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# Towards a shorter, continues and predictable plan-phase in residential development projects

## A study on bottlenecks and solution directions

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# Contents

# 1 Introductie

Nederland kampt met een steeds groter wordend woningtekort[1]. In 2022 was het nationale doel om 900.000 nieuwe woningen te realiseren vóór 2030. In 2023 is deze doelstelling verhoogd naar 981.000 woningen[2], als gevolg van de groeiende vraag naar woningen. Momenteel is er een woningtekort van 451.000 woningen, wat duidelijk zijn effecten heeft op de markt en de maatschappij. Tussen Q4 2019 en Q4 2024 steeg de gemiddelde woningprijs van €312.871 naar €461.797[3], waardoor het voor velen steeds moeilijker wordt om een huis te kopen. Ook de huurprijzen zijn aanzienlijk gestegen[4].

Een van de meest veelbelovende antwoorden op het groeiende woningtekort is **conceptueel en industrieel bouwen** (**C&I**). We zien dat er in de industrie en de literatuur veel verschillende termen worden gebruikt waaronder: industrieel bouwen, systeembouw, rationeel bouwen, modern methods of construction (MMC), advanced building construction (ABC)[5]. In dit rapport hanteren we de term **Industrieel Bouwen** (IC): een vorm van bouwen waarbij processen en technologieën worden toegepast die kenmerkend zijn voor industriële productie. Daarnaast bedoelen we met **conceptueel** het gebruik van productplatforms als “een set van subsystemen en interfaces die een gemeenschappelijke structuur vormen, van waaruit efficiënt een stroom van afgeleide producten kan worden ontwikkeld en geproduceerd” [2].

Dit betekent een verschuiving van ETO-producten (Engineer-to-Order) naar ATO- en CTO-producten (Assemble-to-Order, Configure-to-Order), waardoor standaardisatie mogelijk wordt op het gebied van product, processen, waardeketens en informatie, en er project overstijgend geleerd kan worden.

Industriële bouwers in Nederland hebben de capaciteit om een aanzienlijk deel van de benodigde woningen te leveren. Uit onderzoek blijkt dat de sector in staat zou moeten zijn om jaarlijks 37.000 prefab woningen te bouwen, met de mogelijkheid om dit uit te breiden met nog eens 19.000 woningen als er extra ploegendiensten ingezet zouden worden [1]. Door standaardisatie, herhaalbaarheid en off-site productie kunnen deze bouwers sneller, efficiënter en op grotere schaal woningen leveren. Toch blijft deze capaciteit grotendeels onbenut: slechts 14.300 woningen, een aandeel van 21% van alle nieuwbouwwoningen in 2024, zijn gerealiseerd via industriële methoden [1].

Het probleem zit hem niet in de bouwfase, maar in de lange, complexe en onvoorspelbare planfase die hieraan voorafgaat (zie Figure 2). Conceptueel en industrieel bouwen vereisen stabiliteit en voorspelbaarheid van de vraag om de productie effectief te plannen en op te

[1] Woningbouwopgave stijgt naar 981.000 tot en met 2030 | Nieuwsbericht | Rijksoverheid.nl
[2] Het statistisch woningtekort uitgelegd | Home | Volkshuisvesting Nederland
[3] Datawonen - Koopprijs
[4] Grootste huurstijging in ruim 30 jaar | CBS
[5] Netwerk Conceptueel Bouwen (NCB) prefers the term “conceptual building” as “*Working from repeatable, innovative, integrated, and flexible construction solutions that can be tailored to the uniqueness of each project, including the residents, the location, and the client* [5]” and argue that the term “Industrialisation” refers solely to the method of manufacturing. The report of Roland Berger [1] talks about prefab housing which they define as; “*any house that is made windproof and waterproof within 10 days on-site, and completed within 50 days from the start of construction”*, which lacks the component of standardization and allows ETO processes.

schalen. De huidige planprocedures zijn echter gefragmenteerd, inconsistent tussen regio's en onderhevig aan tal van vertragingen.

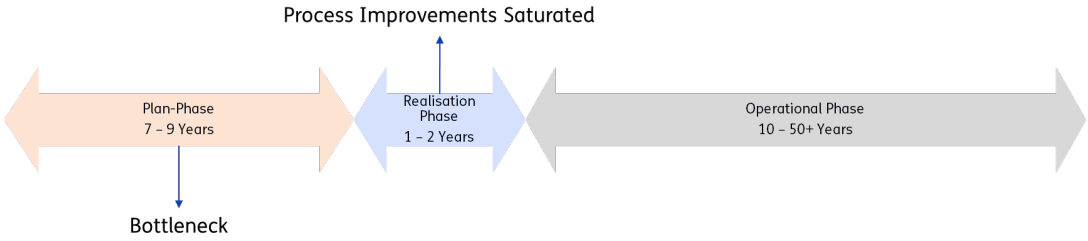


Figure 1. Project timeline

Het is dus essentieel om de planfase te stabiliseren en te verkorten om zo het volledige potentieel van conceptueel en industrieel bouwen te benutten. Zo kunnen bouwers in Nederland effectief en efficiënt bijdragen aan de nationale woningopgave. Deze studie is bedoeld als aanzet tot deze ontwikkeling.

Dit rapport presenteert de resultaten van een studie naar de belangrijkste knelpunten in het huidige planproces en analyseert de oplossingsrichtingen die al in de praktijk worden verkend. Op basis hiervan worden ook innovatierichtingen geschetst die nodig zijn om een planproces te creëren dat snellere, voorspelbare en schaalbare woningbouw mogelijk maakt, zodat de capaciteit van conceptuele en industriële bouwers volledig kan worden benut voor het oplossen van de woningcrisis in Nederland.

*Hoofdvraag*

Deze studie beantwoordt de volgende vraag:

> *Wat zijn de belangrijkste uitdagingen en knelpunten die de doorlooptijd, voorspelbaarheid en continuïteit van de planfase in gebiedsontwikkeling en (conceptuele en industriële) bouwprojecten in Nederland beïnvloeden, en welke oplossingsrichtingen en initiatieven bestaan er om deze aan te pakken?*

*Aanpak*

Om de knelpunten in de planfase te identificeren en bestaande oplossingsrichtingen in kaart te brengen, zijn 16 diepte-interviews gehouden met een diverse groep stakeholders, waaronder ontwikkelaars, gemeentelijke planners, beleidsmakers en experts uit de sector (lijst van geïnterviewden in Appendix A). Daarnaast is documentanalyse uitgevoerd, waaronder sectorrapporten, nieuwsartikelen en wetenschappelijke publicaties (zie Appendix C). De eerste bevindingen zijn getoetst en aangescherpt via validatie-interviews. Tot slot is het rapport gereviewd door experts uit de praktijk (Appendix B).

*Belangrijkste conclusies & leeswijzer*

Hieronder volgt een samenvatting van de belangrijkste bevindingen en conclusies uit deze studie:

- De grootste vertragingen in woningbouw worden niet veroorzaakt door beperkingen in de bouw, maar door de langdurige en onvoorspelbare planfase. Activiteiten in de initiatie- en haalbaarheidsfase zijn gefragmenteerd, iteratief en stagneren vaak door beleidsonzekerheid, capaciteitsgebrek en ongecoördineerde processen. De structuur en activiteiten van de planfase worden beschreven in Hoofdstuk 2.
- Stabilisatie van de planfase is een noodzakelijke voorwaarde om de nationale woningbouwdoelen te halen. Hoewel (conceptuele en) industriële bouwers in Nederland

de capaciteit hebben om op grote schaal bij te dragen, blijft dit potentieel onbenut zolang het planproces niet voorspelbaarder, transparanter en efficiënter wordt.

- De meeste knelpunten in de planfase zijn onderling verbonden, structureel en systemisch. De kernoorzaken zijn gefragmenteerde verantwoordelijkheden, onduidelijke eisen en regelgeving, capaciteitsgebrek bij gemeenten en provincies, en niet op elkaar afgestemde verwachtingen van stakeholders. Alle knelpunten en hun oorzaken worden besproken in Hoofdstuk 3.
- Ontwikkelaars tonen steeds meer terughoudendheid om nieuwe bouwprojecten te starten vanwege uitdagingen bij het opstellen van haalbare businesscases. De financiële haalbaarheid wordt vaak ondermijnd door een gebrek aan transparantie over kostenverhogende eisen zoals infrastructuur, duurzaamheid en sociale woningbouw, die meestal pas later in het proces worden besproken. Dit knelpunt wordt behandeld in Hoofdstuk 3.1.
- Burgerparticipatie en bezwaarprocedures zijn wettelijk noodzakelijk, maar structureel ongeorganiseerd, wat zorgt voor de grootste onvoorspelbaarheid in de planfase. Participatieprocessen moet beter gestructureerd, traceerbaar en in balans zijn met de urgentie van woningbouw. Dit knelpunt wordt besproken in Hoofdstuk 3.5.
- Veel gemeentelijke knelpunten komen voort uit structureel onderbezette gemeenten. Er is een tekort aan personeel, expertise en hulpmiddelen om de planfase efficiënt te managen. Zonder structurele ondersteuning of gedeelde capaciteitsmodellen blijven deze problemen bestaan. Dit wordt besproken in Hoofdstuk 3.2 & 3.3.
- Veel oplossingsrichtingen zijn al in gang gezet door verschillende partijen, maar zijn nog niet opgeschaald of structureel ingebed. Initiatieven als Parallel Plannen, De Bouwstroom en Shared Expertise Pools zijn veelbelovend, maar worden vaak fragmentarisch, als pilot of niet-institutioneel toegepast. Het versnellen en opschalen van deze initiatieven is belangrijk. De bestaande oplossingsrichtingen worden besproken in Hoofdstuk 4.
- Wat ontbreekt is een samenhangend, geïntegreerd model voor een vernieuwd planproces. Er is geen overkoepelende visie op hoe verschillende oplossingsrichtingen samen kunnen komen in een “nieuwe” planfase, die korter (bijv. 2–3 jaar) en voorspelbaar is, door middel van conceptuele en industriële woningbouw. Het ontwikkelen van zo’n model is essentieel voor het realiseren van systeemimpact.
- Opschaling van conceptueel en industrieel bouwen vereist ook een cultuurverandering. De bouwsector is nog sterk gericht op maatwerk (engineer-to-order). Voor de benodigde herhaalbaarheid is een verschuiving nodig naar functioneel specificeren en prestatie-eisen, in plaats van technische details. Dit vraagt om een mentaliteitsverandering bij opdrachtgevers en bouwers.

# Introduction

*Problem Statement*

The Netherlands is facing an escalating housing shortage[6]. In 2022, the national target was set to deliver 900,000 new homes by 2030. As of 2023, this target has risen to 981,000 homes in response to growing demand. We are currently experiencing a housing deficit of 451,000 homes[7], and the consequences are visible in the market and society. Between Q4 of 2019 and Q4 of 2024, the average house price increased from €312,871 to €461,797[8], making homeownership increasingly out of reach for many. Besides, also rental prices increased significantly[9].

One of the most promising responses to this challenge is **conceptual and industrialised (C&I) construction.** We've experienced that the terms; industrialised building, systems building, rationalized building, modern methods of construction (MMC), advanced building construction (ABC) are used amongst others[10]. In this report we use the term **Industrialised Construction** (IC) meaning; A form of construction that utilizes processes and technologies typical of industrial manufacturing. Besides, we use the term **conceptual** referring to the use of product platforms as "a set of subsystems and interfaces that form a common structure from which a stream of derivative products can be efficiently developed and produced" [2].

Which is about making the shift away from ETO (Engineer-to-Order) products towards ATO and CTO products (Assemble-to-Order, Configure-to-Order), allowing standardization in terms of product, processes, value chains and information and therefore the ability to learn over projects.

Off-site industrialised builders in the Netherlands have developed the capacity to deliver a substantial share of the required homes. Research shows that the industry should have the capacity to build 37.000 prefab homes yearly with the possibility to scale to another 19.000 houses when adding extra shifts [1]. Through standardisation, repeatability, and off-site production, these builders can deliver housing faster, more efficiently, and at scale. Yet this capacity remains largely underutilised. Yet, merely 14.300 houses, a 21% share in all residential new build in 2024 was realised through industrialised methods [1].

The issue lies not in the construction phases, but in the long, complex, and unpredictable planning phase that precedes construction, see Figure 2. Conceptual and industrialised construction practices require stability and predictability to plan and scale production effectively. Yet, today's planning procedures are fragmented, inconsistent across regions, and subject to numerous delays.

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[6] Woningbouwopgave stijgt naar 981.000 tot en met 2030 | Nieuwsbericht | Rijksoverheid.nl
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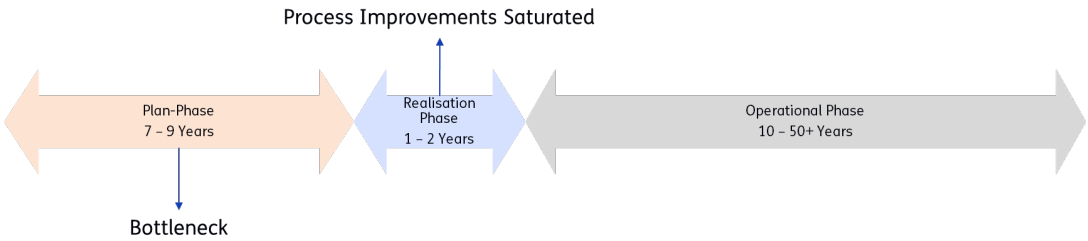


Figure 2. Project timeline

To achieve the full potential of conceptual and industrialised construction and enable builders in the Netherlands to contribute meaningfully to the national housing challenge, there is an urgent need to stabilise and shorten the planning phase. This study is intended to initiate development in this direction.

This paper presents the results of a study aimed at identifying the key bottlenecks in the current planning process and analysing the existing solution directions being explored in practice. Based on this analysis, we also outline areas of innovation required to create a planning process that supports faster, more predictable, and more scalable housing development, such that the capacity of conceptual and industrialised builders can be fully activated in addressing the Netherlands' housing crisis.

*Main Research Question*

This study aims to answer the following question:

> *What are the key challenges and bottlenecks affecting the timeline, predictability, and continuity of the planning phase in urban development and (conceptual and industrialised) construction projects in the Netherlands, and what solution directions and initiatives exist to address them?*

*Approach*

To identify the bottlenecks in the planning phase and map existing solution directions, we conducted 16 in-depth interviews with a diverse set of stakeholders, including developers, municipal planners, policymakers, and industry experts (List of interviewees in Appendix A). In addition to these interviews, we carried out document analysis which included industry reports, news articles, and scientific papers which can be found in Appendix C. The initial findings were then tested and refined through validation interviews. Finally, this present report was subject to reviews by industry experts (Appendix B).

*Key Conclusions and Reading Guide*

The list below summarizes the main findings and conclusions from this study:

- The greatest delays in housing delivery are not caused by construction limitations but by the prolonged and unpredictable planning phase. Activities in the initiation and feasibility stages are fragmented, iterative, and often stalled due to policy uncertainty, capacity shortages, and unstructured coordination processes. The structure of and the activities in the plan phase is described in Chapter 2.
- Stabilising the planning phase is a necessary precondition for meeting national housing targets. Although (conceptual and) industrial builders in the Netherlands have the capacity to contribute to the housing targets at scale, this potential will remain untapped unless the planning process becomes significantly more predictable, transparent, and efficient.
- Most of the bottlenecks identified in the planning phase are interrelated, structural, and systemic. The root causes of the majority of the bottlenecks are fragmented responsibilities, unclear requirements and regulations, capacity shortages in municipalities

and provinces, and misaligned stakeholder expectations. All the bottlenecks identified, and root causes of each bottleneck is discussed in Chapter 3.

- Developers increasingly show reluctance to initiate new construction projects due to challenges in formulating viable business cases. The financial feasibility of projects is often undermined by a lack of early transparency around cost-driving requirements such as infrastructure upgrades, sustainability ambitions, and social housing quotas, which are typically negotiated later in the process. Delays and constant changes in financial assessments because of this and fragmented policy signals create uncertainty, slowing down the initiation of new developments. This bottleneck is discussed in Chapter 3.1.
- Citizen participation and objection procedures remain legally necessary but structurally unorganised, causing the highest degree of unpredictability in the planning phase. While public participation is essential, the lack of clear frameworks and rules for how and when stakeholders can object creates major delays. Participation needs to be better structured, traceable, and balanced against the urgency of housing delivery. This bottleneck is discussed in Chapter 3.5.
- Many of the municipal bottlenecks stem from the fact that municipalities in the Netherlands are structurally under-resourced. Many municipalities lack the staff, expertise, and tools to manage plan-phase processes efficiently. This contributes to delays in policy-making, assessments, permitting, and coordination with other government layers. Without structural support or shared capacity models, these issues will persist. This is discussed in Chapter 3.2 & 3.3.
- Many solution directions to address some of these bottlenecks are initiated by various industry stakeholders, but are not yet scaled or structurally embedded. Promising initiatives like Parallel Plannen, De Bouwstroom, and Shared Expertise Pools, amongst others, are already underway. However, their application is often fragmented, pilot-based, or not institutionalised. Accelerating and scaling these efforts by addressing their limitations are important. The existing solution directions are discussed in Chapter 4.
- What is missing is a cohesive, integrated model for a reimagined planning process. The current landscape lacks a comprehensive vision for how various solution directions can come together into a “new” planning phase, one that is shorter (e.g. 2–3 years), predictable, by means of conceptual and industrialised housing delivery. Developing such a model is critical to scaling systemic impact. The benefits of conceptual and industrialised construction are still largely viewed through the lens of reduced on-site construction time and modest savings in engineering effort. However, a much broader potential emerges when housing concepts are treated as configurable products. This approach enables early testing, visualisation, and optimisation of design choices—including their implications for energy use, mobility, and environmental performance. Realising these benefits, however, depends on having design and permitting processes that support standardisation and reusability.
- Scaling up conceptual and industrial construction also requires a cultural shift. The construction ecosystem remains rooted in bespoke, engineer-to-order processes. Achieving the repeatability needed for industrialisation demands a transition toward functional requirement-driven procurement. This, in turn, calls for a mindset shift amongst the construction clients (developers and municipalities), who are still accustomed to specifying exactly what they want from a technical perspective, rather than allowing flexibility within standardised solutions.

# 2 The plan-phase of residential development projects

The planning phase of housing construction encompasses all phases and activities leading up to the start of physical construction. In this chapter, we take a deep dive into the processes and activities that make up this phase. In the Netherlands, this phase is often complex and ambiguous due to the involvement of numerous key stakeholders with overlapping and sometimes conflicting priorities. As a result, there is no single, well-defined process that applies universally. However, drawing from existing knowledge and the work of Bouwlab[11] , we can outline the key activities that typically take place during this phase. These activities primarily fall into two sub-phases: the initiation sub-phase and the feasibility sub-phase. The activities within these sub-phases are briefly described in the following chapters.

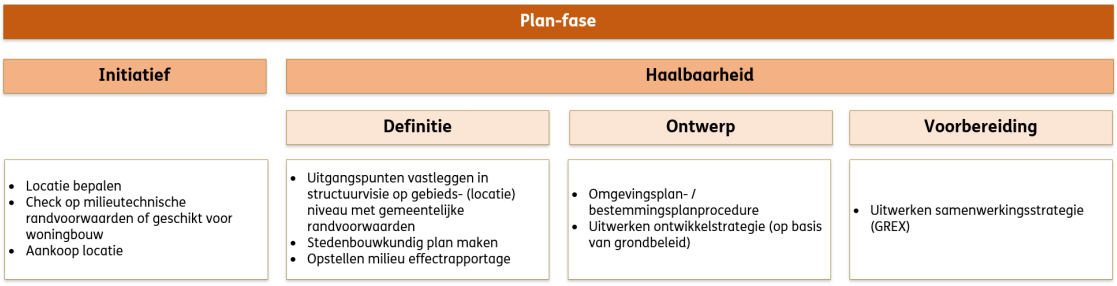


Figure 3 Key phases and activities in the plan-phase, from Bouwlab

## 2.1 Initiation Phase

To initiate the realisation phase of any project, it is first necessary to establish its scope and viability. This is the primary focus of the initiation phase, and involves several required key activities for the same, such as identifying and securing suitable locations, and evaluating financial, environmental, and technical preconditions.

The initiation phase can be triggered in different ways, including market-driven initiatives, unsolicited proposals from private entities, provincial or municipal coalition programs, or specific policy decisions. The activities in this phase are dependent on the way of this initial trigger and the land ownership of the to-be site, resulting in a process that is inherently flexible rather than linear. Despite ongoing legislative efforts to streamline procedures, the initiation phase often involves intricate and sometimes lengthy sub-processes inherent to the specific conditions of each project.

[11] Not officially published at the point of writing this report. Part of VNG, Bouwlab study…

A critical aspect of this phase is land identification and acquisition. This in itself is one of the most time-consuming activities in the plan phase. Once a location is identified, a series of quick scans follow, including an analysis of social priorities and corresponding solution directions, topographical and environmental aspects, legal aspects, and an evaluation of potential collaboration opportunities based on land policy and market conditions.

Another important activity (either in parallel or sequential to the quick scans) is researching the financial feasibility of the project and establishing the means for the same. In parallel, an exploration of key actors and stakeholders is necessary. For example, potential changes in mobility and energy infrastructure must be required for the project, and initial discussions with relevant stakeholders should take place to assess the project's viability.

Ultimately, the initiation phase concludes with intention agreements and an action plan for the next steps. For municipalities, this means formulating an urbanisation strategy and defining a land policy to support future project development. For developers, this means establishing commitments and agreements for the subsequent phases.

## 2.2 Feasibility Phase

The primary objective of the feasibility phase is to transform the strategic plans developed in the Initiation Phase into concrete, feasible, and actionable project plans and agreements. This phase involves dealing with a complex landscape of stakeholders and their diverse interests (as in any other phase, for that matter), and adhering to multiple legal frameworks. It consists of three key sub-phases: Definition, Design, and Preparation.

*Definition*
The Definition Phase focuses on establishing the project scope, including its intended use, size, and preliminary design concepts. In this phase, urban planning concepts are developed, eventually leading to detailed urban development plans. These plans are typically prepared by (landscape and housing) architects, either hired by the municipality or by private developers. In this phase, market research is conducted to determine the most suitable housing types, ensuring alignment with the needs of future residents. Ideally, architects already incorporate industrial housing concepts—this is especially the case in integrated developments, but not always the case. In addition to residential planning, this phase also includes the concept design of public spaces, such as road networks, public amenities, and green areas.

Next, detailed feasibility assessments are carried out to evaluate the technical, financial, and environmental aspects of the project designs. These assessments go beyond the quick scans performed earlier in the Initiation Phase, providing in-depth insights into project feasibility. Furthermore, environmental impact assessments are legally mandated to ensure that new developments integrate with and do not disrupt existing ecosystems. Risk analyses are also conducted at this stage to identify potential project vulnerabilities.

Active engagement with stakeholders, including residents, businesses, and local organisations, is another legally required activity in this phase.

This sub-phase produces several critical outputs, including governmental policies that provide clear guidelines for future developments, land use and real estate development strategies, detailed environmental impact reports, tender agreements for contractors and developers,

and advisory plans addressing essential aspects such as water management, green spaces, and climate resilience strategies.

*Design*
The Design Phase follows, focusing on translating conceptual ideas into definitive, detailed designs developed by the various stakeholders involved. During this phase, detailed design specifications are gathered from different parties, and technical designs are made based on these requirements. The design process remains dynamic, often involving multiple iterations with stakeholder revisions, in some cases, changes in project actors and requirements.

Once the design is sufficiently developed, the permit procedures begin. These procedures can take different trajectories and timespans depending on various conditions, such as zoning regulations, environmental constraints, and stakeholder agreements. The approval process may require adjustments to the design to comply with legal and technical requirements, further contributing to the unpredictable nature of this phase.

The final deliverables from the Design Phase include detailed project designs from the market party, urban development blueprints from the local authority, which include finalised public space plans, necessary regulatory permits, formal cooperation agreements, and planning for realisation.

*Preparation*
The public amenities and utilities also have to be developed alongside the housing buildings. The preparation phase is to ensure this. This phase focuses on finalising cooperation strategies, regulatory approvals, and contractual agreements necessary for construction to begin on the public spaces and utilities. A key activity is the development of a cooperation strategy (GREX), which involves selecting the most suitable development model from six predefined options. The choice of development model significantly influences the governance, financial structure, and risk-sharing mechanisms of the project. Common models include public area development following the traditional approach, public area development using the building claim model, public-private area development through joint ventures, private area development, and private area development through a concession model initiated by governmental authorities (integrale ontwikkeling op overheidsinitiatief).

Deliverables from the Preparation Phase ensure that all necessary legal, financial, and logistical elements are in place before construction begins. These include detailed realisation plans from market parties, finalised building designs, the governmental preparation of tender documents, secured environmental permits, purchase agreements, and final contracts. The tender procedure (for the public spaces) then follows.

# 3 Bottlenecks in the plan-phase

The plan phase of housing development described in the previous chapter is where ambitions are translated into actionable plans. In practice, many housing projects in the Netherlands remain stuck or get considerably slowed down in this early phase due to a complex web of interrelated bottlenecks. This chapter explores the key bottlenecks that contribute to the long and unpredictable nature of the plan phase. Some problems stem from outdated procedures or fragmented responsibilities, while others reflect deeper structural limitations in how we plan, govern, and prepare for housing development. Through a closer look at each bottleneck and its underlying causes, this chapter aims to provide a clearer understanding of where and why the plan phase gets delayed, and what systemic conditions must be addressed to enable faster, more predictable, and more scalable housing development. The following chapters describe each bottleneck and results of a root cause analysis. The bottlenecks described below are not organised based on importance, but based on the process.

## 3.1 Closing the Financial Business Case for Developers and Investors

Bottleneck #1 in the plan phase of housing construction is that closing the business case for developers and investors takes considerable time. On one hand, the capital investment required for housing development is very high because of various reasons. On the other hand, simply getting the complete financial picture and justifying the high investments in the business case is becoming increasingly difficult. The root cause analysis is shown in Figure 4.

High land prices driven by limited availability of developable locations and rising costs of building materials significantly increase the required upfront investment for residential development projects. At the same time, the financial burden on investors is increasing as the costs of developing urban areas are increasingly being shifted to private parties. This shift is mainly due to the cuts to municipal financial resources, such as reductions in bouwimpuls[12], limiting public sector support for new developments.

But the challenge lies not only in the high capital investment; simply understanding the full financial picture demands significant time and effort from investors. Gaining this clarity is time-consuming because developers must navigate an accumulation of requirements, which stem from unclear, complex, and restrictive urban planning policies of municipalities. These requirements are often not transparently defined at the outset (see also bottleneck #2, see Figure 5). Developers must negotiate specifics like the quality or the percentage of social housing with the municipalities during the planning phase, which directly affects revenue models and the resultant business case.

[12] Woningbouwimpuls (WBI) | RVO

The financial picture is further complicated by broader systemic challenges. The Netherlands is in the midst of an energy transition, and developers are expected to plan for new energy infrastructures while also dealing with net congestion, which limits the availability of power capacity in certain regions. Mobility infrastructure transitions must also be factored in, with developers needing to anticipate traffic impacts, plan for public transport integration, and also design for transitions such as fewer cars and electric vehicle infrastructure (which in turn affects the energy infrastructure). For both of these, the developers need to coordinate with other stakeholders.

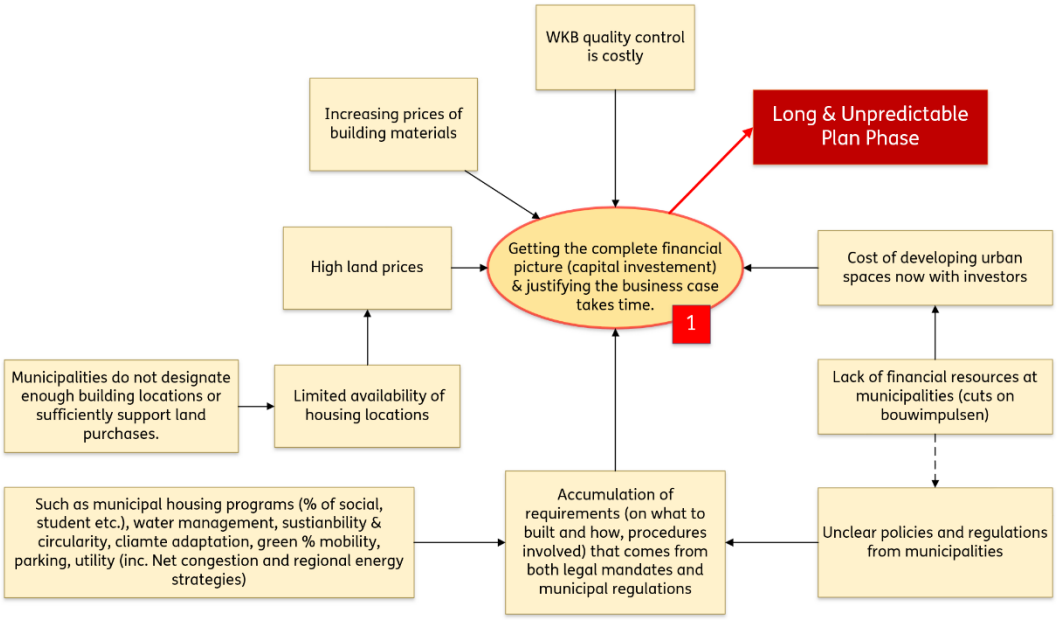


Figure 4. Root cause analysis for the bottleneck 'closing the financial business case'

And in the design itself, a long list of functional, performance, and environmental requirements must be addressed. These include water management (such as drainage, flood control, and water retention), climate adaptation, minimum percentages of green space and parking spaces, etc. These requirements are not defined upfront but are clarified only through consultations with the municipality and other authorities (province, waterboards) during the development process, meaning investors do not have a complete financial picture from the outset. Each of these elements carries cost implications and design constraints, and collectively, they create a highly fragmented and interdependent planning environment that is difficult to model financially in the early stages of a project.

As a result, closing the business case becomes a drawn-out, uncertain, and iterative process, particularly for larger developments. Without a clear financial foundation, lots of projects stall in the planning phase.

## 3.2 Complex Policy Making and Policy Changing Procedures at Municipalities

Municipalities are expected to have a well-defined housing vision and program that guides development, but in practice, many municipalities lack this. This creates uncertainty for developers as, first, the policy-making process becomes part of the project development process,

and second, policies that determine project feasibility may shift during the planning phase, forcing revisions, delays, or even project cancellations. This issue here is the complex and time-consuming nature of policy-making and policy changes within municipalities (bottleneck #2, Figure 5). The process of defining or updating policies, such as the zoning plan (bestemmingsplan), which is replaced by the integrated environmental plan (omgevingsplan)[13], is highly intricate, bureaucratic, and slow, because of its sequential, waterfall nature and contradicting interest [3].

These policies are meant to integrate input from multiple domains and stakeholders, but the sequential (waterfall) approach taken at the policy level makes this integration challenging and drawn out. Because policies are developed and revised in stages rather than through a more integrated process, municipalities often struggle to keep up with the conflicting and overlapping needs of the involved stakeholders (for instance, utility providers, water boards, the province, and mobility).

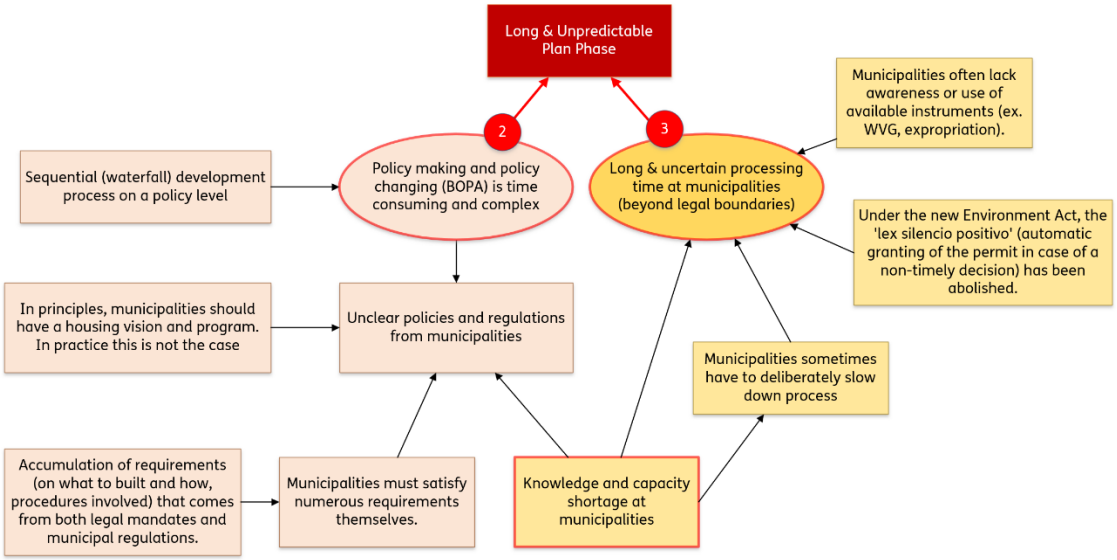


Figure 5. Root cause analysis of municipal bottlenecks (2) ‘Complex Policy Making and Policy Changing Processes at Municipalities', and (3) ‘Long Project Processing Time in Municipalities'

A lot of the issues in this bottleneck can be traced to the fact that municipal governments themselves are facing an acute capacity and knowledge shortage, making it even more difficult for them to streamline and accelerate policy-making. As a consequence, developers are forced to navigate an unpredictable and fragmented regulatory and requirement landscape during the project phase, which otherwise should have been made clear in the policies.

## 3.3 Long and uncertain processing times at municipalities (beyond legal boundaries)

The long and uncertain processing times related to projects (and not policies) at municipalities, which extend beyond legal boundaries (bottleneck #3, Figure 5), further complicate the already inefficient communication between municipalities and developers. Previously, municipalities were legally required to complete permit procedures within a set timeframe, failing

[13] https://iplo.nl/regelgeving/instrumenten/omgevingsplan/omgevingsplan-rechtswege/

which the permit would be automatically granted (Vergunningverlening van rechtswege). However, with the introduction of the Omgevingswet, this automatic approval no longer applies. While the Omgevingswet stipulates a permit period of 8 weeks, a permit is not automatically granted if this timeline is exceeded. Instead, developers now have the option to take legal action against municipalities if the permit process takes too long. In practice, however, few developers choose to sue municipalities, as doing so could strain their working relationships and create additional obstacles for their projects.

Again, as with the previous bottleneck (#2), at the core of this issue is the severe shortage of knowledge and capacity within municipalities (see Figure 5). Many municipalities lack the expertise, resources, and skilled personnel required to efficiently handle construction processes and permit applications, leading to significant delays. With limited staff available to manage an increasing number of projects, the process slows down considerably, and sometimes some projects are intentionally slowed down to relieve pressure. Municipalities are forced to prioritise certain projects over others, creating long queues and uncertainty for some developers. The shortage of knowledge and capacity at the municipal level creates further misalignment with provincial authorities, as it is noted that the municipalities struggle to keep up with planning requirements, environmental regulations, and procedural changes from the provinces.

## 3.4 Additional Assessments and Design Iterations Driven by Local and Provincial Policies

Bottleneck #4 originates from the lack of clear and consistent policies in housing development means that there are no set requirements on where to build what and how much. Since municipalities and developers must navigate an intricate web of legal, environmental, and spatial planning requirements without a unified framework, they are often required to conduct extensive preliminary research to justify and refine their proposals on a project level. Ideally, this should be done on a policy level and driven by municipalities or other authorities, but rather, now this is part of project development and the responsibility of developers. The root cause analysis is given in Figure 6.

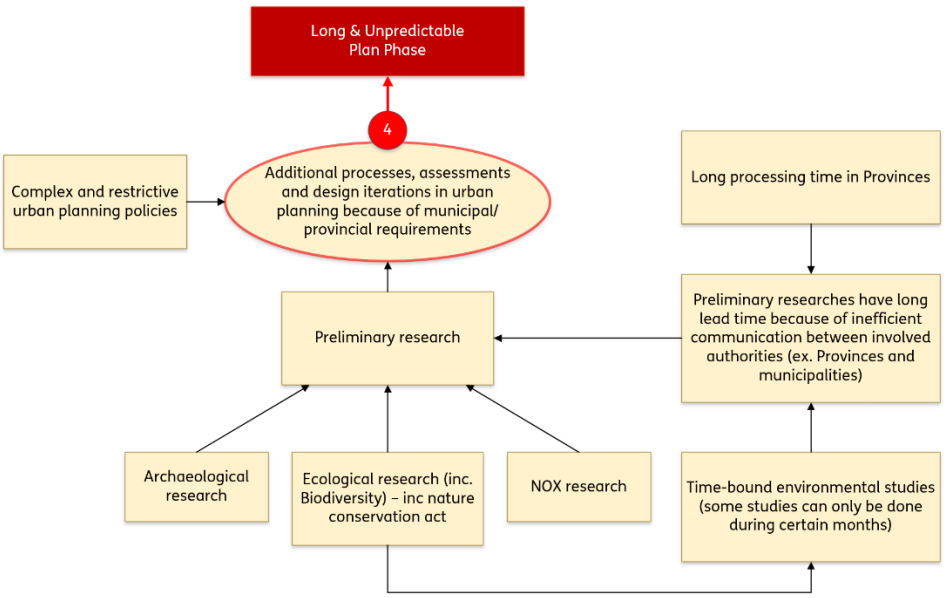


Figure 6. Root cause analysis of bottleneck 'Additional Assessments and Design Iterations Driven by Local and Provincial Policies'

These assessments cover various design aspects, such as energy and mobility networks, required green spaces, and sometimes archaeological research in relevant areas. Then there are also the assessments on environmental aspects such as ecological and biodiversity studies (aligned with the Nature Conservation Act), and NOx emissions research. These regulations are controlled by the province, meaning the municipalities have to coordinate with the province. This communication is often inefficient. Municipalities, provinces, and developers often struggle to coordinate assessment procedures, leading to long lead times before approvals are granted. Processing times in provinces can be extensive, particularly when responsibilities between municipalities and provincial authorities are not clearly defined.

Additionally, some environmental studies are time-sensitive, meaning they can only be conducted during certain months of the year. Biodiversity research, for instance, may require monitoring species during specific seasons, causing unavoidable delays when project timelines do not align with assessment windows, or when this is not known upfront.

## 3.5 Citizen Participation and Objection Procedures

The long and unpredictable plan phase is further complicated by citizen participation and objection procedures (bottleneck #5), which are often unstructured and prolonged. While citizen involvement is essential in urban planning, the absence of clear frameworks for both participation and objections creates significant delays and uncertainty (Figure 7). As a result, participation often becomes uncoordinated and repetitive, requiring the same discussions to take place multiple times and settings. This leads to double work for municipalities and developers, further slowing down project approvals.

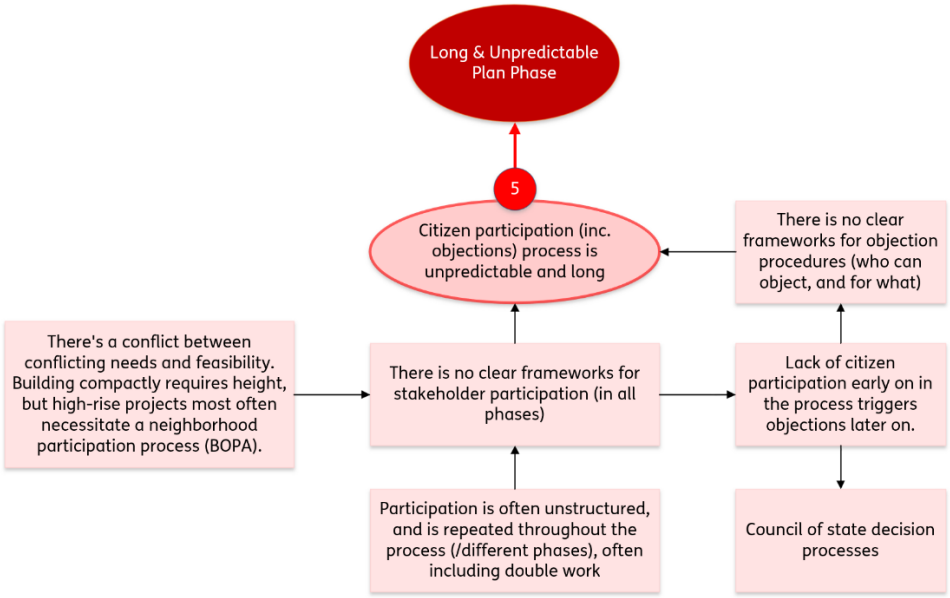


Figure 7. Root cause analysis of bottleneck 'Citizen Participation and Objection Procedures'

Citizen participation is triggered either when policy changes are required or through objection procedures. There are often conflicts between urban development needs and local citizens' needs. For example, building compactly to optimise land use often requires high-rise construction, but such projects frequently require policy changes, which require neighbourhood participation requirements under BOPA procedures. In numbers, one-third of all the houses built are delayed directly or indirectly through objection procedures. In two-thirds of the cases, it was a waste of time to go to the highest administrative court, and if local residents take legal action against housing projects, the 'unfounded' percentage is even higher at 73 per cent [4].

The absence of a structured framework for citizen participation often leaves residents feeling excluded from decision-making, which in turn triggers numerous objection procedures that add further complexity to the process. Additionally, there are no clear guidelines outlining who is entitled to lodge objections, the legitimate grounds for doing so, or the procedures for managing these objections. This ambiguity leads to protracted and frequently contentious legal disputes, with some cases escalating all the way to the Council of State, resulting in even greater delays during the planning phase.

## 3.6 Unstructured Design Iterations

A persistent bottleneck (#6) in the design phase is the unstructured design iterations due to the presence of many communication lines between stakeholders. This leads to rework and coordination delays, contributing to the length of the plan phase. A root cause analysis is given in Figure 8.

One of the core reasons for this is that critical context information is not readily available or accessible at the start of the design process. For example, information about existing utility networks, energy grids, infrastructure assets, and geoinformation about subsurface conditions (i.e. all the information required to set the context[14]) is often missing, outdated, or

[14] Het NCB | conceptueelbouwen.nl | Begrippen Conceptueel Bouwen | Innoveren en dezelfde taal spreken

unclear. Municipalities themselves frequently lack accurate data about their own assets or the condition of surrounding areas. As a result, developers must gather this information on a case-by-case basis, delaying design, creating uncertainty, and opening the door to differing interpretations.

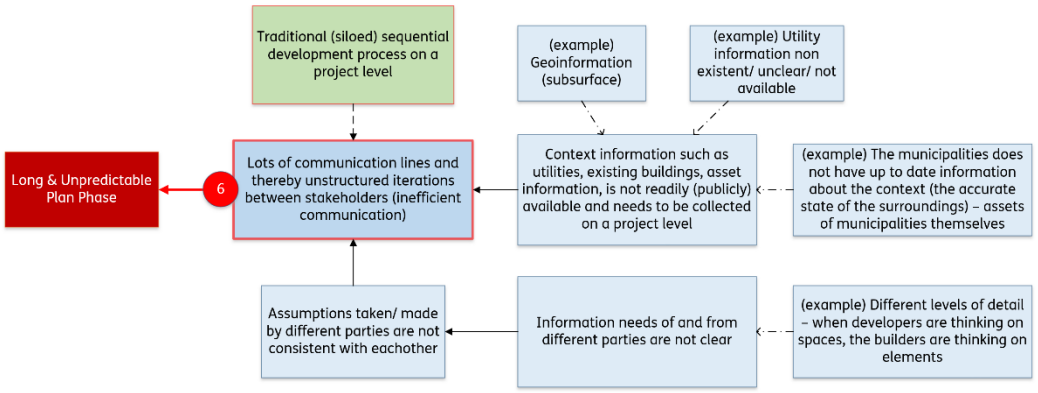


Figure 8. Root cause analysis of bottleneck 'Unstructured Design Iterations'

Another reason for these unstructured iterations is that the information needs of and from different parties are not clearly defined. This, in turn, leads to inconsistent assumptions being made by the different stakeholders involved. Because these expectations are rarely aligned up front, assumptions made by one party often clash with the expectations of another, resulting in repeated iterations to resolve discrepancies that could have been avoided with clearer alignment. Some respondents observed a general reluctance among contractors and suppliers to disclose product information at an early stage. This dynamic creates a feedback loop where parties' express frustration that essential information is withheld, while they often fail to specify clearly what information is required and at which point in the process it is needed. The lack of shared understanding, combined with fragmented or unavailable project context data, creates a design process that is inefficient, iterative, and prone to miscommunication. Another key reason for unstructured design iterations is the traditional, siloed, and sequential project development process, which is elaborated in §3.9.

## 3.7 Extra Handling due to Incompatibility Between Market and Government Systems

Another factor adding inefficiencies to the plan phase is the incompatibility between market and government systems, leading to extra handling, intermediary systems, and non-value-adding work (bottleneck #7, Figure 9). For example, while the market widely uses BIM, many municipalities do not, making data exchange and workflow automation difficult or impossible.

This misalignment forces stakeholders to manually adjust and translate information between systems, increasing the risk of errors, miscommunication, and delays. An option to resolve it is the new DSGO (Digitaal Stelsel Gebouwde Omgeving) agreements, but they are not yet operational. As a result, these workflow inefficiencies introduce unnecessary administrative burdens, slowing down processes and increasing uncertainty.

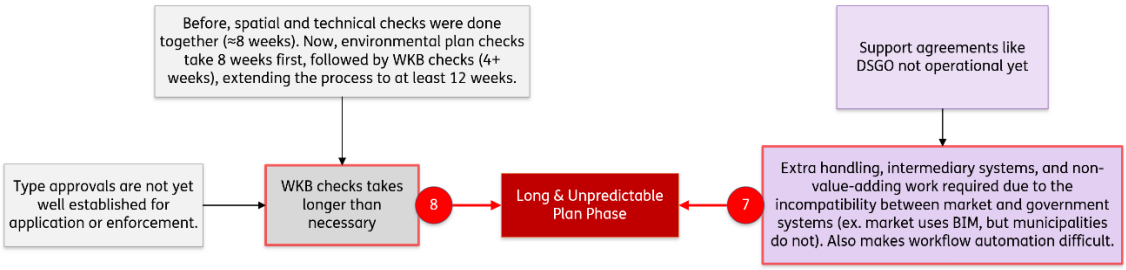


Figure 9. Root cause analysis bottlenecks (7) 'Extra Handling due to Incompatibility Between Market and Government Systems' and (8) 'Delays in WkB Checks'

## 3.8 Delays in Wkb Checks

Bottleneck #8 in the plan phase is the extended duration of Wkb (Wet Kwaliteitsborging) checks, which take longer than necessary and add further delays to project timelines. Previously, spatial and technical checks were conducted together, taking around 8 weeks. However, under the current system, environmental plan checks now take 8 weeks first, followed by WKB checks, which take at least an additional 4 weeks. This sequential approach has extended the overall process to at least 12 weeks (or more), further prolonging project approvals.

A contributing factor to these delays is that type approvals for (modular) construction concepts are not yet well established for application or enforcement (see Figure 9). Without this, additional case-by-case assessments are required even if standard concepts are used.

## 3.9 Persistent Siloed and Sequential Project Development Process (General)

Many of the integration and coordination issues between stakeholders stem from the way projects are still organised; in siloed, sequential processes. This approach, where the processes and stakeholders of each phase are isolated from the next, limits collaboration and makes it difficult to align different stakeholder expectations. Conceptual and industrialised construction is intended to solve this issue, but it is not entirely used to its full potential. Here, we conducted a root cause analysis to understand the underutilisation of conceptual and industrial construction, which leads to siloed, sequential project development processes and, in turn, to a long and unpredictable planning phase (bottleneck #9, see Figure 10).

Utilising the benefits of conceptual and industrial construction depends on the use of standardized products, processes, and supply chains offered by modular concept builders. However, constant variations in demand lead to deviations from the existing Product-Market Combinations (PMCs) of these builders. As a result, each project ends up requiring custom adjustments, ultimately resembling a traditional construction process rather than a conceptual and industrialised one.

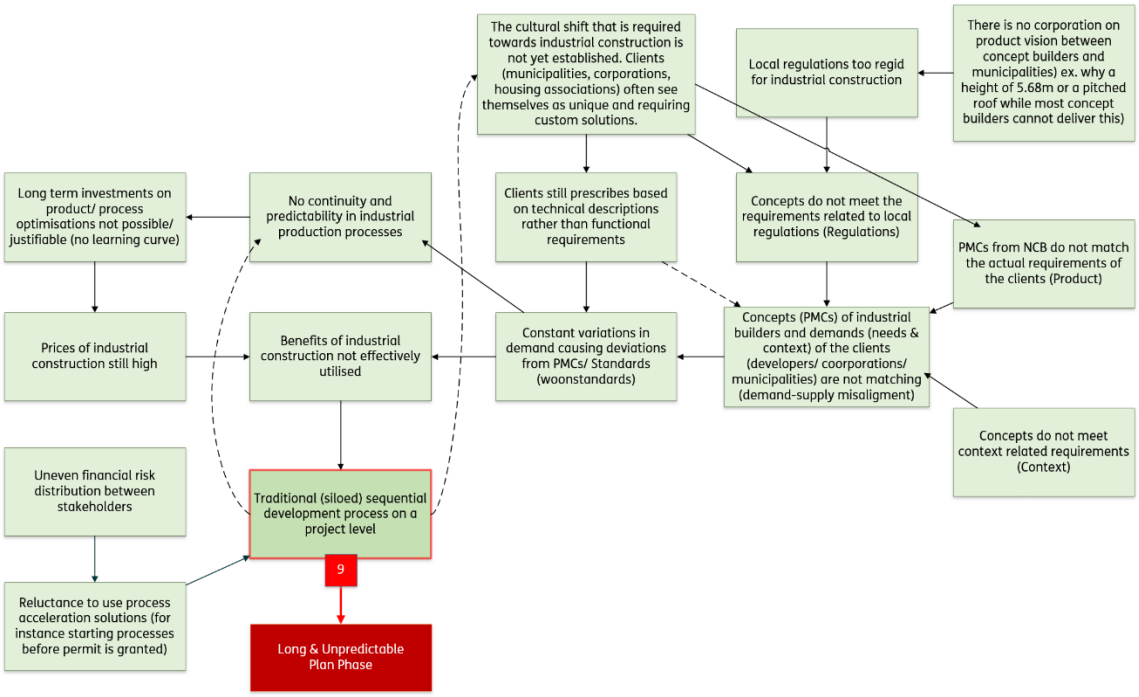


Figure 10. Root cause analysis 'Persistent Siloed and Sequential Project Development Process'

This constant variation in demand is primarily due to a misalignment between demand (clients) and supply (the market). This misalignment has two sides. On one hand, clients (developers, corporations, and municipalities) argue that existing modular construction concepts do not meet their specific needs. For example, local regulations, such as building height restrictions, can vary between municipalities, making it difficult to apply a standard modular concept across different locations. Additionally, contextual factors, like available energy options or environmental requirements, may call for solutions that standard concepts cannot easily accommodate. Clients also frequently point out that standardised floor plan designs do not align with their requirements, further contributing to the demand for customisation.

On the other hand, conceptual construction suppliers struggle with how client requirements are defined. Clients still prescribe based on technical descriptions rather than functional requirements, making it difficult for (modular) housing concepts to be efficiently implemented. Unlike traditional construction, where everything can be custom-built, conceptual and industrial construction requires design choices at a functional level rather than at the technical specification level. Further, there is little to no cooperation on product vision between concept builders and municipalities, complicating the possibilities of arriving at solutions that do not require much customisation. In addition, the municipal requirements are often too rigid to allow for standard designs.

This challenge is largely cultural, as construction clients are used to full customisation and defining their requirements in technical terms, rather than allowing for flexibility in standardised solutions.

The result of this demand-supply misalignment is a lack of continuity and predictability in industrial production processes. Since each project requires unique adaptations, stable investment in standard product or process optimisation becomes unfeasible. Without a learning curve, conceptual and industrial construction does not always become cheaper than traditional construction, which is further positioned as a reason by developers not to opt for such solutions.

## 3.10 Conclusions and Priorities

An overview of the bottlenecks is listed below:

1. Closing the Financial Business Case for Developers and Investors.
2. Complex Policy Making and Policy Changing Procedures at Municipalities.
3. Long and uncertain processing times at municipalities (beyond legal boundaries).
4. Additional Assessments and Design Iterations Driven by Local and Provincial Policies.
5. Citizen Participation and Objection Procedures.
6. Unstructured Design Iterations.
7. Extra Handling due to Incompatibility Between Market and Government Systems.
8. Delays in Wkb Checks.
9. Persistent Siloed and Sequential Project Development Process (General).

The bottlenecks identified in the plan phase of housing development reveal an interconnected problem space where outdated procedures, fragmented responsibilities, unclear frameworks, and capacity shortages create long and unpredictable delays. While each bottleneck has its own dynamics and root causes, together they form a complex web that limits the speed and predictability of housing development in the Netherlands. Thus, addressing these bottlenecks together is important. However, we have to start somewhere. The interviewees of this study identified the following bottlenecks with the highest immediate priorities for change.

The first is bottleneck #2, complex policy-making and policy-changing processes at municipalities. To note that this bottleneck is prioritised alongside the long processing time at municipalities (bottleneck #3). While participants frequently mentioned the policy process, it is mentioned in conjunction to the long processing times. Interviewees emphasised that this bottleneck blocks progress at a fundamental level because many municipalities lack the capacity, expertise, and clarity to develop integrated policies upfront. As a result, policy-making becomes intertwined with individual projects, creating unpredictable shifts and delays. Interviewees stressed the need for accelerating policy development, improving execution capacity, and creating more consistent and standardised frameworks across municipalities, so that developers can operate in a clearer and more predictable environment.

The second is bottleneck #5, citizen participation and objection procedures. While the importance of public involvement is widely recognised, interviewees noted that current processes are unstructured and lack clear boundaries. This often leaves residents feeling excluded, which in turn fuels objections. The result is repetitive rounds of input, uncoordinated dialogues, and objections that delay or derail projects even when they lack legal standing. To avoid these repetitions, there is an urgent need to structure participation more clearly, define proper procedures for both participation and objections, and ensure that engagement genuinely strengthens projects rather than stalls them.

Third, bottleneck #1, closing the financial business case for developers and investors, is critical to be dealt with, simply for the fact that without a solid financial foundation, projects cannot move forward. Interviewees highlighted that developers already face rising land and material costs, and having to navigate additional factors that increase upfront risk, such as

complex energy and mobility requirements and unclear municipal demands, makes the sector increasingly unattractive to invest in. Faster and clearer financial structuring, including government support, exemptions, or simplified requirements, is seen as essential to keeping projects financially viable and moving them out of the planning phase.

Finally, the persistent bottleneck #9, siloed and sequential project development processes, is recognised as a general bottleneck underlying many of the others. This bottleneck was prioritised because interviewees see conceptual, industrialised, and parallel approaches as key ways to reduce delays and improve efficiency. They highlighted that enabling fast-track procedures, type approvals, and better alignment between conceptual builders and municipalities could create major gains in speed and predictability.

Reflecting on these findings, it becomes clear that tackling the bottlenecks of the plan phase is not just a matter of fixing technical issues or tweaking isolated procedures, it’s about shifting the way we work together across government, developers, and society. What stood out to us in the conversations with stakeholders was the shared sense of urgency and frustration, but also a strong belief that change is possible if we choose the right starting points and if the right support is received.

# 4 Solution directions

The previous chapter discussed the bottlenecks that we encounter in the plan-phase of residential development projects. This chapter highlights several solution directions and existing initiatives that we identified to cope with the bottlenecks described in the previous chapter.

Each of these solution directions and existing initiatives within each solution are briefly described in the following chapters. Additionally, the solution directions are mapped to one or several bottlenecks.

## 4.1 Redesigning the Urban Development Processes

A major cause of delay in the planning phase is the fragmented and sequential nature of the (urban) development process (bottleneck #9). Development today is often characterised by horizontal fragmentation across stakeholders and vertical fragmentation across project phases [5]. As a result, activities that could potentially be aligned and executed in parallel are instead handled sequentially, leading to long lead times and unpredictability. In addition, traditional procurement approaches focused on bespoke, project-specific designs limit the potential for conceptual construction at scale. Addressing these challenges requires a redesign of both the planning process and the way projects are procured.

Significant time savings can be realised by reorganising the planning process, involving all key stakeholders early on, and ensuring that decisions across different steps are aligned from the start. Applying methodologies from process optimisation approaches such as LEAN makes it possible to run multiple planning steps simultaneously, rather than following the traditional waterfall model. This shift would allow for faster development cycles and greater predictability across the plan phase.

In addition, creating more transparency in the planning process is critical. Improving insight into project pipelines, where projects are in the process, what decisions are pending, and who is responsible, can help stakeholders better coordinate their activities and increase the overall predictability of project delivery.

However, improving the sequencing and transparency of the planning process alone is not sufficient. Our bottleneck analysis also shows that the underutilisation of conceptual and industrial construction methods is closely tied to how projects are initiated and defined. Most projects are still developed through traditional Engineer-To-Order (ETO) processes, in which developers and housing corporations prescribe detailed technical specifications. This approach leaves little room to efficiently integrate modular and conceptual building systems, which rely on standardisation and repeatability.

To unlock the benefits of conceptual and industrialised construction, a shift is needed in how projects are put to market. Instead of starting from a custom design brief, developers should specify functional and performance requirements and allow the market to respond with existing modular or conceptual solutions. This would make it possible to run short iteration

cycles, quickly explore various options together with the different stakeholders involved, and thereby significantly reduce development time. Shifting the Client Order Decoupling Point (CODP) towards Make-To-Order (MTO) or Assembly-To-Order (ATO) models would better align the planning process with the capabilities of industrial construction.

However, such a change in approach also requires a cultural shift and a human aspect. People are often reluctant to change as change impedes uncertainties. It is therefore important to keep on sharing success stories of projects that successfully implemented new development approaches and, as a result, were able to shorten the plan-phase.

**Current initiatives**

Several initiatives are already moving in this direction:

- Parallel Plannen (developed and guided by Fakton[15] ) focuses on executing tasks within the urban development process in parallel rather than sequentially. Key success factors include continuous information sharing between stakeholders and standardising formal decision-making steps, such as contracts and approvals. Early pilots suggest that applying parallel planning could potentially shorten the plan development phase by up to four years. More information about this initiative can be found here:
  - "Van harder naar slimmer werken met woningbouwversnelling als resultaat" Vereniging van Grondbedrijven (VvG) en Fakton. 21 juli 2021.
  - Plan van Aanpak: "Versnellen processen en procedures woningbouw" BZK. 19 januari 2023.
  - Fakton Presentation Parallel Plannen (in Dutch)
  - Pilot parallel plannen voor versnellen woningbouwprocedures | Versnellen woningbouwprocessen | Home | Volkshuisvesting Nederland

- De Bouwstroom[16, 17], initiated by AEDES and Netwerk Conceptueel Bouwen, is an initiative that focusses on project procurement based on functional requirements rather than technical. It aims to support housing corporations in building faster, smarter, and cheaper by using modular and conceptual building systems more effectively. The programme focuses on professionalising procurement strategies and bundling demand to create the scale needed for industrial production.
- The CRR and the FRK (College van Rijksbouwmeester en Rijksadviseurs & Federatie Ruimtelijke Kwaliteit) published an book-series including "*ruimtelijke kwaliteit bij industriële woningbouw: bouwstenen voor governance"* [6], which does not offer ready-made solutions for every process, but describes the key building blocks necessary to achieve good governance. This framework is complemented by a Roadmap for Spatial Quality.

**Limitations of Current Initiatives**

Although promising, these initiatives also possess limitations that restrict their scalability:

- Parallel Plannen assumes a situation where land ownership and local policies (omgevingsplan) and resulting regulations are already clearly defined. In practice, both these factors are dynamic, and policy-making and adjustments are often still needed, which are themselves time-consuming processes. Moreover, based on the lessons from the early pilot projects, we observe that executing activities in parallel raises questions about risk allocation. For example, if production capacity is reserved before permits are secured, it remains unclear who bears the risk if the permit is ultimately denied.

[15] Fakton - Verbinders van publiek en privaat - Fakton
[16] De Bouwstroom | Aedes
[17] De Bouwstroom – hoe ver zijn we? | Aedes

- Although several Bouwstromen are working well, some are not. We see that each bouwstroom has developed its own way to organise itself with the aim of bundling demand. Yet, bundling demand should not be the goal itself. The goal should be changing the way in which projects are put to market. Not through a technical specification (we see examples of housing corporations developing shared technical specifications within Bouwstromen), but rather based on functional and performance-based requirements that are matched with one of the many conceptual building concepts in the market.

## 4.2 Certifications and Type-approvals for modular and conceptual builders

The certification of housing concepts and processes are both recognised as interesting solutions with relatively modest time-saving potential in the plan phase (6-8 weeks) (bottleneck #3). Additionally, type approvals could help to reduce the costs for quality assurance and therefore speed up the process of justifying the business case (bottleneck #1). Lastly, certification may help in speeding up decision-making processes since it assures the quality of the project for the client.

**Current initiatives**
Type approvals are developed for quality assurance during the design and execution of housing concepts. The housing concept is approved, and the certificate indicates that it complies with national regulations. Certifications include assessment of both products and processes in a hybrid form. There are already two certifications in place: the BRL2840[18] and the BRL7703[19]. The BRL 2840 is specifically for concrete-based housing concepts, and the BRL 7703 is material-independent and can therefore be used by providers of prefabricated housing concepts based on concrete, wood, steel, composite, et cetera. Also, the BRL 0903-01[20] is in place, which allows certification for modular and conceptual construction systems.

Lastly, three Woondealregios committed to arrange a fast-lane procedure for conceptual and industrialised construction methods. Meaning that the permit procedure for modular and conceptual systems that are certified can be done smoothly and within a day[21].

**Limitations of current solutions**
Currently, the certificates that are granted are rather rigid, meaning that they are based on both the product and the process. The fact that it is partly based on the product can hamper innovations and the development of new variations to the existing concept, since the assessment of these additions and changes requires money and time. Besides, the certificate is not valid in case of any project-specific deviations from the certified concept.

## 4.3 Improving Permitting and Regulatory Compliance

A major cause of delays in the planning phase stems from inefficiencies and uncertainties in the permitting and regulatory compliance process (bottleneck #3 and #4). The first step towards improving permitting is ensuring the early publication of clear and unambiguous

[18] BRL 2840: Efficiënte kwaliteitsborging prefab woning concepten
[19] BRL 7703 Grondgebonden industriële woningen
[20] BRL 0903-01 Modulaire bouwsystemen-units voor permanent gebruik en tijdelijke bouwwerken
[21] Programma Innovatie en Opschaling Woningbouw

assessment criteria. Publishing requirements and regulations early, clearly, and in a structured format would give developers greater certainty during project initiation and design phases.

Ideally, these policies should be made available both in natural language and in machine-readable formats to enable digital processing and automation in the (near) future. If this is the case, there is an opportunity to further improve the accessibility and usability of regulations through AI and Large Language Models (LLMs). LLMs make it possible to query complex regulatory documents in natural language, helping developers, municipalities, and citizens quickly find the applicable rules specific to their context without having to manually navigate lengthy texts. This would significantly reduce misinterpretations and the risk of late-stage project revisions due to overlooked requirements.

Building on this foundation, the next step would be the introduction of automated compliance checking and digital permitting. Currently, lots of extra handling and intermediate systems are used to ensure data and information exchange between the market and governmental agencies, making automation difficult (bottleneck #7). Digital permitting procedures should allow the market to submit their 3D-BIM models when applying for permits. Subsequently, software services check the completeness of the models and automatically execute compliance checks to see whether the designs comply with local regulations. This will help municipalities to do more checks at the same time. Note that the certifications and type approvals discussed in section §4.2 focus on compliance with the national regulations within the WKB. The compliance checks discussed here focus on compliance with local rules and regulations.

**Current Initiatives:**

- Omgevingswet and Omgevingsvisie: Under the transition to the new Omgevingswet (Environment and Planning Act), the goal is that all municipalities will eventually have an integral environmental plan that clearly defines all applicable policies and regulations. This is intended to provide early transparency for developers. However, full implementation is expected only by 2032, and there is still uncertainty regarding how these plans will be structured and accessed in practice.
- Omgevingsloket and NLP-Based Querying: As part of the Omgevingswet transition, is also the development of the Omgevingsloket, which aims to centralise all regulations in one place and allow for querying, making it easier for developers and citizens to search and retrieve applicable rules. In addition, there are software companies in the Dutch market building LLM solutions that help municipalities, developers, and private homeowners find and interpret local building regulations through natural language queries.
- DSGO Framework: The Digitaal Stelsel Gebouwde Omgeving (DSGO) initiative is developing a national digital framework to support the data sharing between parties in the construction sector. This is not in place fully yet.
- Automated Compliance Checking knowledge EU Research Projects: Currently, most of the compliance checking is done manually with rules that are written in human-readable documents. To make the shift to automated compliance checking, a machine has to be able to interpret the various rules. This calls for a conversion strategy from human-readable rules to machine-readable/interpretable rules. Different conversion strategies have been considered in various EU projects (CHEKDB, ACCORD, DigiChecks), of which the RASE (Requirement, Applicability, Selection and Exceptions) method [7] and NLP (Natural Language Processing) are of interest for conversion to machine-readable rules. Additionally, if the rules are written

in a specific template, then the rules can be both human-readable and directly machine interpretable without the need to convert.

**Limitations of current initiatives**

While these initiatives represent important steps forward, several limitations remain that constrain their full impact:

- While solutions such as the Omgevingsloket updates and private digital permitting tools improve the findability of regulations, their effectiveness heavily depends on the completeness, clarity, and consistency of the underlying regulatory documents. Where regulations are missing, outdated, poorly structured, or ambiguously formulated, AI tools and digital platforms cannot guarantee reliable or comprehensive results. For example, although private software companies have developed LLM-based systems that make it easier to search local regulations, their accuracy is limited by the quality of the underlying data. In practice, such companies collect policy documents directly from municipalities, but there is no systematic check to ensure that the documents are up-to-date or that no critical information is missing.
- The DSGO initiative provides a promising foundation for structuring and sharing data in the construction sector, including regulatory data, but it is not yet fully operational yet, and the timelines are unclear. Until municipalities systematically publish their policies in structured, machine-readable formats, opportunities for automation and digital workflows will remain limited.
- Although the Omgevingswet envisions integral environmental plans for greater transparency and consistency across municipalities, full implementation is not expected at least until 2032. It is still not clear how this transition will actually take place in practice. In the meantime, regulations remain scattered, inconsistently formulated, and difficult to access, leaving developers with continued uncertainty during the planning phase.
- A related challenge lies in municipalities struggling to define policies that provide sufficient boundary conditions while providing enough flexibility in design. For instance, one of the municipalities we talked to aims to have as few rules as possible. However, this often results in generic rules, which may cause ambiguity as exceptions to the rules are not defined explicitly. The municipality shared the example of the rule “the height of a building cannot be higher than the church”, which does not necessarily mean that you can design a building as high as the church next to the church. Such vague formulations complicate both manual and automated compliance checking, causing uncertainty for developers and permitting authorities alike.
- Although substantial knowledge and methodologies for automated compliance checking exist through projects like CHEKDB, ACCORD, and DigiChecks, no fully integrated, nationally scalable system has yet been realised. None of these projects has a Dutch use case. Current efforts are fragmented across different projects and regions, and converting all municipal rules into consistently machine-interpretable formats remains a major challenge.

## 4.4 Supporting the Design Process with Digital Twins with Multi-Criteria Assessments

Current design processes require numerous communication lines and often result in unstructured iterations between stakeholders (bottleneck #6). Partly, this is because essential context information, such as data on utilities, existing buildings, and other asset data, is not

readily or publicly available, requiring project teams to collect this information individually at the project level. This causes inefficiencies and delays in the planning and design phases.

The use of urban Digital Twins can help structure the design process by providing access to such critical context information upfront and up to date. Further, having relevant data integrated into a Digital Twin allows stakeholders and designers to immediately see the effects of design choices, enabling quicker trade-offs and reducing the number of iteration cycles. This approach is particularly valuable when using conceptual building systems, where early insights into 'product' characteristics, such as estimated energy use of a housing concept, can be incorporated into the broader urban design at an early stage. For example, when designing a neighbourhood based on conceptual building systems and parametric models, it becomes possible to quickly assess the impact of different configurations on energy demand, helping to determine early on whether plans are feasible for network operators.

Generative design builds upon this by enabling the automated creation of design solutions within predefined parameters. Based on certain site-specific constraints, generative systems can produce a variety of feasible designs, allowing stakeholders to select and refine the best options collaboratively for that specific context. To effectively apply generative design in practice, Automated Compliance Checking (discussed in §4.3) should also be integrated to ensure that generated solutions already meet local regulatory requirements, reducing risks of non-compliance later in the process.

**Current initiatives**

- Several companies are working on urban digital twin platforms to help housing corporations, developers and municipalities in their(spatial) design processes. Some of these companies developed SimCity-like configurations and are working on linking databases with (modular) housing concepts to their configurators.
- Various companies and research institutes are working on platforms to facilitate parametric or generative design solutions, often referred to as Digital Twins. These companies offer solutions to design both buildings and neighbourhoods using parametric or generative principles. This used to be done by generating volumes (mass-studies), yet recent developments also allow generating designs based on conceptual designs.
- The initiatives MiniBIM and MiniGIM are adopted more widely from respectively a project development and urban planning perspective using BIM and GIS models at a very early stage in the process. The aim of these initiatives is to quickly assess the feasibility of new plans based on a minimal set of information. Yet, the problem is not the technology, but the differences in data maturity between organisations and therefore the ability to share the right information.

**Limitations of current initiatives**

While urban Digital Twins and generative design platforms represent promising steps forward in supporting and structuring the design process, several limitations constrain their adoptability and impact:

- The effectiveness of Digital Twins heavily depends on the availability, completeness, and quality of underlying data. Yet, much of the essential context information needed for effective design processes, such as data on utilities, existing assets, and environmental conditions, is often missing, outdated, or held in fragmented systems that are not interoperable. Without up-to-date data, Digital Twin platforms cannot deliver reliable or required insights, reducing their practical usefulness.

- Although various companies are developing innovative digital design tools, these platforms often operate in silos, using different standards, data formats, and interfaces (for instance different digital twins for environmental aspects, different for mobility etc). Without a shared framework or common standards, it becomes difficult to scale these tools across projects, regions, or stakeholders, limiting the potential for widespread adoption.
- The link to the practicality of generated designs in such platforms is often missing. This includes, for example, ensuring compliance with local regulations and confirming the industrial manufacturability of modules and elements if relevant. Without these considerations, generated designs may not be practical in the context or easily or efficiently producible using available industrial systems, limiting their real-world applicability.
- Parametric design has strong potential to accelerate information exchange and decision-making, but it remains relatively unknown territory for many stakeholders (finding by parallel plannen[22]).

## 4.5 Shared expertise centre and expert pools

Bottleneck #2 and #3 address the lack of resources at municipalities in terms of money, capacity and knowledge. Shared expertise centres or shared expert pools can be used to support municipalities in dealing with resource shortages. These centres and expert pools can be shared between municipalities to provide knowledge and capacity in policy making (i.e. Omgevingsplannen), permit processes, the implementation of new technology, etcetera. The advantage is that such expertise groups can learn from best practices over different municipalities and share that knowledge throughout. Besides, such a flexible pool of employees allow municipalities to stay on track in busy times to avoid delays in project or permit delivery without having these employees on the payroll.

**Current initiatives**

For instance, the province of Gelderland has already assembled a flexible pool of employees available to assist municipalities in dealing with urban planning issues, project management, et cetera. This pool allows municipalities to access additional expertise without the need to have these employees on their payroll, providing flexibility during busy periods [23].

**Limitations of current initiatives**

Since the shortage of knowledge and capacity is one of the key root causes, shared expertise pools could offer valuable support to the municipalities, but some limitations need to be addressed to ensure their applicability and scalability:

- According to an interviewee, municipalities are often reluctant to request help from shared expertise pools due to concerns that are unclear to us at this moment. This hesitation limits the reach and impact of such initiatives, even when capacity shortages are acute.
- There is still uncertainty about the operational processes and business models that should underpin these shared arrangements. Without clear agreements on how costs, responsibilities, and benefits are divided, it is difficult to build a sustainable and scalable model that all participating municipalities can commit to confidently. For instance, when many municipalities turn to the same expert pool during busy periods,

[22] Presentatie+Parallel+Plannen+(Juli+2024) (1).pdf
[23] Aanpak personeelstekort gemeenten om woondoelen te halen

it may become challenging to fairly prioritise support requests, especially when urgent needs arise simultaneously across regions.

- It is important to consider the risk of the loss of institutional knowledge and memory within municipalities, as knowledge and experience leave once the external support concludes. Without mechanisms to embed and transfer knowledge internally, municipalities may remain structurally dependent on outside help, limiting long-term resilience.

# 5 Recommendations and Innovation Directions

Based on the findings discussed so far and the priorities shared by interviewees, this chapter gives some recommendations for improving the planning phase of housing construction in the Netherlands. These recommendations suggest practical actions, digital tools, and organisational changes that can help reduce delays, improve cooperation, and make housing projects faster and more predictable.

- **Develop a National Policy-Coherence Toolkit:** Making clear, unambiguous, and transparent policies is one of the most difficult challenges municipalities face, especially under the Omgevingswet, where they must integrate multiple domains into a single Omgevingsplan. There is also the risk that, without support, each municipality develops its own fragmented approach and resultant policies, which a) slows down local processes, b) undermines national coherence and c) makes it harder to apply digital tools like automation on compliance checking. A national policy-coherence toolkit could offer municipalities ready-made templates, structured rules, and example frameworks that translate housing, mobility, climate, energy and health policies into clear, locally applicable regulations. Crucially, these templates should help identify potential conflicts between requirements and offer strategies to resolve them. This will speed up local policymaking, reduce ambiguity, and create a foundation for scalable, machine-readable digital solutions.
- **Develop Cross-Scale, Iterative Design Impact Analysis Tools:** Many redesigns, delays, and conflicts in the planning phase arise because regional, city, and site-level decisions are made separately, and the effects of design choices on housing supply, $CO_2$, health, mobility, energy, and biodiversity (among others) only become visible late in the process. Municipalities and their stakeholders need access to a shared, iterative impact-analysis tool that allows them to explore design scenarios early, test trade-offs across scales, and quickly assess the consequences of choices. Conceptual construction strengthens this approach, as the impacts of (industrialised) building concepts can often be estimated more accurately using data from previously built projects. By running rapid design-feedback loops, project teams can align decisions early and avoid costly, time-consuming revisions later. There are already existing initiatives that supports cross-scale impact assessment, mainly the Integrated Impact Assessment Framework proposed in the Urban Planning Reimagined[24] manifest by Brainport Eindhoven. IIAF is a digitally enabled approach that integrates environmental, social, economic, and spatial impacts across scales to support evidence-based and participatory planning . To move from concept to widespread practice, IIAF needs pilots, shared standards, and investment in digital infrastructure and governance so municipalities and stakeholders can consistently apply it.IIAF is a digitally enabled approach that integrates environmental, social, economic, and spatial impacts across scales to support evidence-based and participatory planning [8]. To move from concept to widespread practice, IIAF needs

[24] Urban Developement Initative, Brainport Eindhoven: https://brainporteindhoven.com/udi/nl/

pilots, shared standards, and investment in digital infrastructure and governance so municipalities and stakeholders can consistently apply it [8].

- **Co-Design Urban Planning Standards with conceptual and Industrialised Builders:** As municipalities transition to new integrated Omgevingsplannen under the Omgevingswet, they have a unique opportunity to align local planning rules with the realities of conceptual and industrialised construction. Instead of imposing arbitrary specifications, like maximum building heights or dimensions that slightly misalign with what conceptual and industrial builders can efficiently deliver, municipalities, conceptual and industrial builders, and utility providers should co-design planning standards and concept frameworks together. This collaboration will ensure that industrial concepts fit within local regulations from the start, making it easier to apply conceptual solutions without requiring policy changes or concept changes, both of which are very time consuming.
- **Develop Tools or Services to Automate Context Data Collection for Preliminary Studies with Open Data and IoT Systems:** Many time-consuming project delays stem from preliminary studies, such as biodiversity or environmental impact assessments, which must establish the “as-is” situation (for impact analysis) before development can proceed. Currently, these are often commissioned individually for each project during the project phases, and other realisation activities cannot start until the preliminary research is finished. Municipalities and developers together could anticipate future redevelopment areas and start collecting key context data in advance, for instance, using low-cost IoT sensors, remote sensing, and open data platforms, so that the most time-intensive preliminary studies are already underway or completed in parallel with other processes. Having a tool or service to identify and automate these high-impact data needs would significantly reduce project-level delays when development starts. There is already existing research in this direction, for instance, studies on urban heat islands [9], and devices that include sensors and cameras allowing for to monitoring of biodiversity within a particular area without the need to hire ecologists [10].
- **Introduce an Conceptual and Industrial construction Maturity Scan:** While it is clear that conceptual and industrial construction offers clear opportunities to speed up housing delivery, many municipalities and developers are unsure how ready they are to adopt conceptual approaches or what barriers exist in their specific context. Introducing a quick conceptual and industrial construction maturity scan would help assess their organisational, technical, and policy readiness for conceptual building, highlight key issues, and connect them to targeted support or expertise. This practical diagnostic tool can fast-track adoption by giving stakeholders a clear picture of where they stand and what steps they need to take next.
- **Create a National Functional-Requirement Template and (Modular) Concept Library:** For modular approaches to work, projects need to be defined using functional requirements, but many clients and municipalities struggle to know how to formulate these, and concept builders need the right level of detail to match their solutions. Developing a national functional-requirement template for housing collaboratively developed by key stakeholders (housing corporations, developers, municipalities, utility providers, conceptual builders) would help standardise this process, striking the right balance between what clients need and what suppliers can deliver. Once in place, this template can be linked to a national library of pre-approved housing concepts (for instance, the “conceptboulevard.nl” of NCB[25]) such that designers can confidently select and configure design options without any applicability concerns. Of course, there are limitations on why clients prefer technical

[25] Conceptenboulevard - Vind het woningconcept bij jouw bouwvraag

requirements over functional requirements (for instance, the existing maintenance business models call for standardising technical components across the portfolio of housing corporations). These challenges need to be studied and addressed as well.

- **Explore Risk-Sharing Frameworks to Enable Process Acceleration:** Many promising acceleration strategies, such as parallel plannen, are underused because the distribution of risk is unclear. Developing clear risk-sharing frameworks, including contractual models, insurance solutions, or escrow arrangements, would help stakeholders fairly distribute these risks. This would make parallel processes more attractive and unlock faster, more confident adoption of conceptual and industrialised building and other innovative process acceleration approaches.
- **Reform Citizen Participation with Clear Boundaries and Digital Tools:** Citizen participation often causes major delays because there are no clear limits on what input is valid, when it must be provided, or how it affects project decisions (other than it gets delayed). Municipalities should introduce participation frameworks that define upfront: (1) which topics citizens can influence (e.g. design details, local impacts, not fundamental housing targets), (2) when input must be submitted to count, and (3) how feedback is formally closed at each phase, so discussions do not endlessly reopen. Digital participation tools can help by making participation more accessible, transparently logging inputs and responses, and showing how citizen feedback has been incorporated, creating trust in the process and reducing the likelihood of prolonged, unfounded objections.

# 6 Limitations and constraints

Although this study provides valuable insights into the key bottlenecks and potential solutions directions within the sector, it also has several inherent limitations. The findings are primarily based on sixteen interviews with representatives from various organizations. While this qualitative approach offers depth and rich context, the relatively small sample size makes it less likely that the full spectrum of challenges and perspectives present in the sector has been captured. The selected respondents provide a strong indication of widely recognized themes, but other organizations or actors might have contributed additional or differing experiences.

Furthermore, the results were cross-checked with relevant international and national literature, including academic publications, professional sources, and news articles. Although this triangulation strengthens the reliability of the conclusions, it remains possible that recent developments or less documented practical experiences were not included. The dynamic nature of the sector, characterized by rapid technological, regulatory, and organizational changes, further increases this possibility.

“It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change.”

- Charles Darwin (1809 – 1882)

# References

[1]S. Mehta, L. van de Kamp, P. Salla, G. Keser, B. Till, and M. Rutten, “Prefab homes radar 2024; Tracking prefab housing construction in the Netherlands,” Mar. 2025. [Online]. Available: https://flexwonen.nl/wp-content/uploads/2025/03/Prefab-homes-radar-2024-maart-2025.pdf
[2]M. H. Meyer, *The Power of Product Platforms*. Riverside: Free Press, 2011.
[3]J. Bouwmeester, T. Hartmann, D. Ay, and J.-D. Gerber, “Making room for affordable housing: Project-based negotiations between planning authorities and landowners in Dutch and Swiss densification,” *Land Use Policy*, vol. 144, p. 107264, Sep. 2024, doi: 10.1016/j.landusepol.2024.107264.
[4]J. Quaedflieg, T. Lam, and S. Thiel, “Impact bezwaar- en beroepsprocedures op vertraging woningbouw,” SWECO Nederland B.V., Oct. 2024. [Online]. Available: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiUy6WC9aWPAxWth_0HHWdQIksQFnoECBEQAQ&url=https%3A%2F%2Fwww.tweedekamer.nl%2Fdownloads%2Fdocument%3Fid%3D2025D01736&usg=AOvVaw3KdPsoniOeyPonKS9JdfAx&opi=89978449
[5]A. Adriaanse, “Bruggen Bouwen met ICT.” Sep. 10, 2014. [Online]. Available: https://ris.utwente.nl/ws/portalfiles/portal/5119421/oratieboekje-Adriaanse.pdf
[6]Federatie Ruimtelijke Kwaliteit, and College van Rijksbouwmeester en Rijksadviseurs, “Ruimtelijke kwaliteit bij industriële woningbouw: bouwstenen voor governance,” vol. 3, 3 vols., Federatie Ruimtelijke Kwaliteit, College van Rijksbouwmeester en Rijksadviseurs, 2025, p. 60. [Online]. Available: file:///C:/Users/eetv/Downloads/CVR+FRK_Binnenwerk+Ruimtelijke+Kwaliteit_derde+uitgave_digitaal%20(1).pdf
[7]N. Nisbet, L. Ma, and G. Aksenova., “Presentations of rase knowledge mark-up,” presented at the 2022 European Conference on Computing in Construction, Jul. 2022. doi: 10.35490/EC3.2022.162.
[8]M. Oomen *et al.*, “Manifest of Urban Planning Reimagined: A Digitally Enabled New Way of Working,” Zenodo, Oct. 2023. doi: 10.5281/ZENODO.10014556.
[9]M. Pena Acosta, J. Santos, F. Vahdatikhaki, and A. G. Dorée, “UHI Street Typology Based on Seasonality: A Case Study from Apeldoorn, Netherlands,” *ISPRS Ann. Photogramm. Remote Sens. Spat. Inf. Sci.*, vol. X-4/W5-2024, pp. 255–261, Jun. 2024, doi: 10.5194/isprs-annals-X-4-W5-2024-255-2024.
[10] E. van O. Kloeke, W. D. Kissling, J. Evans, C. Huijbers, J. Kamminga, and G. Schouten, “ARISE: A Dutch dataspace connecting nature and people,” in *Moral design and green technology*, in Life Sciences E-Books Online, Collection 2026. , Leiden Boston: Brill | Wageningen Academic.
[11] E. Buitelaar, M. Van Den Hurk, J. Lebbing, P. Pelzer, and L. Van Karnenbeek, “Land Policy in the Netherlands: An Ambiguous Utopia on the Move,” in *Land Policies in Europe*, T. Hartmann, A. Hengstermann, M. Jehling, A. Schindelegger, and F. Wenner, Eds., Cham: Springer Nature Switzerland, 2025, pp. 203–217. doi: 10.1007/978-3-031-83725-8_13.
[12] T. Taşan-Kok and S. Özogul, “Fragmented governance architectures underlying residential property production in Amsterdam,” *Environ. Plan. Econ. Space*, vol. 53, no. 6, pp. 1314–1330, Sep. 2021, doi: 10.1177/0308518X21996351.
[13] M. Angel Ortega, “Modernizing the Dutch Housing Industry using off-site construction: Removing adoption barriers through innovation policy,” Delft University, 2020. [Online].

Available: https://repository.tudelft.nl/file/File_619c5cfd-fb9f-4dda-8c4b-8edb5de45b03?preview=1
[14] W. Ferdous, Y. Bai, T. Duc Ngo, A. Manalo, and P. Mendis, “New advancements, challenges and opportunities of multi-storey modular buildings – A state-of-the-art review,” *Elsevier - Eng. Struct.*, vol. 183, no. 15 March 2019, pp. 883–893.
[15] T. Hartmann, F. V. Straalen, and T. Spit, “Expectation management at the local scale: Legal failure of public participation for large urban planning projects,” *TeMA - J. Land Use Mobil. Environ.*, vol. 11, no. 1, pp. 133–145, Apr. 2018, doi: 10.6092/1970-9870/5369.
[16] E. Özdemir-Ulutaş and T. Tasan-Kok, “Planners’ role in accommodating citizen disagreement: The case of Dutch urban planning,” *Urban Stud.*, vol. 56, no. 4, pp. 741–759, Mar. 2019, doi: 10.1177/0042098017726738.
[17] E. W. Stapper and J. W. Duyvendak, “Good residents, bad residents: How participatory processes in urban redevelopment privilege entrepreneurial citizens,” *Cities*, vol. 107, p. 102898, Dec. 2020, doi: 10.1016/j.cities.2020.102898.
[18] B.-G. Hwang, M. Shan, and K.-Y. Looi, “Key constraints and mitigation strategies for prefabricated prefinished volumetric construction,” *J. Clean. Prod.*, vol. 183, pp. 183–193, 2018, doi: https://doi.org/10.1016/j.jclepro.2018.02.136.
[19] A. Koutamanis, “Planning Regulations and Modelled Constraints in BIM: A Dutch Case Study,” *Buildings*, vol. 14, no. 4, p. 939, Mar. 2024, doi: 10.3390/buildings14040939.
[20] A. Adriaanse, “Bruggen Bouwen met ICT,” Universiteit Twente, Enchede, Rede uitgesproken bij de aanvaarding van het ambt van hoogleraar Bouwprocesintegratie & ICT aan de faculteit Construerende Technische Wetenschappen van de Universiteit Twente, oktober 2014. [Online]. Available: https://ris.utwente.nl/ws/portalfiles/portal/5119421/oratieboekje-Adriaanse.pdf
[21] M. Ataide, O. Braholli, and D. Siegele, “Digital Transformation of Building Permits: Current Status, Maturity, and Future Prospects,” *Buildings*, vol. 13, no. 10, p. 2554, Oct. 2023, doi: 10.3390/buildings13102554.
[22] P. Mêda, J. Fauth, C. Schranz, H. Sousa, and H. Urban, “Twinning the path of digital building permits and digital building logbooks – Diagnosis and challenges,” *Dev. Built Environ.*, vol. 20, p. 100573, Dec. 2024, doi: 10.1016/j.dibe.2024.100573.
[23] A. Jonkman, R. Meijer, and T. Hartmann, “Land for housing: Quantitative targets and qualitative ambitions in Dutch housing development,” *Land Use Policy*, vol. 114, p. 105957, Mar. 2022, doi: 10.1016/j.landusepol.2021.105957.
[24] X. Hu, H.-Y. Chong, X. Wang, and K. London, “Understanding Stakeholders in Off-Site Manufacturing: A Literature Review,” *J. Constr. Eng. Manag.*, vol. 145, no. 8, p. 03119003, Aug. 2019, doi: 10.1061/(ASCE)CO.1943-7862.0001674.

# Signature

TNO Mobility & Built Environment Delft, 19 February 2026

ValidSigned by W. van Kanten-Roos
on 2026-02-23 16:58:27

W. van Kanten-Roos
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on 2026-02-20 08:49:39

W.C. van der Poel
Project Manager

# Appendix A
# List of Interviewees

Table 1 – List of interviewees

| | Name | Organization | Type of organization |
|---|---|---|---|
| 1 | Anonymous 1 | BOUWQ | Quality assurance |
| 2 | Anonymous 2 | KIWA | Quality assurance |
| 3 | Anonymous 3 | Province Gelderland | Province |
| 4 | Anonymous 4 | VRO (Ministry of Housing and Spatial Planning) | Ministry |
| 5 | Anonymous 5 & 6 | VORM | Developer |
| 6 | Anonymous 7 | Circulair Friesland | Consultant - circularity |
| 7 | Anonymous 8 | Municipality of Almelo | Municipality |
| 8 | Anonymous 9 | Municipality of Almelo | Municipality |
| 9 | Anonymous 10 | Bouw en woningtoezicht | Quality assurance - association |
| 10 | Anonymous 11 | Future Insight | Software |
| 11 | Anonymous 12 | Municipality of Hengelo | Municipality |
| 12 | Anonymous 13 & 14 | Struck | Software |
| 13 | Anonymous 15 & 16 | Semmtech | Software |

| | | | |
|---|---|---|---|
| 14 | Anonymous 17 | Intermaris | Housing Corporation |
| 15 | Anonymous 18 | AEDES | Housing Corporation - Umbrella Association |
| 16 | Anonymous 19 | Heddes Bouw en Ontwikkeling | Developer/Contractor |

Appendix B

# List of reviewers

| | Name | Organization |
|---|---|---|
| 1 | Anonymous 18 & 19 | Netwerk Conceptueel Bouwen (NCB) |
| 2 | Anonymous 20 | Municipality of Eindhoven |
| 3 | Anonymous 5 | VORM & NEPROM |
| 4 | Anonymous 21 | Brainport Development N.V. (Brainport Eindhoven) |
| 5 | IJsbrand van Straalen en Arjen Adriaanse | TNO |

Appendix C

# References for bottlenecks

| Bottleneck (/root causes) | Interview Count | Interviewee Types | Source count | Source type | Source |
|---|---|---|---|---|---|
| **1. Closing the Financial Business Case for Developers and Investors** | 3 | Municipality (x1), Housing corporation (x1), Quality assurance (x1) | 1 | 1. Report<br>2. News paper article | 1. Analyse_woningmarktmodel_CPB.pdf<br>2. Woningbouw op Novex-locaties verloopt stroef: doelstellingen verder uit zicht |
| 1.1 Due to lack of municipal financial resources, costs are shifted to developers/investors | 4 | Municipality (x1), Province (x1), Housing corporation (x1), Quality assurance (x1) | 4 | 1. Report<br>2. Journal paper<br>3. News paper article<br>4. News paper article<br>5. News paper article | 1. Publieke financiële opgave woningbouw in Nederland<br>2. Stagnation in Dutch housing production and suggestions for a way forward<br>3. Social housing lags behind despite rising demand \| NL Times<br>4. Government must pump billions into new housing to meet targets - DutchNews.nl<br>5. Bouwbesluit dwarsboomt circulaire woning: 'Corporaties krijgen business case niet rond' |
| 1.2 Accumulation of requirements on what to build and required preliminary assessments | 2 | Municipality (x1), Province (x1) | 1 | 1. Report<br>2. News paper article | 1. Schrappen Tegenstrijdige en Overbodige Eisen en Regelgeving (STOER) \| Bouwberaad \| Home \| Volkshuisvesting Nederland<br>2. Construction of up to 470,000 homes in jeopardy in the Netherlands, experts say \| NL Times |

| | | | | | |
|---|---|---|---|---|---|
| 1.2.1 Utility and infrastructure capacity planning issues | 1 | Municipality (x1) | 4 | 1. Report<br>2. Report<br>3. Web-page<br>4. News paper article<br>5. News paper article<br>6. News paper article | 1. Publieke financiële opgave woningbouw in Nederland<br>2. handelingsperspectief-netcongestie_2024.pdf<br>3. Wat is netcongestie? \| RVO.nl<br>4. Netcongestie legt bouw stil: tienduizenden woningen vertraagd - BOUW TV<br>5. Bouwprojecten vertraagd door netcongestie, wat te doen?<br>6. Bouwmonitor \| Netcongestie levert bijna een jaar vertraging op |
| 1.3 High land prices and limited land availability | 1 | Housing corporation (x1) | 4 | 1. Report<br>2. Report<br>3. Report<br>4. Report<br>5. Book chapter<br>6. News paper article<br>7. News paper article | 1. Het bouwproces van nieuwe woningen<br>2. Publieke financiële opgave woningbouw in Nederland<br>3. Woningbouw en Marktconcentratie<br>4. Actief grondbeleid en woningbouwproductie<br>5. Land Policy in the Netherlands: An Ambiguous Utopia on the Move [11]Land Policy in the Netherlands: An Ambiguous Utopia on the Move [11]<br>6. Toezichthouder sociale woningbouw: 'Grond is voor nieuwbouw, niet voor speculatie'<br>7. Corporaties zijn duur uit als ze bouwgrond kopen van ontwikkelaars, minister Keijzer bedenkt list |
| **2. Complex Policy Making and Policy Changing Procedures at Municipalities** | 0 | — | | 1. Book chapter | 1. Land Policy in the Netherlands: An Ambiguous Utopia on the Move [6] |
| 2.1 Unclear policies and regulations from municipalities | 4 | Consultant (x1), Municipality (x2), Province (x1) | 3 | 1. News paper article<br>2. News paper article<br>3. Report<br>4. Conference paper<br>5. Journal paper | 1. 'Onduidelijk' beleid houdt duurzaam bouwen van huizen tegen, sector wil dat minister met strengere regels komt \| EenVandaag<br>2. 'Gaat het wel zo goed met industriële woningbouw?'<br>3. Schrappen Tegenstrijdige en Overbodige Eisen en Regelgeving (STOER) \| Bouwberaad \| Home \| Volkshuisvesting Nederland<br>4. Fragmented governance architectures underlying residential property production in Amsterdam [12]Fragmented governance architectures underlying residential property production in Amsterdam [12]<br>5. Making room for affordable housing: Project-based negotiations between planning authorities and landowners in Dutch and Swiss densification [3] |

| | | | | | |
|---|---|---|---|---|---|
| 2.2 Sequential, fragmented (waterfall) decision-making at the policy level | 3 | Municipality (x1), Consultant (x1), Province (x1) | 3 | 1. News paper article<br>2. News paper article<br>3. News paper article<br>4. Thesis<br>5. Journal paper | 1. Why is there a housing shortage in the Netherlands? The Dutch housing crisis explained \| DutchReview<br>2. Social housing lags behind despite rising demand \| NL Times<br>3. Government must pump billions into new housing to meet targets - DutchNews.nl<br>4. Modernizing the Dutch Housing Industry using off-site construction [13]Modernizing the Dutch Housing Industry using off-site construction [13]<br>5. New advancements, challenges and opportunities of multi-storey modular buildings – A state-of-the-art review [14]New advancements, challenges and opportunities of multi-storey modular buildings – A state-of-the-art review [14] |
| **3. Long and uncertain processing times at municipalities (beyond legal boundaries)** | 1 | Quality assurance (x1) | 6 | 1. Report<br>2. Report<br>3. Web page<br>4. News paper article | 1. Actief grondbeleid en woningbouwproductie<br>2. Publieke financiële opgave woningbouw in Nederland<br>3. Versnellen woningbouwprocessen \| Home \| Volkshuisvesting Nederland<br>4. In beeld: Vertraging woningbouw door juridische procedures - PONT Omgeving |
| 3.1 Knowledge and capacity shortages at municipalities | 2 | Province (x1), Consultant (x1) | 1 | 1. News paper article<br>2. News paper article<br>3. News paper article<br>4. News paper article<br>5. EU report | 1. Mountains of paperwork and too few civil servants hindering housing construction \| NL Times<br>2. Meer flexwoningen, maar nog lang niet genoeg: 'Ambtelijke capaciteit moet omhoog'<br>3. Blog \| Tijd voor vertrouwen in plaats van vertraging<br>4. Woningbouw op Novex-locaties verloopt stroef: doelstellingen verder uit zicht<br>5. EURES-Report on labour shortages and surpluses 2024 |
| **4. Additional Assessments and Design Iterations Driven by Local and Provincial Policies** | 3 | Province (x1), Consultant (x1), Municipality (x1) | 3 | 1. News paper article<br>2. News paper article<br>3. News paper article | 1. Stapeling regels leidt tot vertraging en onnodige kosten bij bouw- en projectontwikkeling – Gebiedsontwikkeling.nu<br>2. Why are we still not building enough houses? \| APG |

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| 4.1 Time-bound environmental studies (e.g., season-limited biodiversity assessments) | 2 | Municipality (x1), Province (x1) | | 1. News paper article<br>2. News paper article | 1. Meer werk voor ecologen na stikstofuitspraak RvS, vertraging in de bouw<br>2. Hoe gaan bouwwerkzaamheden en flora en fauna samen? \| Aedes |
| **5. Citizen participation and objection procedures** | 6 | Consultant (x1), Municipality (x1), Housing corporation (x1), Province (x1), Ministry (x1), Quality assurance (x1) | 3 | 1. News paper article<br>2. News paper article<br>3. News paper article<br>4. News paper article<br>5. News paper article<br>6. News paper article<br>7. Report<br>8. Report<br>9. Journal paper<br>10. Journal paper<br>11. Journal paper | 1. 4.000 woningen van Heijmans on hold door bezwaarprocedures - Vastgoedjournaal.nl<br>2. Woningcorporatie is bezwaren nieuwbouw zat: 'Kan heel project stilleggen' \| Hart van Nederland<br>3. Veel bezwaar tegen bouw van heel nieuw dorp, minister zet kibbelende partijen om tafel<br>4. Why are we still not building enough houses? \| APG<br>5. Onderzoek bevestigt: nimby's frustreren bouw vele tienduizenden woningen<br>6. Hoe één echtpaar bouw duizenden woningen vertraagt: 'Soms gaat het om boekwerken van zeshonderd pagina's'<br>7. Rapportage bezwaarprocedures NEPROM.pdf<br>8. Impact bezwaar- en beroepsprocedures op vertraging woningbouw<br>9. Expectation management at the local scale: Legal failure of public participation for large urban planning projects [15]Expectation management at the local scale: Legal failure of public participation for large urban planning projects [15]<br>10. Planners' role in accommodating citizen disagreement: The case of Dutch urban planning [16]Planners' role in accommodating citizen disagreement: The case of Dutch urban planning [16]<br>11. Good residents, bad residents: How participatory processes in urban redevelopment privilege entrepreneurial citizens [17]Good residents, bad residents: How participatory processes in urban redevelopment privilege entrepreneurial citizens [17] |

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| **6. Unstructured design iterations** | 4 | Developer (x1), Ministry (x1), Municipality (x1), Consultant (x1) | 1 | 1. **Journal paper**<br>2. **Journal paper**<br>3. **Journal paper** | 1. Key constraints and mitigation strategies for prefabricated prefinished volumetric construction [18]Key constraints and mitigation strategies for prefabricated prefinished volumetric construction [18]<br>2. Planning Regulations and Modelled Constraints in BIM: A Dutch Case Study [19]Planning Regulations and Modelled Constraints in BIM: A Dutch Case Study [19]<br>3. Bruggen Bouwen met ICT [20]Bruggen Bouwen met ICT [20] |
| **7. Extra Handling due to Incompatibility Between Market and Government Systems** | 3 | Province (x1), Consultant (x1), Ministry (x1) | | 1. **Journal paper**<br>2. **Journal paper** | 1. Digital Transformation of Building Permits: Current Status, Maturity, and Future Prospects [21]Digital Transformation of Building Permits: Current Status, Maturity, and Future Prospects [21]<br>2. Twinning the path of digital building permits and digital building logbooks – Diagnosis and challenges [22]Twinning the path of digital building permits and digital building logbooks – Diagnosis and challenges [22] |
| **8. Delays in WKB checks** | 1 | Quality assurance (x1) | | 1. Report<br>2. Letter to parliament | 1. Monitoringsrapportage 2024 Wet Kwaliteitsborging voor het bouwen voor Ministerie van VRO, Wkb-begeleidingsgroep<br>2. Brief aan Parlement - Monitoringsrapportage Wkb 2024 |
| 8.1 WKB checks are expensive | 3 | Quality assurance (x2), Housing corporation (x1) | | 1. News paper article<br>2. Report<br>3. Letter to parliament | 1. Blog \| Wat kost een externe kwaliteitsborger? • Aannemer<br>2. Monitoringsrapportage 2024 Wet Kwaliteitsborging voor het bouwen voor Ministerie van VRO, Wkb-begeleidingsgroep<br>3. Brief aan Parlement - Monitoringsrapportage Wkb 2024 |

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| **9. Persistent Siloed and Sequential Project Development Process (General)** | 4 | Housing corporations (x2), Developer (x1), Consultant (x1) | | 1. Presentation<br>2. Thesis<br>3. Journal paper<br>4. Journal paper | 1. Fakton -powerPoint-presentatie paralel plannen<br>2. Modernizing the Dutch Housing Industry using off-site construction: Removing adoption barriers through innovation policy [13]Modernizing the Dutch Housing Industry using off-site construction: Removing adoption barriers through innovation policy [13]<br>3. Land for housing: Quantitative targets and qualitative ambitions in Dutch housing development [23]Land for housing: Quantitative targets and qualitative ambitions in Dutch housing development [23]<br>4. Bruggen Bouwen met ICT [20]Bruggen Bouwen met ICT [20] |
| 9.1 Demand-supply mismatch: (modular) builder concepts vs. client needs | 3 | Ministry (x1), Housing corporations (x2) | | 1. News paper article<br>2. Thesis<br>3. Journal paper<br>4. Journal paper | 1. Een woonstandaard bestaat niet, geen mens is hetzelfde - Dutch Design Daily<br>2. Modernizing the Dutch Housing Industry using off-site construction: Removing adoption barriers through innovation policy [13]Modernizing the Dutch Housing Industry using off-site construction: Removing adoption barriers through innovation policy [13]<br>3. New advancements, challenges and opportunities of multi-storey modular buildings – A state-of-the-art review [14]New advancements, challenges and opportunities of multi-storey modular buildings – A state-of-the-art review [14]<br>4. Understanding Stakeholders in Off-Site Manufacturing: A Literature Review [24]Understanding Stakeholders in Off-Site Manufacturing: A Literature Review [24] |

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| 9.2 Prices of conceptual and industrial construction remain high | 2 | Consultant (x1), Housing corporation (x1) | | 1. Thesis<br>2. Journal paper<br>3. Journal paper<br>4. Journal paper | 1. Modernizing the Dutch Housing Industry using off-site construction: Removing adoption barriers through innovation policy [13]Modernizing the Dutch Housing Industry using off-site construction: Removing adoption barriers through innovation policy [13]<br>2. New advancements, challenges and opportunities of multi-storey modular buildings – A state-of-the-art review [14]New advancements, challenges and opportunities of multi-storey modular buildings – A state-of-the-art review [14]<br>3. Understanding Stakeholders in Off-Site Manufacturing: A Literature Review [24]Understanding Stakeholders in Off-Site Manufacturing: A Literature Review [24]<br>4. Key constraints and mitigation strategies for prefabricated prefinished volumetric construction [18]Key constraints and mitigation strategies for prefabricated prefinished volumetric construction [18] |
| 9.3 Reluctance to use acceleration solutions due to unclear financial risk distribution | 2 | Quality assurance (x1), Housing corporation (x1) | | 1. News paper article<br>2. Webpage<br>3. Presentation | 1. Bouwen in de helft van de tijd<br>2. Parallel plannen vraagt gezamenlijk commitment<br>5. Fakton -powerPoint-presentatie paralel plannen |

Bottleneck priorities (top 3 urgent changes)

| Original Bottleneck | Interviewee Count | Interviewee Types |
|---|---|---|
| **2. Complex Policy Making and Policy Changing Procedures at Municipalities** | 3 | Province (x1), Consultant (x1), Housing Corporation (x1) |
| **5. Citizen Participation and Objection Procedures** | 3 | Consultant (x1), Ministry (x1), Municipality (x1) |
| **3. Long and uncertain processing times at municipalities (beyond legal boundaries)** | 2 | Quality Assurance (x1), Province (x1) |
| **9. Persistent Siloed and Sequential Project Development Process (General)** | 2 | Housing Corporation (x1), Municipality (x1) |
| **1. Closing the Financial Business Case for Developers and Investors** | 1 | Municipality (x1) |
| **4. Additional Assessments and Design Iterations Driven by Local and Provincial Policies** | 1 | Ministry (x1) |
| **6. Unstructured Design Iterations** | 1 | Quality Assurance (x1) |
| **7. Extra Handling from Incompatibility Between Market and Government Systems** | 1 | Ministry (x1) |
| **8. Delays in WKB Checks** | 0 | — |

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