Modelling Technological Innovation Systems: A hybrid model

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01

TIS framework

Technological Innovation Systems framework

TIS framework: useful for assessing the development of sustainable transitions

Two approaches

1. Structural
2. Functional

TIS framework: structural approach

- Three structures:
  - Technology
  - Actors and networks
  - Institutions
- Extension of TIS structures: building blocks Ortt & Kamp (2022)

TIS framework: structural approach

TIS building block	TIS structure
Product performance and quality	**Technology**
Production system	**Technology**
Complementary products and services	**Technology**
Product price	**Technology**
Network formation and coordination	**Actors and networks**
Customers	**Actors and networks**
Innovation-specific institutions	**Institutions**

→ Static evaluation of TIS + identification of barriers

TIS framework: functional approach

- Key processes within a TIS
- Two main sets of functions
  - Hekkert et al. (2007)
  - Bergek et al. (2008)
- Edsand (2019):
  - Extended list by Hekkert et al. to context of developing countries
  - E.g. Entrepreneurial activity, resource mobilisation, knowledge development

→ More dynamic evaluation of TIS

02

The hybrid TIS model

Why a hybrid TIS model

*What is the effect of the **structural barriers** on the diffusion of a new technology **over time**?*

Structural approach

- Identification of structural barriers

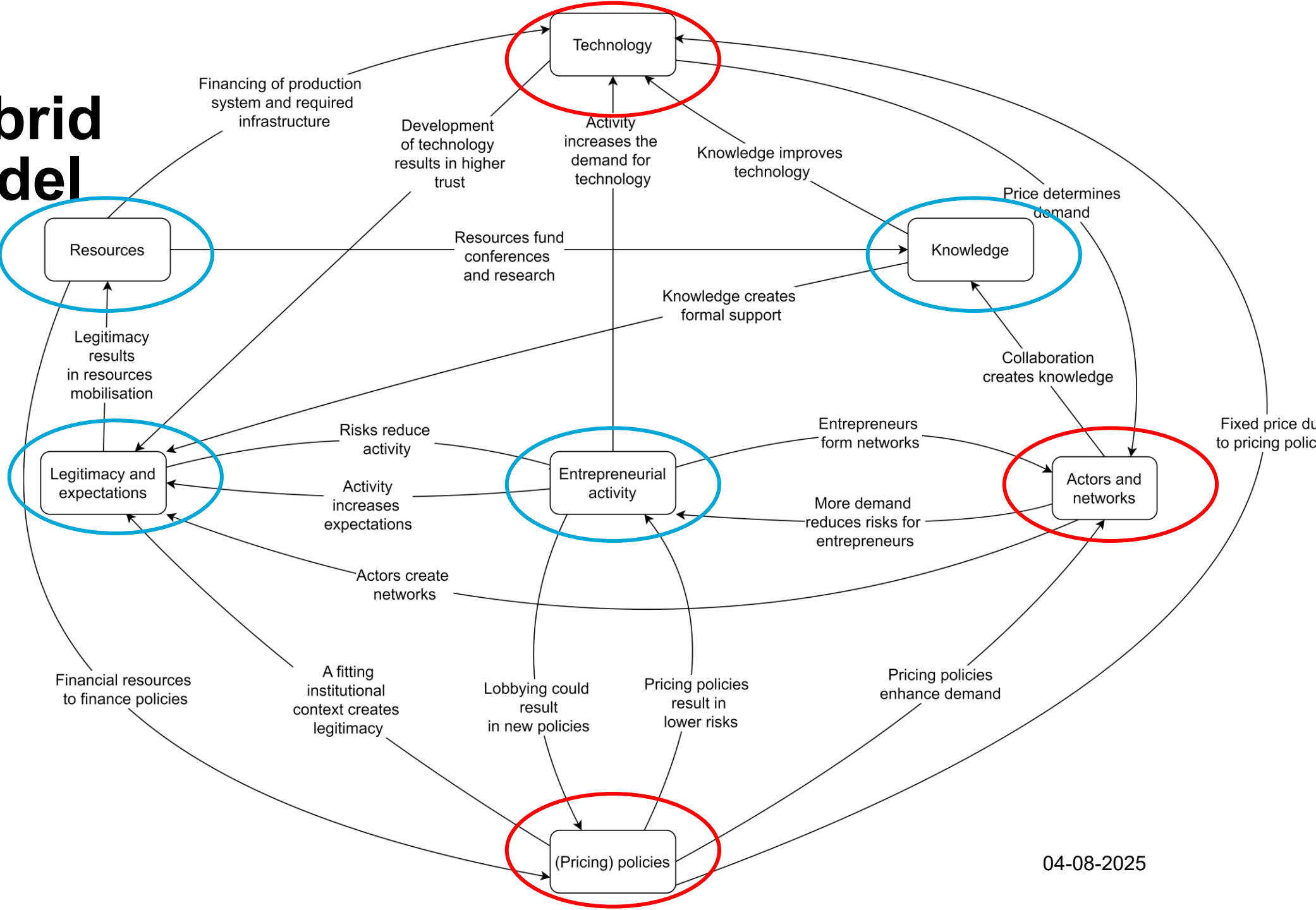
Functional approach

- Assessment of TIS over time

Methodology

- Conceptual connection TIS structures and TIS functions → Hybrid TIS model
  - Review of TIS literature
  - Starting point: Walrave & Raven (2016)
  - Stock Flow Diagram

The hybrid TIS model



Methodology

- Conceptual connection TIS structures and TIS functions → Hybrid TIS model
  - Review of TIS literature
  - Starting point: Walrave & Raven (2016)
  - Stock Flow Diagram
- Application of the hybrid TIS model
  - Case study: LandFill Gas to Energy (LFGE) projects in Africa
  - System Dynamics modelling

03

Application of the model: LFGE

Introduction to LFGE

- Waste to Energy technology
- Digestion of organic content → landfill gas (LFG)
- LFG collection → energy
- Benefits:
  - Reduced emissions
  - Improved power supply
  - Carbon credits

→ Uptake is low.

Barriers to LFGE uptake

Barrier	TIS element	Structural/functional
Viability of the project	Production system	Structural
Funding	Production system	Structural
Waste management	Complementary products and services	Structural
Access to electricity grid	Customers	Structural
Lack of regulations on LFG handling	Innovation-specific institutions	Structural
Public landownership	Entrepreneurial activity	Functional
Demand/availability of end users	Customers	Structural

04

SD modelling

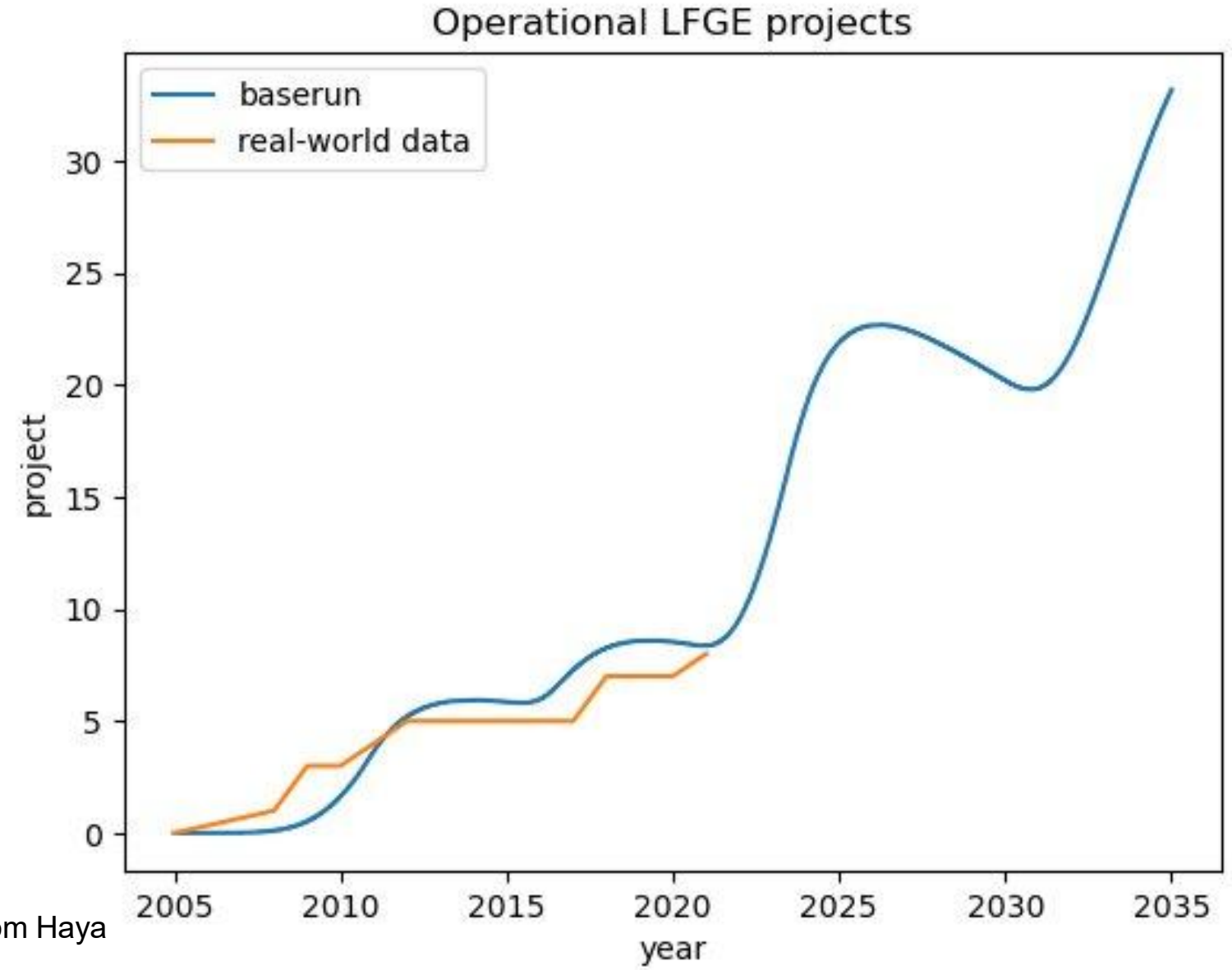
SD model

- Stocks:
  - TIS functions
  - TIS building blocks
- Empirical data:
  - Entrepreneurial activity → KPI
  - Economic and institutional components
- Other TIS components: S-curve

Model parameter	Value
Start year	2005
Duration	30 years
Timestep	0.005 years
Integration	Euler

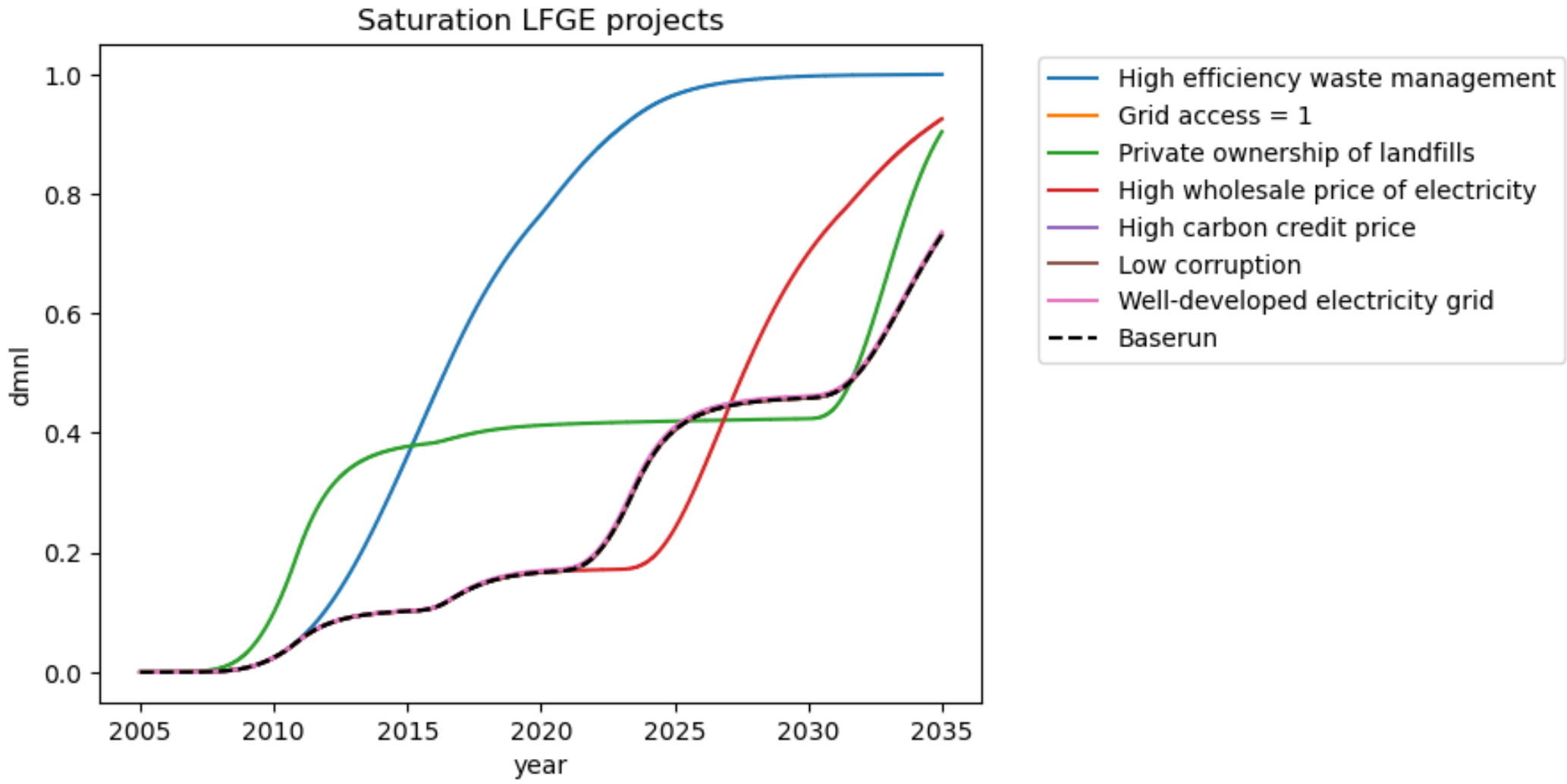
SD model - Validation

- Behavioural reproduction test

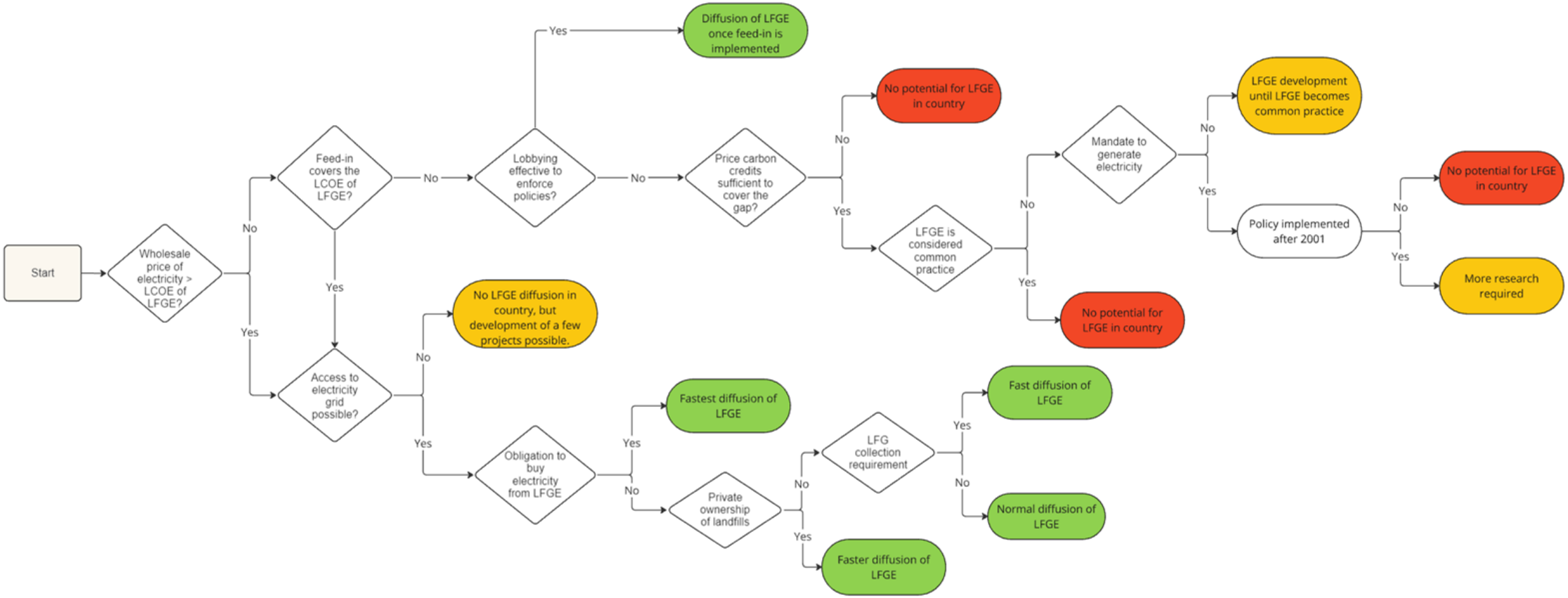


Real-world data collected from Haya et al. (2024)

SD model - results



SD model - results



05

Discussion and conclusion

Discussion

- Connection two approaches useful
  - Most barriers related to TIS structures
  - Relations found between TIS structures and TIS functions
- Model shows plausible results
  - Reproduction real-world data
- Allows for comparing barriers + assessing effect of policies

- Sensitivity to definition of TIS components
- Specific to developing countries

Limitations and future work

- Further test model
  - More case studies
- Extend the model
  - Include regime
  - Include outflows
  - Investigate different phases in TIS development

Conclusion

- Novel approach to investigate a TIS
- Assessing structural barriers over time

- Allows for policy testing
- Potential to contribute to effective resource allocation

Thank you!

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References

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