INTERNATIONAL CONFERENCE 2026

ENERGY, EFFICIENCY AND INTELLIGENCE

Integrated modelling for sustainable development and resilient energy infrastructure

CONFERENCE THEME

Innovations for Sustainable Development and Resilient Infrastructure



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Energy availability is necessary — but no longer sufficient

The keynote's central argument brings three decision lenses together.

01 ENERGY

Reliable, diversified and increasingly sustainable supply

02 EFFICIENCY

Greater economic and social value from every unit delivered

03 INTELLIGENCE

Data-driven forecasting, benchmarking and adaptive decisions

Sustainable energy systems integrate availability, operational efficiency and intelligent decision-making.

RESEARCH EVOLUTION

Move beyond “How much energy?” to “Why, compared with what, and what next?”

Conventional supply–demand planning remains important, but it cannot answer the full decision problem.



Energy intelligence connects historical evidence to credible, actionable improvement.

INTEGRATED MODELLING

IDA explains. ANN predicts. DEA benchmarks and supports optimisation.

The power of the framework lies in the connection among the methods — not in any method alone.

1 IDA — EXPLAIN

Separate changes into activity, structural and energy-intensity effects.

2 ANN — PREDICT

Learn nonlinear relationships and estimate an expected energy-consumption baseline.

3 DEA — BENCHMARK

Compare performance with an efficiency frontier and quantify improvement potential.

UNDERSTAND THE SYSTEM

ANTICIPATE ITS BEHAVIOUR

IDENTIFY THE OPPORTUNITY

Diagnosis → prediction → benchmarking → better decisions

Explain what changed — and why

Logarithmic Mean Divisia Index separates the observed change into interpretable drivers.

CHANGE IN ENERGY USE

ACTIVITY

Scale of production or economic output

STRUCTURE

Composition of sectors or products

INTENSITY

Energy used per unit of output

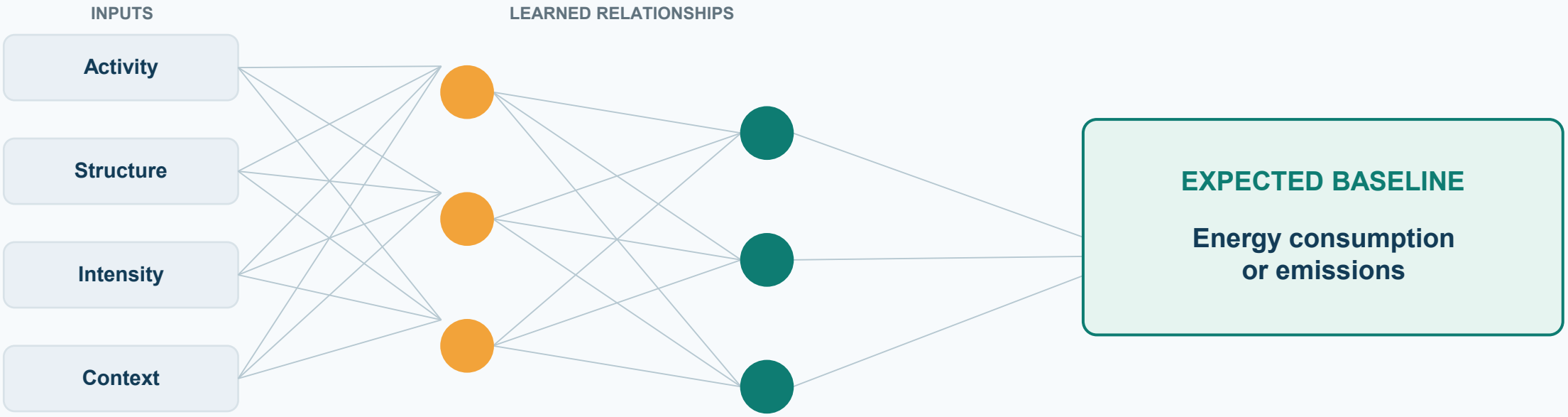
THE DIAGNOSTIC VALUE

Different drivers require different interventions.

Growth may require cleaner supply; structural change may require industrial strategy; worsening intensity may require technology, maintenance or process redesign.

Learn nonlinear relationships to establish a credible baseline

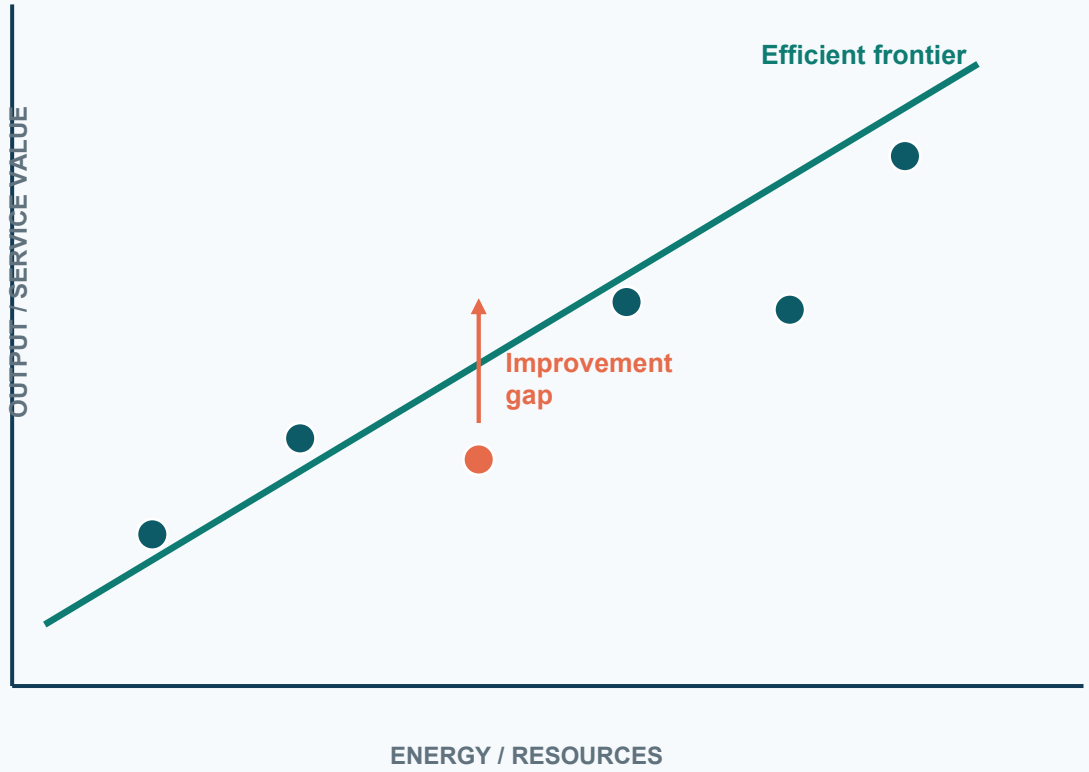
A baseline clarifies whether performance is improving after accounting for changing conditions.



Prediction supports judgement; it does not replace engineering knowledge or professional responsibility.

Compare performance against an achievable efficiency frontier

DEA estimates the improvement gap while accommodating multiple inputs and outputs.



DEA asks three practical questions

- Who performs well under comparable conditions?
- How large is the efficiency gap?
- What combination of changes could close it?

EVIDENCE FROM INDUSTRIAL SYSTEMS

The same modelling chain reveals different improvement opportunities

Canada and South Africa illustrate why context matters.

CANADIAN INDUSTRIAL SECTOR

15 industrial sectors

≈ 1.6%

improvement to frontier

A mature system may operate close to its efficiency frontier — yet marginal gains can still produce substantial system-scale benefits.

SOUTH AFRICAN INDUSTRIAL SECTOR

11 energy-intensive sectors

LARGER GAP

potential energy savings

In an emerging energy-intensive economy, activity, structural change and intensity can create a much wider space for intervention.

COMPARATIVE LESSON

Transfer the method — not the conclusion

Evidence-based intervention begins by understanding the system in front of us.



Move beyond measuring energy consumed toward understanding the mechanisms that produce it.

The answer determines the intervention

Energy-related emissions can rise for different reasons — and each reason points to a different response.

1 ACTIVITY

How much is produced?

2 STRUCTURE

What is being produced?

3 INTENSITY

How much energy per unit?

4 ENERGY MIX

Which sources provide it?

TARGETED MITIGATION PATHWAY

Decarbonisation rarely comes from one lever; efficiency and energy-mix change often have to advance together.

The electricity challenge is a systems problem

Generation is only one part of a connected infrastructure, operational and institutional system.



INDUSTRY — **Cost + competitiveness**

COMMUNITIES — **Access + quality of life**

INSTITUTIONS — **Finance + confidence**

Energy access, industrialisation, affordability, environmental sustainability and climate resilience are one development challenge.

SYSTEM RESPONSE

Build systems that are reliable, efficient, intelligent and resilient

The response must improve the whole system rather than add disconnected interventions.

ENERGY

Reliable, diversified and increasingly sustainable supply

Grid • renewables • storage • distributed energy

EFFICIENCY

More economic and social value from every unit delivered

Technical losses • operations • demand • productivity

INTELLIGENCE

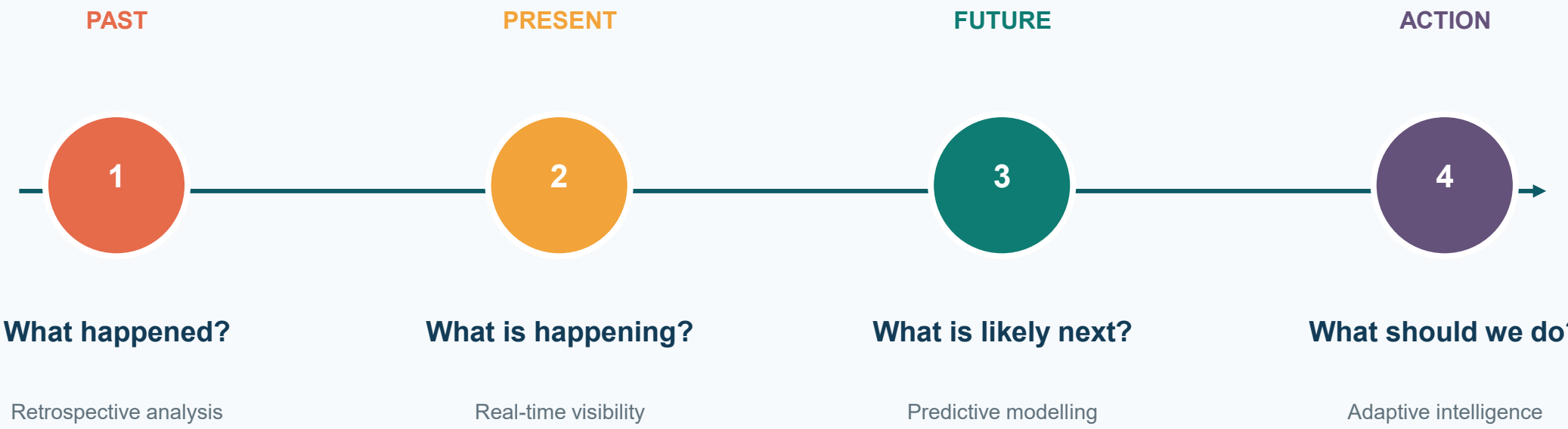
Decisions that anticipate, benchmark and adapt

Data • forecasting • monitoring • decision support

The goal is not only additional capacity — it is a system capable of delivering and improving under stress.

Move from retrospective analysis toward adaptive intelligence

Dynamic, distributed and data-intensive energy systems require models that learn and respond.

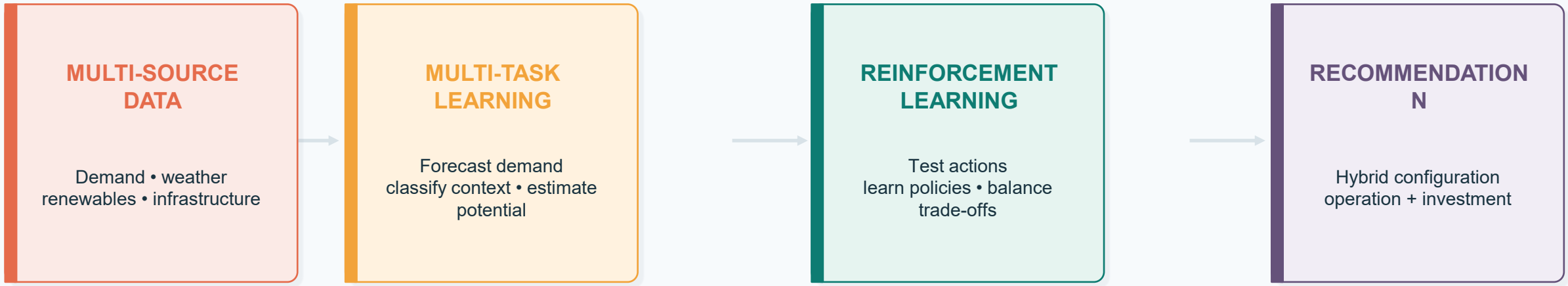


The research direction evolves toward Multi-Task Learning + Reinforcement Learning (MTL–RL).

MTL–RL PLANNING

Turn diverse information into context-aware hybrid-energy decisions

Artificial intelligence has value only when it enables better infrastructure and human outcomes.



RELIABILITY | LOWER WASTE | LOWER EMISSIONS | GREATER ACCESS

Better decisions are the objective: improve reliability, reduce waste and emissions, expand access and strengthen resilience.

RESILIENT INFRASTRUCTURE

Integrate physical strength, operational efficiency and adaptive intelligence

Resilience means anticipating disruption, absorbing shocks, adapting and continuing essential service.

01

PHYSICAL RESILIENCE

Robust generation, transmission, distribution, storage and distributed-energy infrastructure

02

OPERATIONAL EFFICIENCY

Reduce avoidable technical, commercial and process losses

03

ADAPTIVE INTELLIGENCE

Use data, forecasting and intelligent control to anticipate risk and improve performance

Technology must be matched by regulation, financial sustainability, data governance, institutions and human capital.

Models become valuable when they improve real decisions

Impact requires collaboration, shared data, living laboratories, pilot projects and interdisciplinary skills.

INDUSTRY	Where should efficiency investment be made?
UTILITIES	Where can losses and service gaps reduced?
REGULATORS	How can performance be compared objectively?
POLICY + COMMUNITIES	Which pathway is reliable, affordable and locally appropriate?

RESEARCH SUCCESS = publications + demonstrable contribution to improved systems and better decisions

Five priorities for intelligent, resilient energy systems

The optimal system must balance reliability, productivity, access, emissions and human well-being.

01

REAL-TIME ENERGY MANAGEMENT

Continuously update analytical and optimisation models

02

AI + DIGITAL TWINS

Integrate adaptive decision support into planning and operations

03

CONTINENTAL BENCHMARKING

Learn from comparable sectors and systems across Africa

04

HUMAN-CENTRED OPTIMISATION

Link energy, climate resilience, productivity and well-being

05

RESEARCH–POLICY CONNECTION

Translate model findings into investment and regulatory action

Sophisticated models matter only when they inform practical decisions and implementation.

CONCLUSION

If we can explain, predict, benchmark and adapt — we can act.



Why the system behaves as it does

What is likely to happen next

What performance is achievable

What action should be taken

ENERGY **EFFICIENCY** **INTELLIGENCE** **TRANSFORMATION**

Move from energy crisis to resilient transformation — and from modelling systems to improving lives.

Thank you