Implementation of circular economy in the built environment

Kaewunruen, Sakdirat; Baniotopoulos, Charalampos

European Cooperation in Science and Technology

UNIVERSITY OF BIRMINGHAM

CircularB

Implementation of Circular Economy in the Built Environment

Dr Sakdirat Kaewunruen and **Professor Charalampos Baniotopoulos**
School of Engineering, University of Birmingham

Sustainable Infrastructures Research Group

SUSTAINABLE DEVELOPMENT GOALS

Sustainable & smart materials	Lifecycle performance & forensics	Infrastructure engineering & resilience	Reliability and risks
AI and Data Sciences	Net Zero Energy Buildings	Noise and Vibration mitigations	Systems thinking for greener infrastructure

Research Team: 24 PhD students, 1 visiting scholars and over 20 MEng/MSc/BEng students

Dr Sakdirat Kaewunruen (Zac) E-mail: s.kaewunruen@bham.ac.uk
Lead – Sustainable Infrastructures Research Group

Online

COST Action CA21103

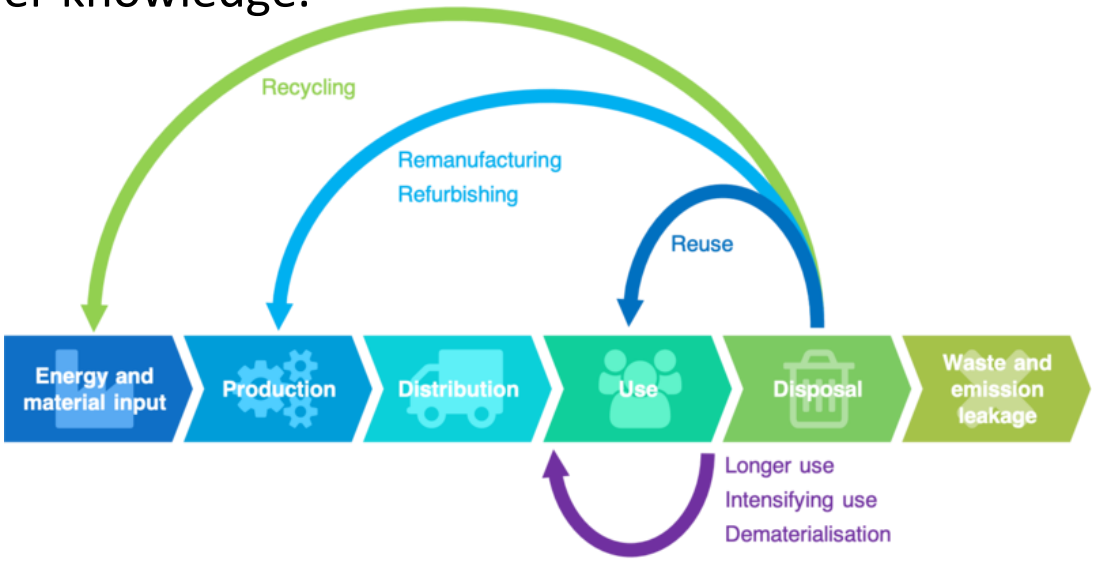
Implementation of Circular Economy in the Built Environment" (CircularB)

The main aim of the Action is to define the methodology to develop a common circularity framework for inclusive application and assessment in new and existing buildings to support decision-making for all value chain stakeholders and appraise the implementation level of the European Circular Economy Action Plan (ECEAP).

COST Action CA21103

Implementation of Circular Economy in the Built Environment" (CircularB)

- By developing a **benchmark database** – based on each country/region conditions, culture and traditions – the direct use of the tool is enabled, supporting both designers in developing more sustainable buildings and national/local governments in assessing and promoting their CE targets.
- **Construction, assembly, adaptability, deconstruction and business model guidelines** will be identified for new and existing buildings to enhance CE in buildings and promote stakeholder knowledge.
- The rating tool will also be integrated into the **Open BIM** workflow for better-informed design decisions, automated assessment, efficient value chain management, and circular feedback using central BIM models



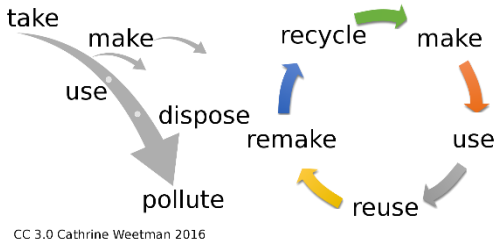
COST Action CA21103

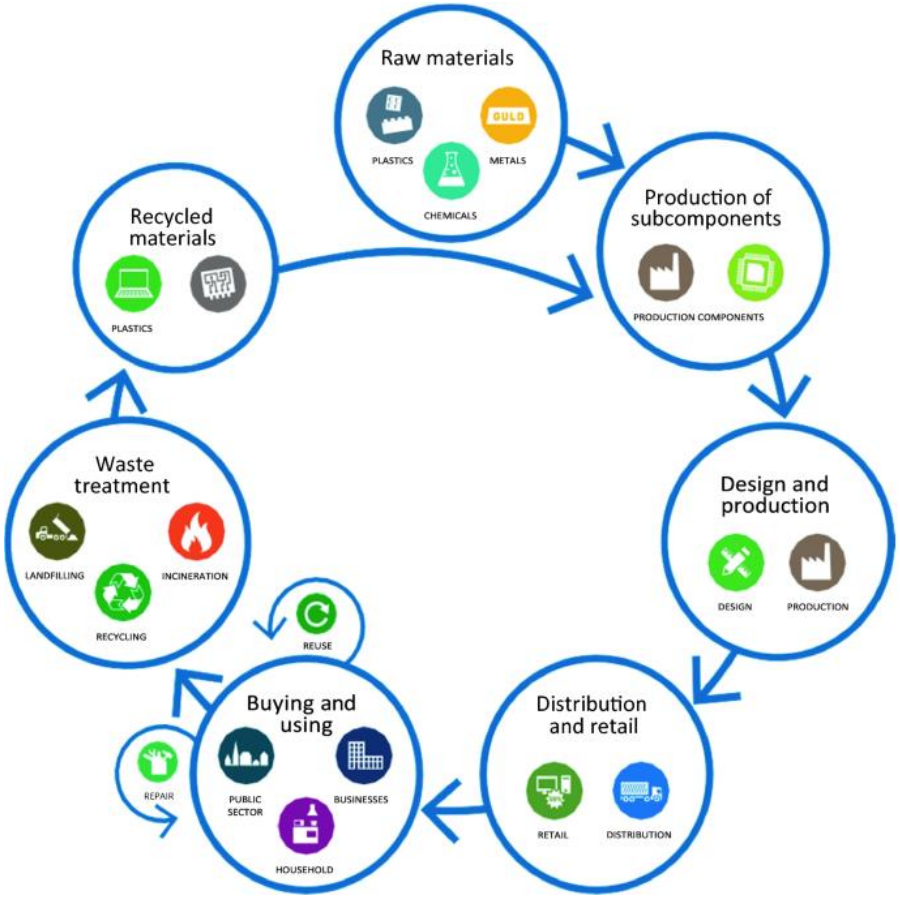
Implementation of Circular Economy in the Built Environment" (CircularB)

The action embraces inclusive and multi- & interdisciplinary approach

Areas of Expertise:

- Civil engineering: Sustainable engineering, adaptation to long-term environmental changes
- Civil engineering: Architecture engineering
- Other engineering and technologies: Sustainability for other engineering and technologies





https://www.cost.eu/actions/CA21103/

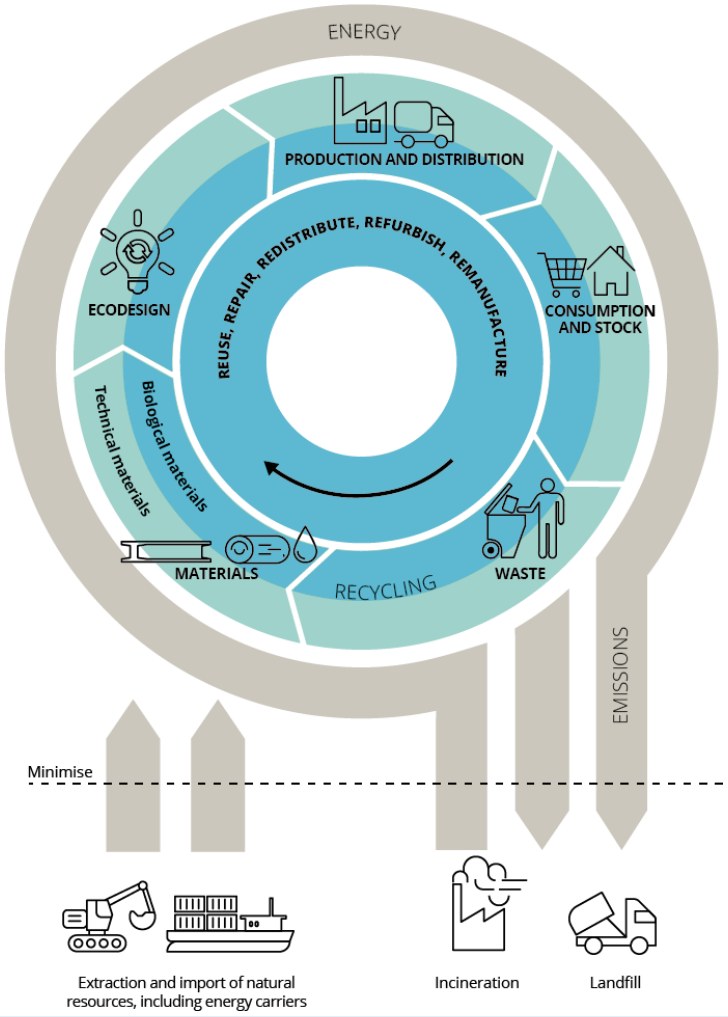
COST Action CA21103

Implementation of Circular Economy in the Built Environment" (CircularB)

CircularB COST Action involves 61 organisations from 28 different COST countries, including Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Finland, Germany, Greece, Ireland, Italy, Latvia, Malta, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

University of Birmingham is a UK hub. Please participate in various networking events to be sponsored by the Action.

https://www.cost.eu/actions/CA21103/



COST Action CA21103

Implementation of Circular Economy in the Built Environment" (CircularB)

CircularB COST Action brings together a network of stakeholders with a significant impact on different life cycle stages of buildings. Actors from multidisciplinary fields will be able to communicate to enhance circularity implementation in buildings constantly.

- **Academia** from different European universities with distinct expertise (Architecture, Construction Materials, Economics, Engineering, Management, Urban Planning, ...);
- **Research institutes** currently working on CE topics, as assessment methods, efficient management of CDW, materials recycling and reuse, and design strategies, among others;
- **Practitioners**, including building design offices, contractors, consultants, material producers and supplier companies, waste management companies, and international environmental consultancy...;
- **National and local authorities and policymakers**, including European municipalities;
- **National associations**, including building and construction institutes, material producer representatives, professional associations, civil society, NGOs, etc.

https://www.cost.eu/actions/CA21103/

COST Action CA21103

Implementation of Circular Economy in the Built Environment" (CircularB)

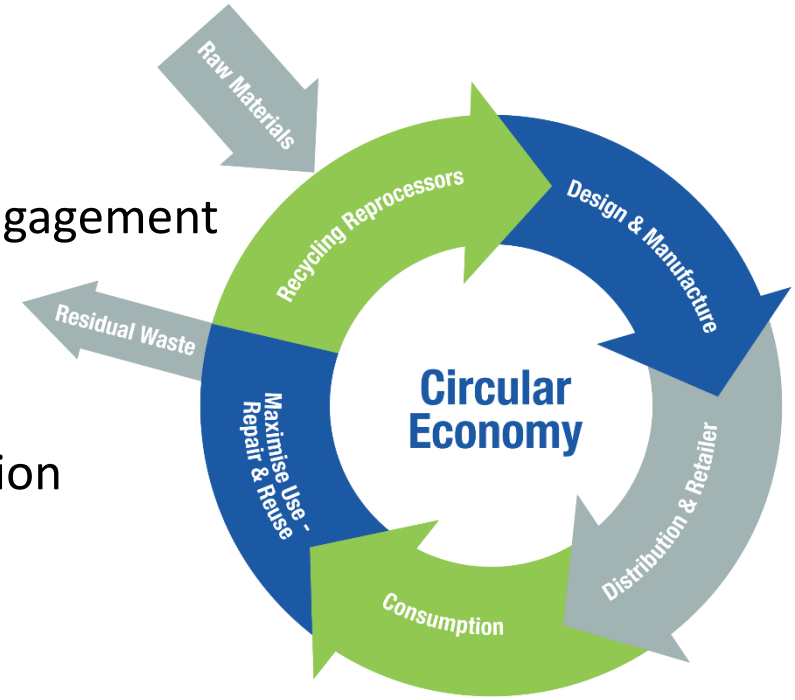
The CircularB COST Action aims at delivering a holistic approach to circular buildings including all technical, technological, social, legal, economic and environmental aspects. In order to cover all of the proposed aspects, the research will be divided into 4 WGs:

WG1: Circularity strategies and best practices

WG2: Circular value chain and stakeholder engagement

WG3: Circular KPIs framework

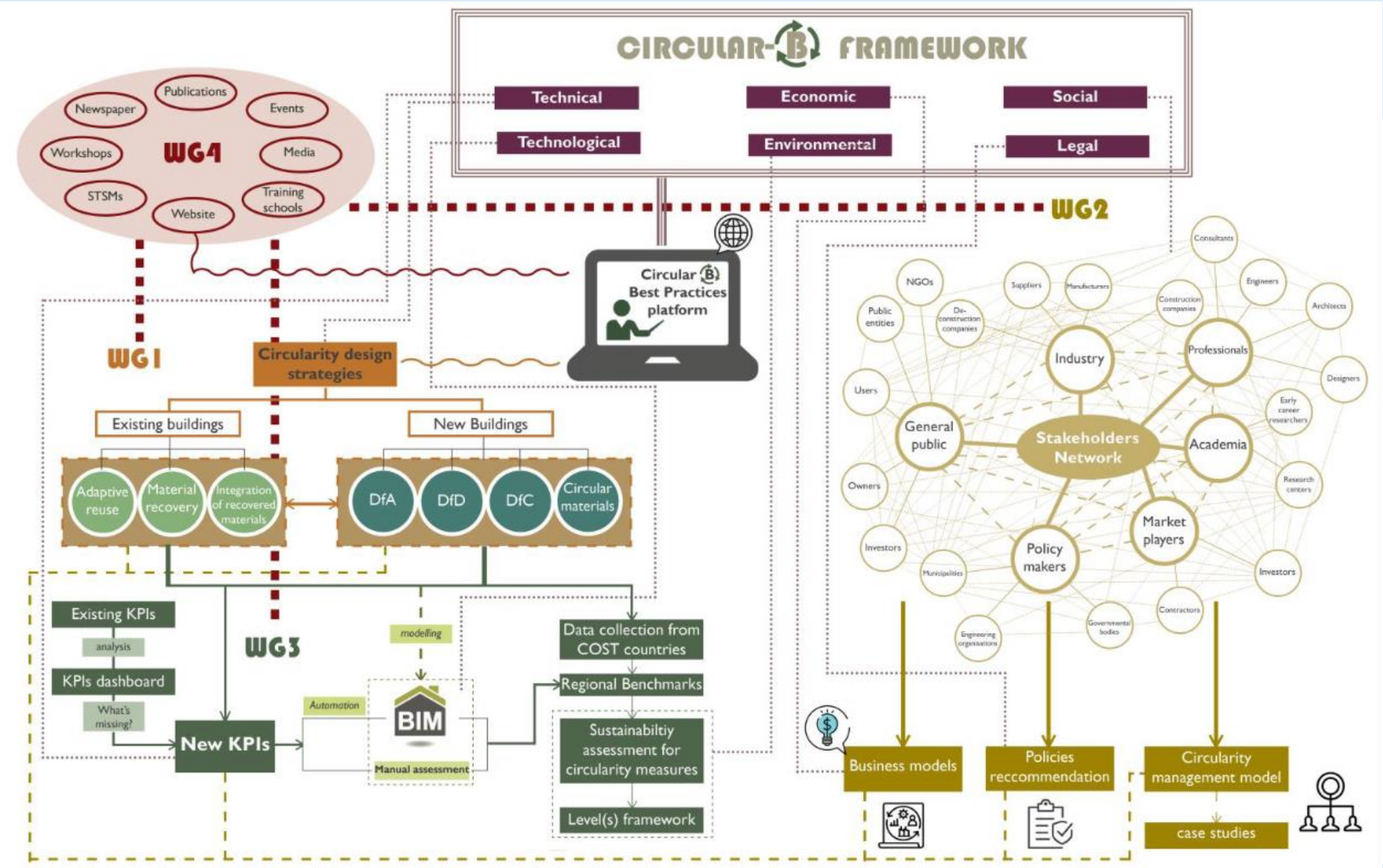
WG4: Dissemination and results communication



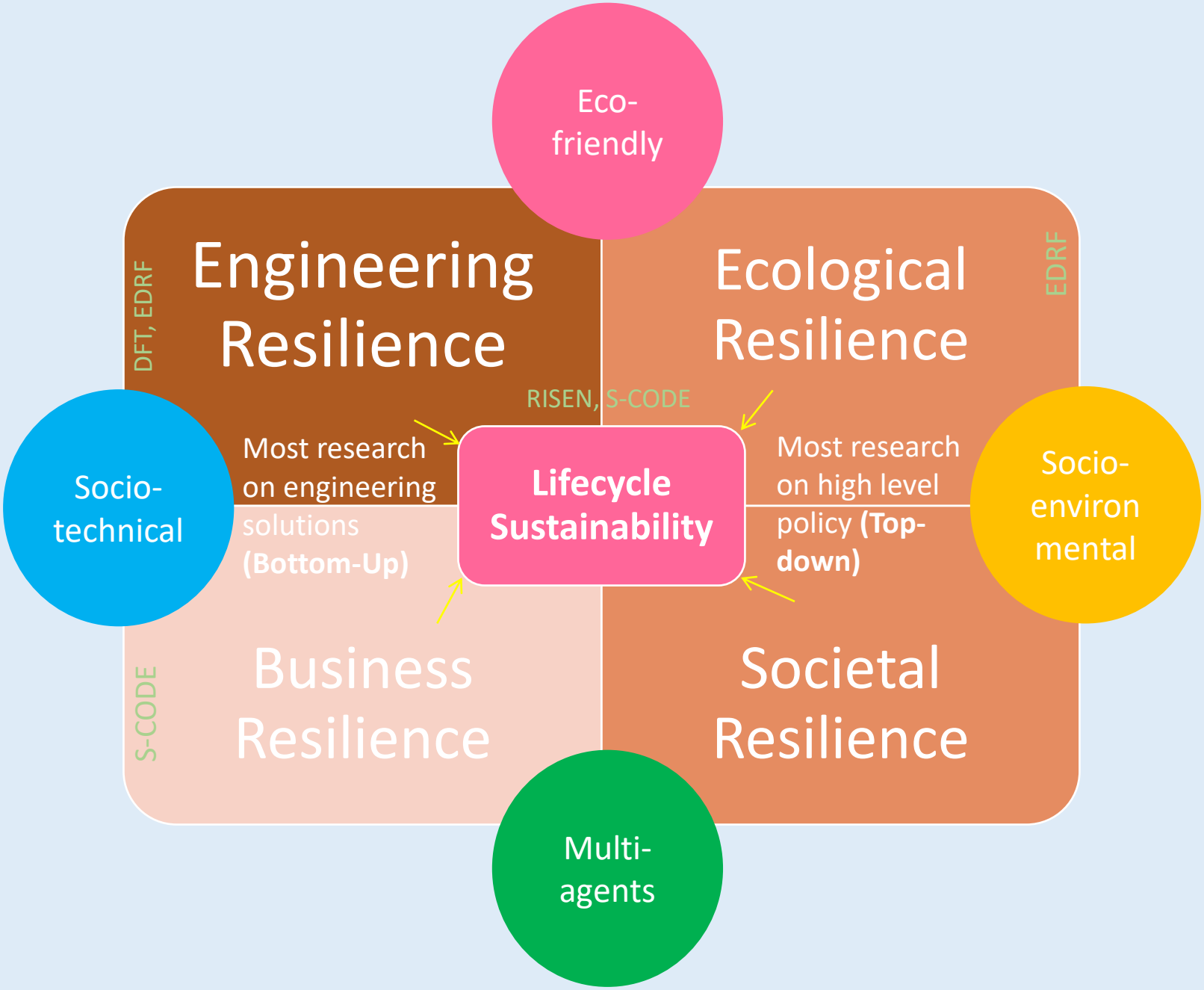
Start date - 27/10/2022 **End date** - 26/10/2026

https://www.cost.eu/actions/CA21103/

COST Action CA21103



Resilience Thinking

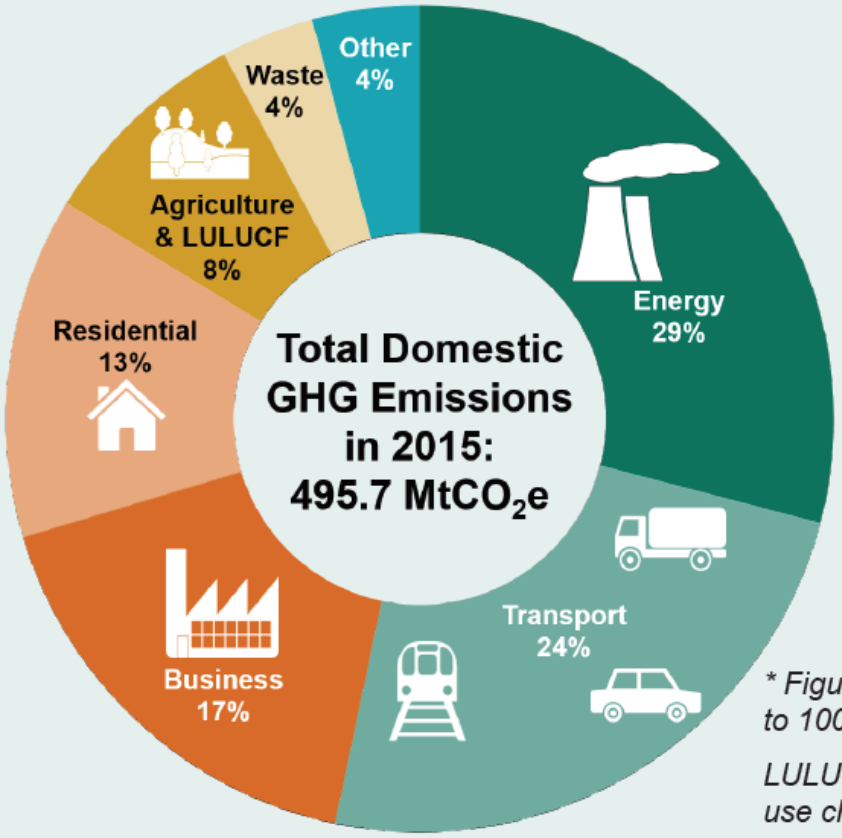


TRANSPORT

CO_2

UK greenhouse gas emissions

Domestic emissions from all sectors: 2015*



** Figures may not add up to 100% due to rounding.*

LULUCF - Land use, land use change and forestry.

495.7 million tonnes of CO_2 equivalent ($MtCO_2e$) is the total net domestic emissions from all sources.

24% of UK domestic greenhouse gas emissions were from transport, up from 15% in 1990.

93% of total domestic transport greenhouse gas emissions were from road transport.

TRANSPORT

CO_2

Kaewunruen et al. (2016) Frontiers in Transportation and Transit Systems; UIC (2016)

TRANSPORT

CO_2

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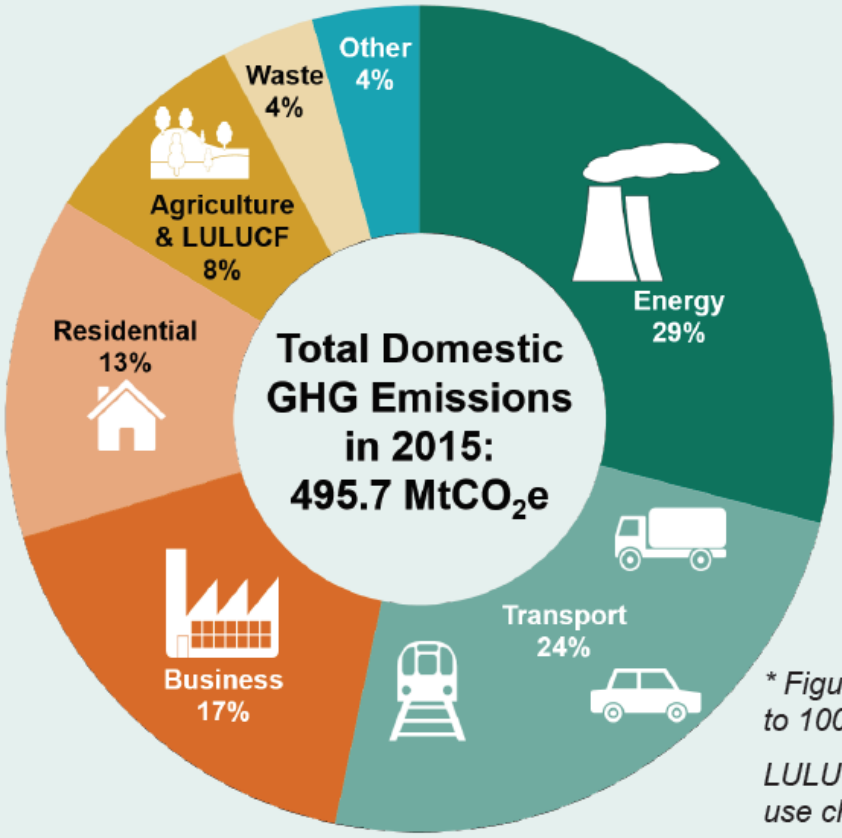

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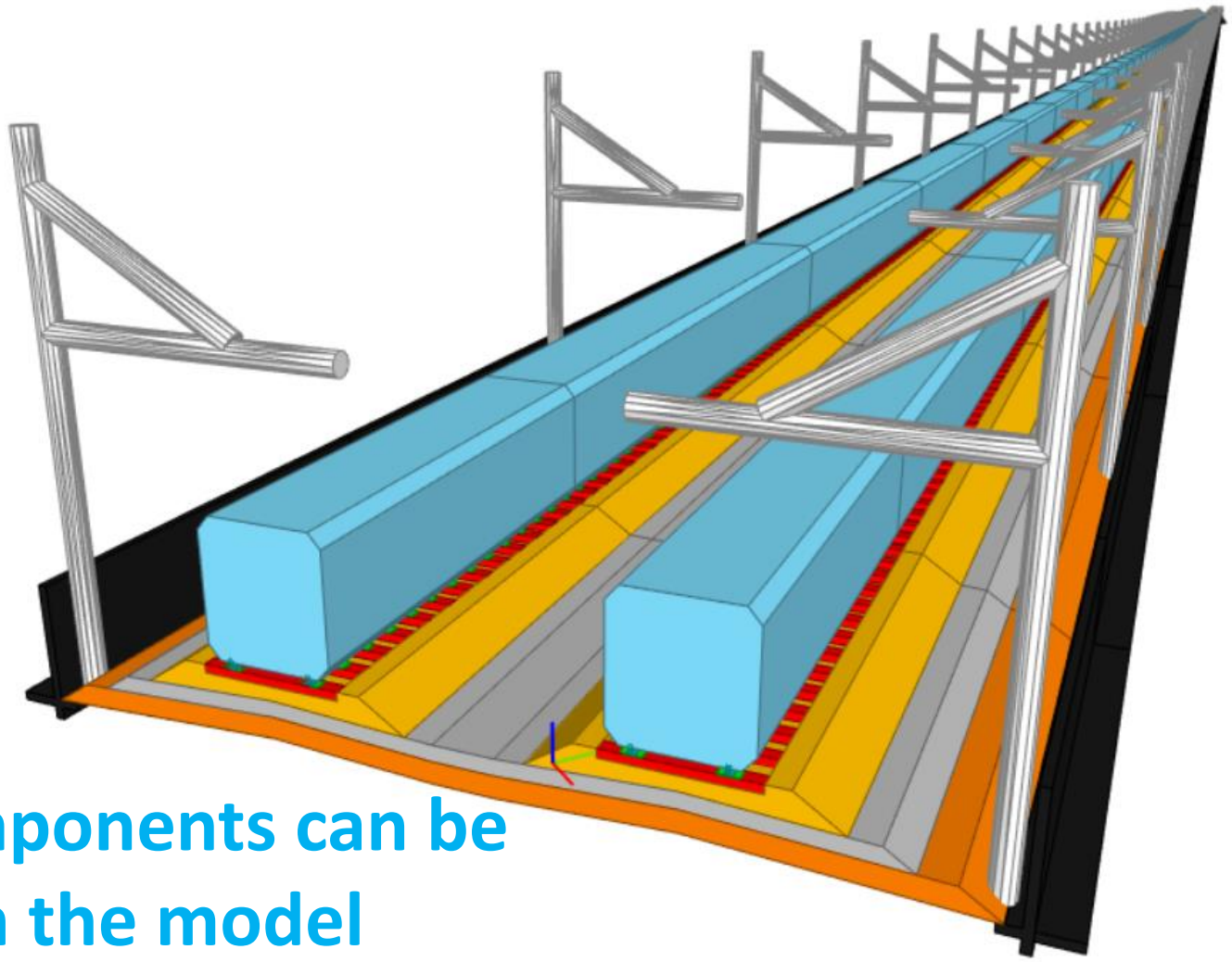
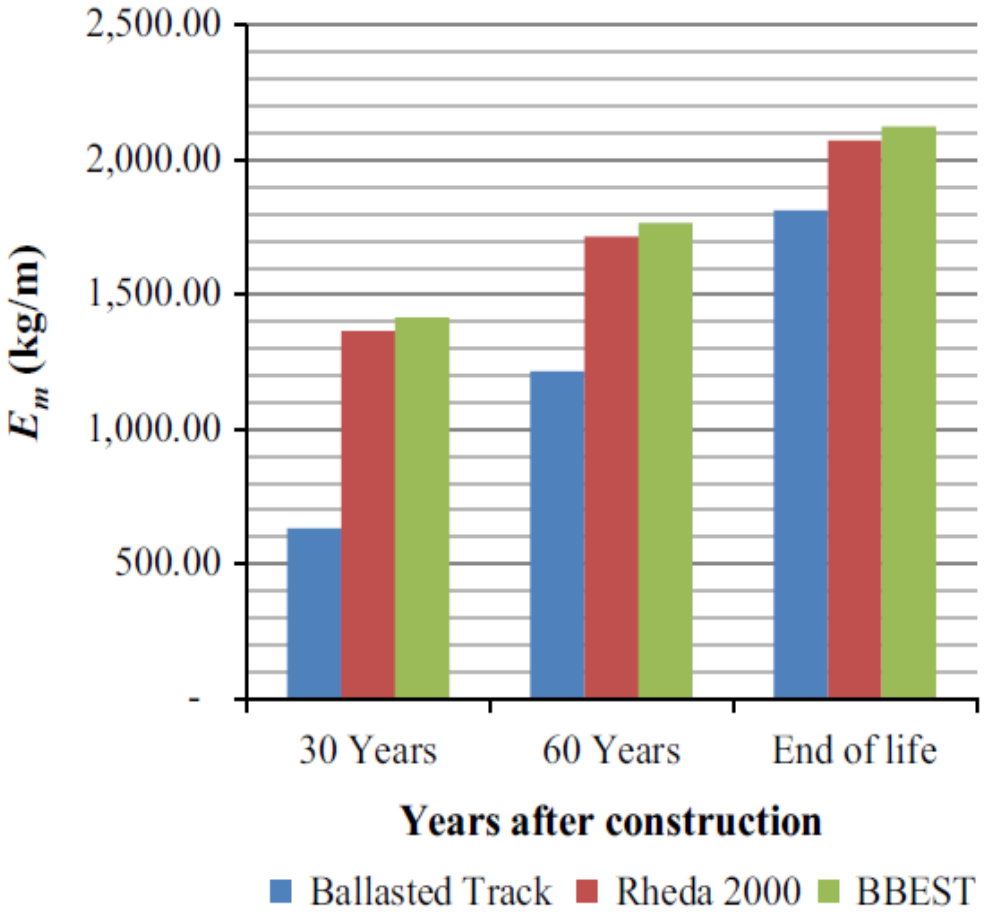
Digital Twins for Smart City



Any components can be added in the model

Kaewunruen et al. (2015) Frontiers in Environmental Sciences

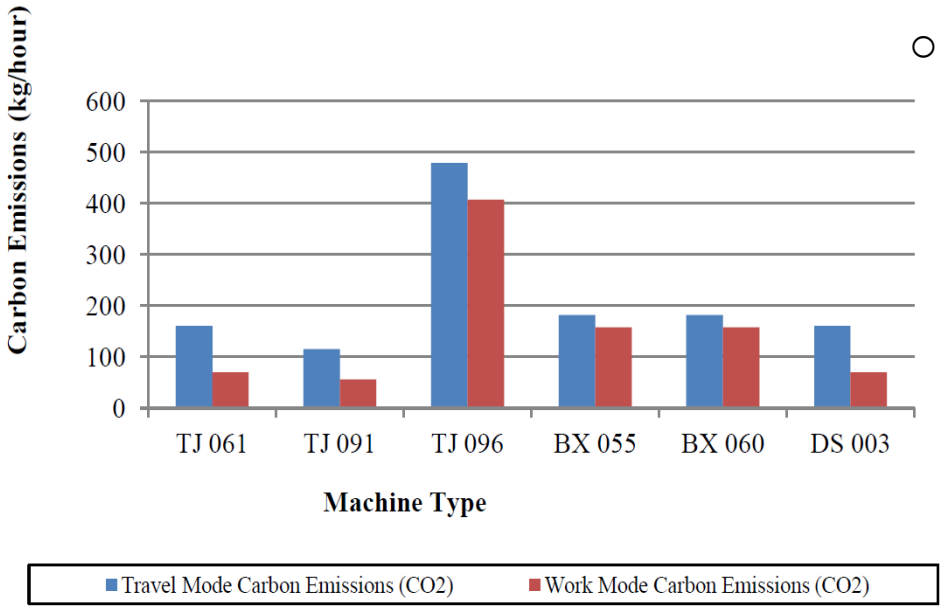
Systems-based strategy to achieve carbon-efficiency



- Extensive monitoring and measurements of railway construction management practices (>> 60 real projects) were rigorously conducted.
- Life cycle carbon emission from plain-line railway renewal activities are assessed.
- Field data suggests the carbon footprint due to ballasted track construction and maintenance is less than that of ballastless tracks over the lifespan.

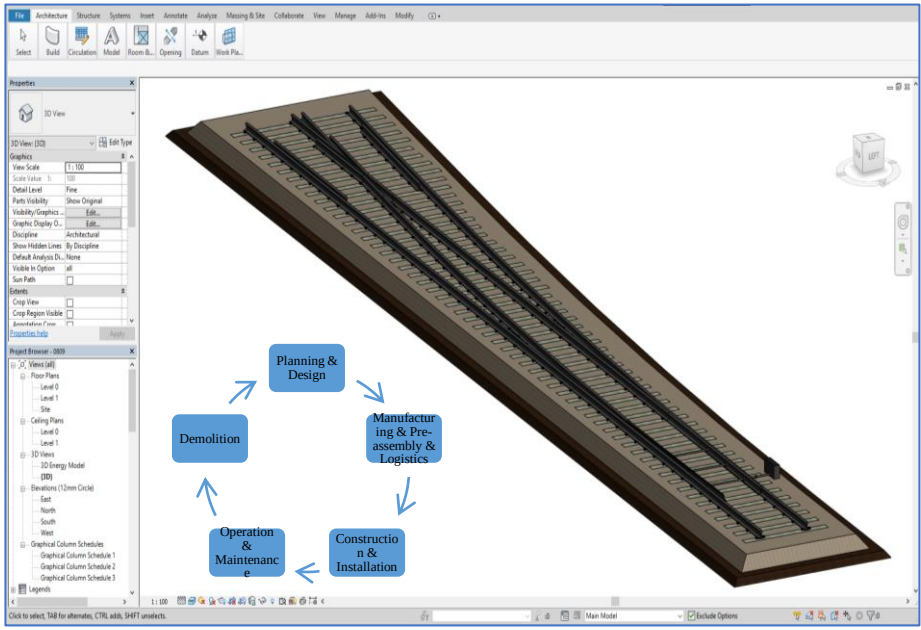
Krezo et al. (2016) Transportation Research Part D: Transport & Environment

Systems-based strategy to achieve carbon-efficiency



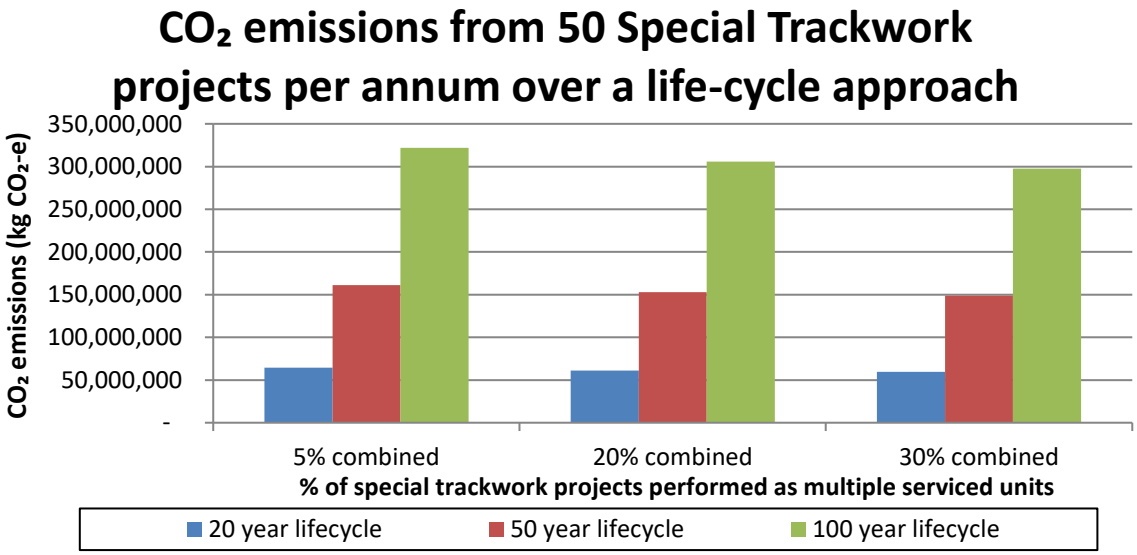
- By adopting the right combination of work equipment, carbon efficiency can be optimised through appropriate use of resurfacing machines (by using 6D BIM = 3D + Schedule + LCC + CO_2e).

- Resurfacing machine TJ061 and TJ091 (single head) are the most efficient tampers. It is found that although the dual head tamper (TJ096) is more productive, it is not carbon-efficient.

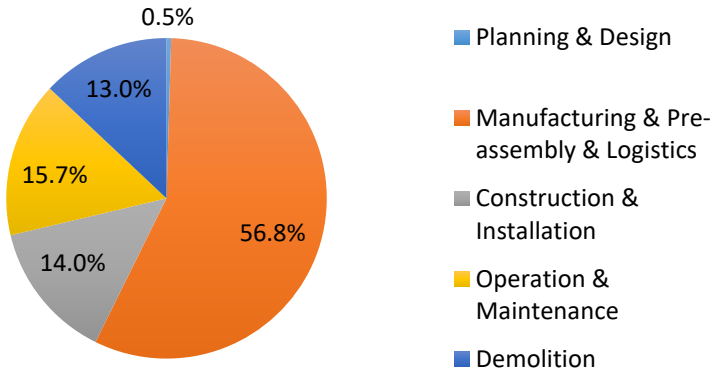


Kaewunruen and Liang (2019) Cleaner Production

Systems-based strategy to achieve carbon-efficiency



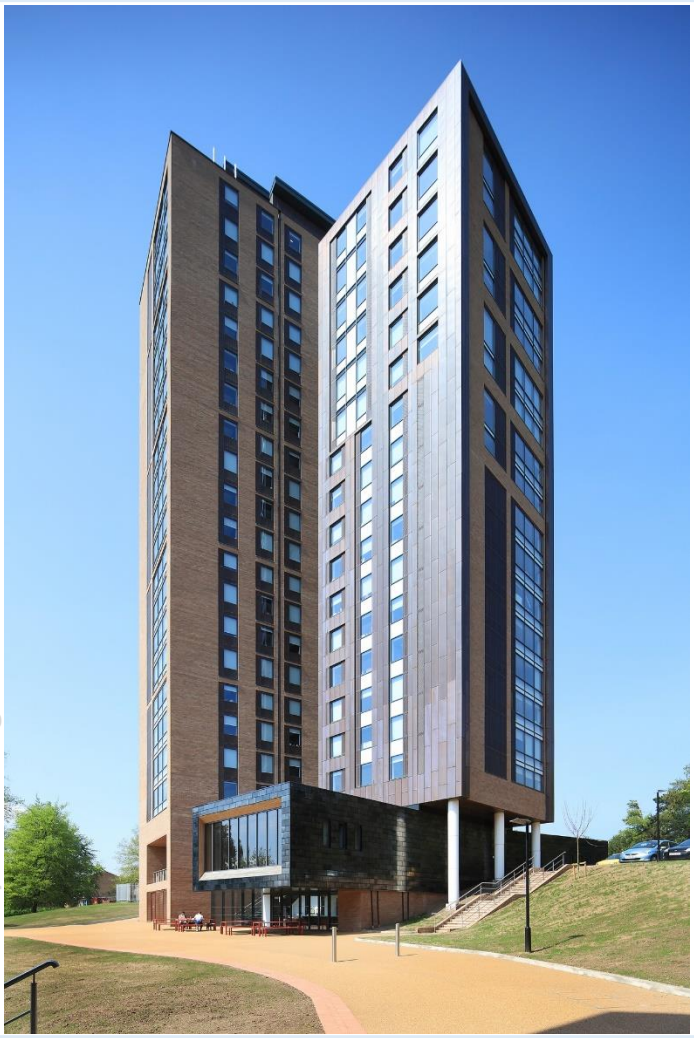
- Using **6D BIM** can significantly help opmitise lifecycle CO_2 emissions.



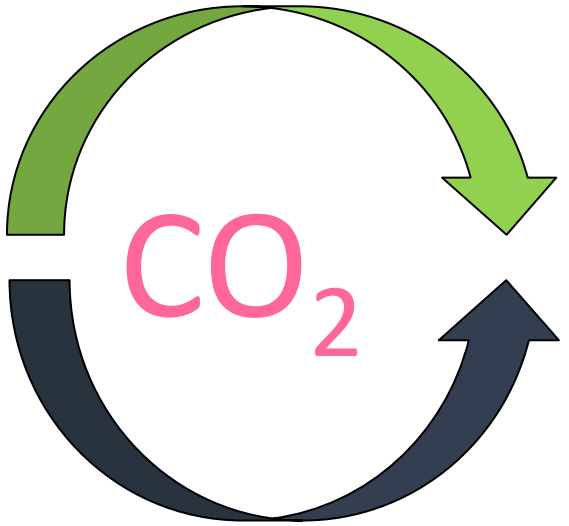
- The comparative results showed a 31% reduction in CO_2 emissions by using this parallel construction strategy and should be considered by construction and rail transport managers to help reduce CO_2 emissions from future special trackwork re-construction projects.

https://doi.org/10.3390/su12062436

Better **Energy Forecasts** to achieve **Net Zero** Energy Buildings



University of Birmingham 's Student Residence: Chamberlain Hall

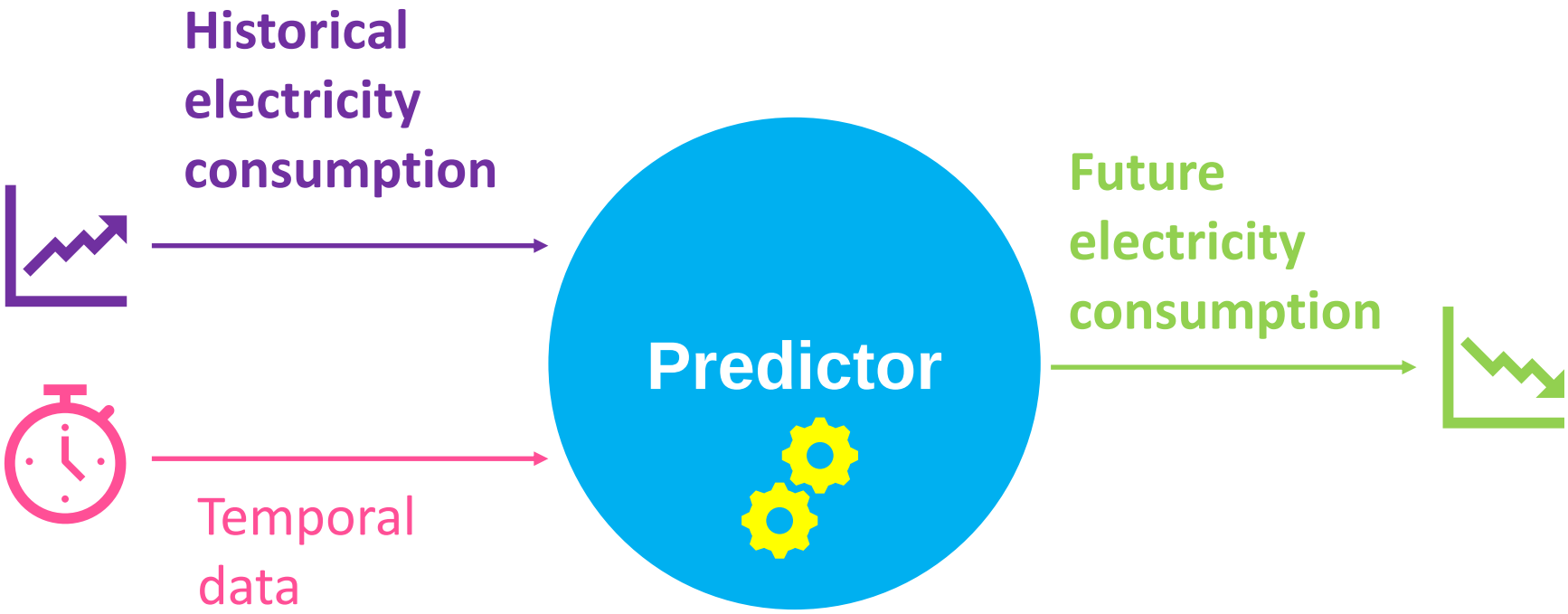


Develop a machine learning model forecasting electricity consumption to eliminate CO_2 in a public building

https://doi.org/10.3390/app12199788

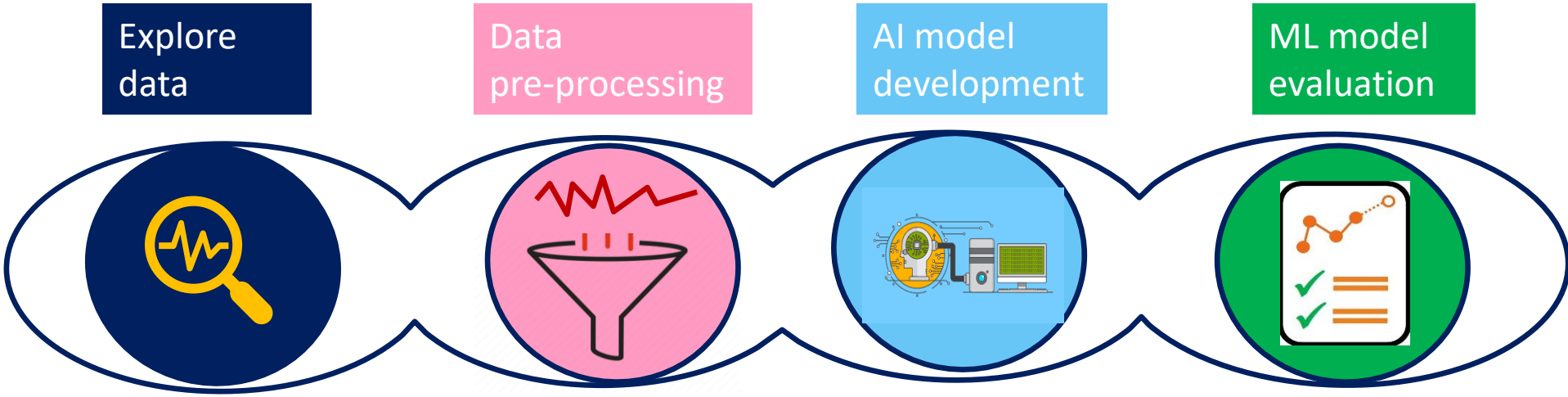
Better **Energy Forecasts** to achieve **Net Zero** Energy Buildings

Goal:



Better **Energy Forecasts** to achieve **Net Zero** Energy Buildings

Hierarchical approach



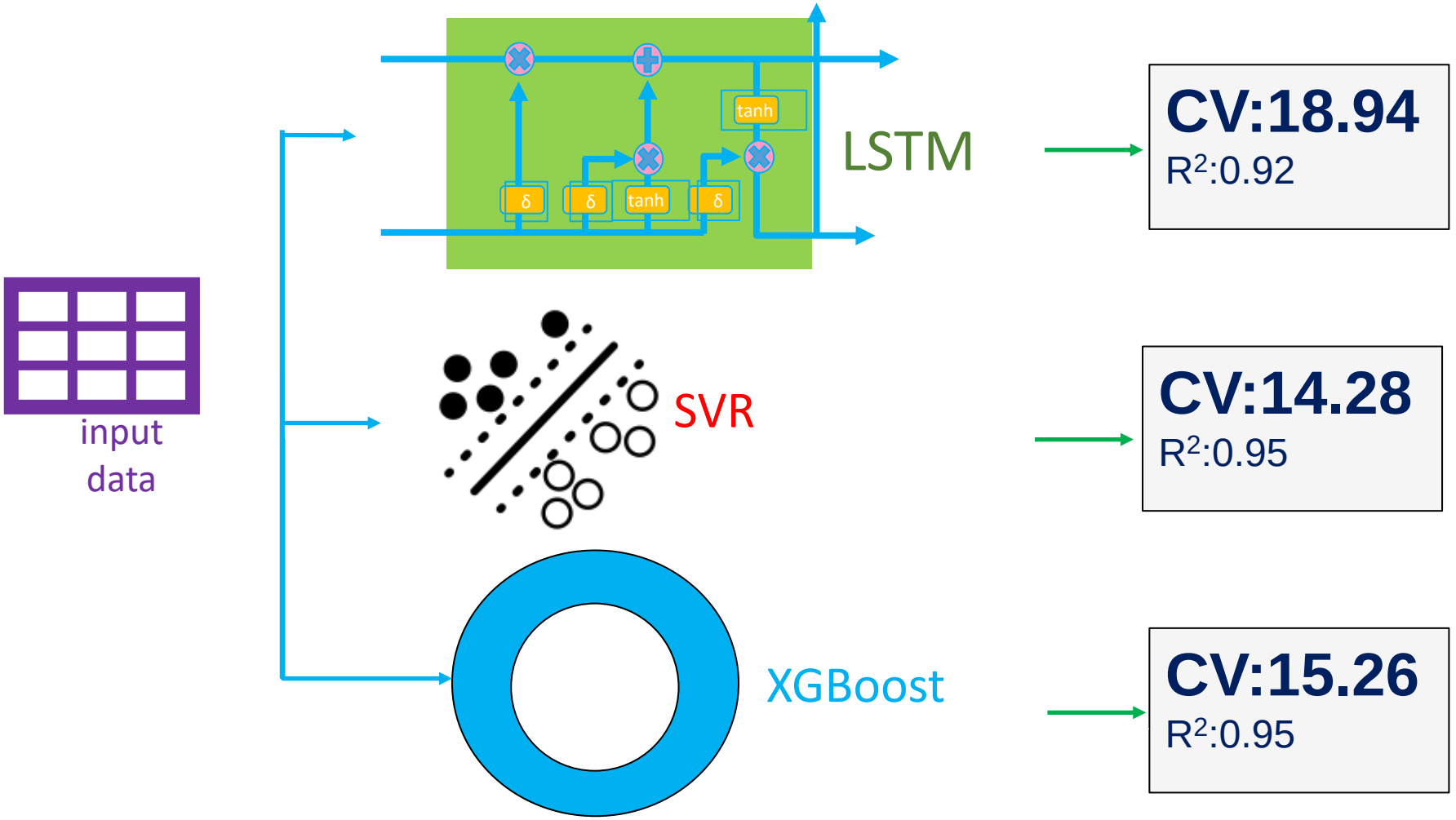
- Visualization
- decomposition

- Handling Outliers
- Transformation of temporal data
- Formatting data for AI models

- LSTM
- SVR
- XGBoost

- CV
- R^2

Better **Energy Forecasts** to achieve **Net Zero** Energy Buildings



Ideas to Impact

Our research is a part of

- **Action TU1404** TOWARDS THE NEXT GENERATION OF STANDARDS FOR SERVICE LIFE OF CEMENT-BASED MATERIALS AND STRUCTURES
- **Action CA15125** Designs for Noise Reducing Materials and Structures (DENORMS)
- **Action CA15202** Self-healing As preventative Repair of Concrete Structures (SACOS)

applied sciences

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Advances in Circular Economy in the Built Environments

Guest Editors

Dr. Sakdirat Kaewunruen, Dr. Yunlong Guo, Prof. Dr. Charalampos Baniotopoulos, Dr. Chayut Ngamkhanong

Deadline

31 March 2023

Special Issue

mdpi.com/si/140097

Invitation to submit

- **Action CA20109 Modular Energy Islands for Sustainability and Resilience (2021-2024)**
  www.modenerlands.eu
- **Vice-chair Prof C Baniotopoulos**

Ideas to Impact

Our research contributes to

- British Standard Committee (BSI) and Rail Safety and Standard Board Committee (RSSB) for Railway Sleepers and Bearers
- ISO Standard Working Group (269/1) for Plastic and Composite Sleepers
- ISO Standard Working Group (269/4) for Recycling of Rolling Stocks

Conclusions

Summary

- This presentation will highlight collaborative research into Big Data, Digital Twins, and AI applications for improving sustainability and carbon footprint in transportation and transit systems in urban environments.
- The collaborative research are aligned with United Nation's Sustainable Development Goals.
- With proven research insights and open data science, 6D BIM can be used to enhance sustainability in railway industry.

Thank you very much for your kind attention