

```
Blockchain {  
  chain: [  
    {  
      index: 1,  
      timestamp: 1668080936468,  
      transactions: [],  
      nonce: 0,  
      previousBlockHash: 'hash'  
    }  
  ]  
}
```

Integrating blockchain-based

Material Passports (BBMPs)

into practice for a circular

built environment.

A closer look at opportunities
and barriers.



abbreviations

AEC industry/sector	Architecture, engineering, and construction
CE	circular economy
MPs	Material Passports
DPPs	Digital Product Passports
BBMPs	blockchain-based Material Passports





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PROJEKT Mitten in Kreuzberg findet sich eine spannende Mischung aus ökologisch saniertem Bestand und modernen Neubauten nach höchsten energetischen Standards: [Die Macherei Berlin-Kreuzberg](#). ... mehr

Bauweise: Holz-Hybrid (M40), Konventionell (M50, M60)

BGF: 29.000m² (M40), 35.000m² (M50), 8.700m² (M60)

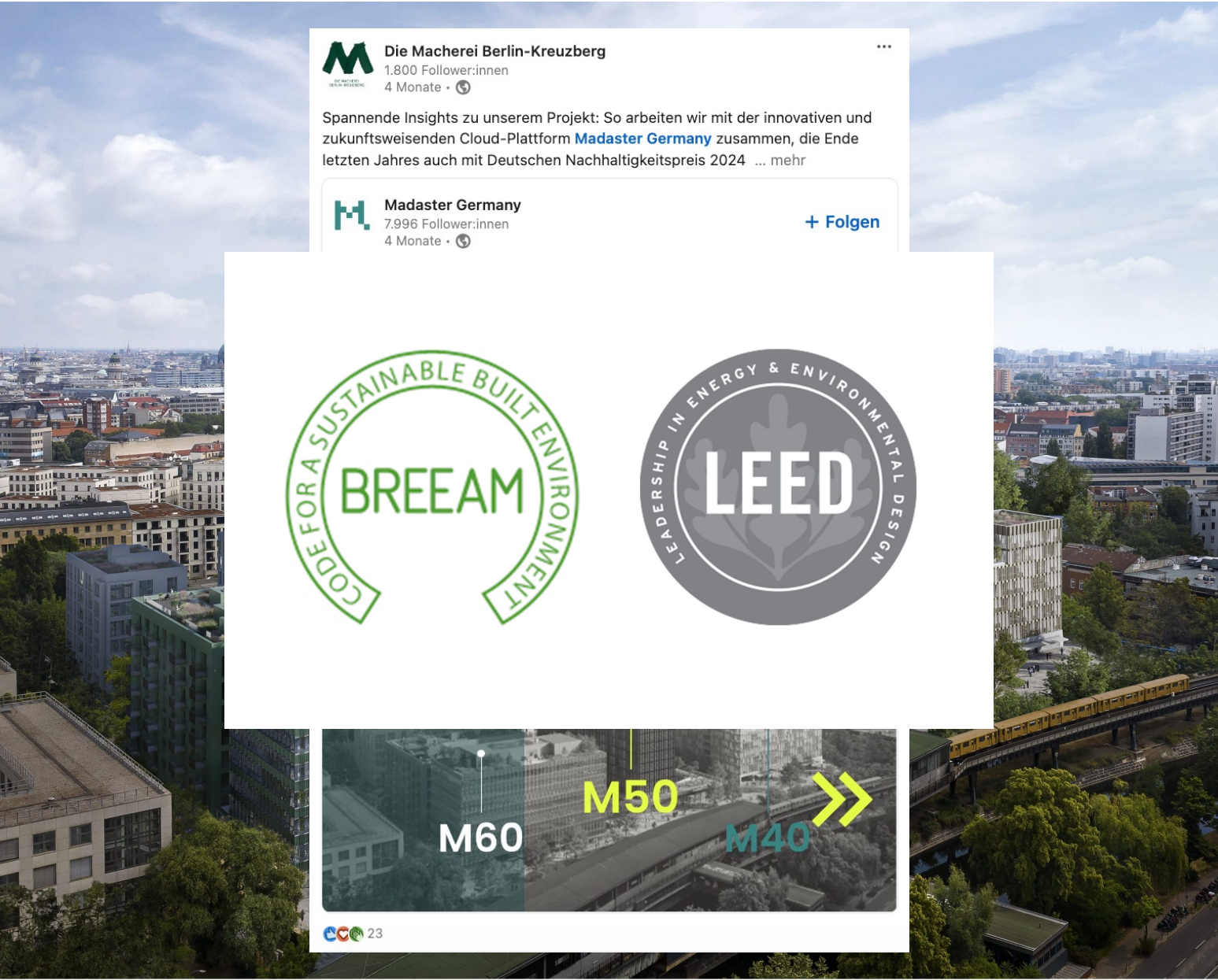
Projektart: Neubau (M40, M50), Bauen im Bestand (M60)

Nutzungsart: Büro, Einzelhandel, Gastronomie, Fitness

Aktive Partner: Art-Invest Real Estate, Eike Becker Architekten, Sauerbruch Hutton, ROBERTNEUN, KEC Planungsgesellschaft



👍❤️🌱 23



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S30E03 – BIM & Blockchain: a dip into the BUZZ

BOSScast

Welcome to a new episode of the BOSScast - the podcast where students and starters inspire with interesting stories from interesting guests for your future! After...

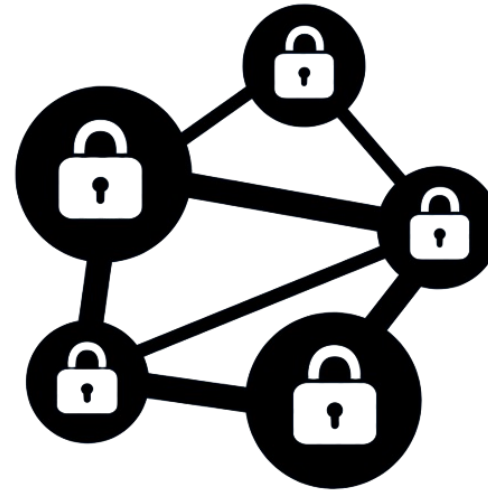


May 2023 · 7 min 28 sec left

MATERIAL PASSPORTS

+

BLOCKCHAIN TECHNOLOGY



2 concurrent transitions

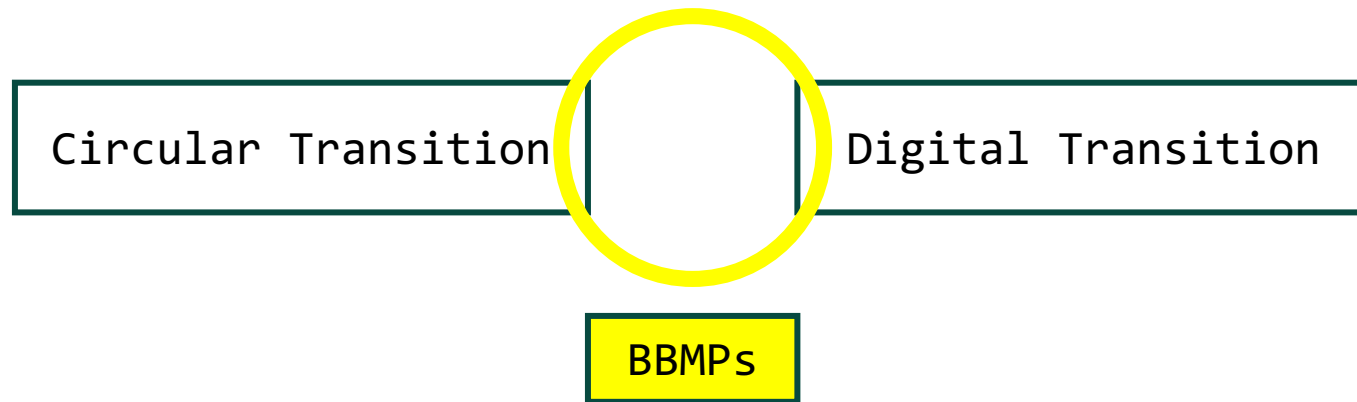
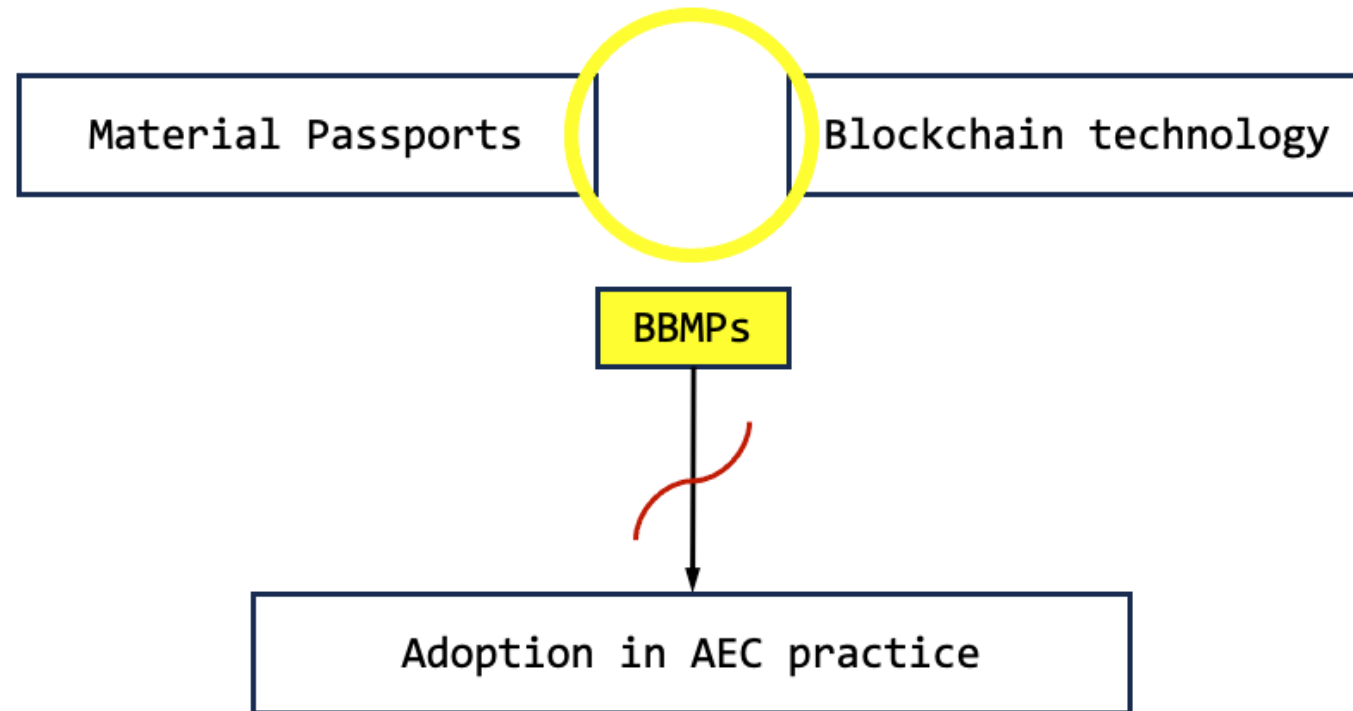


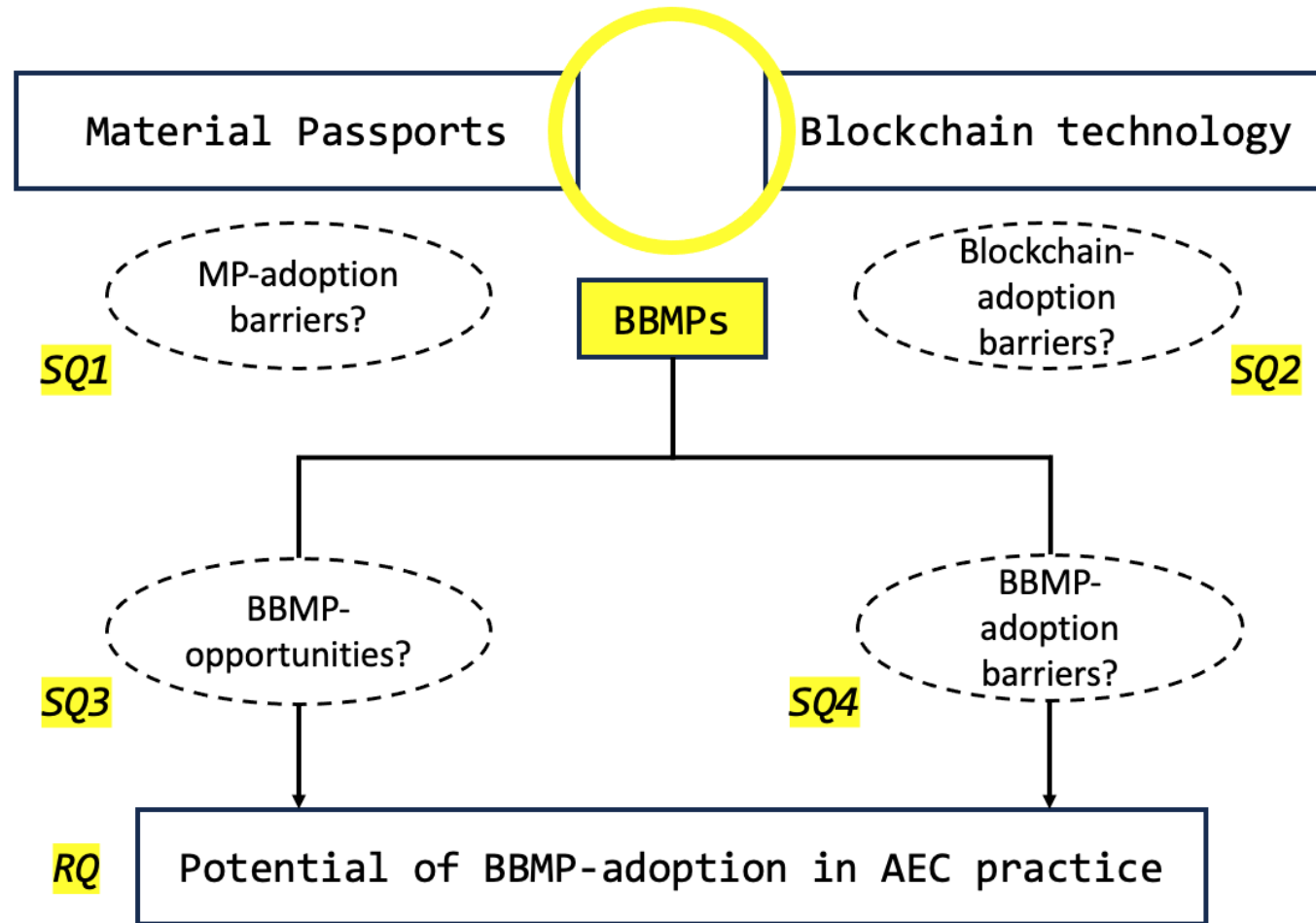
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- Introduction
- Methodology
- Findings
- Discussion
- Conclusion



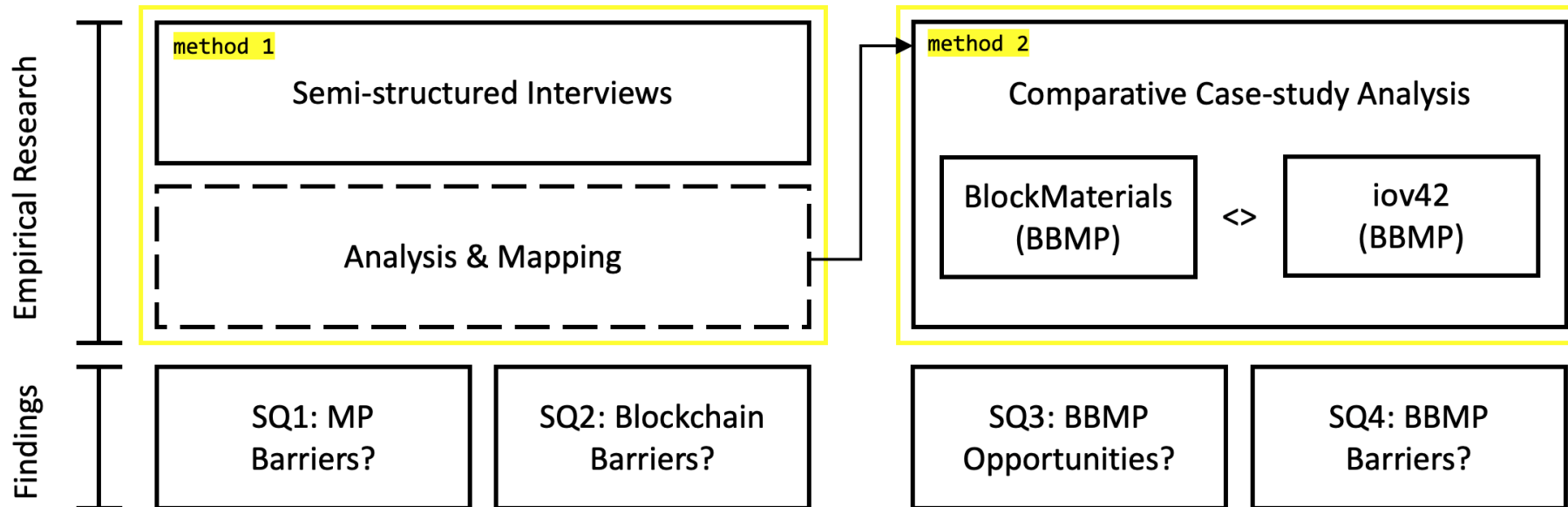
**GAP = adoption of BBMPs in practice
→ Opportunities? Barriers?**

What is the potential of integrating blockchain-based Material Passports (BBMPs) into practice?



methodology

- System of methods
- Assessment framework & coding



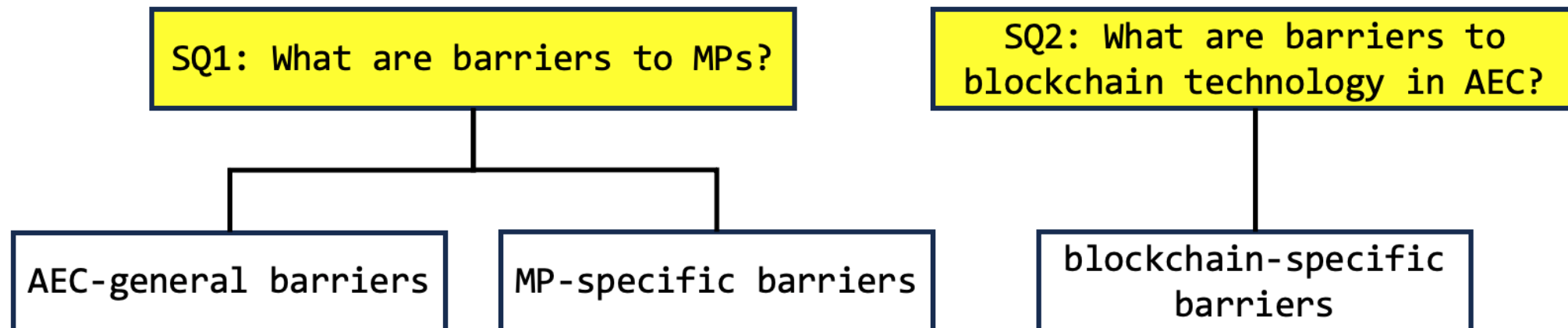
P	E	S	T	L	E
Political	Economical	Social	Technological	Legal	Environmental
Example: - Current tax policy - Brexit - Trade policies - Political stability - Government policy	Example: - Inflation rate - Exchange rates - Economic growth - Interest rates - Disposable income - Unemployment rate	Example: - Lifestyle attitudes - Cultural barriers - Population growth - Population age - Health consciousness - Target demographics	Example: - Level of innovation - Automation - Technological awareness - Cybersecurity - Technological change - Internet availability/speed	Example: - Employment laws - Discrimination laws - Health and safety - Copyright protection - Consumer safety	Example: - Weather - Climate change - Environmental policies - NGO pressure - Recycling - Pollution - Sustainability

method 1 - semi-structured interviews

- SQ1: What are barriers to Material Passports?
- SQ2: What are barriers to blockchain technology in AEC?

- Scope: 8 interviews

findings



findings

- SQ1: What are barriers to Material Passports?

AEC-general barriers

P Political	E Economical	S Social	T Technological	L Legal	E Environmental
<ul style="list-style-type: none"> - Adverse economic-political context 	<ul style="list-style-type: none"> - Chicken & egg problem - Industry fragmentation (AEC-industry) - Market-competitiveness (AEC-industry) 	<ul style="list-style-type: none"> - Change res (AEC-indus 	<ul style="list-style-type: none"> - Lack of digitalization & technology literacy 		

"...there's also ... the element of individuals that are saying "Oh, I don't know how to use technology!", but ... they use a smartphone everyday and we're not really asking you to do anything much more than what our smartphone can do."

(RI.1.R, 2024)

MP-specific barriers

P	E	S	T	L	E
Political	Economic	Social	Technological	Legal	Environmental
	<ul style="list-style-type: none"> - Lack of financial incentives (MPs) 		<ul style="list-style-type: none"> - Inadequate information provision (MPs) - Lack of knowledge (CE & MPs) - Technical practicalities (MPs) - Technology readiness (MPs) 	<ul style="list-style-type: none"> - Regulatory frameworks (MPs) 	

"So the biggest problem is you need to invest to get the right data and the right description."
(MP.1.D, 2024)

findings

- SQ2: What are barriers to blockchain technology in AEC?

blockchain-specific barriers

P	E	S	T	L	E
Political	Economical	Social	Technological	Legal	Environmental
		<ul style="list-style-type: none"> - Lack of trust & general scepticism (blockchain) 	<ul style="list-style-type: none"> - Lack of knowledge (blockchain) - Technical practicalities (blockchain) - Technology readiness (blockchain) 	<ul style="list-style-type: none"> - Regulatory frameworks (blockchain) 	<ul style="list-style-type: none"> - Environmental impact (blockchain)

"...there is this one ... big problem of data protection in personal data included in blockchain. ...it's very hard to get rid of personal data in blockchains and personal data in the European Union ... is super broad. So a unique identifier could already be a set of personal data." (LF.1.LA, 2024)

PESTLE	Barrier	Literature review	Semi-structured interviews	Quantity of mentioning (interviews)
Political	Adverse economic-political context		✓	5
Economical	Chicken & egg problem		✓	5
	Industry fragmentation (AEC-industry)	✓	✓	2
	Lack of financial incentives (MPs)	✓	✓	39
	Lack of financial incentives (blockchain)	✓		0
	Market-competitiveness (AEC-industry)	✓	✓	9
Social	Lack of trust & general scepticism (blockchain)	✓	✓	24
	Change resistance (AEC-industry)	✓	✓	21
Technological	Inadequate information provision (MPs)		✓	35
	Lack of knowledge (CE & MPs)		✓	15
	Lack of knowledge (blockchain)	✓	✓	16
	Lack of digitalization & technology literacy	✓	✓	4
	Technical practicalities (MPs)	✓	✓	25
	Technical practicalities (blockchain)	✓	✓	9
	Technology readiness (MPs)	✓	✓	20
	Technology readiness (blockchain)	✓	✓	16
Legal	Regulatory frameworks (MPs)	✓	✓	63
	Regulatory frameworks (blockchain)	✓	✓	9
Environmental	Environmental impact (blockchain)	✓	✓	1

method 2 – comp. case-study analysis

- SQ3: What opportunities do BBMP-providers see in applying blockchain technology to address MP-barriers?
- SQ4: What are challenges that current and early attempts at BBMPs face?
- Scope: 2 cases
 - + Case 1 – 3 interviews
 - + Case 2 – 2 interviews

_cases

method 2

Comparative Case-study Analysis

BlockMaterials
(BBMP)

<>

iov42
(BBMP)

_cases

	Case 1	Case 2
Name	BlockMaterials	iov42
Origin	Netherlands	England - UK
Core business	Research & applied research within CE in AEC	Software development, T&T
Employees	5-10	ca. 30
Passport solution	Blockchain-based Material Passport (BBMP), AEC only	Blockchain-based Digital Product Passport (BB-DPP), AEC-use cases
Scale	Building	Material/component
Operational scope	Netherlands	Global
BBMP target scope	Existing building stock (AEC)	New materials (AEC-use cases)
System design	Private permissioned	Private permissioned
DLT-design option	Public permissionless	Private permissioned
DLT-integration	Outsourced (ReCheck.io) - Ethereum	In-house development

GIRDAX

MATERIALENPASPOORT

Eigenaar (organisatie):

Datum + tijd paspoort generatie: 2023/05/26 15:08:14:200:002

Documentnummer: 2303060000021.001

Aangevraagd door: [REDACTED]

Appendix E

NLS/B	
(21.1)	h2

Materiaal	
Materiaal	Staal
Productcode	00581181
Categorie	Wanden
Materiaalgroep	Buitenwand, niet constructief
Kleur	Groen
Kwaliteit*	Redelijk
Demontage status*	Goed
Producthergebruik	Product hergebruik

findings

- SQ3: What opportunities do BBMP-providers see in applying blockchain technology to address MP-barriers?

BBMP-opportunities	Description	Case
Facilitating future contracts for material reuse	Awarding unique identities to materials through the adoption of BBMPs enables the transfer of ownership of a material before delivering the physical asset.	1
Material marketplaces	Online platforms facilitating the trade of registered secondary materials, similar to eBay.	1
Active material stock trade	Active trading of ownership rights to materials bound in buildings, making real estate investment accessible and generating additional cash flow through trading fees.	1
PaaS (Products-as-a-Service)	Facilitated through track-and-trace (T&T) based on BBMPs, manufacturers retain ownership of materials in buildings and lease them to the developer.	1
Full asset tracking throughout material life cycle	Track-and-trace (T&T) of assets along their supply chain with potential for full lifecycle tracking facilitated by fundamental properties of blockchain technology and Material Passport-integration.	2
Residual material value transparency	Registering building materials makes residual value transparent, lowering project financing costs for asset owners.	1
Premiums for product transparency	Manufacturers will charge market premiums for transparent material provenance data, compensating investments for data collection.	2
Life cycle assessment (LCA)	LCAs based on building inventory for regulatory compliance.	1
Regulatory compliance	Blockchain provides “single layer of truth” for reporting, making Material Passports auditable and facilitating regulatory compliance.	1, 2

BBMP-opportunities	Description	Case
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findings

- SQ4: What are challenges that current and early attempts at BBMPs face?

case 1 – BBMP-adoption barriers

P	E	S	T	L	E
Political	Economic	Social	Technological	Legal	Environmental
<ul style="list-style-type: none"> - Economic-political context 	<ul style="list-style-type: none"> - Chicken & egg problem - Incentives (BBMPs) 	<ul style="list-style-type: none"> - Lack of trust & general scepticism (blockchain) - Change resistance (AEC-industry) 	<ul style="list-style-type: none"> - Inadequate information provision (BBMPs) - Lack of knowledge (CE & MPs/blockchain) - Lack of digitalization & technology literacy - Technical practicalities (BBMPs) - Technology readiness (BBMPs) 	<ul style="list-style-type: none"> - Regulatory frameworks (BBMPs) 	
<p>"...it's called the innovation death. You have to do investments in order to get into the world, but the ecosystem doesn't provide the flow in materials or the flow in money to get your investment running." (01_BM, 2024)</p>					

case 2 – BBMP-adoption barriers

P	E	S	T	L	E
Political	Economical	Social		Legal	Environmental
<ul style="list-style-type: none"> - Economic-political context 	<ul style="list-style-type: none"> - Lack of financial incentives (BBMPs) 	<ul style="list-style-type: none"> - Lack of trust general scene (blockchain) - Change resistance (AEC-industry) 	<ul style="list-style-type: none"> - Inadequate information provision (BBMPs) <ul style="list-style-type: none"> (CE & MPs/ blockchain) - Lack of digitalization & technology literacy - Technical practicalities (BBMPs) - Technology readiness (BBMPs) 	<ul style="list-style-type: none"> - Regulatory networks (BBMPs) <p>"But you realise that humans make mistakes on a daily basis. So you always have to have some kind of a mechanism that still allows you to say that, yes, a mistake has been fixed." (02_iov42, 2024)</p>	<ul style="list-style-type: none"> - Environmental impact (blockchain)

PESTLE	Barrier	Case 1 – Block-Materials	Case 2 – iov42
Political	Adverse economic-political context	✓	✓
Economical	Chicken & egg problem	✓	
	Industry fragmentation (AEC-industry)		
	Lack of financial incentives (BBMPs)	✓	✓
	Market-competitiveness (AEC-industry)		
Social	Lack of trust & general scepticism (blockchain)	✓	✓
	Change resistance (AEC-industry)	✓	✓
Technological	Inadequate information provision (BBMPs)	✓	✓
	Lack of knowledge (CE & MPs/ blockchain)	✓	✓
	Lack of digitalization & technology literacy	✓	✓
	Technical practicalities (BBMPs)	✓	✓
	Technology readiness (BBMPs)	✓	✓
Legal	Regulatory frameworks (BBMPs)	✓	✓
Environmental	Environmental impact (blockchain)		✓

discussion

- Stalemate-situation
- Secondary Material Marketplaces
- Active Material Stock Trade (“Fluid Asset” Trading)
- Platform-lock in
- Data accuracy
- Clash of paradigms

“fluid asset” trading

- Quasi-“long position” on materials → great idea!
- But:
 - + In case of disassembly: sell their ownership to the handler of physical asset? Or lose money?
 - + Share of rental income? + PaaS?

platform-lock in

- MP-providers keep MPs behind paywalls or for asset owners only
 - platform-lock in of CE-relevant information

clash of paradigms

- Blockchain = by design decentralized technology
- Current socio-economic paradigm = centralized

→ fundamental barrier to BBMP-adoption!

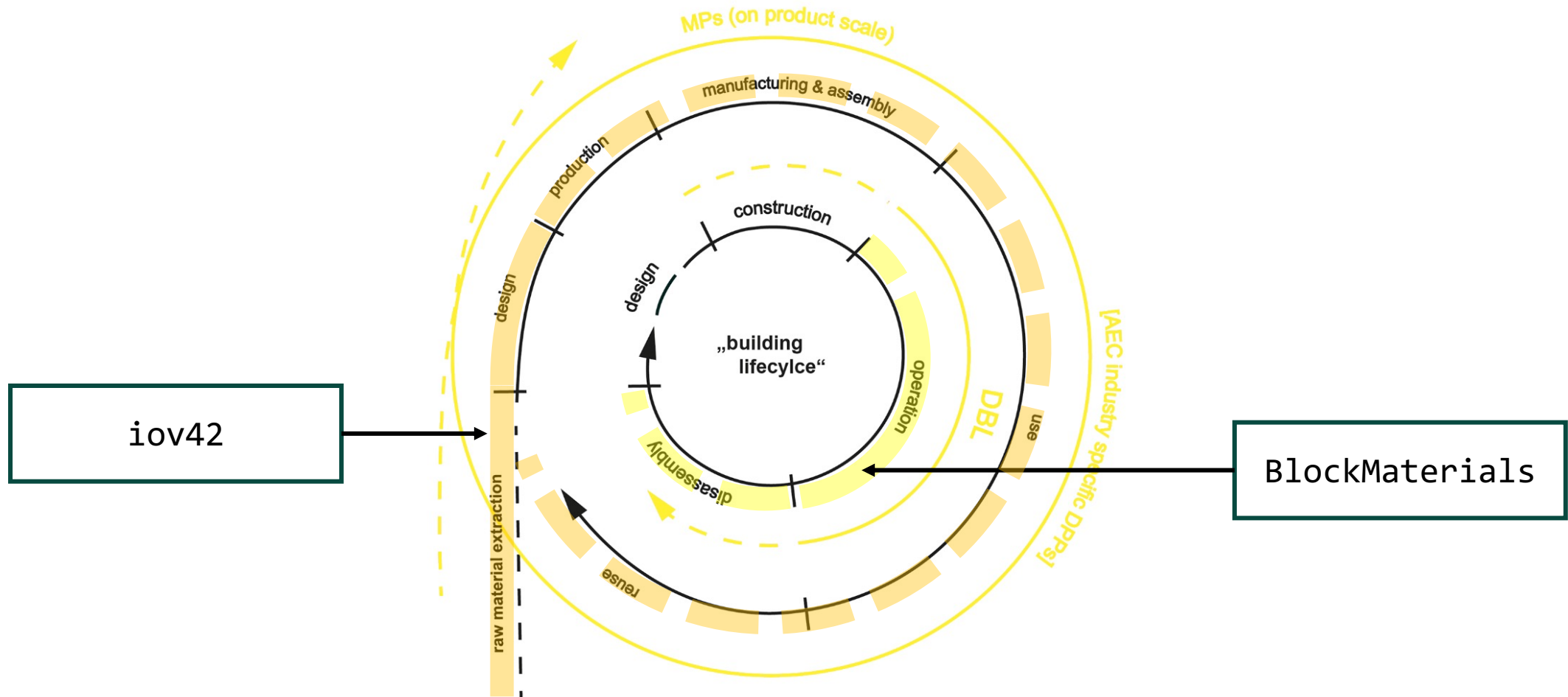
conclusion

- RQ: What is the potential for integrating blockchain-based Material Passports (BBMPs) into practice?

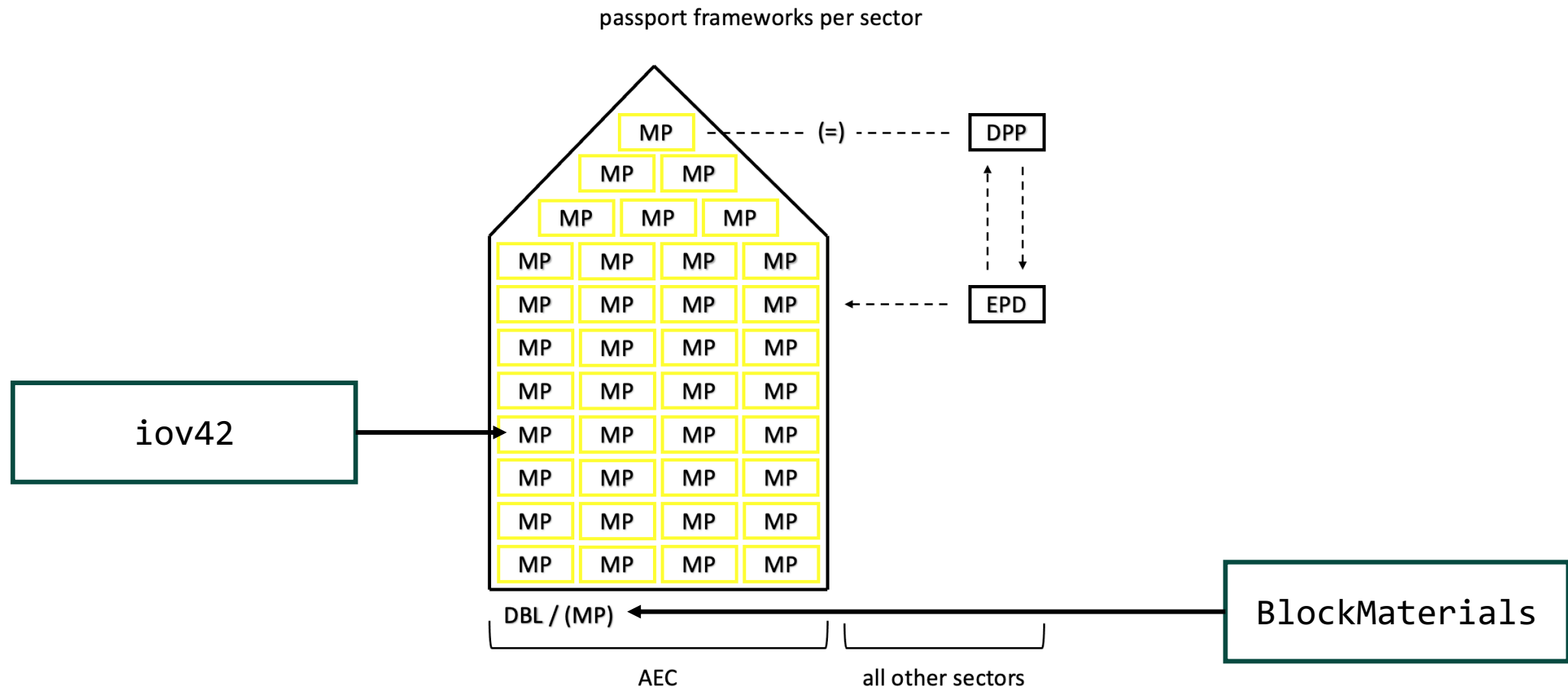
recommendations for future research

- Larger sample, broader sample
- Re-examine topic when higher adoption levels
- Exploration of potential enablers for BBMP-adoption
- Integration of..
 - + BBMPs + secondary material marketplaces (+ BIM)
 - + BBMPs + various T&T (+BIM)
 - + BBMPs + active material stock trading platform
 - + Multiple passport instruments

_case comparison



_case comparison



PESTLE	BBMP-adoption barrier
Political	Adverse economic-political context
Economical	Chicken & egg problem
	Industry fragmentation (AEC-industry)
	Lack of financial incentives (BBMPs)
	Market-competitiveness (AEC-industry)
Social	Lack of trust & general scepticism (blockchain)
	Change resistance (AEC-industry)
Technological	Inadequate information provision (BBMPs)
	Lack of knowledge (CE & MPs/ blockchain)
	Lack of digitalization & technology literacy
	Technical practicalities (BBMPs)
	Technology readiness (BBMPs)
Legal	Regulatory frameworks (BBMPs)
Environmental	Environmental impact (blockchain)

contributions to academia & practice

- Academia: starting point for further research
 - + Synthesis of existing knowledge (MPs & AEC, blockchain for AEC, AEC-adoption issues)
 - + Case-study analysis of early attempts at BBMPs
 - + Identification of research gaps (BBMP-opportunities & barriers)
- Practice: inform future decision making
- Regulators: understanding of implications of current regulation on BBMP-adoption
- Developers: scout solutions for digital & circular transition
- Investors: realize economic potential of digital & circular transition

limitations & recommendations

Limitation	Measure	Aim	Recommendation
Limited reproducibility of case studies & subjectiveness of researcher	Standardized approach to expert & case-study interviews	Uniformity in data collection	-
	Several iteration rounds in coding process	Improve consistency of data analysis	-
Limited sample size & generalizability (literature/ interviews)	Structured approach to selection of relevant literature, followed by snowballing	Optimize quality & depth of data	Larger scope & wider sample size
	Timely research design planning & interview scheduling + semi-structured interview format		
Researcher's prejudice (data collection) + limited experience in conducting research	Interview planning + format	Reduce subjectivity & let interviewee elaborate	-
Limited number of cases + varying quality	Maximum quantity of cases exhausted	Optimize quality & depth of data	Wait for higher adoption levels
Quantity ≠ quality (no validation/prioritization of findings)	No prioritization of findings	No prioritization	Add research method (focus group discussion)