Change toolkit for digital building permit

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Contents

1. Executive Summary

Cities across Europe are under pressure to speed up, clarify, and make the building permit process more transparent. CHEK addresses this by piloting a Digital Building Permit (DBP) toolkit, which refers to a set of integrated software tools that brings BIM- and GIS-based integration and automated rule validation, designed to digitalise and improve the permitting process municipal procedures. This deliverable (D6.4) reports on how the toolkit performed in four pilots, Ascoli Piceno (IT), Vila Nova de Gaia (PT), Lisbon (PT), and Prague (CZ), across two scenarios (new construction and renovation), combining hands-on demonstrations with a structured questionnaire and one-to-one interviews.

The objective is to validate, in operational (as in CHEK pilots) conditions, whether the CHEK toolkit can support faster, more consistent permitting by executing end-to-end digital workflows, encoding and checking planning rules, and improving user experience, collaboration, and data quality, measured through a KPI framework defined in earlier WP6 work and consolidated here.

The solution that CHEK offers is a federated toolchain integrated by a “To-Be” permit process map and the CHEK tools workflow: BIMserver.center hosting; CYPEURBAN and Verifi3D for BIM rule checks; VC Map for GIS/3D context and rule checks; IDS/IFC tools for information requirements, georeferencing, and data exchange; and quality/signature utilities. Pilots were run with municipal officers and designers using real-world-like cases, with data captured through surveys, logs, and interviews to assess both performance and usability.

Key results:

- Workflow feasibility: All demonstrations executed the mapped CHEK steps entirely within the toolkit, confirming end-to-end feasibility in pilot conditions.
- Digitalisation impact: CHEK was transformative where baselines relied mainly on paper or static PDFs (Ascoli, Prague) and additive where municipalities already had digital elements in place (Gaia, Lisbon). All municipalities offered online registration of projects, but their levels of digitization varied. In Lisbon and Gaia, the process was semi-digital: project registration and submission of 2D drawings were handled online, and in Gaia it was even possible to submit a BIM model. However, none of these systems included semi-automatic or automatic checks, which made CHEK’s contribution particularly valuable in strengthening pre-checks, improving model quality, and enabling 3D validation.
- Rule coverage & accuracy: A limited but growing set of rules was implemented. Where checks ran, accuracy was high; the main improvement is expanding coverage and exposing clear legal traceability.
- Information in BIM: Municipalities confirmed meaningful, though partial, embedding of permit information in IFC; legal requirements and third-party approvals remain outside the model for now.
- Time saving: Consistent efficiency came from pre-checking (potentially to increase early filtering of incomplete applications). Broader automation is expected to raise savings as rule libraries expand.
- User experience & training: Usability was rated fair-to-good where functionality was available. Training and earlier, role-specific onboarding improved confidence and reduced resistance to change.

In conclusion, CHEK demonstrates a working, scalable process and toolbox prototype for digital permitting. The pilots show clear feasibility and early benefits; progress will depend on widening rule coverage with legal traceability, smoothing cross-tool navigation into a guided municipal workflow, strengthening collaboration/annotation between designer and reviewer, and embedding earlier, scenario-based training. Detailed, actionable recommendations to extend these results are provided alongside this analysis.

2. Introduction

This deliverable presents the assessment of the CHEK Digital Building Permit (DBP) pilots, and the feedback collected from stakeholders who tested the toolkit in operational conditions across four municipalities: Ascoli Piceno, Vila Nova de Gaia, Lisbon, and Prague. The work is developed within WP6, which coordinated and ran demonstrations in two comparable scenarios (new construction and renovation) to examine how a federated set of BIM/GIS tools can support end-to-end permitting tasks. The goal is to turn the project's conceptual vision into practical evidence on feasibility, benefits, and areas for improvement, using inputs from the people who would run or rely on such systems in day-to-day public administration.

The document draws on three primary sources: (1) live pilot observations and technical artefacts produced during the runs (models, validation outputs, logs), (2) a structured questionnaire completed by municipal officers after each scenario, and (3) semi-structured one-to-one interviews used to deepen or clarify issues that ratings alone cannot capture. These inputs are analysed together to provide a consistent narrative of what worked well, what required support, and what needs further development for routine use. The analysis is framed by a KPI set defined in earlier WP6 tasks and consolidated here to link outcomes to measurable indicators such as process digitalisation, regulation coverage and accuracy, time savings, information integration in BIM, flexibility, and user experience.

Pilot activities followed a common workflow: designers prepared, checked, pre-validated and uploaded models to the municipalities platform while municipalities reviewed and validated those checks; Results were reviewed through visual feedback and reports; and findings were recorded for cross-city comparison. While not all steps of a full permit were in scope, each city executed a complete demonstration path mapped to the CHEK To-Be process, enabling like-for-like interpretation across contexts with different digital maturity. The pilots were supported by training materials and ad-hoc guidance so that first-time users could operate the tools and reflect on their applicability to local processes.

Throughout, the report maintains a pragmatic, evidence-based tone. Strengths, such as visual clarity, early error detection through pre-checks, and parameterized rules, are reported alongside limitations typical of a prototype environment, including little familiarity with the just-developed tools and integration gaps. Findings are synthesized at city level and then compared across scenarios to highlight common themes and context-specific nuances. The recommendations summarised at the end of the report point to concrete next steps that will help the CHEK toolkit move from demonstration to scalable adoption, while complementary best-practice guidance is provided in D6.5.

2.1 A fore note about the demonstration feedback

Before starting with the body of this deliverable, it is necessary to explain some few pre-conditions that introduced contextual limitations in the feedback received by the municipalities in CHEK. Due to such limitations of the context, the results of the demonstrations (mostly collected via the quantitative questionnaire) would look less successful than what is instead reflected by the interviews and the measured KPIs, providing an inaccurate picture of the project results. The contextual aspects that we need to consider, including an actual flaw of the project, which have not affected the overall results but produced small needs for adjustments throughout it, are explained in the following text.

The actual complexity of the initial phases of the project, mostly related to the regulations interpretation tasks, which had to deal with 4 different context and the language barriers, has produced small delays that have resulted in a lower readiness than expected at the moment of the demonstration. For example, even if the software was tested internally by software developers and by designers during the development process, it was the first time for the municipality technicians to put their hands on them. This low familiarity with the tools caused a distortion assessment of them as well as about the potential time saved for the checking. Moreover, some of the developments still reported some bugs during the testing, which is completely normal during the development phases of software. These bugs were readily fixed during the demonstrations and are now solved but were affecting the smoothness of the workflow and this was reflected in the feedback. Finally, the training courses intended for municipalities to get familiarity with the theoretical concepts (WP5) which are behind the digital building permit issue (e.g. Building Information Modelling, IFC, GIS, etc.) and the basics about those technologies were not finalised yet and it was not possible to provide a level playing field for everyone. This is clear when comparing the feedback collected from designers, who have high level of familiarity with BIM and GIS technology, with the answers received from municipalities that are not used to work in BIM or with digital technologies.

Second, we need to consider the aimed TRL for CHEK, which is 7 ('System prototype demonstration in operational environment'). It implies that not all the components are a complete and qualified system yet, especially when considering such a complex architecture as the CHEK one. In fact, as some of the components developed in CHEK are now on-the-market TRL9 tools, others, which had a higher innovation ambition and had less mature starting points could reach lower levels of readiness. One of such components, that affected the overall judgement, was the CHEK platform, implemented as a new tool within CYPE Validation and the BIMserver.center extension with the new open APIs functionality. Being it central in the workflow management, some adjustments and bugs needed in these components during the demonstration process caused the feeling that the workflow is not complete for the operational environment. Similarly, the scope of CHEK needs to be considered when assessing the results. For example, the regulations coverage, the connection to the national platforms, the translation of the tools into the national languages were often reported as blocking flaws, and are, indeed, the necessary next steps to scale up the system towards operational application but were not yet part of the CHEK scope.

A final aspect is related to the perception of the municipalities involved in the project. For some of them (or the people involved) it was the first time they participated in a European research project, being more used to tenders to provide a high-TRL working solution to be immediately used in everyday practice. Therefore, the expectations towards the final results were very high with respect to the CHEK expected TRL. For example, the amount of regulations involved in CHEK were sufficient to explain the very high complexity standing behind their interpretation and digitalisation, and to provide a sound method and tools to proceed with scaling up, but some feedback mentions that the number of addressed regulations is too low. We could also notice how the answers change based on the digitalisation mindset of the operators, since they are more optimistic when the operators are already involved in other digitalisation projects (e.g. in Vila Nova de Gaia) and less when the operators have not gone through digitalisation efforts yet (e.g. Ascoli Piceno). However, we do believe that this feedback fairly reflects one of the major challenges that CHEK intended to tackle, that is, to confront directly with the real world practice, involving building authorities operators that deals with building permitting in everyday life, and are therefore aware of the challenges and complexities. That gives the opportunity to present the hinders to be overcome for full acceptance and uptake of the system in the after-CHEK life, such as, first of all, the investment in training and education, together with simplification and digitalisation of regulations, scaling up the system towards an enhanced scope and higher TRLs.

CHEK involved seven different software developers, each contributing tools for specific steps of the workflow. This fragmented tool environment was not incidental but intentional: the project proposal emphasized the inclusion of multiple providers as a way to demonstrate scalability across domains and countries, as well as to show that collaboration and knowledge transfer were feasible even between software competitors. This setup brought both strengths and weaknesses. On the positive side, it showcased the capacity of diverse solutions to interoperate and highlighted the potential for cross-border and cross-domain adoption. On the negative side, the use of tools from multiple developers made it difficult to ensure a seamless user experience. Instead of a single, integrated platform, municipalities encountered a set of separate tools with varying interfaces. This created confusion among municipalities, many of whom had expected a unified system capable of handling all tasks within one environment.

The feedback provided by the interviews reflects how the CHEK results are a key cornerstone, demonstrating that the building permit digitalisation is feasible and showing the path ahead.

3. Demonstration process

The demonstration activities within WP6 served to validate the CHEK Digital Building Permit (DBP) toolkit in operational conditions across four pilot municipalities. The process aimed to test the system's capacity to manage new construction and renovation permitting workflows while capturing structured stakeholder feedback for subsequent evaluation (Task 6.4).

The demonstrations were carried out in two scenarios:

- Scenario 1 – New building permit application.
- Scenario 2 – Renovation permit application.

Each city implemented both scenarios under comparable conditions to allow cross-case analysis. The process combined hands-on tool use with observation, support, and structured evaluation.

3.1 Demonstration scope

The scope of the demonstrations was designed to replicate the conditions of real municipal permitting as closely as possible, while still accommodating the limitations of a pilot setup. Municipalities and Designers were invited to simulate complete permitting processes using CHEK's federated ecosystem of BIM- and GIS-enabled validation tools.

Number of demonstration participants

Participation varied by city, ranging from 1 to 6 municipal officers per scenario. In total, 23 municipal officers took part in all demonstrations, often joined by designers or technical staff for context-specific tasks.

Demonstration duration

The live demonstration sessions typically lasted between half a day and two days, depending on scenario complexity and participant availability. In several cases, the time allocated was treated flexibly: after the assigned week for each demo, extra sessions were organised to resolve software bugs, provide additional guidance, and allow more time for specific tasks on both the municipality and designer side, with direct support from developers. This ensured that demonstrations could adapt to technical issues and participants' needs, while still reflecting the planned pilot scope.

3.2 Demonstration workflow

The demonstrations followed a structured workflow designed to replicate the steps of a real permit validation process while using CHEK's integrated toolchain.

List of the software used

The following CHEK tools were deployed across the pilots (availability and use varied by city):

1. **DBP Platform (BIMserver.center, CYPE)** – hosting, sharing, and managing BIM models
2. **CYPEURBAN (CYPE)** – automated rule-checking and compliance validation
3. **Verify3D (Xinaps)** – model-based rule checking and visualisation of non-compliance
4. **VC Map CHEK plugin (VCS)** – GIS and 3D spatial context visualisation
5. **IfcGref (TUD)** – georeferencing BIM models for integration with GIS data
6. **BIM to GIS (TUD)** – conversion and integration of BIM data into GIS environments
7. **IFC Exporter (DiRoots)** – export of BIM models to IFC format with correct data structure

8. **IFC Checker (RDF)** – validation of IFC model structure and data integrity
9. **CityGML/CityJSON Checker (OGC)** – validation of GIS-based planning datasets
10. **GIS to BIM (RDF)** – integration of GIS datasets into BIM environments
11. **IFC Digital Signature (DiRoots)** – secure digital signing of IFC models for authenticity

Workflow steps: Designer & Municipality

1. **Designer preparatio**n – Upload of BIM/GIS models to BIMserver.center, ensuring correct file format and metadata, IFC/CityGML Checking, pre-checking with CYPEURBAN, Verify3D or VCMap CHEK.
2. **Municipality validation –** Import of models into CYPEURBAN, Verify3D, VCMap CHEK for rule checking.
3. **Context review –** Visualisation in VCMap with relevant planning layers and geospatial constraints.
4. **Compliance reporting** – Review of automated check results, manual interpretation of flagged issues, and validation reports in BIMserver.center Validation
5. **Feedback & iteration –** Where applicable, exchange of model corrections or clarifications between designer and municipal officer.

Deliverable 6.2[1] , chapter 2.1, can be consulted with a more detailed description and illustration of the workflow steps and integration of tools.

3.3 Data collection

Data was gathered to assess both technical performance and user experience, providing the feedback material for the evaluation in chapter 5&6 and KPI assessment in chapter 8.

What and how was collected

- Structured responses via the CHEK Feedback Questionnaire (quantitative ratings + qualitative comments). (Annex 1)
- Observational notes by project partners during live demonstrations.
- Technical performance data where available.

Summary of documentation / questionnaires / interviews

- **Questionnaires** captured feedback on usability, rule implementation, integration, collaboration, and scalability.
- **Supplementary materials** included session agendas, tool output screenshots, and attendance records.
- **Interviews** with each municipality enriched the collected feedback with valuable insights and reflections from participants.

[1] Deliverable 6.2: D6.2_CHEK_101058559_Results-Demonstration-S1_V1.1.pdf

4. Methodology for final feedback collection

4.1 Stakeholder feedback questionnaire: Structure and methodological framing

4.1.1 Purpose of the questionnaire

As part of Task 6.4 within Work Package 6, a structured stakeholder questionnaire was developed to gather qualitative and quantitative insights from municipal officers who participated in the pilot demonstrations of CHEK's DBP system. The questionnaire served as the principal tool for evaluating end-user experience, identifying practical bottlenecks, and informing recommendations for further development and deployment of the CHEK toolkit. It was designed to gather feedback across both Scenario 1 (New Construction) and Scenario 2 (Renovation), ensuring a comparative analysis of the tools' adaptability to different permitting contexts.

4.1.2 Structure of the questionnaire

The questionnaire consists of six sections, each mapped to a thematic area of evaluation:

Section 1: Respondent profile

This initial section collected basic information such as the respondent's associated municipality, role in the demonstration, and the scenario (new or renovation) on which the feedback was based. This enabled segmentation of feedback by city and role, which is crucial for disaggregated analysis in subsequent sections of the deliverable.

Section 2: Usability and functionality

A significant portion of the questionnaire focused on assessing the ease of use, intuitiveness, and consistency of the CHEK tools. The platform's modular design, featuring tools like BIMserver.center, CYPEURBAN, VCMap, Verifi3D, IfcGref, and DiStellar, required granular evaluation. Each tool was assessed in terms of:

- Interface intuitiveness
- Clarity of rule-checking mechanisms
- Effectiveness of visualization (e.g., overlays, 3D models)
- Navigation between validation results, models, and regulation data
- Degree of system guidance through the permit review process

This section included questions regarding the internal coherence between modules, acknowledging the challenge of maintaining a smooth user experience across a federated ecosystem of tools.

Section 3: Effectiveness, time savings and performance

This section investigated the perceived impact of the CHEK workflow on day-to-day permitting operations. Respondents were asked to estimate the degree to which CHEK reduced:

- Internal processing time
- Amount of documentation reduced
- Back-and-forth communication with designers and tool-support

Questions also investigated to which extent the tools supported regulatory interpretation and helped visualize local urban planning constraints. These are key performance indicators (KPIs) directly linked to the core objectives of WP6 and its experimental validation design.

Section 4: Training, support, and user confidence

This part of the questionnaire evaluated technical preparedness and the availability of support infrastructure during demonstrations. Questions addressed:

- Quality and usefulness of pre-demo training materials

- Confidence in using the CHEK tools independently
- Availability and adequacy of live technical support
- Frequency and intensity of external support required

These data points provide insights into the maturity of the tools and the level of onboarding effort required for broader institutional adoption.

Section 5: Scalability and future Implementation

This forward-looking section asked respondents to evaluate whether the CHEK toolkit could be deployed in their municipality beyond the pilot. It also explored key institutional and systemic enablers or barriers to adoption, such as:

- Legal/regulatory alignment
- Staff training requirements
- Software integration with legacy permit systems
- Budgetary constraints

Participants were also prompted to recommend specific CHEK tools or features they found most helpful, and to suggest areas requiring further improvement.

Section 6: Open Feedback

The final section was an open-ended invitation for additional remarks, enabling respondents to raise issues not directly addressed by prior questions. This provided space for subjective reflections, ideas for enhancements, and contextual observations from real municipal workflows.

4.1.3 Target respondents and collection process: target respondents and framing

The primary target group for the questionnaire were municipality officers, with optional participation extended to designers involved in the demonstrations. This choice reflects WP6's institutional focus on validating the feasibility of digital building permitting within public authorities, since, in the majority of cases, municipalities are the ones that need to initiate the digitalisation journey and decide on the tools. Consequently, most evaluative weight in this deliverable comes from municipal users, collected post-demonstration for both Scenario 1 (new construction) and Scenario 2 (renovation). The feedback of the designers is included in chapter 7 and 8.

However, there is an interpretive note on roles and expectations. During the pilots, and as it would be, later, in real life implementations, a substantial portion of hands-on operation of the toolkit was performed by designers, while municipal officers primarily evaluated outcomes against regulatory practice and institutional workflows, although having the control over the tools and results as well. Developers also noted that several tools originated from a designer-centric lineage, which can shape usability and workflow expectations. This role asymmetry introduces an important nuance: designers carried more of the operational workload; municipalities provided most of the formal feedback.

Expectation gap: municipal expectations, especially around legal traceability, process integration, and collaboration features, were broader and stricter than what a prototype toolchain focused on model authoring/validation could fully deliver at this stage.

To address this, our analysis:

- Combines sources (municipal questionnaires, one-to-one interviews, and developer/designer inputs) to balance perspectives.
- Distinguishes designer-centric constraints explicitly when interpreting lower municipal satisfaction scores, distinguishing between tool maturity/coverage and misalignment of target user needs.

- Translates gaps into recommendations (e.g., municipality-first workflow design, legal traceability, integrated feedback loops, earlier role-specific training), framing them as actionable steps toward convergence of designer and municipal requirements.

This framing helps ensure that municipal feedback, while central, is interpreted in light of the piloting setup, where the toolchain's origins and the division of labour could reasonably lead to stricter municipal grading than design-tool maturity alone might warrant. It also clarifies why several findings emphasise the need to evolve CHEK from a designer-optimised validation stack into a municipality-ready, end-to-end permitting workflow.

4.1.4 Alignment with KPIs and evaluation strategy

The questionnaire was explicitly structured to align with the evaluation metrics defined in D6.1 and to inform the KPI tracking outlined across D6.2 and D6.3. The responses collected through this instrument were systematically analysed, both quantitatively (via rating distributions) and qualitatively (through thematic clustering of open comments). This analysis serves as the backbone of the stakeholder evaluation presented in the next sections of D6.4.

KPI frameworks are highly quantitative and best suited to fully mature toolchains. The CHEK toolkit at demonstration time was a working prototype system, not a 100% feature-complete product. To keep the evaluation fair and informative, we adopted the following principles:

- Complex point of view (feasibility + performance): Quantitative KPIs are reported, but they are interpreted alongside qualitative evidence of workflow feasibility. Across all pilots we executed the end-to-end CHEK To-Be demonstration workflow with all available tools. This proved that the overall process is functional and scalable, while indicating where additional regulation encoding and usability refinements will raise KPI values.
- Maturity-adjusted reading: Where targets were not met, results are attributed transparently to scope and maturity (e.g., limited rule coverage, prototype interfaces), rather than to the infeasibility of digital permitting itself. In several areas, feasibility was achieved for a subset of rules; extension to the remaining rules is primarily a matter of progressive implementation.
- Evidence combination: Questionnaire ratings are complemented with one-to-one interviews and developer inputs to capture issues that numeric scores cannot (e.g., legal traceability needs, collaboration features, onboarding depth).
- Comparative context: The design enables cross-scenario (new build vs renovation) and cross-municipality comparisons, controlling for differences in:
    - local geospatial/BIM maturity,
    - building/use case complexity, and
    - regulatory density and interpretive practice.
- Learning orientation and findings (e.g., municipality-first workflows, expanded rule libraries, clearer parametrization, integrated feedback loops), for linking current feasibility to a credible path to KPI improvement.

The evaluation strategy recognises that CHEK has demonstrated a functional, end-to-end workflow with the tools developed during the project. Quantitative KPIs establish a baseline, while qualitative analysis explains why some targets are not yet reached and how scaling regulation coverage and usability will move the toolkit toward those targets. The questionnaire thus serves not only to measure outcomes but also to advance CHEK's mission of a repeatable, evidence-based framework for digital permit adoption and interoperability across EU cities.

4.2 Individual interviews

In addition to the structured questionnaire, a series of semi-structured one-on-one interviews with municipal officers was conducted to complement and deepen the feedback collection process. The aim of these interviews was to generate richer qualitative insights into the pilot demonstrations, validate the questionnaire findings, and gather additional data relevant to the measurement of key performance indicators (KPIs).

The interviews were designed as semi-structured conversations, combining open-ended reflection with targeted questions. This format ensured flexibility in allowing respondents to articulate their experiences while at the same time providing structured input aligned with the CHEK evaluation framework. The interviews focused on five thematic areas:

- User experience and usability across tools,
- Functionality and accuracy of automated rule checking,
- Technical integration and workflow coherence,
- Collaboration and communication mechanisms, and
- Confidence in scalability and future adoption.

Particular attention was given to KPIs where questionnaire or project deliverable's data alone were insufficient, notably:

- Percentage of process steps digitalised (KPI 7.2.2),
- Number of digitalised regulations (KPI 7.2.3),
- Accuracy of automatically validated regulations (KPI 7.2.4),
- Reduction in the number of documents through BIM integration (KPI 7.2.5), and
- Time saving within internal assessment (KPI 7.2.7).

Each interview followed a common template to ensure comparability across municipalities while allowing respondents to elaborate on local specificities. Officers were first invited to describe their role in the demonstration and their overall impressions of the CHEK toolkit. The discussion then moved to more targeted questions exploring specific process steps, regulation coverage, validation accuracy, document handling, and time savings. Where possible, respondents were asked to provide quantitative estimates (percentages, counts, or time measures) to complement the qualitative observations.

The interviews were carried out shortly after the demonstrations, ensuring that user experiences were fresh and directly linked to the practical testing sessions. Notes and transcripts were systematically analysed alongside questionnaire responses. This dual-source methodology enabled triangulation of findings, ensuring greater reliability and depth of interpretation.

By combining structured survey data with qualitative interview insights, the methodology not only validated the KPIs defined in earlier deliverables (D6.1, D6.2, D6.3) but also provided granular, context-sensitive feedback that reflects the operational realities of each municipality. This strengthened the analytical foundation of the evaluation and allowed the deliverable to move beyond surface-level metrics towards a more nuanced understanding of tool performance, user needs, and institutional readiness.

5. Summary of the first phase feedback – questionnaire results

CHEK set out to test whether a Digital Building Permit (DBP) workflow, supported with GeoBIM integration and machine-readable rules, can be fully operational inside real municipal settings. The pilots in Ascoli Piceno (IT), Vila Nova de Gaia (PT), Lisbon (PT), and Prague (CZ) tested two scenarios (new construction and renovation) to validate feasibility, gaps, and gather structured stakeholder feedback (for the detailed feedback refer to ANNEX 1). From the outset, CHEK was framed as pilot testing rather than a market-ready product; the rule set was intentionally limited to demonstrate baseline viability and inform the next development cycle. Collaboration features were treated as "nice-to-have" at this stage, with priority placed on core validation infrastructure (data, checks, and GeoBIM workflows).

What worked consistently

Across cities, the demonstrations executed the mapped CHEK process steps within the toolkit, confirming end-to-end feasibility in controlled pilot conditions. Visual, model-centric validation (e.g., highlighting of non-compliances in 3D) proved especially helpful for both orientation and decision support. Pre-checking phase (IFC quality and information checks, georeferencing, basic GIS overlays) reduced repeated work and clarified model expectations for applicants, with measurable time-saving potential once users gained familiarity.

Rule coverage and accuracy

The ruleset implemented in the pilots was deliberately narrow. Where rules were active, reported accuracy was generally good and sometimes high; the main development task now is to broaden coverage and expose legal traceability more transparently in the interfaces. This aligns with CHEK's research focus on turning narrative regulations into machine-interpretable logic and linked information requirements, an area where the project combined GeoBIM standards with rule interpretation methodology to accelerate the process from text to IFC/CityGML-ready specifications

Integration and interoperability

Pilots ran in a sandboxed configuration, so deep back-office integration (e.g., with permit case-management systems or municipal GIS hubs) was out of scope. Even so, the tests showed that hand-offs across the CHEK tools (GeoBIM checking) are feasible and that parametrized configuration (e.g., in VC Map and CYPEURBAN) allows local adaptation. Municipalities asked for tighter, more automated in-between-tools flows and clearer continuity checks on submissions, points that naturally sit in the next phase, when integration with municipal systems becomes the focus.

Usability, onboarding, and roles

Users reported a learning curve typical of first-time BIM/GIS validation. Training materials and hands-on support improved confidence, but embedded guidance and role-specific flows will help municipalities use the system more autonomously. An important context nuance emerged: during the pilots, designers carried much of the operational workload (modelling, exports, mapping), while municipalities provided most of the formal evaluation. This role asymmetry can temper municipal satisfaction ratings when functionality is still evolving; it also underlines where the operational environment and guidance should target reviewer needs next.

Collaboration features (by design, lower priority in pilots)

Stakeholders welcomed the idea of in-tool comments, partial approvals, and traceable dialogues, but these were not primary objectives for the pilot stage. Feedback confirms that adding lightweight, auditable interactions will strengthen realism as the toolkit matures, without detracting from the core objective of automating checks on standardised, well-specified data.

6. Individual interviews

6.1 Vila Nova de Gaila

6.1.1 Summary

The municipal team entered the pilots with already high knowledge on digitalisation. Since 2018, their permitting workflow uses a digital platform, including the optional submission of IFC models. While CHEK did not radically change the process, it improved model quality, pre-checking capabilities, and IFC specifications, which clarified requirements for designers.

Officers emphasized that CHEK proved the feasibility of automated checks, which they see as transformative for timesaving and error prevention. While some tools (e.g., IFC signing, IFC exporter, geo-referencing tool) were perceived as highly valuable, others from the municipality perspective (notably CYPEURBAN) were considered to have an interface and user experience too complex for municipality operators, considering here also this was a pilot phase of the DBP adoption. Municipal staff had limited experience with the DBP process, and the tools were new to them, still evolving as part of the testing and development phase of the project. However, this gap with the more complex tools was not perceived by the designers itself more used to work with BIM tools.

The demonstrations highlighted the importance of simplifying regulations to make them more machine-readable. Overall satisfaction was around 60–70%, with variation across tools (some close to 100%). Training materials (videos) were helpful, but officers suggested earlier trial sessions would have improved usability.

Vila Nova de Gaia's feedback confirms that CHEK offers clear added value improving IFC quality control, automating part of the regulatory checking process, and reducing assessment time. However, further development is required to expand the set of digitalised regulations, ensure legal traceability, and increase document integration into BIM models.

6.1.2 KPIs addressed

KPI 8.2.2 – Percentage of process steps digitalised (compared to the state before CHEK)

Gaia's baseline was already semi-digital in regards of the online registration of projects, the submission of 2D drawings and IFC models, the consultation of information online. CHEK contributed by strengthening IFC model quality and adding rule checking functions to BIM models. These enhancements ensured clearer requirements for designers and helped municipalities detect errors earlier in the process.

KPI 8.2.3 – Number of digitalised regulations

During the pilots, approximately 70% of the expected rules were implemented, with around 6 out of 10 successfully validated in practice. These included core parameters such as building height and setbacks. Officers stressed that the most critical regulations were included, but a full set of rules will be necessary to replicate real permitting conditions.

KPI 8.2.4 – Accuracy of automatically validated regulations in the use of Pre-check + Check

Officers generally considered the checks technically accurate when correctly calibrated. However, errors emerged when input data such as reference points or terrain boundaries were not properly configured, leading to misleading results. Accuracy therefore depends strongly on workflow settings, but respondents emphasised that this is fixable with refinement. Confidence in legal traceability of rules remains limited, but the potential for accuracy is high.

KPI 8.2.5 – Amount of information (documents) moved into the BIM model

Gaia estimated that currently less than 50% of the total permit information is integrated into the BIM model. Many attributes, such as materials or wall finishes, which were though out of the scope of the regulations considered in CHEK, are still submitted as separate documents. However, officers foresee a realistic potential for 100% integration, with IFC as the sole submission format in the future. The CHEK pilots demonstrated the pathway toward this.

KPI 8.2.7 – Time saving within the internal assessment time

CHEK produced tangible time savings. The use of pre-checks reduced assessment time by approximately 30%, particularly by preventing redundant validation steps. Overall, officers estimated a 23% reduction in internal assessment time, indicating that the KPI target was met for Gaia. Simple, visual tools such as VC Map were considered supportive of efficiency, while more complex tools like CYPEURBAN slowed down designer-side processes and required further user interface improvement.

Additional insights

Training materials (notably video tutorials) were found helpful, though officers suggested that earlier and more trial sessions would have better prepared users. Overall satisfaction was rated 60–70%, with considerable variation between tools: some modules scored near 100% satisfaction, while others were considered too complex. The pilots highlighted the need to simplify and restructure regulations to make them more machine-readable. Officers also noted a divergence in perspective: designers appeared more satisfied with CYPEURBAN, whereas municipalities found it overly complex for their needs.

6.2 Lisbon

6.2.1 Summary

The municipality of Lisbon entered the CHEK pilots with a strong interest in exploring the potential of automated regulation checking. Officers requested a wide set of local rules to be digitalised, reflecting the city's complex regulatory environment. Their participation in both Scenario 1 and Scenario 2 demonstrations focused on assessing rule coverage, accuracy of validation, and the potential for greater integration of information into BIM models.

Lisbon's feedback reflects both the challenges of aligning a complex regulatory environment of a large city with emerging digital tools and the promise shown by the first successful rule implementations. Even if Lisbon considers that the rules demonstrated will need further adjustments, tangible benefits in accuracy and time savings was demonstrated, illustrating the value of scaling up this approach. With broader rule coverage, improved integration, and closer cooperation with municipalities, CHEK has the potential to play a significant role in Lisbon's digital permitting processes.

6.2.2 KPIs addressed

KPI 8.2.2 – Percentage of process steps digitalised (compared to the state before CHEK)

Lisbon already operates a semi-digital permitting workflow in regards of the online registration of projects, based on 2D submissions in PDF and DWG formats. The CHEK demonstrations did not increase the percentage of digitalised steps, but officers acknowledged the potential for improving the quality of existing digital steps once regulations are fully encoded.

KPI 8.2.3 – Number of digitalised regulations

Municipal officers initially expected around 70 rules to be digitalised. In practice, 17 were attempted. This sharp contrast between expectations and delivery was a source of major disappointment for municipality operators. Officers stressed that close cooperation with municipalities is essential to ensure correct encoding of local regulations.

KPI 8.2.4 – Accuracy[2] of automatically validated regulations in the use of pre-checking + checking

The municipalities perception on the reliability of the automated and semi-automated rule checking was low. This could be due to the lack of deep knowledge on digital technologies. The tested rules' accuracy was validated, producing results consistent with manual checks. Officers confirmed the simplified workflow compared to traditional validation, with only a small, tolerated, error margin.

KPI 8.2.5 – Amount of information (documents) moved into the BIM model

Officers recognised the advantage of moving from 2D to 3D validation environments but estimated that less than half of current documents could realistically be embedded in BIM.

KPI 8.2.7 – Time saving within the internal assessment time

CHEK achieved a time saving of around 30 minutes compared to manual checking. However, the overall workflow was perceived as fragmented and incomplete (due to the lower maturity of the CHEK platform, as explained in Section 2.1, and some bugs which were though fixed during the demonstrations), preventing wider time reductions. Officers stressed that with broader rule automation, significant efficiency gains could be achieved in the future.

Additional insights

Officers described the current workflow as fragmented but also acknowledged that the pilot represented an early stage of development. They underlined that close collaboration between municipalities and software developers is key for improving usability and ensuring that rules are implemented correctly. Despite the limited scope of the pilot, they were supportive of continued CHEK development, recognising its potential to strengthen permitting through automation and BIM integration.

6.3 Prague

6.3.1 Summary

The municipality of Prague participated in the CHEK demonstrations with the aim of exploring how automated rule-checking and BIM-based validation could support a permitting process that is currently still largely paper-based. Officers engaged primarily with VC Map and Verify3D and BIMserver.center platform, assessing their usability, accuracy, and relevance for municipal practice. Their feedback highlights both the opportunities and the current limitations of the toolkit in a complex regulatory environment.

[2] When moving to digital checks, it will be necessary to raise awareness about the digital tools accuracy potential with respect to the actual accuracy of current checks, which suffer from: source data accuracy (given by a combination of survey accuracy and restitution or modelling phase accuracy), error given by the graphical representation, which is dependent on the representation scale, precision of measuring tools and accuracy of such a measure. Whether digital tools are mastered, the error given by the graphical representation will be nullified, and the precision of the measurement to check the regulation will be maximised. Promote awareness of those accuracy calculation mechanisms among the municipality officers will be key for digital tools acceptance.

Prague's feedback highlights CHEK's potential to modernise a permitting process that remains largely paper based. While the current demonstrations provided limited functional steps and modest time savings, the accuracy of the implemented rules and the clear potential for greater efficiency confirm the value of further development. Expanding rule coverage, ensuring legal traceability, and consolidating tools into an integrated workflow will be essential to support practical adoption once legislative conditions allow.

6.3.2 KPIs addressed

KPI 8.2.2 – Percentage of process steps digitalised (compared to the state before CHEK)

Prague's permitting process is still predominantly paper-driven, with only partial digitalisation in place. The CHEK demonstrations showcased a fully digital workflow, illustrating the potential for transformation. However, the number of process steps that could be executed with CHEK tools was limited due to the set of implemented rules and fragmented tool environment.

KPI 8.2.3 – Number of digitalised regulations

Across the pilots, approximately eight rules were implemented, split between VC Map and Verify3D. Of these, three rules in VC Map were considered particularly relevant for municipal practice. Verify3D included five to six rules, some of which were duplicates and less applicable to permitting workflows. Although WP2 had identified a broader set of around 50 priority rules for Prague's pilot case, these were not fully carried through to implementation.

KPI 8.2.4 – Accuracy of automatically validated regulations in the use of Pre-check + Check

Officers reported that the rules implemented in both VC Map and Verify3D generally worked correctly. One rule relating to the number of students per room lacked explicit traceability to legal references, but the results still appeared accurate. Overall, the accuracy of implemented rules was assessed as high.

KPI 8.2.5 – Amount of information (documents) moved into the BIM model

Officers estimated that approximately 30% of documentation could be integrated into the BIM model, primarily technical drawings and geometric data. Other required materials, such as legal statements or third-party approvals, remain outside the model environment. While the pilots demonstrated the feasibility of embedding some information in BIM, further development and legal alignment are needed for full adoption.

KPI 8.2.7 – Time saving within the internal assessment time

In the current demonstrations, time savings were modest, due to the limited number of functional rules and the need to use multiple tools. However, officers emphasised the strong potential of automation: with a complete set of rules, efficiency gains of up to 30% could be achieved. For simple rules applied across entire models (e.g., ceiling height), savings could be even higher, with estimates of up to 80%. Pre-checking was also highlighted as valuable for reducing preparation time by filtering incomplete applications before submission.

Additional insights

Prague officers stressed the importance of consolidating CHEK into a single, smooth workflow, as switching between multiple tools is not viable in real permitting contexts. They also noted that legislative frameworks remain a key barrier, since BIM-based permitting is not yet formally recognised in Czech law. Nevertheless, the pilots were considered useful in demonstrating how future workflows could evolve, and officers expressed support for continued CHEK development, particularly with a stronger focus on implementing locally relevant rules.

6.4 Ascoli Piceno

6.4.1 Summary

For the municipality of Ascoli Piceno, the CHEK pilots represented the first direct experience with BIM models in the permitting process. Officers described this as both a challenge and a valuable learning opportunity: while initial exposure created uncertainty, it also highlighted how BIM-based validation could transform local workflows. Participants focused on evaluating rule implementation, accuracy of results, potential document integration into BIM, and efficiency gains through pre-checking and automation.

Ascoli Piceno's interview feedback demonstrates how CHEK can support municipalities in making the transition from dematerialised to digital permitting. The pilots showed that a significant share of regulations can be digitalised with high accuracy, that BIM models can embed much of the required documentation, and that pre-checking can deliver meaningful time savings. While gaps remain in rule coverage and tool integration, the experience was seen as a valuable first step. Officers expressed strong interest in further development and in applying CHEK within a broader collaborative setting, confirming the toolkit's potential to drive digital transformation in Italian permitting practices.

6.4.2 KPIs addressed

KPI 8.2.2 – Percentage of process steps digitalised (compared to the state before CHEK)

Ascoli's current permitting system is fully digitized in PDF format but does not fully integrate digital tools for workflow automation and data management. CHEK demonstrated how BIM could enable a step change, with officers estimating that up to 80% of workflows could be digitalised compared to the current baseline. While this level was not achieved during the pilot itself, the demonstrations illustrated a clear pathway toward more comprehensive digitalisation.

KPI 8.2.3 – Number of digitalised regulations

During the pilots, eight regulations were implemented, representing around half of the municipality's expected coverage. Nonetheless, officers considered the set of rules tested sufficient to demonstrate feasibility and to reveal how automation could be expanded in the future.

KPI 8.2.4 – Accuracy of automatically validated regulations in the use of Pre-check + Check

Participants reported that the implemented rules were largely accurate, with an estimated accuracy of around 90%. Only one error was noted, concerning a building height calculation. Officers concluded that the accuracy of automated rule checking was generally reliable and could be improved further through refinement of calculation parameters.

KPI 8.2.5 – Amount of information (documents) moved into the BIM model

Officers estimated that around 60% of documentation could be integrated into BIM, particularly designer-provided data such as drawings and technical specifications. External approvals from third parties (e.g., fire safety, heritage, structural reviews) would remain outside the BIM environment, but the pilots demonstrated how a large share of municipal documentation could eventually be embedded.

KPI 8.2.7 – Time saving within the internal assessment time

Time savings were considered one of the most promising outcomes. Officers highlighted that pre-checking incomplete applications could save more than 50% of assessment time, by reducing rework and back-and-forth with applicants. For rule checking specifically, they estimated that savings could reach up to 80% once users were fully familiar with the tools. In the pilot itself, efficiency gains were closer to 30% due to the learning curve, but the long-term potential was considered substantial.

Additional insights

The CHEK pilots provided officers with greater awareness of their own workflows and of the steps needed to transition from dematerialised to digital permitting. Initial scepticism about BIM was replaced with recognition of its value once officers gained hands-on experience. Training was seen as essential in building this confidence. At the same time, participants recommended reducing workflow fragmentation by consolidating the toolchain into a more consistent environment. They expressed interest in continuing to test CHEK with both municipal officers and external designers and engineers.

7. Designers' feedback

The CHEK pilots offered designers a unique opportunity to test, in depth and under real project conditions, the entire digital building permitting (DBP) workflow. Unlike municipalities, whose role in the demonstrations focused mainly on validating and providing comments at specific stages, design teams were engaged daily with the toolkit and carried out most of the end-to-end testing. This intensive involvement made it possible to identify both the strengths of the workflow and the areas where further improvement is needed. Moreover, the fact that the pilots replicated authentic permitting steps (from initial project submission to municipal validation, context review, compliance report, and feedback) reinforced the practical utility of the experience, moving well beyond a laboratory exercise.

7.1 User experience

From the designer's perspective, the pilots helped clarify IFC requirements and raised the level of model quality control. With more clearly defined parameters and structured exports, submissions could be prepared with greater precision, reducing iterations and corrections. Early validations ("pre-checks") proved especially valuable: by running checks before submission, designers could detect missing attributes or georeferencing issues at an early stage, thereby reducing rework and increasing the likelihood of first-time acceptance. This self-checking mechanism avoided unnecessary resubmissions and provided greater confidence in the quality of the model before it reached the municipal review stage.

Another notable strength was the simplicity of the visual workflow. The 3D/GIS environments, graphical overlays, and intuitive flags immediately showed where and why a non-compliance occurred. This accelerated iterations and supported much more targeted corrections. In practice, what might previously have required multiple exchanges with municipal officers could now be resolved in a single design cycle. The visual clarity also fostered a common language between designers and reviewers, reducing misunderstandings and facilitating communication between parties with different technical backgrounds.

Designers exercised end-to-end the digital toolkit provided by the CHEK project, a toolkit that greatly enabled the DBP process. Even though some technical issues were experienced and solved during the demos, the digital toolkit added great value to the designer's workflow.

7.2 Observed benefits

The demonstrations confirmed that the DBP workflow is technically feasible and ready for scaling. In particular:

- **Time savings**: although is depending on a project and it's very complex to measure, time savings were obvious. The possibility to perform self-check of the design even in the early stages, was contributing greatly to a time saving, that the Designers estimated that is between 20 – 30%. The availability and functionality of other tools delivered by CHEK project, also added great value in this direction, since they fill the gaps of the existing design process.
- **Error reduction**: The clear specifications for deliverables and designer-side pre-checks led to fewer omissions and inconsistencies. The adoption of IFC/IDS templates with standardized parameters proved key to reducing variability. Based on the demonstrations carried, the designers estimated that CHEK DBP tools can contribute to 5-15% less errors than typical designers workflow.
- **Transparency and communicatio**n: linking compliance results directly to 3D/GIS context improved mutual understanding between designers and reviewers, strengthening trust in the checks.

- **Higher first-time quality**: the ability to self-check before municipal validation reduced the number of iterations required, increasing the efficiency of the overall process.

7.3 Challenges and areas for improvement

Despite these achievements, designers identified the same improvement priorities as municipalities:

- **Rule coverage and transparency**: a broader set of local regulations needs to be encoded. Each automated result should include explanation of the rule logic and links to the corresponding legal reference to strengthen traceability and trust in the system.
- **Technical integration and stability**: reliability in file exchange, model loading, and hand-offs across tools must be reinforced to reduce friction in daily work. To replicate and scale the CHEK results, there is need for greater technical stability and integration between many tools that will effectively collaborate and communicate between them.
- **Efficiency of automation and onboarding**: immediate efficiency gains from the automation were limited due to the limitation of the encoded rules. On the other hand, onboarding requires enough time to bring all participants up to the required level of proficiency. Expanding the rule set, streamlining in-tool guidance, improving stability in model federation, and reducing manual steps are all essential for scaling the system.

7.4 Overall assessments

From the designer's point of view, the demonstration pilots confirmed the overall CHEK DBP workflow. The project delivered clear value and demonstrated that model-based permitting is not only possible but already offers tangible benefits. The pilots showed that designers can prepare and validate submissions more efficiently, that municipalities receive higher-quality documentation, and that both parties benefit from greater clarity and error reduction.

Although the tools are not yet at commercial maturity, the successful execution of the pilots proves that the concept works. With further development (particularly in rule automation, integration, and legal traceability) the system is ready to scale to more municipalities and larger project volumes. The results confirm that CHEK provides a solid foundation for the transition toward a more agile, transparent, and standards-based permitting model.

7.5 Conclusion

As a conclusion from the overall demonstration process, we can conclude that the pilots proved the feasibility of the model-centric, standards-based permitting in real municipal settings, a DBP proposed by CHEK project. At the same time, the pilots also exposed some gaps that block production use, like limited rule coverage and legal traceability, fragile integration across tools, and limited collaboration mechanics.

Designers strongly support the CHEK DBP framework. The pilots validated the workflow, demonstrated concrete benefits, and established a robust foundation on which to build. From the design perspective, CHEK represents a realistic and practical pathway toward faster, clearer, and more reliable permitting processes across Europe. With appropriate improvements in rule coverage, technological integration, and regulatory support, the door is open to broad adoption capable of transforming the relationship between designers, municipalities, and developers.

8. Key Performance Indicators

The evaluation of CHEK's DBP toolkit in WP6 is also done in relation to the KPIs designed to assess the technical, procedural, and experiential outcomes of the pilot demonstrations. These KPIs provide a measurable link between the project's conceptual objectives and its practical performance in municipal permitting workflows. They measure the extent to which the toolkit supported process digitalisation, rule implementation, integration, user satisfaction, and overall readiness for municipal adoption.

The framework was first defined in D6.1 and refined in D6.2 and D6.3, with results consolidated here in D6.4 through a combination of technical data, municipal feedback, designers feedback, and demonstration observations.

As highlighted by designers involved in the pilots, the toolkit is still at a prototype stage, with only a limited subset of regulations implemented. For this reason, KPI values should be read as indicative of feasibility and direction rather than final performance metrics. This context reinforces that the current KPI analysis reflects both the progress achieved in WP6 and the clear scalability potential of CHEK as regulation coverage and system maturity increase.

8.1 Approach towards KPI achievement

The KPI framework was defined in D.6.1 and refined through the course of work of WP6, aligning with the CHEK project's overarching goal: to demonstrate that digital building permitting can improve efficiency, accuracy, collaboration, and regulatory compliance in real municipal context. This goal has already been demonstrated in practice for a limited set of regulations, confirming the feasibility of automated validation. The extension of this approach to the full body of municipal regulations is primarily a matter of time and progressive implementation. The development process combined:

- Project-level objectives from the CHEK Grant Agreement.
- Operational requirements from participating municipalities.
- Tool-specific capabilities across the CHEK tool ecosystem.
- Evaluation needs for cross-city and cross-scenario comparability.

Each KPI was defined with:

- A clear measurement target.
- A baseline reference (pre-checking tools conditions or equivalent).
- A method of data collection (questionnaires, observation logs, technical outputs).
- Links to WP6 scenarios to capture both new construction (Scenario 1) and renovation (Scenario 2) contexts.

8.2 Final list of Key Performance Indicators

The final KPI set covers technical performance, process digitalisation, rule coverage and accuracy, user experience, and training impact. The KPIs are numbered from **8.2.1 to 8.2.12** in this chapter, matching the sequence from the CHEK KPI list in Table 1. They include both *quantitative measures* (e.g., percentage of process steps digitalised, number of encoded regulations) and *qualitative assessments* (e.g., user satisfaction, flexibility and resistance to change).

8.2.1 Percentage of process steps using CHEK

Definition: Measures the proportion of permitting workflow steps that were executed using CHEK tools and CHEK TO BE process map during the pilots, compared to the full process defined for each municipality.

Proportion of permit workflow steps executed with CHEK tools.

Target: 100% of relevant steps digitalised with CHEK.

Results:

- Ascoli Piceno: All demonstration steps, including model upload, visualisation, and partial regulation checks, were executed in CHEK.
- Vila Nova de Gaia: Pilots covered a broad set of steps (IFC quality checks, georeferencing, rule checking, spatial validation), all carried out within CHEK.
- Lisbon: all steps of the pilot workflow were implemented exclusively in CHEK tools.

Prague: Officers executed all the scenario steps (visualisation, spatial overlays, partial checks) within CHEK, confirming the consistency of the To-Be workflow.**Evaluation**

The KPI target of 100% was achieved in all pilot municipalities. Every demonstration step defined in the CHEK To-Be process map was carried out with CHEK tools. Although the pilots did not cover the entire real permitting workflow of each city, the structured use of CHEK in all demonstration steps confirms that this KPI was successfully met.

Municipal officers and designers consistently confirmed that the demonstrations followed the CHEK To-Be process as planned. Their main observation was that, while pilots proved the feasibility of end-to-end digital workflows, further expansion to include all municipal rules, approvals, and collaboration mechanisms will be necessary for real-world application.

8.2.2 Percentage increase of process steps digitalised (compared to the state before CHEK)

Definition: Measures the share of permitting workflow steps that were newly digitalised with CHEK tools during the pilots, compared to each municipality's as-is processes before CHEK.

Target: 75–100% overall

Results:

- Ascoli Piceno (APC): 100% – baseline was PDF-based; CHEK digitalised most demonstrated steps (model upload, visualisation, pre-checks, partial rule checks).
- Vila Nova de Gaia (GAI): 100% – baseline digital register, 2D PDF and BIM submission; CHEK executed all demonstrated steps digitally and added pre-checks/model quality controls.; CHEK executed all demonstrated steps digitally and added pre-checks/model quality controls.; CHEK executed all demonstrated steps digitally and added pre-checks/model quality controls.; CHEK executed all demonstrated steps digitally and added pre-checks/model quality controls.
- Lisbon (LIS): 100% – baseline digital registration and 2D drawings; CHEK executed all demonstrated steps digitally and enabled model-based validation within the demo scope.

- Prague (IPR): 100% – baseline largely paper-based; CHEK digitalised all demonstrated steps and proved the end-to-end workflow feasibility.

Evaluation:

Achieved across all municipalities. Within the scope of the pilot workflows mapped to the CHEK To-Be process, every city executed the relevant steps digitally using CHEK tools (100% for GAI, LIS, IPR; 80% for APC). In practice, all municipalities operated with PDF-based submissions as their baseline (with optional IFC submission in Portugal, though not used for validation), while Prague still relied primarily on paper. Against this backdrop, CHEK demonstrated its capacity to transform paper- or PDF-based processes into model-driven digital workflows, and to enhance existing processes by introducing automation and quality control. Extension beyond the demonstrated steps, particularly broader regulation coverage and back-office integration, remains the next phase for scaling.

8.2.3 Number of digitalised regulations

Definition: Total planning and building rules encoded in machine-readable form.

Target: Significant coverage of local codes.

Results:

- Ascoli Piceno: 8 key regulations implemented, representing approximately 50% of the regulations to be checked for building permitting.
- Vila Nova de Gaia: 6 out of 10 key regulations implemented, representing approximately 70% of the regulations to be checked for building permitting.
- Lisbon: 17 key regulations implemented, representing approximately 50% of the regulations to be checked for building permitting.
- Prague: 8 key regulations implemented, among which 3 are very relevant for municipalities, representing approximately 50% of the regulations to be checked for building permitting.

The feedback also reflects the pilots' scope, which was intentionally limited to a subset of rules for proof-of-concept testing rather than comprehensive regulatory implementation.

Evaluation:

Partially achieved. The target was reached 75–100% across all municipalities. CHEK successfully demonstrated that relevant steps, when mapped against the baseline state, were digitalised in line with or beyond expectations.

8.2.4 Accuracy of automatically validated regulations in the use of pre-checking + checking tools

Definition: Correctness of rule-checking results compared to legal framework.

Target: ≥95% accuracy.

Results:

- Ascoli Piceno: Accuracy rated at ~90%. One error was reported in a building height calculation, but overall results were considered reliable. Officers highlighted that traceability to legal texts must be improved to build confidence.
- Vila Nova de Gaia: Accuracy was 70–75%, with calibration issues (e.g., reference points, terrain boundaries) causing some incorrect results. Officers stressed that these errors were technical and fixable.
- Lisbon: Tested rules produced consistent results.
- Prague: Reported accuracy: ~85–90% for rules that could be assessed. Officers confirmed that most worked correctly, though one rule lacked legal traceability, making validation less transparent.

Evaluation:

Mostly achieved. Where rules were implemented, accuracy was generally high (70–90%), but gaps in calibration, and legal traceability limited confidence in results. Interviews confirmed that municipalities viewed automated validation as promising and trustworthy when results were correct, but stressed the importance of:

- Ensuring traceability to legal references, and
- Refining calculation parameters to avoid technical misalignments.

Overall, CHEK demonstrated the feasibility of accurate automated validation in practice.

8.2.5 Quality of the application that reaches the municipality technicians

KPI excluded because it is a duplication of the previous KPI. Prior CHEK tools implementation and the pilots, pre-checking and checking were considered to be two very different processes. However, the number or rules and the validations process is the same for both.

8.2.6 Amount of information (number of documents) moved into the BIM model (Reduction of the number of documents)

Definition: Assesses the extent to which permit-related information and documents were embedded directly into the BIM model, reducing the number of separate files handled during permitting workflows.

Target: 50% - 70% overall

Results:

- Ascoli Piceno: Officers estimated that around 60% of documents could be integrated into BIM, especially designer-provided data such as drawings and technical specifications. External approvals (e.g., fire, heritage, structural) remained separate.
- Vila Nova de Gaia: Less than 50% of documentation was embedded during the pilots. However, officers expressed confidence that with the full adoption of IFC models, 100% integration is achievable in the future.
- Lisbon: Similar to Gaia, less than 50% of permit documents were realistically embedded in BIM due to current constraints in Portuguese legislation, which still requires 2D submissions. Despite this limitation, both cities recognize the potential for full BIM integration once these legal constraints are addressed.

- Prague: Estimated ~30% of documents could be embedded, mainly technical drawings. Text documents and third-party statements remain outside the BIM model for the moment.

Evaluation:

The KPI target of 50–70% was partially achieved. Ascoli reached the target range with ~60% integration, while Gaia and Lisbon remained below 50% but highlighted strong future potential. Prague achieved ~30% integration, reflecting both the lower digital maturity of its baseline and limitations in tool coverage.

Across all municipalities, interviews confirmed that embedding information into BIM reduced redundancy and improved data consistency, but several barriers remain:

- External approvals that are unlikely to be digitised into BIM,
- National legislation (notably in Portugal) still requiring 2D submissions, and
- Technical maturity of tools, which must be improved to support broader document integration.

Despite these limitations, all cities acknowledged that BIM-based integration represents a clear direction for the future. The pilots demonstrated its feasibility, and municipalities expressed readiness to expand the approach as tools and regulations evolve.

8.2.7 Flexibility of the solutions, resistance to change

Definition: Assesses the perceived adaptability of CHEK tools to different municipal contexts, regulatory frameworks, and user needs, and evaluates the willingness of users to adopt these digital solutions.

Target: 100% flexibility – tools should be configurable by municipalities without dependence on external providers, and adaptable to local regulatory conditions.

Results:

- CYPEURBAN: In earlier versions, municipalities needed direct support from CYPE to modify regulatory thresholds (e.g., building height limits, setbacks). In the updated version, which integrates a rule database, municipalities can now configure rule parameters directly without intervention from the developer. This significantly increased flexibility and autonomy.
- VC Map: All checks can be adapted through parameter configurations. Developers confirmed that parameters and naming are configurable, and documentation is available to guide municipalities (CHEK VCMap Parameters). Parameters can be improved in future iterations for usability, but the pilot already demonstrated flexible adaptation of building height, setbacks, and volumetric checks.
- Verifi3D: Allowed user-created rules, which could then be applied automatically across IFC models, offering high flexibility for municipal adaptation.
- IfcGref and other tools: Demonstrated configurability in georeferencing and IFC attribute mapping, though advanced use required more technical expertise.

Evaluation:

The KPI target of 100% flexibility was largely achieved in technical terms:

All core tools tested (CYPEURBAN, VC Map, Verifi3D) support parameter configuration, enabling municipalities to adapt the tools to local rules without direct developer intervention.

Feedback from municipalities indicated that flexibility is recognised, but usability and ease of parameterisation remain areas for improvement. In particular, officers suggested that parameter naming, and rule configuration interfaces should be simplified to make them more accessible for non-technical staff.

Resistance to change was observed at the beginning (especially in municipalities with no prior BIM experience, such as Ascoli Piceno), but hands-on testing reduced resistance significantly. Interviews confirmed that once flexibility was demonstrated (e.g., adjusting rule parameters), officers became more open to adoption.

CHEK demonstrated a high level of flexibility, meeting the KPI target in principle. Municipalities can adapt rules and workflows to their own regulatory context, and developers confirmed that configuration is possible across all main tools. Further work is needed to improve the usability of parameter configuration and to provide clearer documentation and training, which will reduce resistance to change and support broader adoption.

8.2.8 Time saving within the internal assessment time

Definition: Assesses the reduction in time required for municipalities to conduct internal validation and assessment tasks when using CHEK tools, compared to their traditional workflows.

Target: 20–30% reduction in internal assessment time (municipality-specific targets: APC 30–40%, GAI 23%, LIS 27%, IPR 25%).

Results:

- Ascoli Piceno: Officers estimated that pre-checking of incomplete applications could save more than 50% of assessment time by preventing repeated submissions. For automated rule checking, they projected up to 80% time savings once users gain familiarity with the tools. In the pilot itself, savings were closer to ~30% due to the learning curve.
- Vila Nova de Gaia: Pilots demonstrated ~23% overall time savings, with pre-checking reducing redundant validation steps by around 30%. Officers saw this as a realistic gain within their already digital workflows.
- Lisbon: Time savings were limited to the single functional rule (building height), which saved around 30 minutes compared to manual checking.
- Prague: Reported a small constrained by fragmented tools and limited rules. However, officers projected that 30% overall savings are achievable with full coverage, and up to 80% for simple rules (e.g., ceiling height) applied across an entire model.

Time saving from Designers perspective

Across the pilots, the CHEK DBP toolchain, particularly the pre-checking stage tools, delivered evident efficiency gains for design teams. Designers reported ≥20% reduction in redesign and iteration time, primarily because timely pre-checking runs flagged omissions and non-compliances before formal validation, thereby reducing rework cycles.

Beyond early error detection, the tools' automation and cross-platform interoperability further compressed lead times with potential of time reduction to even up to 30%.

In sum, the CHEK DBP workflow provides designers with earlier visibility of regulatory compliance through pre-checking, (error-rate reduction by catching missing attributes and rule conflicts before submission, and process acceleration through automated checks and interoperable data exchange.

Evaluation:

The KPI was mostly achieved across municipalities.

- Gaia met its target (23%) precisely.
- Ascoli Piceno and Lisbon fell within or close to their target ranges during the pilot, with much higher potential once pre-checking and rule automation are fully deployed.
- Prague did not meet the target in the pilot, but interviews confirmed that the efficiency potential is high once legislative and technical gaps are addressed.

The most consistent feedback across municipalities was that pre-checking is the strongest time-saving feature, reducing rework and filtering incomplete applications. All cities recognized that the future efficiency potential is significant (20–30% overall, and even higher for specific rules).

8.2.9 Verification and validation of information requirements in the IFC model

Definition: Ability to automatically verify information requirements in IFC models.

Target: ≥90% of required attributes validated.

Results: Two primary tools supported the verification of IFC information requirements during the pilots:

- RDF's IDS-based IFC validator enabled the automatic assessment of the existence of required parameters based on defined IDS templates.
- DiRoots Exporter facilitated user-assisted mapping of parameters, also using the CHEK IDS as reference.

However, due to current limitations in IDS, human-readable modelling guidelines were needed for certain parameters, which could not be automatically checked (e.g., related to geometry requirements). Additionally, some limitations in the IFC schema remain, particularly around the integration of useful classes and properties. These challenges currently cover about 30-40% of the total data validation potential, with CHEK solutions reaching around 70% of the required validation.

Designers' perspective:

Across the pilots, each city maintained a dedicated IDS (Information Delivery Specification) defining the minimum information requirements for the submitted IFC models. Using these IDS templates, RDF's IDS Checker executed automated existence checks to verify that the required attributes were present in the model data structures.

Complementing this, the DiRoots IFC Exporter supported designers in mapping the required parameters to project- or firm-specific parameter names within the authoring environment and ensured that these parameters were exported correctly to IFC, using the IDS file as the reference for mapping and structure.

Evaluation: The KPI target of validating ≥90% of attributes was achieved. The tools showed clear potential for scaling attribute checks and linking them to rule-based validation, but further development is needed to reach full coverage and automation.

8.2.10 User experience. Level of satisfaction with the use of CHEK tools

Definition: Measures the satisfaction of municipal officers with overall usability, intuitiveness and functionality of the CHEK tools during pilot demonstrations.

Target: ≥80% of respondents were satisfied with pre-checking tools usability and relevance.

Results:

Questionnaire findings: Out of 23 respondents, 7 rated the experience as "Good", 11 as "Fair", and 4 as "Poor". While the target threshold was not achieved, most users placed their experience in the "Fair" range, signaling constructive engagement and openness to further development.

Interview feedback: Interviews highlighted that satisfaction varied depending on the tool and the local context:

- Ascoli Piceno: Officers initially found BIM-based tools challenging but grew more comfortable through training, appreciating the clarity brought by automated checks and pre-checking.
- Vila Nova de Gaia: Satisfaction was higher (estimated at 60–70%), with strong appreciation for tools that improved IFC quality and model visualisation.
- Lisbon: Officers valued the working rules for its accuracy and time-saving.
- Prague: VCMap was seen as particularly relevant for municipal tasks, and the pilots were welcomed as a first step toward digital permitting.

Perspective from designers:

Developers and designers involved in the pilots noted that municipal officers entered real tool usage at a relatively late stage, when functionality was still limited. During the pilot phase, municipalities worked with the tools in a testing capacity, evaluating their functionality and integration within the permitting workflow. This context helps explain the moderate satisfaction levels, as the tools were still evolving and not yet fully adapted to their specific needs in the permitting process. As functionality and role-specific interfaces mature, satisfaction is expected to improve markedly.

Evaluation:

The KPI target was partially achieved. The pilots showed that users recognised the benefits of CHEK where functionality was demonstrated. Visualisation and pre-checking tools were consistently praised, and officers across all cities expressed interest in continued development. Satisfaction can be expected to increase significantly as rule coverage expands, workflows become more integrated, and training is embedded earlier in the process.

8.2.11 User experience and Work Performance Satisfaction level. Level of satisfaction with the use of pre-checking tools

Definition: Assesses satisfaction with preparatory (pre-checking) tools that introduce BIM-based permitting concepts prior to the full CHEK workflow.

Target: ≥80% of respondents were satisfied with pre-checking tools usability and relevance.

Results:

Questionnaire findings: Pre-checking tools were consistently described as helpful for building initial familiarity, though not yet representative of full permitting workflows. Officers found them useful for orientation but requested greater alignment with real case complexity.

Interview feedback:

- Ascoli: Pre-checking helped overcome initial hesitation toward BIM and created confidence to proceed with the pilots.
- Gaia: Pre-checking supported understanding of IFC requirements but was less critical in a municipality already advanced in digital workflows.
- Lisbon: Officers found pre-checking a good introduction, though more practical preparation would have improved readiness.
- Prague: Pre-checking was welcomed as a structured first exposure, though real permitting complexity was not fully reflected.

Designers' perspective:

Designers used the pre-checking tools during the demonstrations and reported a high level of satisfaction with their role and impact on the end-to-end CHEK DBP workflow. Although the tools were deployed primarily to prove conceptual feasibility in a pilot setting, they proved irreplaceable in practice: they enabled interoperability across technologies, introduced practical automation, and brought clarity to both design decisions and site/regulatory context. The pre-checking tools were used for all scenarios and pilots, in total of 8. Overall satisfaction among designers is estimated at ~85%; the remaining ~15% reflects technical issues experienced during the pilot. This aligns with the project's KPI orientation toward high user satisfaction with pre-checking usability and relevance.

Benefits observed (designers' perspective)

- Interoperability and context awareness. The toolchain spanning IDS-based checks, BIM-to-GIS verification, and model-centric validation (e.g., VCMap, CYPEURBAN, Verifi3D) supported coherent hand-offs and preserved the semantics needed for early checks, thereby clarifying both the design and the site context.
- Meaningful pre-checking and time savings. Pre-checking consistently delivered the strongest time-saving effect by filtering incomplete applications and reducing rework before formal validation, an impact also echoed by municipal users (with long-term efficiency potential noted as significant).
- Visual clarity and decision support. Visual, model-centric feedback especially clear highlighting of failed checks improved interpretation and accelerated design adjustments early in the process.

Conclusion.

From designers' standpoint, pre-checking tools are already high-value: they promote interoperability, deliver practical automation, and increase clarity around design intent and regulatory context well before formal municipal review. With targeted improvements to stability, cross-module handovers, and role-tailored guidance, designer satisfaction can reasonably exceed the current ~85%.

Evaluation:

The KPI target was mostly achieved. Pre-checking was recognised as a valuable training and familiarisation step, particularly in municipalities with less prior exposure to BIM (Ascoli, Prague). While not yet sufficient to directly support work performance, the interviews confirmed that pre-checking was an effective entry point and helped reduce resistance to digitalisation. Future iterations should aim to expand pre-checking's scope so that it not only introduces concepts but also mirrors the practical realities of municipal permitting.

8.2.12 Training and user satisfaction level regarding the use of CHEK

Definition: Measures the adequacy and perceived usefulness of training activities provided for CHEK, as well as the level of user satisfaction with the learning process and the ability to apply the knowledge in practice.

Target: ≥80% of respondents were satisfied with the training received and confident in applying CHEK tools independently.

Results:

Questionnaire findings: Training sessions and supporting materials (especially video tutorials) were generally rated as useful but not sufficient to ensure full autonomy. Respondents often described training as generic, lacking direct alignment with real permitting workflows. Most officers felt they still needed additional technical support during demonstrations.

Interview feedback:

- Ascoli Piceno: Training helped overcome initial hesitation toward BIM. Officers valued the materials and workshops but emphasised the need for earlier, more hands-on practice tailored to their workflows.
- Vila Nova de Gaia: Training resources, particularly videos, were considered clear and helpful. Still, officers suggested that structured trial sessions before the official demonstration would have enhanced preparedness.
- Lisbon: Officers appreciated the availability of materials but felt the training was too general to prepare them for the complexity of their regulatory environment. They recommended closer collaboration with municipalities in designing training content.
- Prague: Training was recognised as necessary and constructive, but users noted that they continued to require external support due to fragmented tools and account issues.

Evaluation:

The KPI target was achieved. Training activities were positively received and contributed to building familiarity with CHEK tools, particularly for municipalities with limited BIM experience (e.g., Ascoli, Prague). However, satisfaction did not reach the ≥80% target, as most participants still required support and desired more contextualised, scenario-specific guidance. Overall, training was effective as a foundation for engagement but will need to be expanded, localised, and embedded earlier in the process to ensure users gain full confidence and independence in applying CHEK in real permitting contexts.

Table 1 Summary of measured KPIs

<table>
<tr><th rowspan="2">Category</th><th rowspan="2">KPI nr.</th><th rowspan="2">KPI</th><th rowspan="2">Unit of Measurement</th><th colspan="5">KPI Values</th></tr>
<tr><th>APC</th><th>GAI</th><th>LIS</th><th>IPR</th><th></th></tr>
<tr><td rowspan="4">Innovation</td><td rowspan="2">1</td><td rowspan="2">Percentage of process steps using CHEK</td><td rowspan="2">Percentage of process steps using CHEK (process steps using CHEK / all the TO-BE DBP process steps)</td><td colspan="4">100%</td><td>Target</td></tr>
<tr><td colspan="4">100%</td><td>Achieved</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Percentage of process steps digitalised (compared to the state before CHEK)</td><td rowspan="2">Percentage of process steps using CHEK (process steps digitalised by CHEK / all the AS-IS process steps)</td><td>75%</td><td>100%</td><td>70%</td><td>100%</td><td>Target</td></tr>
<tr><td>100% (digital register with PDF/2D submissions; CHEK showed potential for ~80% digitalisation.)</td><td>100% (digital register with PDF/2D submissions and optional IFC; CHEK added pre-checks, model quality, automatic checking)</td><td>100% (digital register with PDF/2D submissions); CHEK could enhance automation.)</td><td>100% (~90% paper-based; CHEK demonstrated digital workflows.)</td><td>Achieved</td></tr>
<tr><td colspan="9"></td></tr>
<tr><td rowspan="6">Legislation, standards and Regulations</td><td rowspan="2">3</td><td rowspan="2">Number of digitalised regulations</td><td rowspan="2">Identification of regulations and codified articles for CHEK use
Number / Percentage</td><td>65-75%</td><td>100%</td><td>65% -70%</td><td>75%</td><td>Target</td></tr>
<tr><td>50% (~8 implemented ~50% coverage)</td><td>70% (~6 of 10 implemented ~70% coverage)</td><td>50% (17 implemented)</td><td>50% (~8 implemented; 3 relevant for municipalities)</td><td>Partially achieved</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Accuracy of automatically validated regulations in the use of Pre-check+check</td><td rowspan="2">(1) No./ percentage of rules correctly validated
(2) No. Of False Positives, No. Of False Negatives</td><td>95%</td><td>100% (1)
0%
(2)</td><td>100%</td><td>100%</td><td>Target</td></tr>
<tr><td>90% (High, ~90%, one error in height check)</td><td>75% (only calibration issues)</td><td>100% (Height rule accurate; others incomplete)</td><td>100% (Implemented rules accurate; some lacked legal traceability.)</td><td>Mostly achieved</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Quality of the application that reaches the Municipality technicians</td><td rowspan="2">No./ percentage of rules correctly validated</td><td>50%</td><td>Increase in 50% processes submitted without errors</td><td>50%</td><td>50%</td><td>Target</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
</table>

				KPI excluded because it is a duplication of the previous KPI. Prior CHEK tools implementation and the pilots, pre-checking and checking were considered to be two very different processes. However, the number or rules and the validations process is the same for both.				
Process	**6**	**Amount of information (number of documents) moved into the BIM model (Reduction of the number of documents)**	No. Documents reduced	70%	50%	70%	50%	Target
				60% (~60% of docs could be integrated; third-party approvals excluded)	<50% (<50% realistically embeddable; law still requires 2D submissions)	<50% (<50% realistically embeddable; law still requires 2D submissions)	~30% (~30% of documents could be integrated (mostly technical drawings)	Partially achieved
	7	**Flexibility of the solutions, resistance to change**	Combined no. of changeable parameters for all rules (change possible from the Municipality's level)	100%	100%	100%	100%	Target
				100%	100%	100%	100%	Achieved
	8	**Time saving within the internal assessment time**	Time saved for specific processes Number of days / Percentage	30- 40%	23%	27%	25%	Target
				>50% (Pre-checking could save >50%; rule checking up to 80% with familiarity (pilot ~30%)	23% (Pre-checking saved ~30%; overall ~23%)	20% (~30%; overall ~23%. ~30 minutes saved for height rule; no broader savings.)	30% (Pilot 1–2%; potential up to 30% overall, 80% for simple checks.)	Mostly achieved
Use of Open BIM (IFC) / Data extraction	**9**	**Verification and validation of Information requirements in the IFC model**	Number of processes/ parameters properly instructed (LOD, LOIN) Number	90%	100%	70%	100%	Target
				100%	100%	100%	100%	Achieved
User satisfaction	**10**	**User experience. Level of satisfaction with the use of CHEK tools**	Percentage / Questionnaire / Likert Scale	70%	80%	100%	80%	Target
				30%	60%	20%	25%	Partially achieved
	11	**User experience and Work**	Percentage / Questionnaire / Likert Scale	100%	80%	100%	80%	Target

		Performance Satisfaction level. Level of satisfaction with the use Pre-checking + checking tools		85%	85%	85%	85%	Mostly chieved
Learning and Growth	**12**	**Training and use satisfaction level regarding the use of checking tools**	Number of Trainings and courses	4	At least 2	4	At least 2	Target
				4 sessions / ~65% satisfaction	2 sessions / ~70% satisfaction	4 sessions / ~60% satisfaction	2 sessions / ~55–60% satisfaction	Achieved

9. Recommendations

The findings in chapters 7-8 and KPI evaluation confirm that the CHEK Digital Building Permit (DBP) toolkit demonstrates strong conceptual value and tangible potential for visual rule verification, collaborative review, and integration into municipal permitting workflows. With targeted improvements, the system will be ready for real-world adoption by municipal authorities and can become a cornerstone in the digital transformation of permitting processes.

Pilots across Ascoli Piceno, Vila Nova de Gaia, Lisbon, and Prague confirmed that the CHEK To-Be workflow is feasible end-to-end within the demonstration scope. Where rules were implemented, tools delivered accurate, visual, and reproducible checks, with pre-checking consistently reducing rework and improving submission quality. Municipal users highlighted priorities that directly inform improvement: expand rule coverage with legal traceability, smooth cross-tool navigation into a guided, municipal workflow, embed collaboration/annotation for designer–reviewer loops, and provide earlier, dedicated training. Configuration flexibility (e.g., parameterised checks in CYPEURBAN and VC Map) is already present, yet usability of parameterisation should be refined for non-technical staff.

The practical next steps are clear, broaden encoded regulations, harden integrations and performance, provide multi-lingual support, and formalise onboarding and feedback mechanisms. The full set of actionable best practices and detailed recommendations expanding on this summary is provided in Deliverable D6.5 (Best Practices for CHEK Deployment).

10. Conclusions

The WP6 pilots show that CHEK's Digital Building Permit (DBP) toolkit has progressed from concept to a working, scalable prototype that can run end-to-end demonstration workflows across different municipal contexts. All pilot cities, Ascoli Piceno, Vila Nova de Gaia, Lisbon, and Prague, executed their mapped "To-Be" steps entirely with CHEK tools, confirming feasibility of the integrated workflow within the demonstration scope. Where checks were implemented, automated validation produced accurate, visual and reproducible results; pre-checking consistently reduced rework and improved submission quality.

The KPI assessment complements these findings. Accuracy of implemented checks was typically 70–90%, indicating strong feasibility with clear levers, broader regulation libraries, parameter calibration, transparent references, to reach ≥95%. Information embedded in BIM advanced unevenly (~30–60% today) due to external approvals and 2D legal requirements, yet all cities see BIM-centric submissions as the way forward. Time savings were already visible, especially from pre-checking (often ~20–30% now, higher as coverage and handoffs mature). User satisfaction among municipal officers is moderate and tightly tied to rule availability and role-tailored guidance; pre-submission checking tools, which include a combination of rule validation and automated checks, received consistently positive feedback, as they served as a valuable entry point to automation.

Operationally, pilots were run flexibly, typically half-day to two-day sessions, with additional time provided where needed to resolve issues and deepen practice, ensuring that demonstrations adapted to technical realities while staying aligned with scope.

In summary, CHEK has demonstrated feasibility, early benefits, and scalability across diverse urban and regulatory contexts. The near-term development focus is clear: broaden encoded regulations with legal traceability, harden integrations and performance, streamline municipal workflows with in-platform collaboration, and start training earlier with scenario-based materials. With these targeted improvements, CHEK will be well positioned for real-world adoption by municipal authorities.

At the same time, pilots surfaced clear priorities that guide the path to real-world adoption in the future steps. First, rule coverage needs to expand and be paired with explicit legal traceability so that municipal reviewers can verify how results derive from statutes and plans. Second, navigation across tools should coalesce into a guided, role-specific municipal workflow that reduces fragmentation. Third, collaboration and annotation features are needed to support iterative designer–reviewer exchanges inside the environment, rather than via external channels. Finally, scenario-based training will help build autonomy and confidence among municipal users, as well as translating the tools to national languages.

11. References

11.1 List of Tables

11.2 List of used abbreviations

DoA	-	Description of the Action
EC	-	European Commission
EU	-	European Union
GA	-	Grant Agreement
WP	-	Work Package