YBG GLOBAL · EXECUTIVE BRIEFING

Industrial Thermodynamic Intelligence™ Series · Paper No. 01

Thermodynamic Visibility™ and the Industrial Capital *Allocation Problem*

A policy-grade framework for prioritising capital deployment into industrial decarbonisation through visibility of the operational thermodynamic performance of existing infrastructure.

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Operating entity for YBG Global · Australia · Hong Kong

Series · Industrial Thermodynamic Intelligence

Audience · Industrial operators · Infrastructure investors · Development finance · Industrial policy

EXECUTIVE SUMMARY

A capital allocation framework for the industrial transition.

Industrial decarbonisation has entered a capital allocation phase. Hundreds of billions of dollars are expected to flow into steel, cement, power generation, petrochemicals, refining and adjacent heavy industries over the coming decade, deployed across hydrogen, carbon capture, electrification, alternative fuels and efficiency programmes. The constraint is no longer the availability of decarbonisation pathways. The constraint is the evidence base on which capital is allocated between them.

Investment confidence in industrial transition projects depends upon performance visibility of the assets that already exist. Most industrial infrastructure operates without a structured, engineer-defensible view of its thermodynamic state. Fuel consumption, heat rate, emissions intensity and reliability are observed; the thermodynamic causes that drive them are not. In the absence of that visibility, capital allocation decisions are made on inference rather than on physics.

This briefing introduces Thermodynamic Visibility™ as a foundational layer beneath industrial decarbonisation — a precondition for prioritising capital across competing technology pathways. It is not a competing decarbonisation technology. It is the analytical layer that makes the choice between them defensible.

THE INDUSTRIAL CAPITAL ALLOCATION PROBLEM

Three structural realities now shape industrial transition planning. First, the existing industrial asset fleet — thermal power, integrated steel, cement, petrochemical, refining and process-heat infrastructure — represents committed capital that will continue to operate for decades. Second, multiple decarbonisation pathways compete for the same finite capital envelope, each with materially different cost, maturity and emissions trajectories. Third, the volume of capital available, while large in absolute terms, is small relative to the engineering surface area of global heavy industry.

The consequence is a prioritisation problem. Which assets should receive efficiency investment, which should receive retrofit, which should receive replacement, and which are candidates for hydrogen, electrification or carbon capture? The question cannot be answered credibly without a defensible reading of how each asset performs today and how close that performance is to its physical envelope.

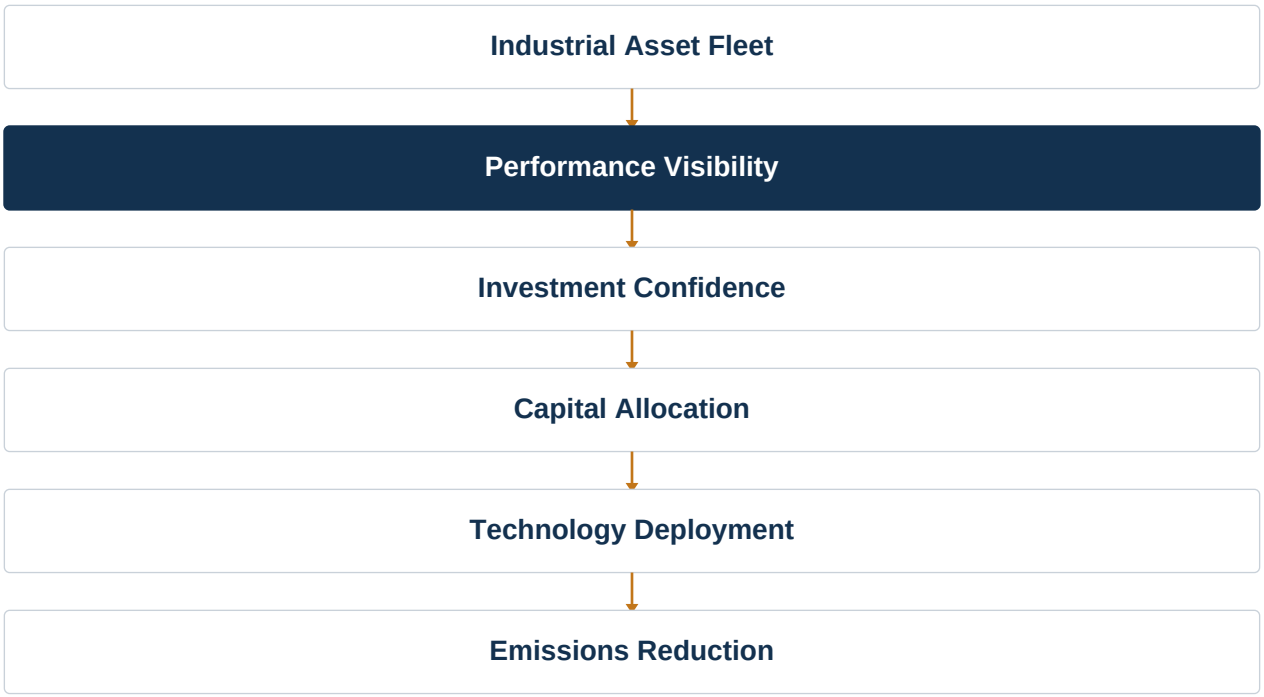


Figure 1 · The capital allocation chain. Performance visibility is the upstream constraint on every subsequent decision.

THE MISSING LAYER

Thermodynamic Visibility™.

Thermodynamic Visibility™ is defined as the ability to render the operational physics of industrial infrastructure visible, traceable and engineer-defensible. It is the analytical layer through which the thermodynamic state of an asset — the conversion of fuel into useful work, the transfer of heat across surfaces, the losses accumulated across the operating envelope — is reconstructed from existing operational data and expressed in terms that engineering, executive and investment audiences can act upon.

Visibility sits beneath every industrial transition pathway. Before hydrogen, before carbon capture, before electrification, before alternative fuels, and before the deployment of the capital that would finance them, the question is the same: *what is the thermodynamic performance of the asset that exists today, and what is the gap between that performance and what is physically achievable?*

INDUSTRIAL THERMODYNAMIC INTELLIGENCE — FOUR-LAYER FRAMEWORK

The framework progresses from the observable state of the asset to a defensible capital allocation position. Each layer is a precondition for the layer above it.

LAYER 01
Existing Asset State
- How is the asset performing today?
- What is the fuel intensity across the operating
- envelope?
- What is the emissions intensity by load and condition?

LAYER 02
Performance Envelope
- What operating states have been achieved historically?
- What is the best-observed performance of the asset?
- What is achievable performance under current
- configuration?

LAYER 03
Thermodynamic Opportunity Assessment
- What can be improved operationally?
- What requires retrofit?
- What requires replacement?

LAYER 04
Capital Allocation Prioritisation
- Which assets deserve investment first?
- Which projects deliver the greatest emissions impact?
- Which deliver the greatest return on capital deployed?

Figure 2 · The four-layer Industrial Thermodynamic Intelligence framework.

THE INDUSTRIAL DECARBONISATION DECISION STACK

From physics to emissions reduction.

The industrial transition is often described as a financing problem or a technology problem. It is more accurately described as a decision-architecture problem. The diagram below expresses that architecture as a stack: each layer depends on the integrity of the one beneath it.

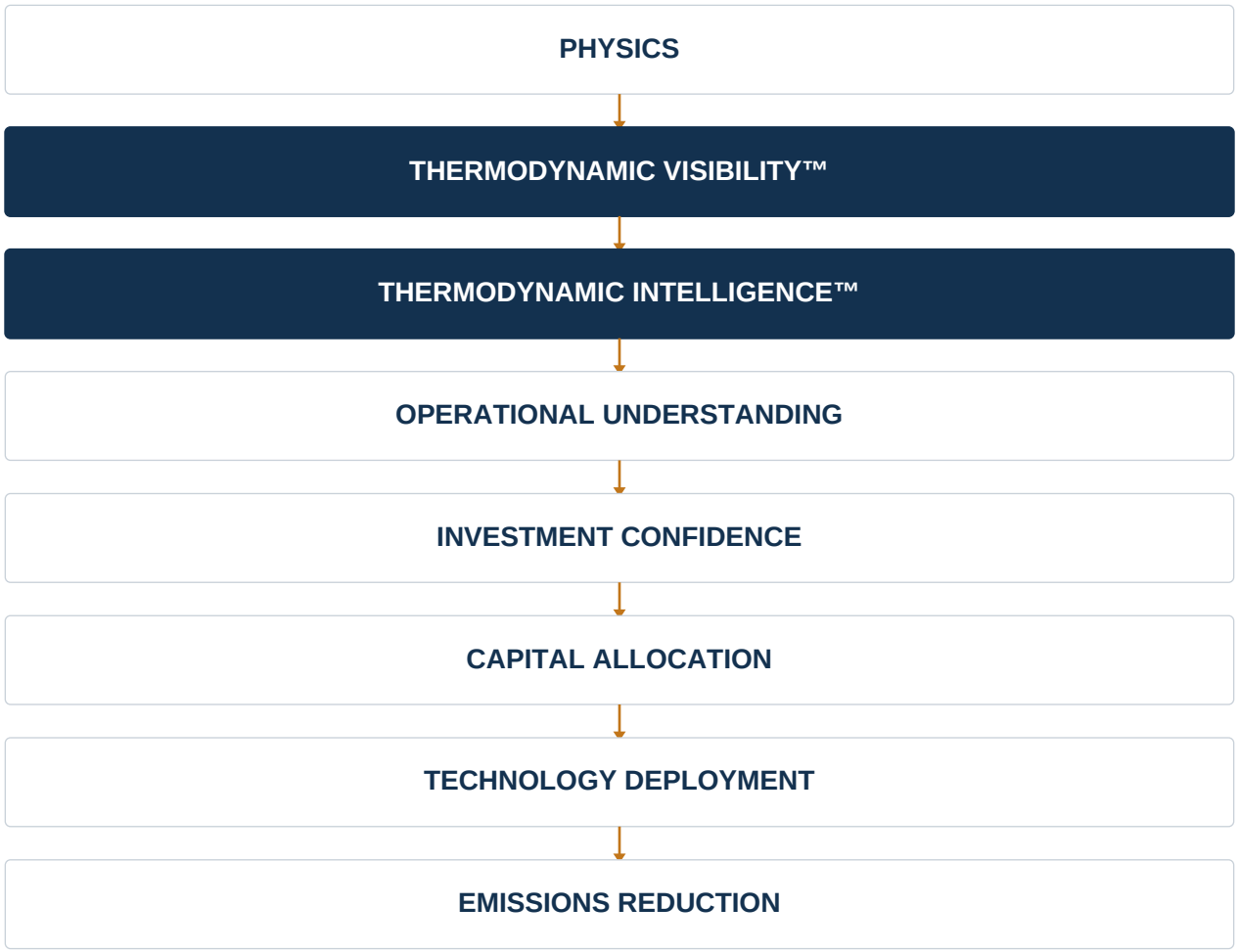


Figure 3 · The Industrial Decarbonisation Decision Stack. Capital allocation and technology deployment are downstream artefacts of upstream visibility.

IMPLICATIONS

For industry, investors and policy.

Industrial Operators

Operators are increasingly required to defend capital plans to boards, regulators and external financiers. Thermodynamic Visibility™ provides the engineering basis for prioritising between operational improvement, retrofit and replacement, and for sequencing transition investments against an understood performance envelope.

Investors and Infrastructure Funds

For infrastructure investors evaluating industrial decarbonisation opportunities, the underlying asset's thermodynamic state determines the realisable return on any transition technology layered above it. Visibility supports diligence, downside calibration and pre- and post-investment performance verification.

Governments and Industrial Policy

Industrial policy is shifting from broad incentive frameworks toward instrumented, outcome-linked support. Programmes that condition disbursement on measurable thermodynamic improvement, rather than on capital expenditure alone, require a visibility layer capable of distinguishing structural performance gains from operational or market-driven variability.

Development Banks and Climate Finance

Multilateral lenders and climate finance institutions deploying concessional capital into industrial transition projects require a defensible basis for allocating between candidate assets and for verifying that improvements claimed are improvements delivered. Thermodynamic Visibility™ provides an audit-grade, physics-anchored reference layer for that allocation and verification.

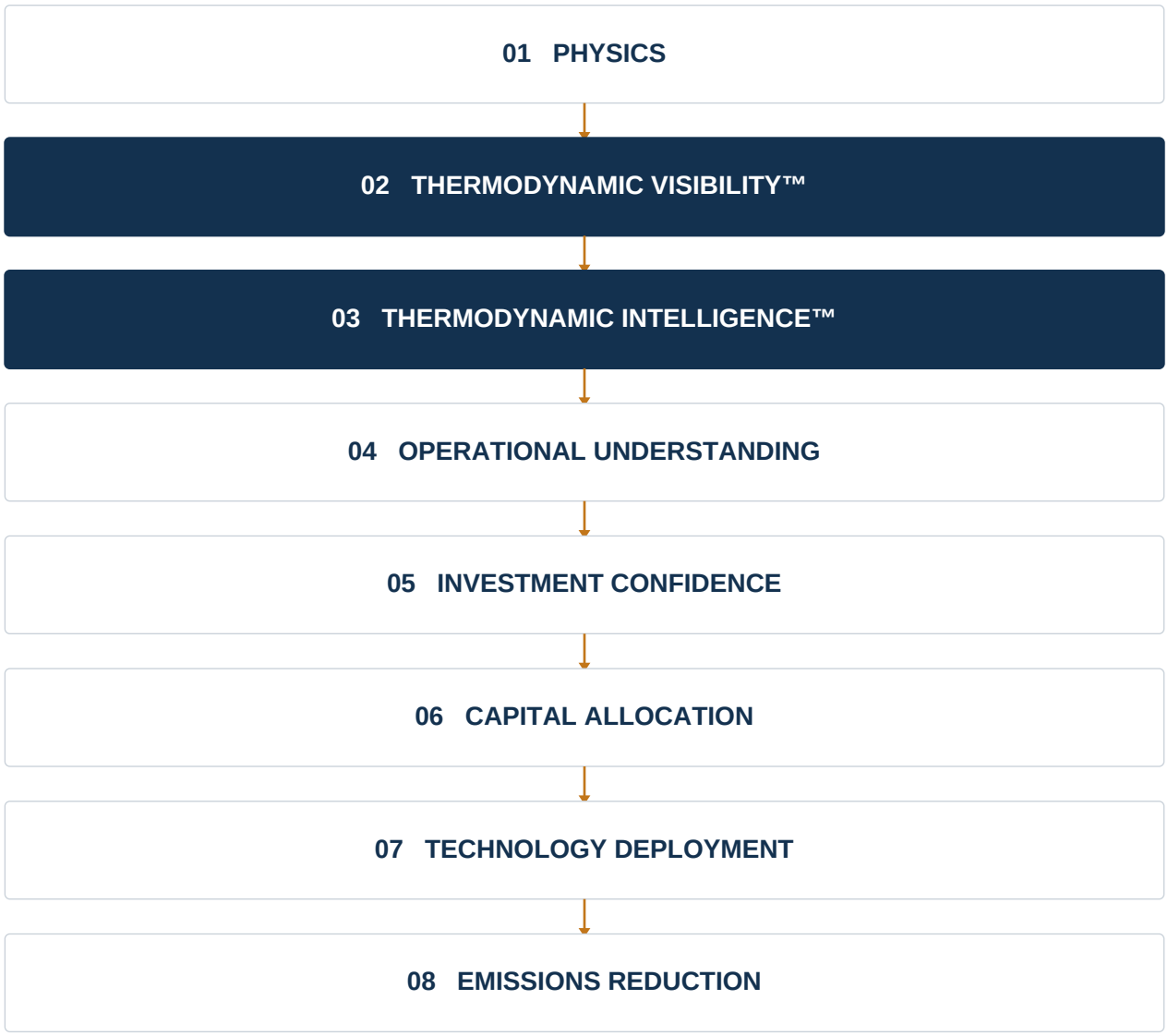
CONCLUSION

The next industrial transition may be financed with capital, but it will increasingly be guided by thermodynamic intelligence. Visibility of the operational physics of existing infrastructure is the precondition for confident allocation of capital across the pathways that will define the next two decades of heavy industry.

APPENDIX A · STANDALONE INFOGRAPHIC

The Industrial Decarbonisation Decision Stack.

Reusable visual asset. Each layer depends on the integrity of the layer beneath it; capital allocation and technology deployment are downstream of the visibility of physics.

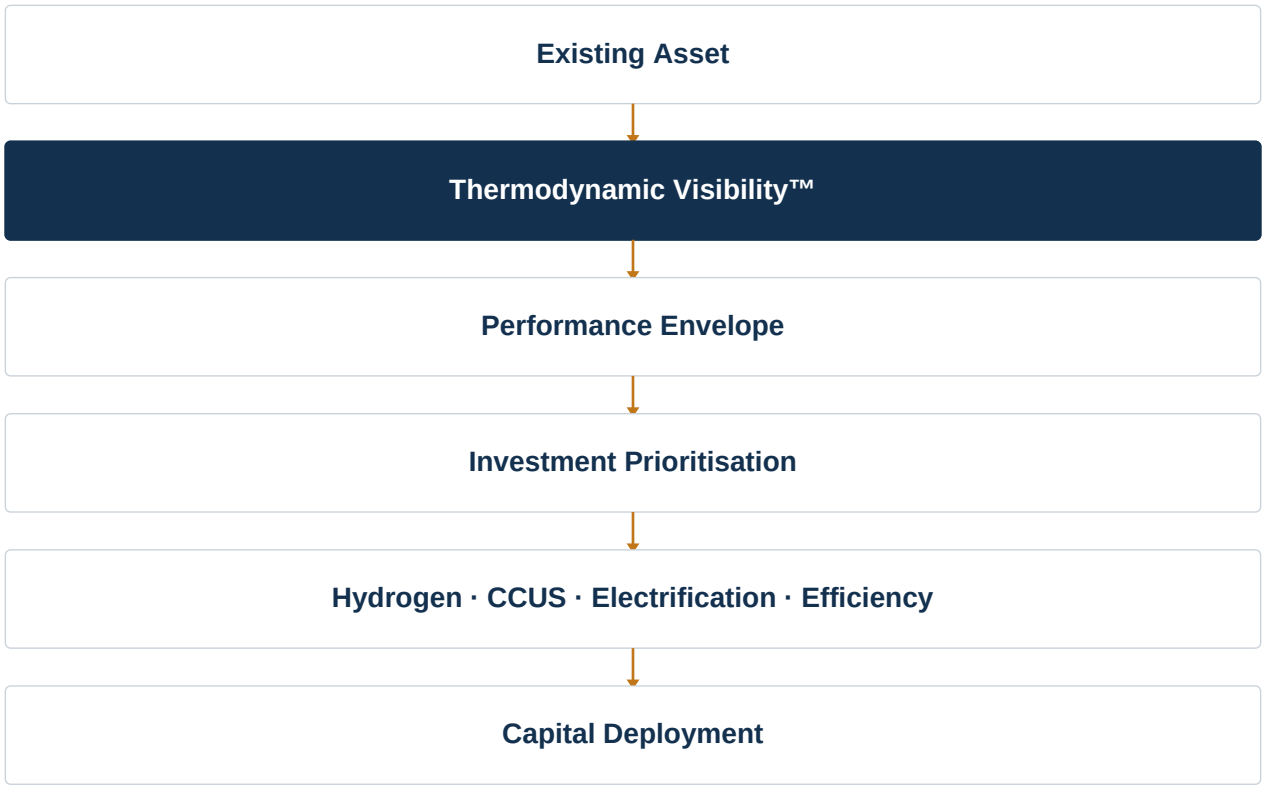


Appendix A · YBG Global · Industrial Thermodynamic Intelligence™ Series.

APPENDIX B · ONE-PAGE FRAMEWORK

From Existing Asset to Capital Deployment.

A sequencing framework for industrial transition planning. Each stage is the input condition for the stage below it.



Appendix B · YBG Global. The technology pathway is selected against — not ahead of — the visibility of the underlying asset.

REFERENCES & SUPPORTING CONTEXT

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About YBG Global. YBG Global is the operating identity for the Industrial Thermodynamic Intelligence™ architecture developed by YBG Group International. The architecture renders the operational thermodynamic performance of industrial infrastructure visible, traceable and engineer-defensible — a foundational layer beneath industrial decarbonisation, capital allocation and the next generation of transition technology deployment.