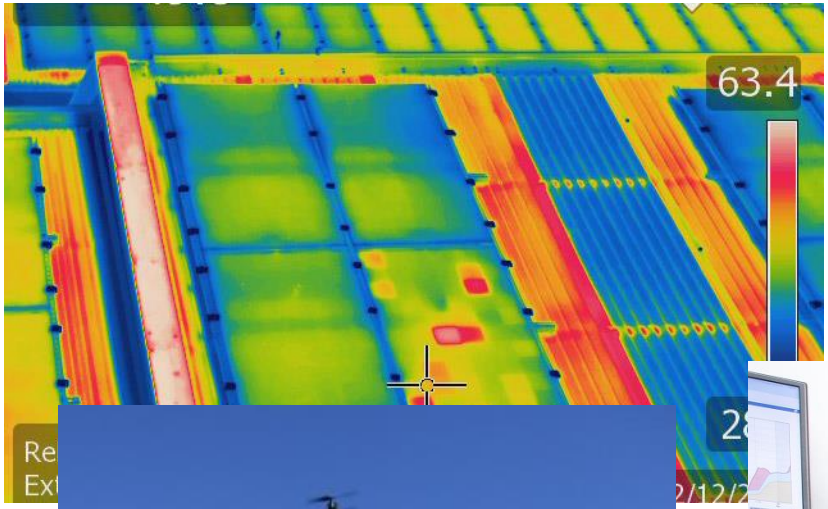
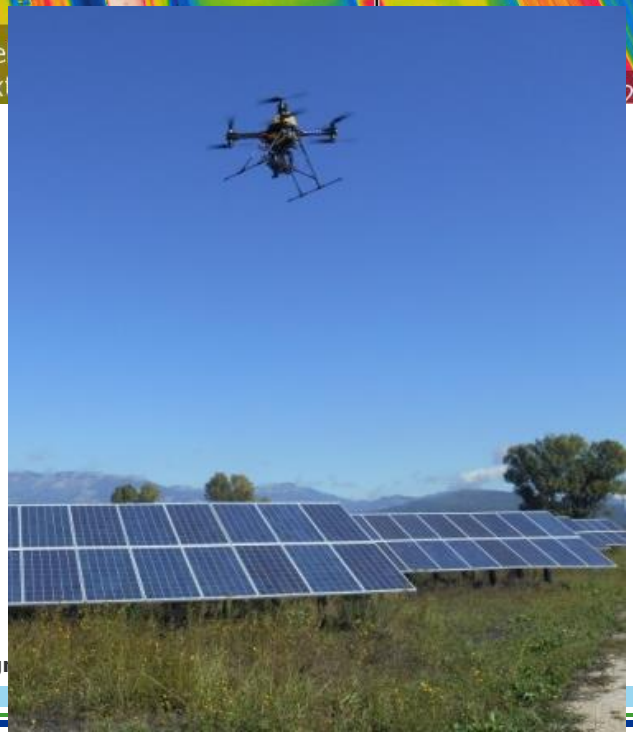
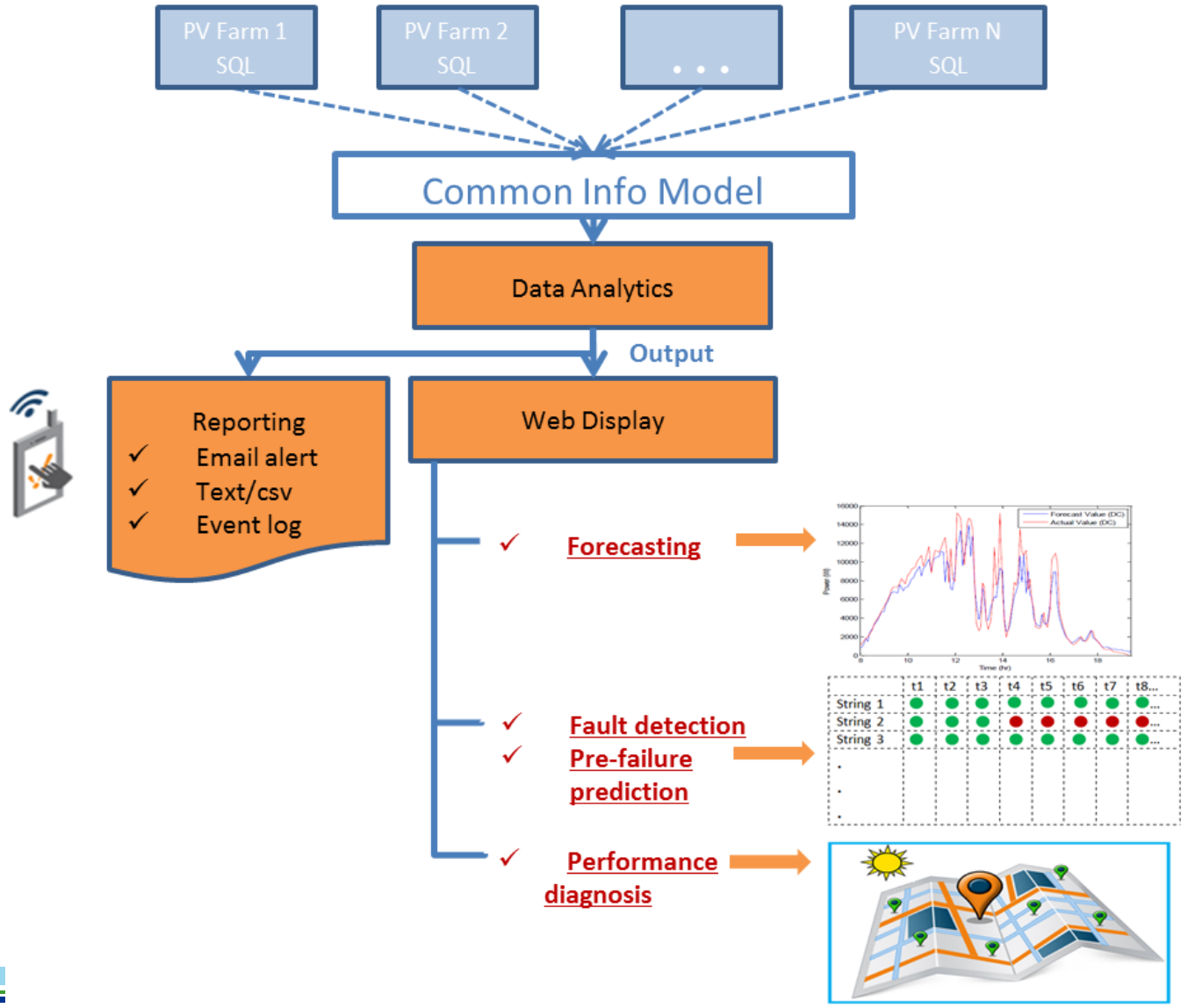
Drone inspection for solar farm



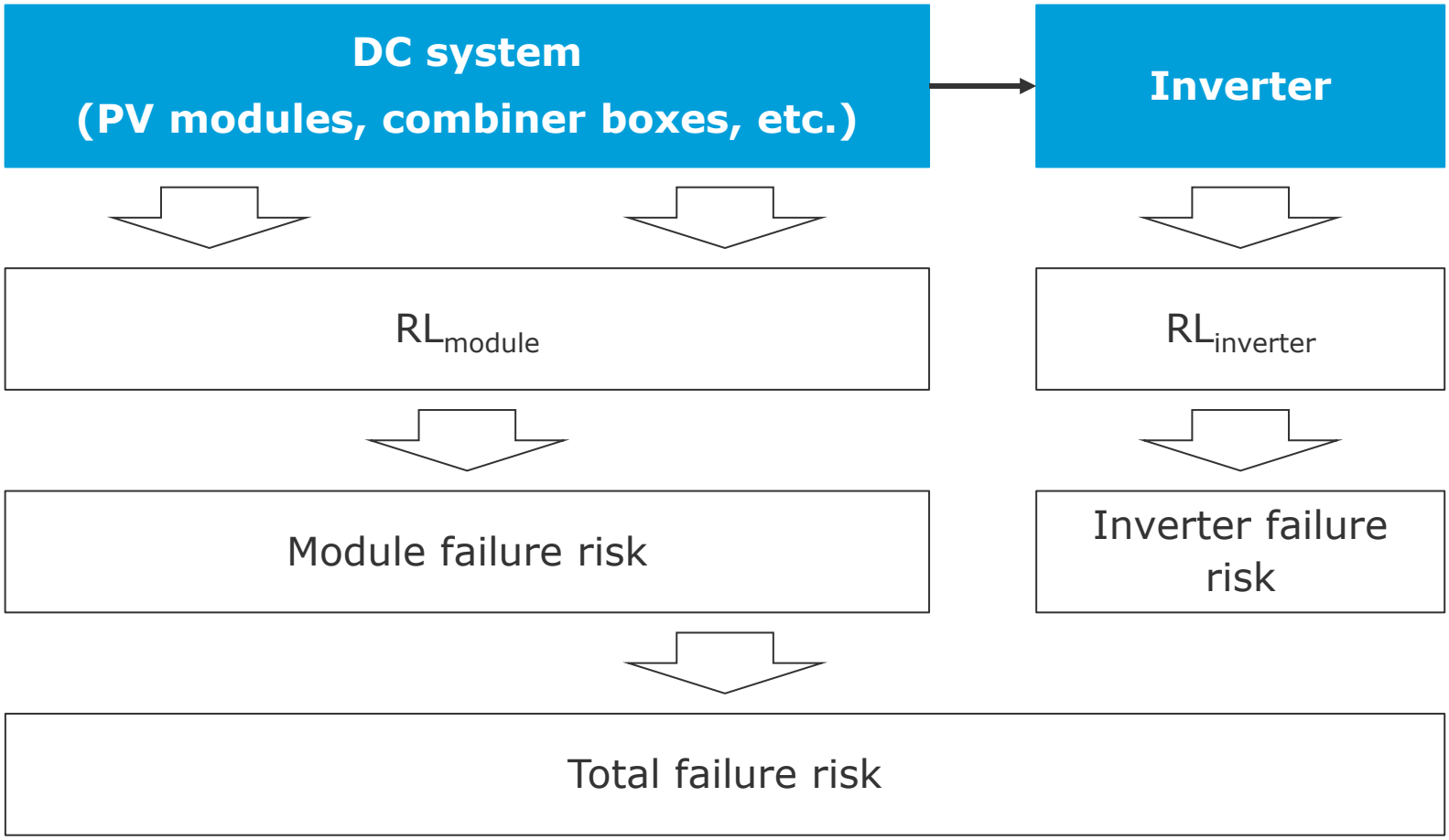


DNV GL hosted Norway Prime Minister Erna Solberg for an unveiling of the latest product in its smarter operations services for wind and solar farms.

Big-data driven short-term failure prediction



Assessment of Health and Risk of PV Plant



What else are we doing for Solar?

We are DNV GL

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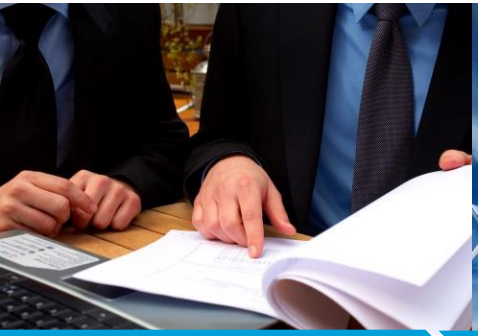
Energy's global service portfolio




Policy | Production | Transmission & distribution | Use

Service areas

- Power testing, inspections and certification
- Renewables advisory services
- Renewables certification
- Electricity transmission and distribution
- Energy efficiency services

Strategic topics

- Smart energy cities and smart grids
- Energy storage
- Future transmission grids
- **Solar**

Solar

Energy assessment

Independent engineering

Due diligence

Project management

Technology review & Strategic support

Performance evaluation

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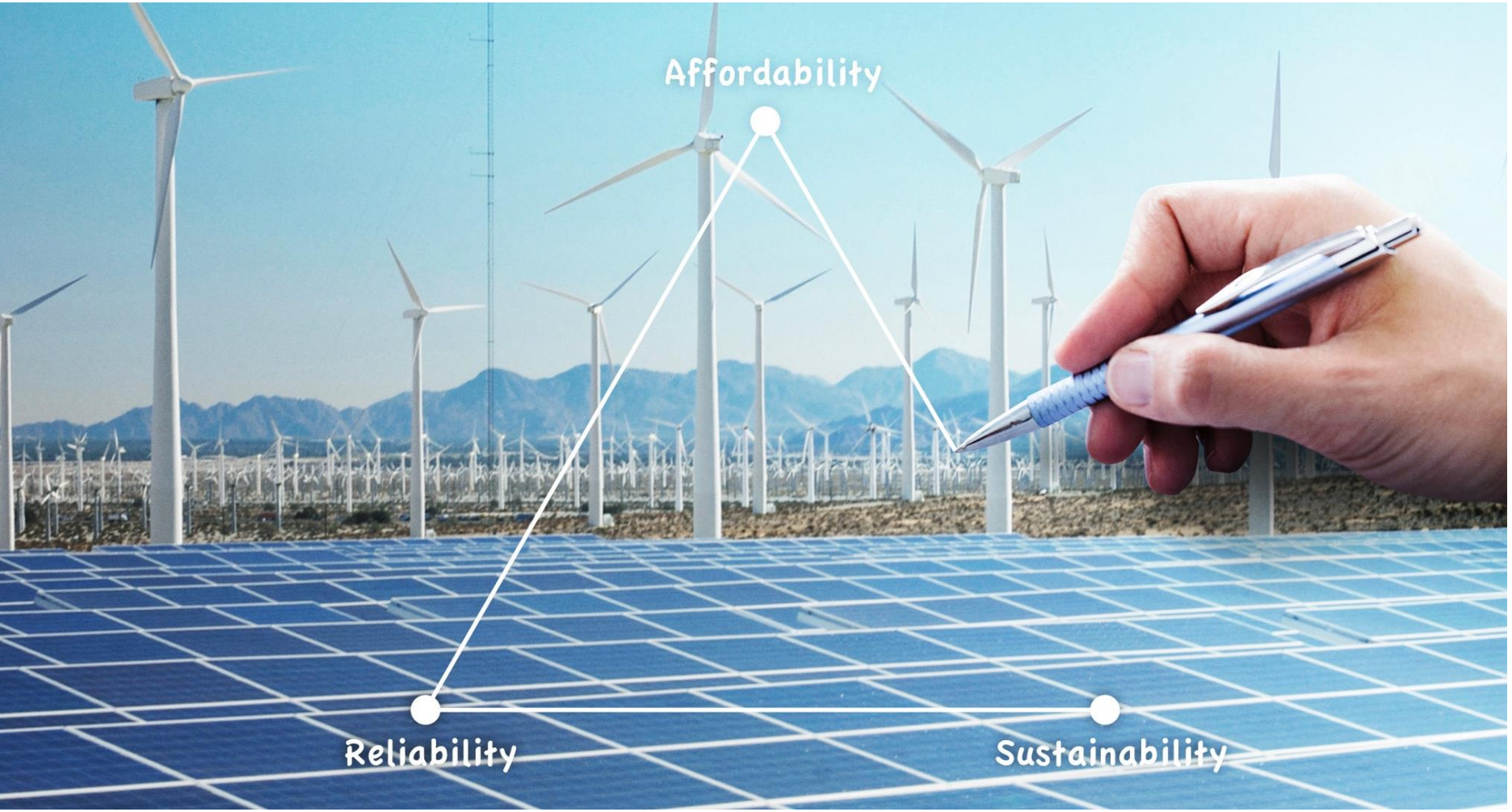
Assisting companies in solving the energy trilemma



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Risk-based Asset Management for Solar Farm

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