

A photograph of the Hand Bridge in Bali, Indonesia. The bridge is a walkway supported by two large, grey stone hands that appear to be holding it. The bridge is crowded with people, many of whom are holding umbrellas. The background shows a clear blue sky with some clouds and a lush green forest below. The bridge is supported by several wooden pillars.

Circular Infrastructure Business Models

Insights from the Open Learning Environment
Circular Bridges and Viaducts

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Executive summary

Infrastructure construction projects have a heavy environmental footprint. At the same time, large parts of existing infrastructure require renovation and there is a growing future need for additional infrastructure that is safe, durable and economically viable. There is a clear need to explore how we can merge the requirement for increased sustainability in infrastructure with the practical requirements. Circular business models potentially hold the answer to this question.

In this report, the Business and Value Case working group that was part of the Open Learning Environment Circular Bridges and Viaducts* in the Netherlands details its findings on four possible circular business models for infrastructure. The four circular business models include:

1. Coordination of modular infrastructure by a government agency,
2. Buy-back guarantees by infrastructure companies,
3. Viaduct As a Service and
4. Infrastructure companies and its clients jointly operating in consortia ('All-in Consortium').

* By viaduct we mean a a bridge-like structure composed of several smaller spans that crosses a dryland, wetland or valley or that forms an overpass or flyover.

All four business models bring challenges that need to be jointly addressed. A good residual value calculator and a digital database/marketplace with information on such aspects as the quality, materials used and availability of existing building blocks would greatly facilitate the transition to more circular business models. Of the four business models, we consider the All-in Consortium scenario to be the most stimulating for the circular economy by truly sharing long-term pains and gains for all relevant parties involved.

On the basis of shared insights, the working group also recommends criteria for inclusion in the first circular infrastructure tender in the Netherlands. Recommendations address circular infrastructure requirements, yet also suggest that public funds can be used to develop important enablers to circular infrastructure, such as residual value calculators and solid data management systems.

Demonstrating the impact of this unique public-private partnership ('PPP'), the results of the Open Learning Environment, and specifically those of the Business and Value Case working group, will also be shared at the World Economic Forum ('WEF') Annual Meeting in Davos, Switzerland on 23 January 2020. The Dutch Ministry of Infrastructure and Water Management and ING Bank are both members of the Platform for Accelerating the Circular Economy ('PACE'), a WEF spin-off. The fruitfulness of the Open Learning Environment truly lies in the diversity of the partners connected with this initiative and that participate in the discussions. By presenting the work of the Open Learning Environment in Davos, the group of interconnected partners working on advancing the circular economy will be enlarged globally.

This report is published as part of the Platform for Accelerating the Circular Economy (PACE). PACE is a public-private collaboration mechanism and project accelerator dedicated to bringing about the circular economy at speed and scale. It brings together a coalition of more than 70 leaders and is co-chaired by the heads of Royal Philips and the Global Environment Facility. It was initiated at the World Economic Forum and is currently hosted by the World Resources Institute.

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The motivation for circular infrastructure

Infrastructure such as roads, bridges, viaducts, dykes and locks are resource-intensive and consist predominantly of heavy materials such as stone, concrete and steel. Consuming large quantities of natural resources that subsequently need to be processed and transported to produce infrastructure also leads to significant CO₂ emissions.

According to the Dutch government programme, The Netherlands circular in 2050 (Rijksoverheid, 2016), construction in the Netherlands is responsible for approximately 50% of all raw materials consumption, approximately 35% of all CO₂ emissions, 40% of total energy consumed and 30% of total water consumption. In the EU, the construction sector also creates approximately 25-30% of all waste (Circle Economy and WBCSD, 2018). In the Netherlands, approximately 97% of all construction and demolition waste is reused (Transitieteam, 2018), yet mostly for low-value applications in the infrastructure sector such as concrete granulate for road foundations.

With 40,000 bridges and viaducts in the Netherlands, most of which were built between 1960 and 1980, a significant number will need to be replaced in the coming decades. In order to meet climate and circular economy ambitions whilst ensuring the quality, usability and safety of infrastructure, new sustainable solutions need to be available at scale and be of economic interest to all parties involved.

As the CiSCA study (2019) concluded, EU construction companies' circular efforts will be mostly driven by government action (acting as launching customer) and changing market demand, especially since the construction sector is highly demand-driven and competitive. The CiSCA (2019) table below provides an overview of the seven main drivers of circular endeavours by European construction companies.

“With 40,000 bridges and viaducts in the Netherlands, most of which were built between 1960 and 1980, a significant number will need to be replaced in the coming decades.”

Business drivers for circular construction in the EU

Threats



Political agenda

Main driver, consists of Policy and Legislation, and Taxation.



Resource scarcity

Minor business driver at the moment, key reason however for wanting circular economy for society at large and the planet.

Opportunities



Market demand

Main opportunity, with government bodies as launching customers, followed by the B2B segment.



Product value

Significant potential to realise new business models, enhancing value for both customers and companies.



Cost optimisation

Interesting when considering less material usage and enhanced efficiency. Significant potential can be increased when taxation levels the playing field vs. linear propositions and virgin raw materials required.



Brand equity

Opportunity that is difficult to quantify but that could be sizeable, also interesting for attracting and retaining talented employees.



Sector initiatives

Minor opportunity, not enforceable in many cases, yet sector initiatives are suitable for co-creation and joint learning.

Source: CiSCA, 2019

Illustrating Public-Private Partnerships: the Open Learning Environment Circular Bridges and Viaducts

An illustration of government action and commitment to the circular economy is the Open Learning Environment Circular Bridges and Viaducts in the Netherlands (Bouwcampus, 2019). This is a unique example of public-private cooperation and a clear sign that the circular economy features on the political agenda.

The trigger for this Open Learning Environment was the Dutch government's participation in a consortium for the first (pilot) circular viaduct in the Netherlands, alongside construction company Van Hattum & Blankevoort and concrete company Consolis/Spanbeton. Noticing that several Dutch construction companies such as Dura Vermeer and Heijmans were also piloting circular infrastructure, the Dutch government (Rijkswaterstaat) brought all these parties together, including a bank such as ING, economic advisers, business model experts and procurement teams from several layers of government (Dutch national, regional and municipal). This was the beginning of the Open Learning Environment, in which a large group of diverse stakeholders jointly started investigating circular infrastructure. The group of approximately 60 people was organised into six different work streams: Procurement, Value Chain Cooperation, Design, Material, Data and Business & Value Cases.

During a nine-month period, from March to November 2019, the Open Learning Environment's working groups explored Circular Infrastructure. Based on the output of the six working groups of the Open Learning Environment, among other groups, the Dutch Ministry of Infrastructure and Water Management will launch a first (subsidised) public tender for circular infrastructure in 2020.

The report at hand focuses on the insights of the Business and Value Case working group. This working group was led by sustainability and circular economy experts of construction company Dura Vermeer and ING Bank. The other members of the working group consisted of professionals from the national public works agency Rijkswaterstaat, the municipality of Rotterdam, construction company VolkerWessels (Van Hattum & Blankevoort), economic advisor Rebel, integrated sustainability strategist Except Integrated Sustainability, investor Aberdeen Standard Investments, ING Bank, concrete company Consolis/Spanbeton and engineering company Wagemaker. For a list of individual representatives of these companies and contributors to the development of the insights shared in this report, please refer to Annexe 1.

“This is a unique example of public-private cooperation and a clear sign that the circular economy features on the political agenda.”

The applied framework to develop solid circular business models required for scaling-up

As mentioned, the Dutch construction & infrastructure sector is exploring circular business opportunities, driven largely by circularity on the political agenda and changing client demand, where the government acts as a launching customer.

To successfully transition to circular business models, however, companies in this sector need to overcome several challenges, the most important one being the development of clear circular business models and business cases for the large manufacturers but also their key suppliers and clients (CiSCA, 2019). Building on earlier work by CiSCA (2019) and Rebel and CE Delft (2018), the Business and Value Case working group explored four different business models that may be of interest in the context of circular infrastructure.

The following four principles and assumptions governed the efforts of the working group:

1. The aim is to develop business models that enable circular viaducts/bridges at scale

To focus its discussions, the working group did not discuss tender criteria or, for example, the definition of circular infrastructure (the what). The exploration was focused on business models, the how. Readers in search of definitions of the circular economy can consult such documents as the CE Finance Guidelines (FinanCE working group, 2018) or the Circle Economy and WBCSD report (2018).



2. The existing circular (modular) viaduct was taken as a fixed starting point to facilitate the brainstorming sessions of the working group

The existing piloted circular viaduct has building blocks made of concrete developed to last 200 years. These blocks can be fully reused when the viaduct is taken apart, underlining the modular character of the viaduct and potentially helping to extend the economic life of viaducts. According to Rebel and CE Delft (2018), the average life of viaducts from a technical perspective is 80 years, yet the actual realised life is substantially lower at 46 years on average. The reasons for a lower average life include:

1. railway construction requiring the extension of the existing viaducts,
2. improvement efforts for the flow-through of existing infrastructure and
3. changing regulation and standards for infrastructure.

Despite the building blocks' technical life of 200 years, in its discussions the working group assumed a technical life of 100 years because a period of 200 years would be too long to oversee, including in terms of technical and market developments. Note that for the piloted circular viaduct, the Dutch government is the owner of the building blocks as these have been bought from the suppliers. For more information on the circular viaduct, please refer to the website of Rijkswaterstaat (2019).

3. There are a limited number of infrastructure clients and these are all public organisations

'Clients' are considered to be government bodies at national, regional and municipal level.

4. The number of objects in scope is relatively large, with large variation in sizes

Based on a conservative estimate from the working group, the total market size for circular infrastructure in the Netherlands is close to EUR 5 billion over the next 20 years. This equates to EUR 250 million per year. These numbers are based on the current number of 40,000 bridges and viaducts, of which approximately 12% meets the maximum span length criteria for the current modular construction solution in place, combined with the need for renovation or replacement within the next 20 years. This market potential equals 5 million m² of surface, being 36% of the total bridges and viaducts' surface. The current circular viaduct in the Netherlands is costed at EUR 2,000 per m² to build, leading to a total market potential of EUR 5 billion for circular infrastructure in the coming 20 years. Note that this number only reflects replacement and renovation and still excludes expansion of the existing set of viaducts and bridges.

Earlier in 2019, the Dutch Minister for Infrastructure and Water Management, Cora van Nieuwenhuizen, announced that the budget available for renovation and replacement of bridges and viaducts would more than double from 2021, from EUR 150 million per annum to EUR 350 million per annum (Dutch Ministry of Infrastructure and Water Management, 2019). This means that the EUR 250 million per annum would come under the new annual budget from 2021, in plenty of time considering the government's ambition to include circular criteria in all public tenders from 2023.

On the basis of the above-mentioned principles, a brainstorming session took place to identify which business models the working group would explore in more detail. The chosen business models show a varying degree of disruptiveness versus the current linear approach, plus also a difference in incentive for the supply chain to develop truly circular propositions.

Initially, a scorecard was developed that encompasses business model assessment criteria broken down into Organisational, Financial, Technical and Legal aspects, see Annexe 2 for details. Based on the discussions that took place within the working group, the Organisational aspect was most frequently touched upon. Cooperation, the division of roles in a value chain, ownership versus usage and liabilities versus possible benefits were all raised much more frequently than details of Legal, Technical and Financial matters. This emphasis on Organisational matters is therefore also reflected in the description of the business models below.

The emphasis of the working group was therefore more on business models than on economic feasibility and value cases. It must also be noted that any calculations relating to circular infrastructure are open to a broad range of possibilities. Touching upon the investigation by other working groups of the Open Learning Environment, matters such as design (e.g. modular) and material (concrete, wood, steel, etc.) would need to be considered, in addition to the relevant business model; ownership versus pay per use for example. Interested readers can refer to the societal cost/benefit analysis for circular infrastructure by Rebel and CE Delft (2018). This report includes a number of case studies illustrating the value case for circular infrastructure.

Whilst the working group did not conduct an economic feasibility study or calculate the value case, the concept of value was discussed because it is essential in every business model analysis. Similar to the Rebel and CE Delft study (2018), the working group understood the concept of value to be broader than just optimising financial gains. Ultimately, however, the quantified value should be a reflection of the market's economic, social and environmental considerations when deciding on purchasing/constructing circular infrastructure.

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Transitioning from linear to circular business models

Recap of the business as usual linear scenario

Before elaborating further on the four selected business models potentially suitable for circular infrastructure, first a brief word on the linear business model as we see it in the current infrastructure environment. Typically, an infrastructure company at the end of the supply chain coordinates the construction of public works. This entails the collection of critical elements and the coordination of the assembly on site. The client is a public organisation, buying public works and becoming the owner of the infrastructure. Some government bodies that do not have balance sheets depreciate these assets to zero book value immediately when they take ownership of the asset. In the Netherlands, users of infrastructure do not pay the government directly for usage. Maintenance and repairs are not necessarily undertaken by the party that constructed the asset. To visualise this business model as usual, please refer to image 1 in Annexe 3.

When discussing the circular business models below, please note that the working group assumed the scenario of a modular viaduct, consisting of building blocks made of concrete, with a technical life of at least 100 years. It will be clear that the different business models provide a different level of circular incentive to the parties involved and bring about different practical advantages and challenges. To visualise the circular business models, please refer to Annexe 3.



Circular business model 1: Coordinating Client

Brief description of the business model

In this business model, the client orders an infrastructure project with infrastructure company (A). Suppliers and contractors/subcontractors produce circular building blocks. Subsequently infrastructure company A uses these building blocks to construct the circular object. The object is then sold to the client/government. The client pays infrastructure company B for maintenance when the viaduct is in use, with company C being hired for deconstruction after the initial lifetime. Blocks can then either be stored or reused on a new project (e.g. by infrastructure company A). Tight coordination of the building blocks' availability and quality is required for this system to work.

Please note that in practice, DBM contracts are sometimes used as well, under which one infrastructure company is paid by the client for design, building/construction and maintenance, i.e. the roles are not always split in practice. For this business model, however, we have assumed the traditional model in which design and construction are undertaken by infrastructure companies other than the maintenance and deconstruction companies.

The business model in more detail

Company A starts the construction with existing building blocks and ensures the additional supply of new building blocks when necessary. To optimise the usage of all existing building blocks, a good insight into the volumes, location, quality and availability of existing building blocks is required. For this, the market needs to be

transparent and good coordination is required. Different levels of government work on different infrastructure agendas, therefore ideally an overarching government entity will be responsible for coordination. This coordinated effort can take the shape of a platform (infrastructure agency) on which building blocks could perhaps be stored when not in use. Knowing the location of the building blocks is important, but equally important is the quality of the building blocks. Material passports are often mentioned in these discussions. These documents provide information on the materials used and the condition and quality of the building blocks over time. With several parties working on the development of these material passports, the market is exploring the practical suitability of the current platforms in development. In addition, there is also a need for a good tool to understand the residual value of the building blocks, depending on aspects such as materials used, hours of labour involved. On this basis, the Dutch independent research organisation TNO (2019) is developing a residual value calculator, although further steps are needed to make this tool fit for use by the market.

In addition to the coordination of the location/availability and insight into the quality/material/value of the building blocks, an important requirement for this business model to work is uniformity/standardisation of buildings blocks when it comes to shape and size. Building blocks need to seamlessly connect to each other and must be easy to disconnect without significant damage to the building blocks, like Lego. Only developing criteria for the design still leaves room for innovation by infrastructure companies when it comes to the material used, for example. In terms of reuse, each building block will be assessed and checked for suitability for the infrastructure project at hand. Information from the coordinating platform or material passports will greatly facilitate this process.

While the blocks are being used in a viaduct, maintenance will be conducted by infrastructure company B. At the end of the life of the viaduct, on the instructions of the client the object will be disassembled by another infrastructure company, C, with the aim of subsequently optimising reuse. This is when cooperation with the coordinating platform is essential.

An important aspect from a risk perspective is that the client will buy building blocks that are fit for use for at least 100 years. This set-up entails a long-term commitment on the part of the client, placing the market risk disproportionately on the client compared to the infrastructure companies and their suppliers.

Depending also on the exact tender criteria, infrastructure companies and suppliers might not have a strong incentive to develop truly circular infrastructure as these parties are no longer directly connected to the building blocks after they have been sold for the first time.

Circular business model 2: Pre-agreed Buy-back

Brief description of the business model

Similar to the first business model, we have assumed that the client orders an infrastructure project with infrastructure company A. Suppliers and contractors/subcontractors produce the circular building blocks, while infrastructure company A subsequently uses the building blocks to construct the circular object. The object is then sold to the client. The client pays infrastructure company B for maintenance

when the viaduct is in use, with company C being hired for deconstruction after the end of the initial useful life. However, unlike in the first business model, in this scenario infrastructure company A has the obligation to buy back the building blocks at the end of the initial useful life/usage period. Any risk of damaged building blocks, including inadequate maintenance or deconstruction, resides with the client. Company A would not be obliged to buy back the blocks if they are not in a good condition.

The business model in more detail

Again, assuming that company A starts building with existing building blocks and ensures the additional supply of new building blocks where necessary, ownership of the viaduct resides with the client when the viaduct is temporarily acquired for use. If the viaduct is owned by the government, the government appoints a party for maintenance (B), with company C being responsible for deconstruction and return delivery to company A. Company A then reuses as many building blocks as possible when taking on a new construction request from the client. Even with the government no longer ultimately owning the building blocks, the need for some coordination of the building blocks' availability and the respective quality and value of such blocks remains essential, including the liability of the client if the building blocks are delivered in a poor condition. Market dynamics will determine the extent to which infrastructure companies reuse the building blocks they own, including buying or leasing building blocks from other infrastructure companies. When considering the costs related to quality testing, refabrication, certification, transportation, etc. of existing building blocks, it must still be economically interesting versus building new blocks.

Strict rules need to be defined upfront for the Buy-back scheme related to the building blocks. It needs to be determined when and at what pre-agreed price the building blocks are to be bought back, such as a deposit scheme and right to cancel the buy-back if building blocks are not in the pre-agreed condition. Pre-agreement on a price is complicated by the responsibilities of the owner/user/party maintaining and deconstructing the building blocks versus the infrastructure company delivering and buying back the blocks. For infrastructure company A, this scheme involves a considerable degree of uncertainty. This is further strengthened by unpredictable price fluctuations in natural resources such as construction-grade sand and iron ore, plus other costs such as labour expenses combined with the uncertainty of the moment of buy-back. Moreover, in this Buy-back scenario connected to the long technical life of the building blocks, the market risk largely resides with infrastructure company A. If the government decides to change the tender criteria and, for example, no longer considers modular design desirable, infrastructure company A still has the obligation to buy back these building blocks. This and other risks have to be mitigated in the contract between the client and infrastructure company A.

By introducing the buy-back element, infrastructure companies with this obligation will feel a strong circular incentive to ensure good quality and durable building blocks. After all, it is in their own interest to ensure they retain ownership of high-value building blocks that can be economically exploited for longer, up to 100 years in this case.

Circular business model 3: Viaduct As a Service

Brief description of the business model

In this business model, the client will not become the owner of the building blocks. The client expresses the need for a viaduct at a certain location, meeting certain tender criteria. Company A orchestrates the construction of the viaduct, reusing existing building blocks as much as possible. Unlike in the other scenarios, maintenance and deconstruction/reconstruction are all arranged (not necessarily performed) by company A. The client pays a regular fee to company A, who then provides an all-in infrastructure solution to the client.

The business model in more detail

Infrastructure company A plays a leading role by ensuring that the required building blocks are available and by coordinating construction, maintenance, deconstruction, logistics, etc. Infrastructure company A is the owner of the building blocks and provides the entire Viaduct As a Service to its client. The client pays a fee on a pre-determined regular basis for an agreed period of 30 years, for example, with the option of extending the contract. Price-setting can be based on usage intensity, such as the number of cars crossing the viaduct, or based on total construction, maintenance, deconstruction expenses and the initial length of the contract (to recover costs and mitigate financial risk). However, the long technical life of 100 years versus relatively shorter rental periods complicates matters. Infrastructure company A is the entity incurring the full market risk, being exposed to possible changes in the client's requirements and technological developments that may make the existing building blocks less desirable. In addition, the residual value of the building blocks cannot be

accurately estimated upfront, and for there to be an actual residual (monetary) value, a market for second-hand building blocks needs to be developed first. It is indeed also an option that at the end of the first contract period, another infrastructure company takes over the ownership of the building blocks, including the other responsibilities such as maintenance, deconstruction, etc. Nevertheless, at this point in time, infrastructure company A is not assured of a second-hand market and a buyer for the building blocks in say 30 years' time. As a result, the company could be inclined to mitigate these risks by reducing the expected, although uncertain, residual value of the blocks as much as possible whilst minimally meeting the circular tender criteria of the client and/or by increasing the monthly fee. The risk of less durable building blocks is mitigated by the fact that ownership by infrastructure company A does create a strong circular incentive, as developing durable building blocks facilitates longer economic exploitation of the same assets, with less maintenance (and hence fewer costs). In the end, what we aim to achieve with the circular economy is assets that are of good quality and sustainably built, that depreciate at a slower rate and not even to zero. Motivating the supply-chain partners as well remains key. They must be incentivised to also deliver durable quality and co-ownership of the building blocks can be considered in these cases.

Continuing to address the financial implications of this scenario, in a typical sales scenario, infrastructure company A would receive payments in large chunks during the construction of the viaduct and at the time of the hand-over of the object to the client/owner. However, in a service and no-sales scenario, no such sizeable amounts are received by infrastructure company A. Regular payments will flow in and provide stable cash flows. However, this also leads to bank financing requirements during construction (increasing the company's working capital needs) and upon completion by having the slowly depreciating asset on the balance sheet of company A. This needs long-term

financing, gradually repaid with the service-based cash flows from the client. Financing requirements will be very long-term and beyond even one rental contract period. The risk of not closing a new rental contract or extending the existing rental contract poses a threat to the infrastructure company's financial health, yet also increases the risk for financiers.

Now that bank financing is required, the topic of residual value in relation to financing also needs to be discussed. As concluded by Circle Economy (2019), there will only be an economic residual value if there is a market available. For circular building principles to have an effect on the actual book value of assets, auditors need to sign off on this. Banks that provide financing based on the financial statements and guided by accounting rules and forecast market developments would therefore be hesitant to increase financing up-front on the assumption that the value of circular assets will be higher or lower repayments based on the assumption of less depreciation and no depreciation to zero/a higher residual value at the end of a lifetime. Residual value relates closely to the material passports and residual value calculators previously discussed.

As a final consideration for the service model, the working group discussed the option of lease-like entities taking over the ownership of the building blocks and leasing the building blocks to the infrastructure companies. This would solve the financing burden for the infrastructure companies, yet it would also reduce the circular incentive of infrastructure company A (and its supply chain). A potential solution could be for the lease company to make a partial payment to infrastructure company A on delivery of the building blocks and for the balance to be paid depending on the economic life of the product.

Circular business model 4: The All-in Consortium

Brief description of the business model

This business model assumes close cooperation between suppliers, infrastructure companies and the client with joint responsibility and a better division of risks and benefits. This true public-private partnership merges at least one client with one infrastructure company in a consortium. In the consortium, the strong suits of the respective parties determine responsibilities. Furthermore, the consortium manages a pool of viaducts, has one shared wallet and is jointly responsible for reusing building blocks.

The business model in more detail

Based on a regular tender process ensuring quality (including circularity), the final decision for consortium partners is based on getting the right parties to the table. Trust, cooperation and transparency are key. Once the right partners have been selected, a joint team consisting of the client and infrastructure company (located in a shared office) will start the preparations. In the case of construction companies, logical responsibilities would involve sourcing all the required elements for the viaduct, interacting with suppliers and ensuring proper maintenance and deconstruction/reconstruction/construction of the objects. A client/government body is good at asset management, has the overview of the infrastructure project, and can provide an insight into the available budget to develop an adequate business case.

Agreements that need to be made between the parties are:

1. any additional expenses of initial circular infrastructure construction versus non-circular infrastructure will be shared 50/50 by the consortium. The infrastructure company will also invest in circular infrastructure and interests will be aligned.
2. Possible setbacks but also windfalls will be split 50/50. For example, if the supplier contracted by the infrastructure company drops a building block, the costs will be split 50/50, but a higher (positive) residual value than anticipated will also lead to a fair distribution of the additional upside.
3. The consortium partners are jointly responsible for finding a new destination for the building blocks on deconstruction at the end of the initial life. This joint responsibility will be facilitated by the alignment of financial interests, the consortium having a shared wallet. As is the case in the As a Service and the Buy-back scenarios, ownership/co-ownership of assets is a strong incentive for developing and building circular infrastructure beyond mere compliance with the tender criteria, including circularity.

Robust agreements need to be made of course about how to deal with the different opinions of the parties. During the tendering process, the outlines of such agreements will be decided, to be detailed once the consortium is launched.

Ultimately, consortia can manage pools of 5-50 viaducts, for example, depending on which consortium partners enter into a partnership with other construction companies or clients. This structure will also ensure the inclusion of other parties in the circular infrastructure efforts.

Recommendations for a first circular infrastructure tender in the Netherlands

Based on a Strategic Business Innovation Research ('SBIR') subsidy programme, the Dutch Ministry of Infrastructure and Water Management will launch a first public tender for infrastructure that explicitly includes circular criteria.

The recommendations for the tender criteria from the Business and Value Case working group are based on the above analysis of the four different business models and a session the working group had with Dutch circular economy think tank, Circle Economy.

Recommendations can be split into two categories,

1. three criteria for tenders of circular infrastructure projects as crystallised in a session with Circle Economy and
2. identification of two essential enablers for circular business models that are still in their infancy and that would greatly benefit from public funds for further development.

1. the working group recommends that the tender winner needs to incorporate the following elements into the business model:
 - a. A pre-agreed residual value higher than zero with a clear calculation method.
 - b. The aim for circularity, quality and durability must be embedded in the business model.
 - c. A fair distribution of pains and gains among value chain partners.

The working group is convinced that by following these three principles, circular infrastructure is closer to being realised in an environmentally conscious and economically beneficial manner. The recommendation is limited to three key criteria since innovation would not benefit from too many criteria. It was recommended to ask the eventual tender winner(s) to feed back on the business model used in terms of what went well, what could be improved, what is needed for success, etc.

2. If subsidy funds can also be applied more broadly than one specific infrastructure object, public funds could be used to develop circular business model enablers. Such circular enablers would mainly be:
 - a. A residual value calculator, as referred to a number of times in this document..
 - b. A strong data storage system for circular blocks with universal standards, objective quality, a CE label etc., quite similar to a material passport. Transparency in the range of building blocks is essential.

It is up to the Dutch government to determine how these tender recommendations are applied in practice.

Wrap-up

Having assessed four different business models, we consider the Buy-back, the As a Service and the All-in Consortium models to be best in terms of circular incentives for the infrastructure companies and their suppliers. In all these business models, the companies responsible for design, materials choice and construction will also be the ones connected to the long-term value of the building blocks.

This is because of a different ownership structure compared to business as usual and the Coordinating Client scenario. Of the business models assessed, the All-in Consortium option is considered to be most circular since long-term pains and gains will be mostly evenly split, encouraging long-term thinking and circularity by all parties involved. The Coordinating Client scenario is considered to be the least circular because the infrastructure companies will not be connected to the value and quality of the building blocks in the long term. This connection stops at the time of sale, especially if another infrastructure company is responsible for maintenance.

The working group still sees a few challenges that need to be addressed if the market is interested in adopting the identified business models anytime soon. The main hurdle for the Coordinating Client scenario is that a disproportionate part of the responsibility for the transition to circular infrastructure will be with the government. This business model not only places most risk with the government, but also lacks a good circular incentive for the infrastructure companies involved and their supply chains. The main questions that need to be answered before we expect a form of

Buy-back model to take off is an estimation of residual value, hence also the above recommendation for the subsidy application. The As a Service model poses significant financial challenges that require a suitable solution. The extent to which market parties would be comfortable working in the Consortium setting of having a shared wallet and being fully transparent remains to be seen. The feasibility and applicability of all four business models would benefit from a good residual value calculator and a digital database/marketplace with information on aspects such as quality, materials used and availability of existing building blocks.

The first circular infrastructure tender will be able to shed further light on the practical suitability of different business models. The working group encourages all feedback on the business model experience and we hope that all insights will be shared as publicly as we have done in this report.

As the Open Learning Environment demonstrates, public-private partnerships are a powerful tool for circular and other forms of innovation and we hope to see more of this kind of initiative going forward.

- > 1 – Participants working group
- > 2 - Business model scorecard
- > 3 - Illustration of the business models

Annexe 1

Participants working group

Organisation	Representative(s)	Expertise	Contact details
Rijkswaterstaat	Anke Zindler	Government procurement of infrastructure, involved with first circular viaduct	anke.zindler@rws.nl
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VolkerWessels (Van Hattum & Blankevoort)	Peter van der Wee	Infrastructure development, involved with first circular viaduct	pvanderwee@vwinfra.nl
Rebel	Emile Barendregt, Luuk van Gemert	Economic models, conducted societal cost-benefit analysis of circular infrastructure	Emile.Barendregt@Rebelgroup.com
Except Integrated Sustainability	Tim Horsten	Integrated Sustainability Consultants, Strategic Business Modelling, Innovation and Design	tim.horsten@except.nl
Aberdeen Standard Investments	Olaf van der Sar	Infrastructure investing / financing	olaf.vandersar@aberdeenstandard.com
ING Bank	Arjan van der Lee, Julien Ehrmann, Mayke Geradts	Infrastructure financing, circular business models, studied circular viaduct for CiSCA report	sustainable.finance@ingbank.com
Consolis/Spanbeton	Kees Quartel	(Pre-stressed) concrete, involved with first circular viaduct	C.Quartel@spanbeton.nl
Wagemaker	Jan Blonk	Engineering	j.blonk@wagemaker.nl
Dura Vermeer	Karlijn Mol	Infrastructure development	k.mol@duravermeer.nl

Annexe 2

Business model scorecard

Subject	Items
Organisational	<ul style="list-style-type: none"> Contractual set-up of the scheme Parties involved, who is the ultimate risk taker? Insurance scheme Logistics Data Management
Financial	<ul style="list-style-type: none"> Contractual payment mechanisms, volume risk and deductions Robustness of Cash flow, both at CFADS (Cash Flow Available for Debt Service), FCF (Free Cash Flow) to Equity levels Risks to cash flow profile, measured in sensitivity analysis (min/max and average ratios (gearing, IRR, DSCR, LLCR, PLCR) Comp on Term vs Residual value => measured through market value and NPV depending on the business model Others: tax rate, inflation risk, construction costs overruns, delays risk and liquidated damages, Routine and Heavy Maintenance costs, interest rate risk (hedging costs), contingency budget Hand back risks and ownership/intellectual property transfer Scrap % of building blocks expected at each stage in the process, for 100 years

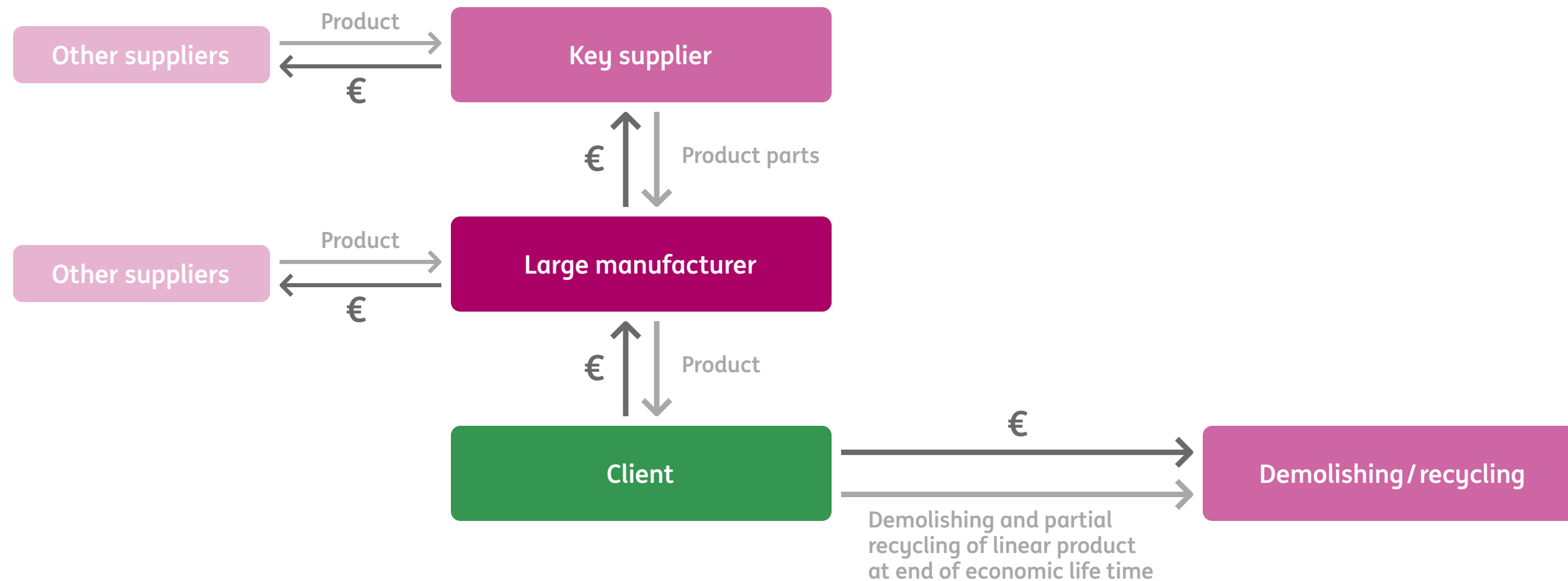
Subject	Items
Technical	<ul style="list-style-type: none"> Technical complexity/novelty of the solution (to be assessed by independent third parties) Who is responsible for the construction of the elements (at inception and during the construction and the operational phase)? Who is responsible for the design risk (at inception and during the construction and the operational phase)? Who is responsible for the construction risk (at inception and during the construction and the operational phase)? How long is the latent defects period on all previous items (re 100 year timespan) How long is the guarantee period for non-latent defects such as components, equipment, installation works (i.e.; non-structural defects)?
Legal	<ul style="list-style-type: none"> Ownership structure and change of ownership risks Contract with client and responsibility (joint and several) Subcontracts and responsibility (joint and several) Direct agreements and step-in rights / period Liability (also for end users re faults in the construction/ installation/ design) Liability caps Permits/ authorisation risks Risk of appeal/challenge, change in law, Authority change, termination Where resides the intellectual property

- > 1 - Participants working group
- > 2 - Business model scorecard
- > **3 - Illustration of the business models**

Annexe 3

Illustration of the business models

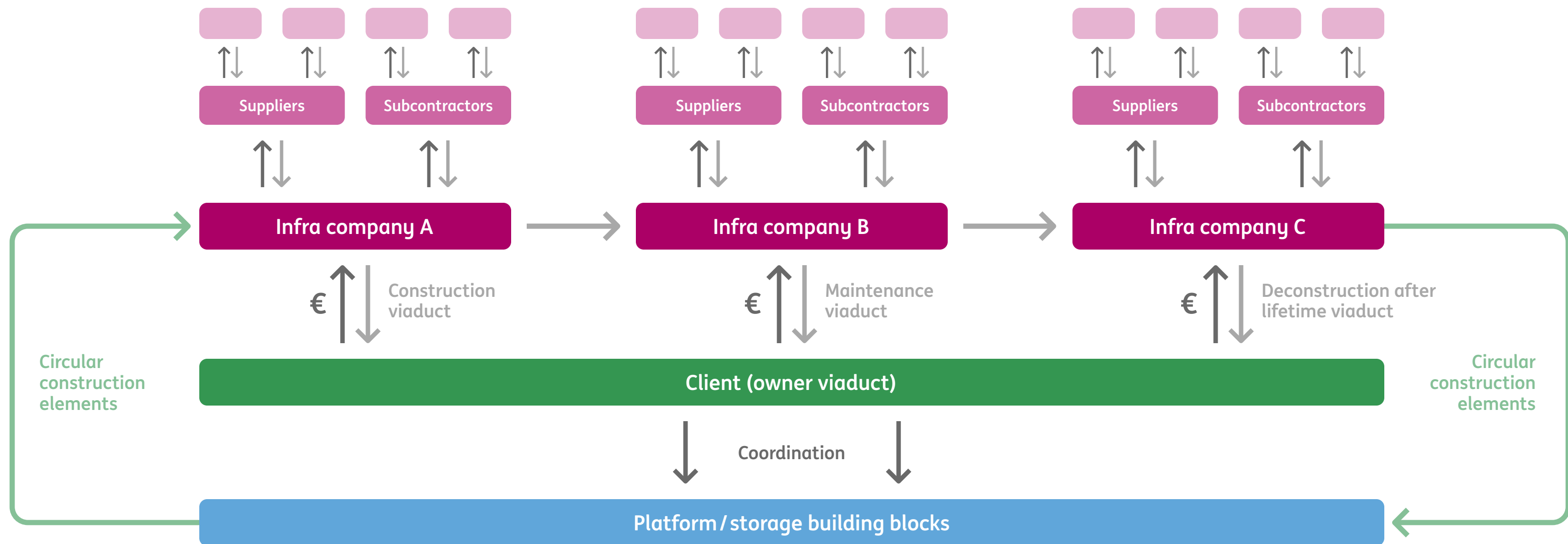
Linear offering – Business as usual



Source: CiSCA, 2019

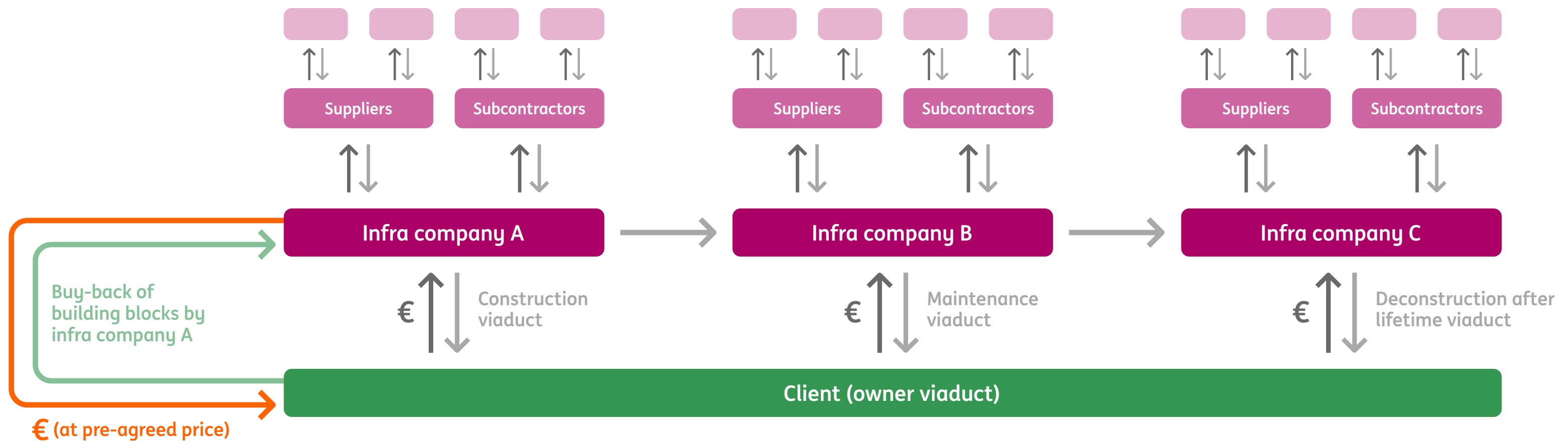
- > 1 - Participants working group
- > 2 - Business model scorecard
- > 3 - Illustration of the business models

Circular business model 1: Coordinating Client



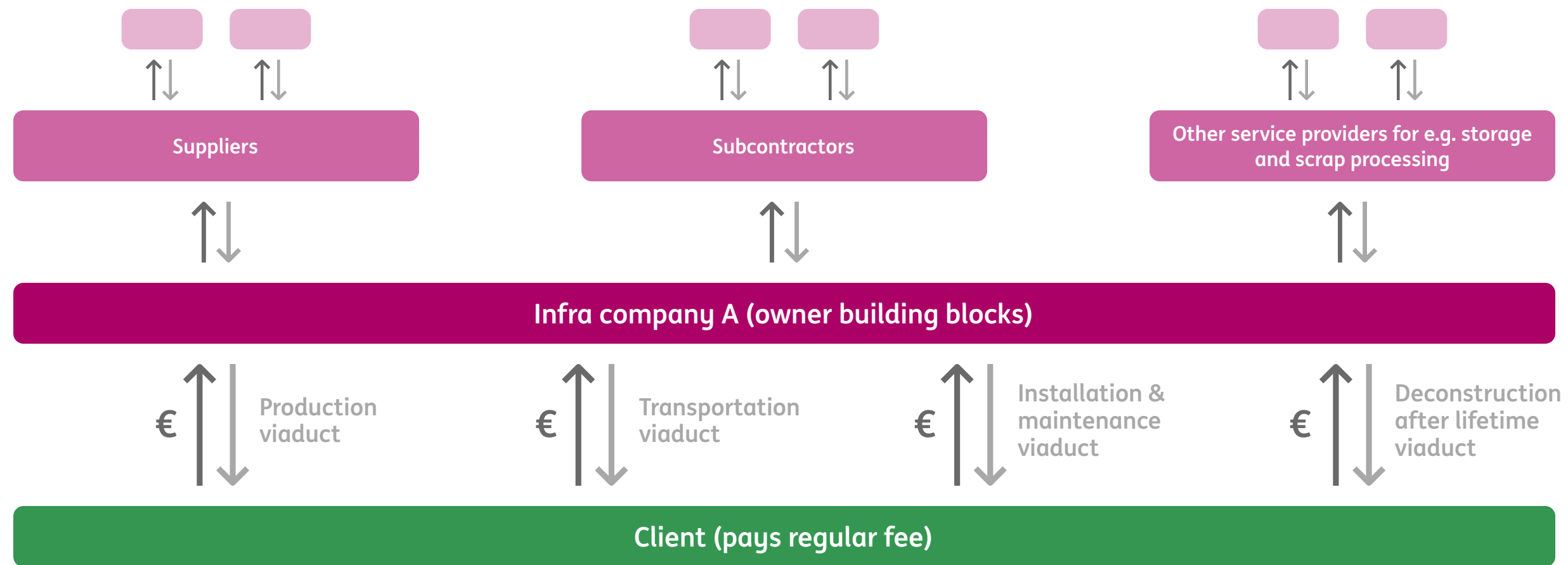
- > 1 - Participants working group
- > 2 - Business model scorecard
- > **3 - Illustration of the business models**

Circular business model 2: Pre-agreed Buy-back



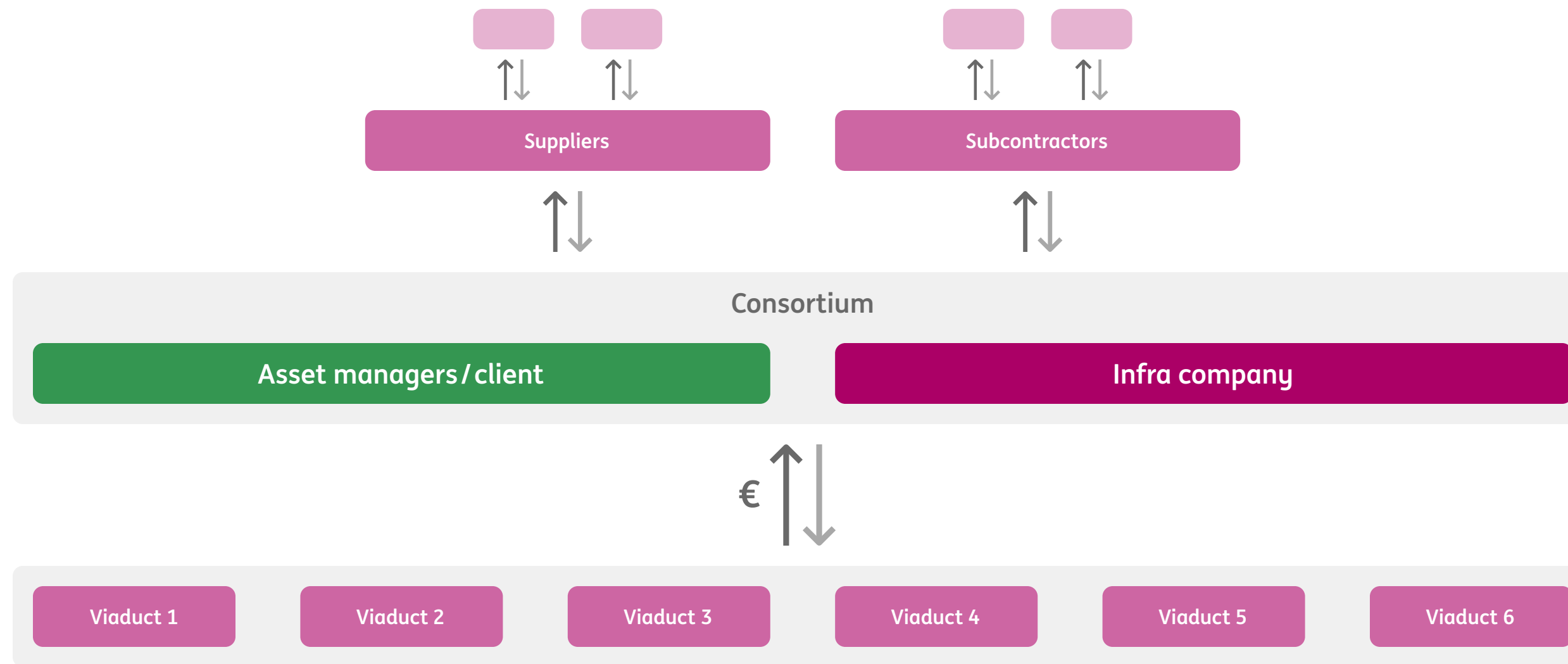
- > 1 - Participants working group
- > 2 - Business model scorecard
- > **3 - Illustration of the business models**

Circular business model 3: Viaduct As a Service



- > 1 - Participants working group
- > 2 - Business model scorecard
- > **3 - Illustration of the business models**

Circular business model 4: The All-in Consortium



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