DIGITALSTADT DARMSTADT

WHITE BOOK SMART CITY

Long version

DIE STRATEGIEMANUFAKTUR
Strategie ▪ Innovation ▪ Vernetzung

e-hoch-3
eco impact experts

FOREWORD

12 June 2017: A milestone was set on this day – the city of Darmstadt was awarded the title of 'Digital City.' The BITKOM prize was an award and confirmation of how Darmstadt had already developed into a showcase smart city by virtue of its history and starting position.

So it's no coincidence that we have been awarded the title by the IT industry association and the German Association of Towns and Municipalities. It is the result of years of thought and preparation. The development and promotion of electrical engineering is the cradle of digitalisation in Darmstadt: A proud heritage that is constantly being developed by a unique IT cluster.

The winning of the BITKOM competition and the launch of our initiative represent an intensification of this development. The state of Hesse was an important pillar and a valuable supporter as we embarked on our journey into the digital future. I would like to express my heartfelt thanks for this and, in particular, I appreciate the partnership and ongoing cooperation. Thanks to the 5 million euros in funding from the state of Hesse, we have continued to develop digitalisation over the past five years and tried out the future. We have broken new ground, especially with our aim of contributing to a European counter-model to the US digitalisation strategies based on privatisation and capitalisation and, above all, to the digitalisation strategies of totalitarian systems that rely on control and surveillance – with ethical guidelines that place data protection and data sovereignty as the highest priorities.

Darmstadt is a smart city that provides examples of how digitalisation can solve the challenges of a modern city. For us, the Smart City is an integrated

aspect of sustainable and ecological urban development. From the environment, energy, mobility and the establishment of a data platform to administration, trade/tourism and cybersecurity to education, society and culture, almost all fields of service of general interest are covered. The diversity of the fields of action shows that smart city development is an interdisciplinary and cross-organisational project. Citizenship, which we involve in the further development of infrastructure projects, also plays a major role here. The opposition and criticism we have experienced have been valuable to us and have ultimately helped us evaluate our ambitions and approaches. Transformation processes can only succeed together with external experts, partners from science and research, internationally active companies and a forward-looking and cosmopolitan citizenry.

As a pioneer of this development in Germany, we have always understood our responsibility as a model city to mean that we share our knowledge with the public. The knowledge we have acquired is intended to help other cities on their path to digitalisation. This White Book, which was produced by an independent team of consultants, is a valuable aid in this regard. It focuses on the philosophy and dimensions of a smart city, highlights four selected projects and offers recommendations for action based on the results.

Benefit from our experience, read it and feel free to contact Digitalstadt Darmstadt GmbH if you have any questions or feedback.

With warmest regards,

Jochen Partsch
Mayor of Science City Darmstadt

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CONTENTS

THE SMART CITY TAXONOMY DEVELOPED IN CONJUNCTION WITH THE WHITE BOOK HAS THREE SPECIAL CHARACTERISTICS:

1. It combines analysis and indicator development at the micro level of the projects with the indicator systems at the meta level. If necessary, this enables, in principle, seamlessly variable granularity in the design of indicators and key figures for evaluation projects and in the design of monitoring systems for smart cities.

2. The basis of the taxonomy is the five-dimensional smart city definition, which for the first time systematically and equally takes into account the aspects of participation and co-design as well as the key success factor of institutional and organisational innovation alongside the technological, social and ecological innovation dimensions.

3. The underlying understanding of a smart city as a multidimensional networked city that needs to be systematically conceived and designed in order to be climate-neutral, good to live in for people and resilient.

0 EXECUTIVE SUMMARY

The White Book places the results of the evaluation of the projects of Digitalstadt Darmstadt funded by the state of Hesse in the context of the German and European smart city discussion and develops an innovative smart city taxonomy against this background. The guidelines in the appendix offer a practical tool for evaluation, but can also be used as a quick assessment tool in the context of smart city project development.

Using the example of four selected projects, including a trial phase, the evaluation developed a (prototype) evaluation approach for the 20 state projects. The indicators used were developed from the projects in a kind of 'bottom-up' process, incorporating the experiences and results of numerous digitalisation, sustainability and smart city indices.

At the end of the White Book there are 30 recommendations for action for the different levels of design of the smart city: the level of the projects, the central level of the municipality(ies) and region(s) and, last but not least, the level of funding programme design at the federal and state levels. They not only serve to optimise the smart city projects themselves, but also to promote the redesign of organisational and institutional framework conditions. The same applies to the need to consolidate and duplicate project results in order to accelerate a digitally supported transformation towards a climate-neutral future.

1 INTRODUCTION

Digitalstadt Darmstadt is considered one of the pioneer cities of digitalisation in Germany. This applies in general, but especially in the field of medium-sized cities. Development in Darmstadt was recognised and accelerated by winning the Bitkom 'Digital City' competition in 2017.

Since then, the success of Digitalstadt Darmstadt has been reflected in the consistently high ratings of digital and smart city rankings such as the Bitkom Smart City Index, which lists Darmstadt as the best municipality in Hesse amongst the top five cities in Germany.

The role of 'pathfinder' can also be seen in the fact that the state of Hesse and the newly established Hessian State Chancellery for Digital Strategy and Development have deliberately established and promoted Darmstadt as an 'experimental space for digitalisation.' The experiences gained here have also been incorporated into the state's new digital strategy – to make Darmstadt a showcase for digitalisation for other municipalities in Hesse and beyond.

After four years, Digitalstadt Darmstadt GmbH (DDG) commissioned Strategiemanufaktur and e-hoch-3 to evaluate the projects funded by the state of Hesse. After winning the 'Digital City' title, the state of Hesse has given DDG around € 5 million in funding, which has gone into 20 very different digitalisation projects.

Projects were evaluated in a multi-stage process (see point 2). The results form the basis for the White Book Smart City. They are factored into the current smart city discussion, evaluated again and condensed in order to derive indications and recommendations for future work. Thus, from the ex-post perspective of evaluation, a design and control perspective is developed in the sense of monitoring.

THE PROCEDURE CAN BE DESCRIBED IN FIVE STEPS:

1. Selection of projects
2. Evaluation of projects
3. Development of smart city indicators
4. White Book with recommendations for action
5. Guidelines for project (self-)evaluation

WHITE BOOK – OVERVIEW

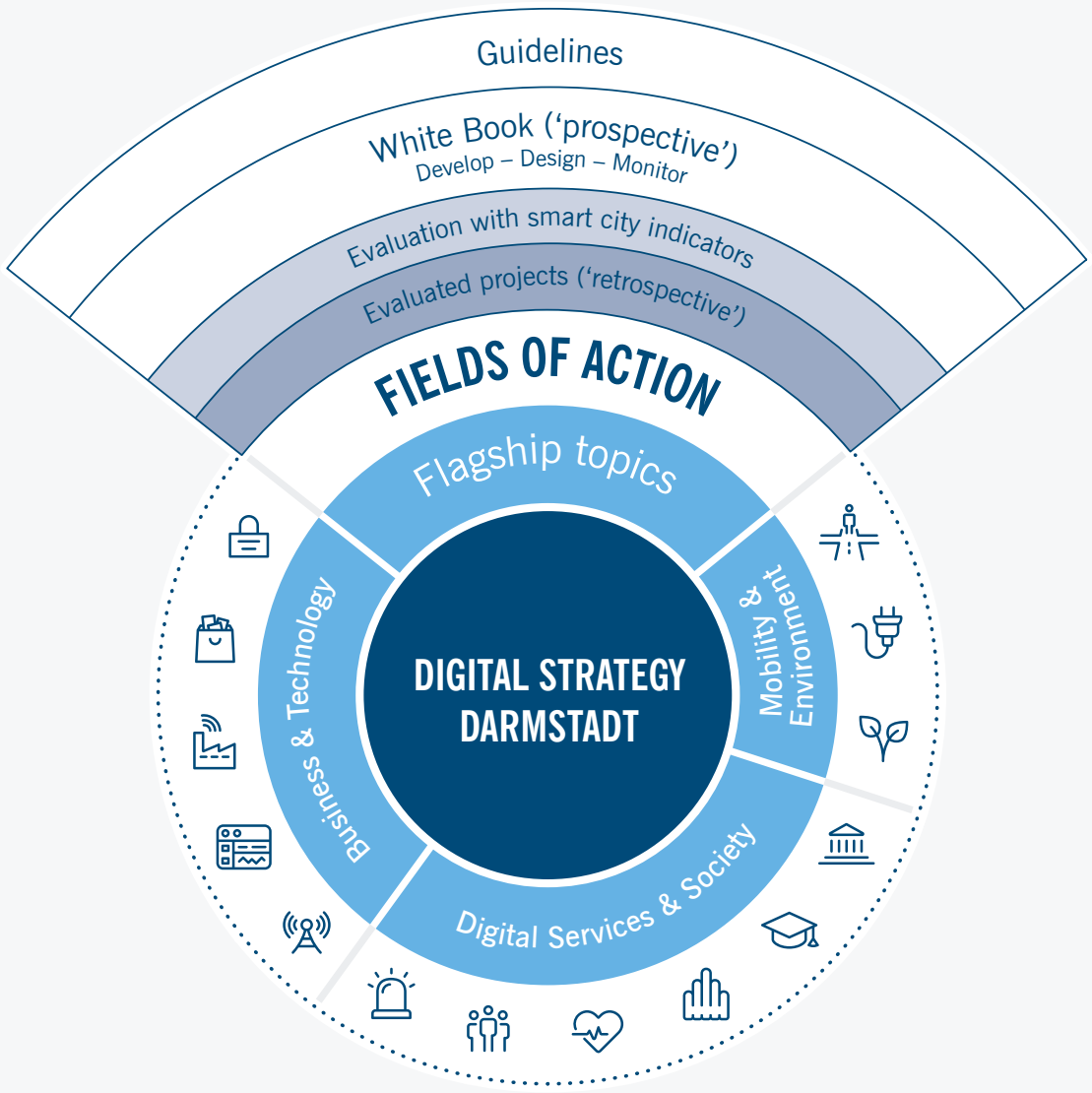

Fig. 1: Procedure for evaluating Digitalstadt Darmstadt projects and link to white book with guidelines, own presentation (Die Strategiemanufaktur/e-hoch-3)

1.1 FROM A DIGITAL CITY TO DIGITALSTADT DARMSTADT

Digitalstadt Darmstadt had a classic starting point for German municipal digitalisation. The driving forces were a small group of people from the 'inner circle' who wanted to secure the future viability of the city together. It was the leaders of the city and municipal enterprises, experts from science and business, but also representatives of the chambers that gave the impetus to this development.

After the success of the Bitkom competition, the city established Digitalstadt Darmstadt GmbH as the coordination and control unit for its numerous projects. Its structure is characterised by the close integration of the city, the city administration and the city economy.[1]

An Ethics and Technology Advisory Board was also set up early, which adopted ethical guidelines for the work of the smart city[2] in 2019. In terms of content, the nine points in particular focus on the aspect of the common good (1st guideline) and sustainability (2nd guideline).

With the establishment of Digitalstadt Darmstadt GmbH, Darmstadt soon established the model of 'external' management[3] of the Smart City activities, in which the management was not located within the administration.

At the management level, however, DDG represents an interesting 'hybrid form of organisation' because the managers sometimes perform a dual function, linking the external GmbH solution with the city administration and the city economy. This is a first structural step that tends to promote an integrated and networked view of projects.[4]

One consequence of winning the Digitalstadt competition was the creation of a strategy for Digitalstadt Darmstadt. The order of 'strategy comes after projects' is a widespread pattern that naturally results from the arcs of the actors and the progress of digitalisation. The individual offices of the city administration and individual companies in the city economy follow current trends or are recruited by companies for specific digitalisation projects.

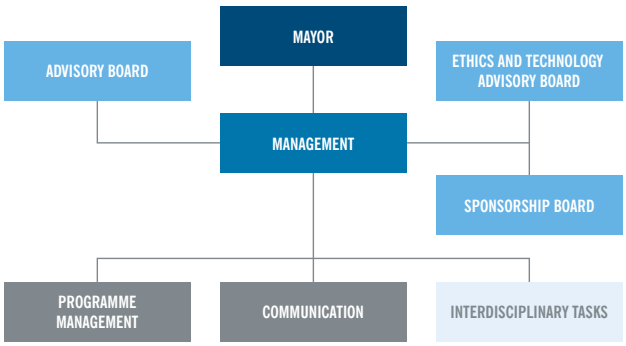

Fig. 2: Structure of DDG (source: Smart City strategy)

1 See the strategy of Digitalstadt Darmstadt, p. 36 ff.

2 See the article by Gerd-Rainer Damm, advisory board member https://shop.arl-net.de/media/direct/pdf/ab/ab_031/04_damm.pdf, last accessed on 5 April 2022.

3 In addition to external management, the recent report by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) entitled 'Im Zentrum steht die Nachhaltigkeit' ['Sustainability is at the Heart of Everything'] on the first series of Smart Cities model projects distinguishes two internal forms: management and control within existing structures and the establishment of executive departments, usually in the area of responsibility of the mayor. p. 11 ff.

4 As a result of a change of position, the personnel link to the city administration has now ceased to exist.

In this sense, digitalisation is often a 'bottom-up process' that does not follow a pre-existing strategic master plan. This may lead to largely 'random and uncoordinated' developments.

With its three lighthouse themes (Mobility and Environment, Digital Services and Society, Economy and Technology), five core objectives (secure, sustainable, forward-looking, participatory, valuable for us) and 14 fields of action (Mobility, Energy, Environment, Administration, Education, Culture, Health, Society, Security and Civil Protection, IT Infrastructure, Data Platform, Industry 4.0, Trade and Tourism, Cybersecurity), the Smart City strategy has a very comprehensive and qualitative approach (see the diagram on the strategy overview).

The smart city strategy is anchored in the digital strategy by way of the integrated nature of the approach. Similar to the digital roadmaps in New York under former mayor Bloomberg, all fields are considered from the perspective of digitalisation. This perspective is the pivotal point that forms a sort of 'digitalisation prefix' for the other topics. For example, the Viennese smart city approach is the opposite, with its three basic objectives of quality of life, conservation of resources and innovation, to which the digitalisation strategy is subordinate.

Over the past four years, the perspective on digitalisation in the context of DDG projects such as the Smart City Laboratory and the Data Platform has significantly changed and evolved. Citizen participation has evolved as part of the work of the Smart City Laboratory or towards digital projects 'without a screen or keyboard.'

The two themes of 'Involving urban society' and 'Sustainability' already play an important role today and are set to be used even more intensively in future.

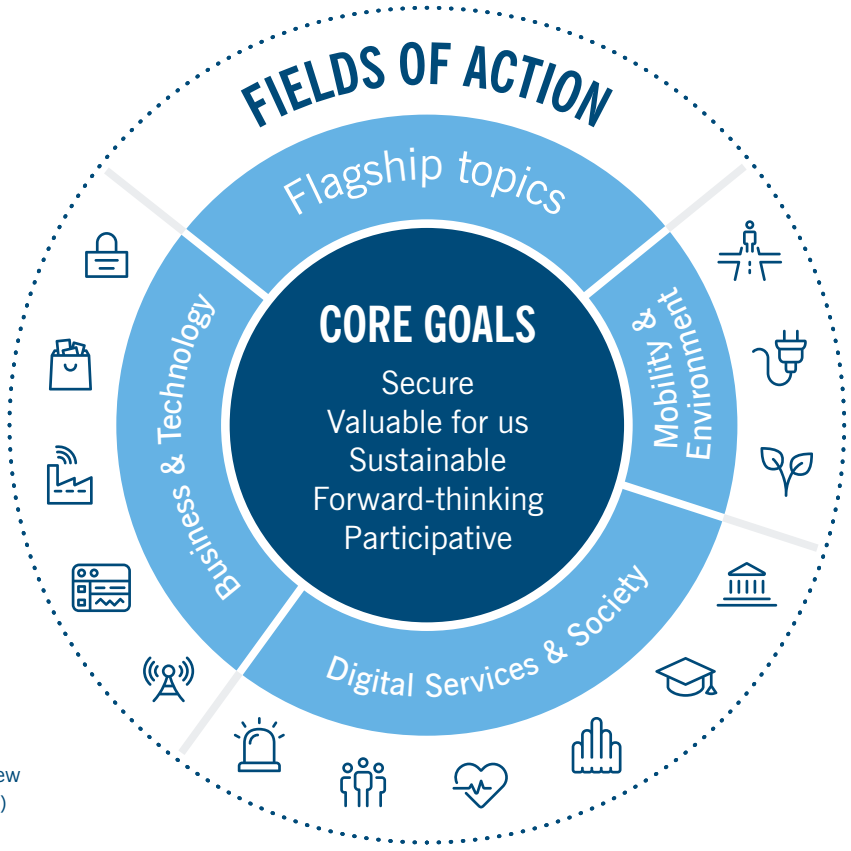

Fig. 3: Figure: Smart City Darmstadt – strategy overview (Source: Smart City strategy)

> “The Smart City Vienna framework strategy effects more active engagement with climate change and the related innovation topics, and a deepening of Vienna’s environmentally sensitive basic orientation.”

Thomas Madreiters
Director of Planning,
City of Vienna

1.2 SMART CITY – A CHANGING CONCEPT

The fact that Bitkom, the industry association of the German digital industry, held the smart city competition and awarded the title 'Digital City 2017' shows the focus and origin of the debate. The city was and is essentially conceived from the point of view of technology and its possibilities. It is an approach of technological innovation. As digitalisation is the key distinguishing feature on the road to a smart city, it is very difficult to differentiate between digital cities and smart cities. This is also reflected in the Smart City Charter, which has the subtitle 'Making Digital Transformation Sustainable in Municipalities'. In the end, the distinction between what is a means and what is an end is the distinguishing feature: Do you think of the city primarily as a digital imperative (digital city) or do you ask where goals can be better achieved through digitalisation (smart city)?

This initially narrow technological focus has grown significantly in recent years. The topics of 'sustainability', 'participation' and 'quality of life' have become emancipated and play a much stronger role. Digitalisation is evolving from an end to a means. One indication that this shift away from digitalisation projects is also taking place in Germany is the title of the evaluation of the first series of smart cities: 'Im Zentrum steht die Nachhaltigkeit' ['Sustainability is at the Heart of Everything']. In the context of the European Commission's support for smart cities and communities (DG CONNECT), this dimension was a key target of the funding programmes from an early stage.

The broadening of the objectives of the smart city areas was generally observed in the international debates of recent years, including at the Smart City World Expo in Barcelona, whose focus has evolved from a smart city trade fair of 'big tech' with its technological offerings, to the growing participation of local authorities at the fair, to a strong user involvement and co-design approaches in the projects presented, such as SmarterTogether (Vienna – Lyon – Munich).

While the focus of the six topic areas 'Smart Economy, Smart Environment, Smart Mobility, Smart Living, Smart People, Smart Government' was more on the first three technical areas, the topics and projects dealt with increasingly also included the social and societal aspects of Cohen's Smart Cities Wheel.

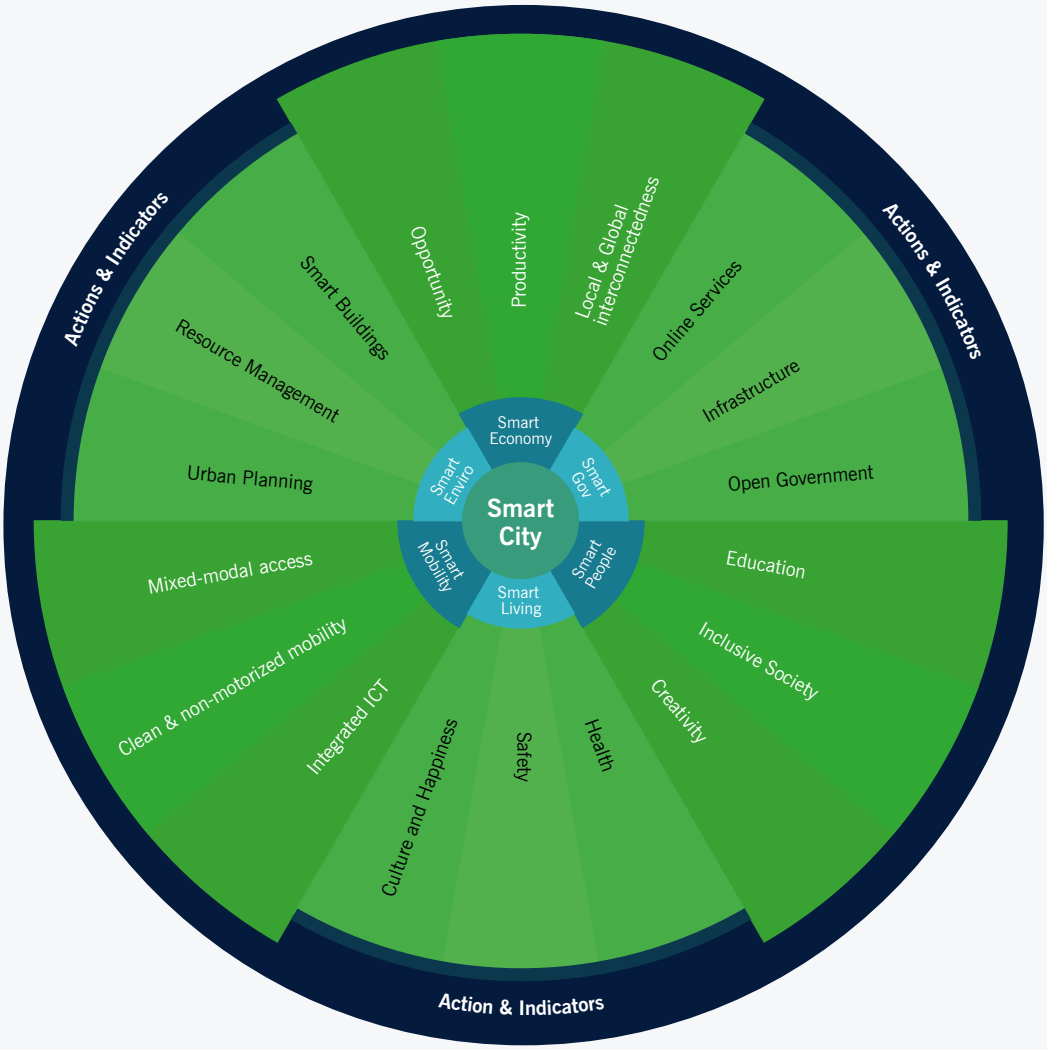

Fig. 4: Boyd Cohen's Smart Cities Wheel (in: Boyd 2016, p. xiii[6])

6 Cohen, B. (2016), The Emergence of the Urban Entrepreneur. How the Growth of Cities and the Sharing Economy Are Driving a New Breed of Innovators. Santa Barbara.

In Darmstadt, this is particularly reflected in the Smart City Laboratory project, a trend that is currently being observed in many German municipalities. Digitalisation is linked here with society's increasing demand for participation and the need to open up institutions, be they administrations (open government, open data) or science organisations (open science).

Back in 2011, the development company Arup developed a smart city perspective for the Australian city of Melbourne, which summed up many of the current debates in Germany, the impact of digital services of general interest and the dialogue patterns cities will have in the future:

> "A Smart City is one in which the seams and structures of the various urban systems are made clear, simple, responsive and even malleable via contemporary technology and design.
>
> Citizens are not only engaged and informed in the relationship between their activities, their neighbourhoods, and the wider urban ecosystems, but are actively encouraged to see the city itself as something they can collectively tune, such that it is efficient, interactive, engaging, adaptive and flexible, as opposed to the inflexible, monofunctional and monolithic structures of many 20th century cities."

In the German-speaking countries, the city of Vienna had already adopted a very long-term (until 2050) and integrated smart city approach in 2013 and summarised it in the Smart City Vienna framework strategy. This integrated approach combines the existing and the new. Three main objectives are set: Resource efficiency, innovation leadership and quality of life. In Vienna, the digital strategy is a sub-strategy of the smart city strategy.

In 2021, the OECD also presented a definition of smart cities that proposes a very pragmatic and reduced definition. According to this definition, smart cities are:

> „ … Cities that use digitalisation and engage stakeholders to improve people's well-being and build inclusive, more sustainable and more resilient societies. "

This definition therefore has a clear target focus and sees digitalisation as the means of achieving these goals as effectively as possible.[7]

7 see Fritz 2021, p. 3.

1.3 SMART CITY – DEFINITION OF THE WHITE BOOK

The shortest definition of a smart city (see section 1.2) is: A smart city is a connected city.[8] Connected is understood here in multiple terms: economic-technological, social-societal, ecological-sustainable, institutional-organisational, and as a network of business, academia, administration and (civil) society. In all these dimensions, digitalisation is the key element. The intelligent linking of data makes it possible to control a smart city in a timely and targeted manner.[9]

The complexity of a smart city can only be conceived, designed and controlled systemically. In connection with the evaluation of the Smarter City Karlsruhe projects (2014), five systemically considered dimensions of innovation were developed (see illustration). The focus is on the sustainable and climate-neutral quality of life of the people in the city or region.

8 See Will 2017 and Will 2021.

9 The volume by Etezadzaheh, C. (ed.) (2020) provides an overview of the multifaceted application dimensions of digitalisation, often broken down by topic. Smart City – Made in Germany. Die Smart-City-Bewegung als Treiber einer gesellschaftlichen Transformation. Springer Vieweg, Wiesbaden, and Mertens, A./Ahrend, K-M./Kopsch, A./Storck, W. (ed.) (2021) Smart Region. Die digitale Transformation einer Region nachhaltig gestalten. Springer Gabler, Wiesbaden.

FIVE (INNOVATION) DIMENSIONS OF A SMART CITY:

1. Technological-economic dimension
2. Social-societal dimension
3. Institutional-organisational dimension
4. Sustainable-ecological dimension
5. Participatory or ‘co-dimension’ (human-centred).

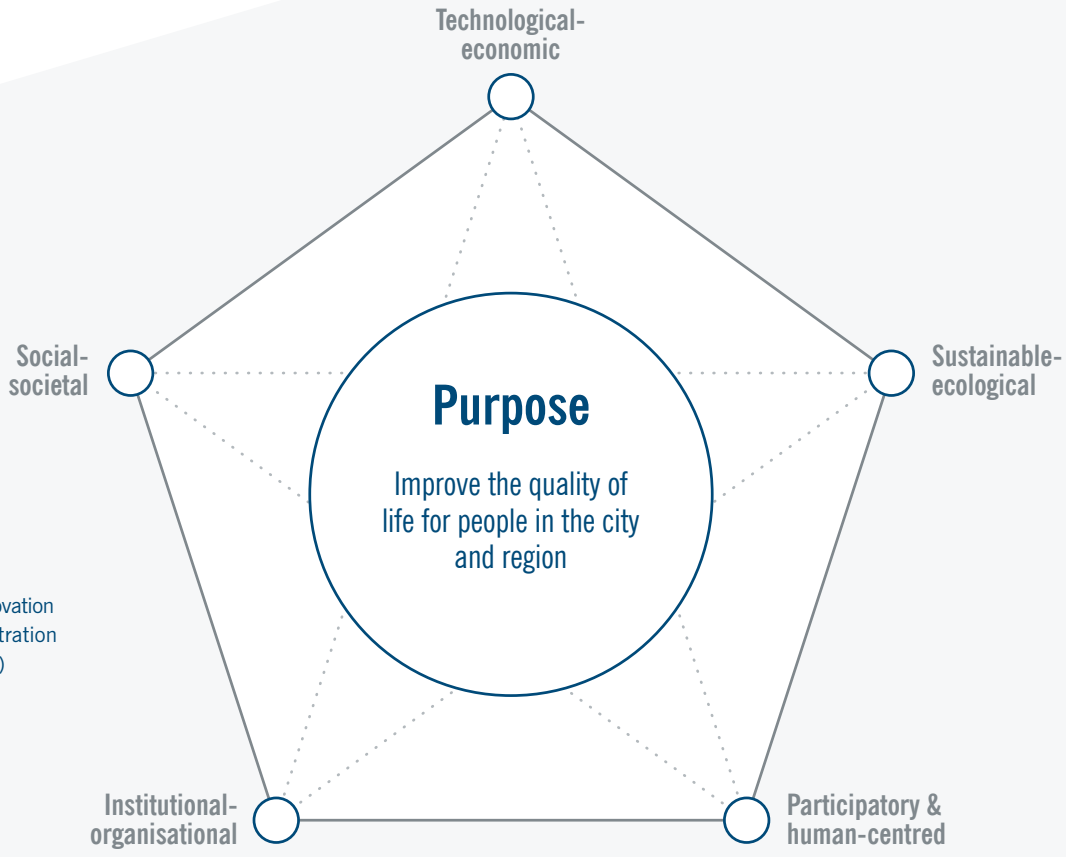

Fig. 5: Dimensions of innovation of a smart city, own illustration (Die Strategiemanufaktur)

This definition of smart cities links up the previous lines of definition and debate in the digital city and smart city discussions, integrates them and adds the dimension of 'how' to the content-related dimensions of the 'what', which has so far been insufficiently accounted for as a success factor. It's about institutional innovation.

The working methods of organisations also significantly influence the outcome of content and play a key role in the consolidation of new approaches. The effective implementation of project results therefore requires a critical review of the current organisational design. This involves the further development of existing structures and the re-wiring of the individual organisational units both internally and externally.

The first example of a comprehensive administrative modernisation[10] in the context of the smart city is the thematic scope or IQ solution developed by Die Strategiemanufaktur for the city of Karlsruhe in 2014 and now implemented, an expanded matrix organisation coupled with a citywide innovation team that represents the link between key issues within the administration and serves as a radar for future issues.

The growing importance of this dimension is reflected in a number of recent debates and reports, including a new report to the Club of Rome, which addresses the issue of 'structural silos' and speaks of the fragmentation of knowledge, administration and responsibility as a crucial barrier to transfer (Berg 2020, p. 252 ff.). The founding of the New Institute in Hamburg also tries to focus more on these systemic relationships.

10 See also: Will 2017 and Will 2021.

FROM SMARTER CITY KARLSRUHE TO THE IQ PROCESS

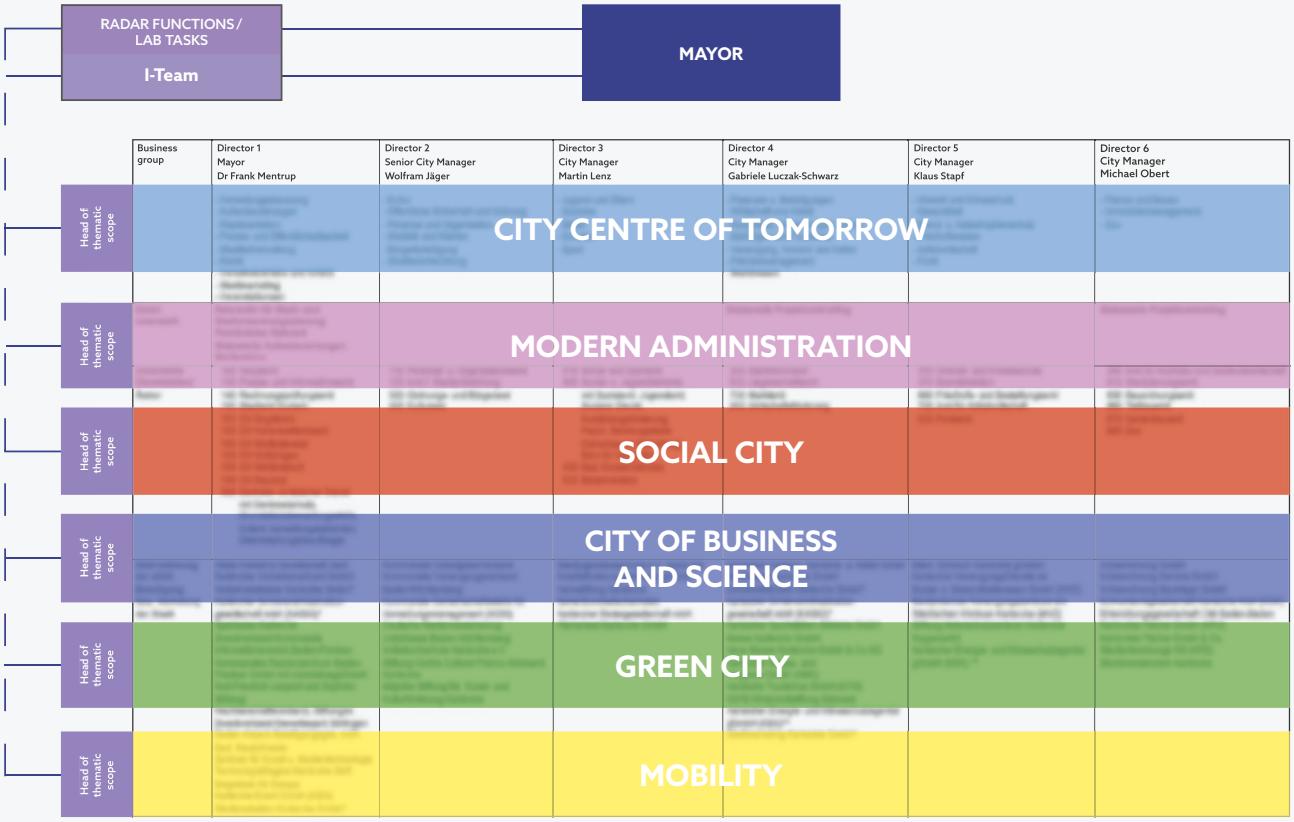

Fig. 6: Institutional innovation of a smart city using the city of Karlsruhe as an example, own presentation (Die Strategiemanufaktur)

2 SMART CITY TAXONOMY

The development of smart city taxonomy is based on three lines of development. Firstly, this is the general discussion about evaluation, monitoring and impact-oriented management. Secondly, the development of 'major indicator sets' and thirdly, the state of the general debate in the context of smart city development.

This general discourse forms the background for the 'bottom-up approach' of evaluation developed during the evaluation of Digitalstadt Darmstadt. Here, the indicators were developed from the projects and arranged according to the smart city definition. This taxonomy also enables good application in practice and can be differentiated from the easy-to-use basic pattern of the guidelines in a kind of 'slider principle', by expanding it accordingly in the smart city dimensions using the available key figures of the approaches described below (CITYkeys, OECD etc.).

The continuously increasing availability of all types of data (mobility data, sensor data, open government data etc.) and the possibility of linking them via platforms such as the Darmstadt Data Platform are opening up completely new control possibilities, the development of new business models and digital solutions for a liveable and climate-neutral city.

2.1 PERFORMANCE MEASUREMENT

The question of the effectiveness of funding programmes has existed from the outset and has been a focus of empirical social research for decades, which has developed numerous detailed methods for measuring them. The question of effectiveness is raised through the evaluation of funding programmes and is then generally used for the establishment of regular monitoring for steering purposes. Both instruments are part of a performance measurement. This basically has the following objectives:

- Fulfil an accountability and reporting obligation
- Availability of control information
- Transparency vis-à-vis and information to the public
- (Ideally) become part of a continuous development and improvement process

The German tradition of public governance is very qualitative and differs fundamentally from the strong Anglo-Saxon tradition, which is also geared towards measurability and competition and, for example, is increasingly being promoted by European funding programmes.

The overall assessment and initial analysis for the selection of the projects to be evaluated also took these aspects into account.

PRACTICAL CHALLENGES COVERING AT LEAST FIVE ASPECTS:

1. Are the evaluation results, which are usually available ex post, used in practice?
2. How can the evaluation results be linked with strategic management and corresponding monitoring?
3. Is it a question of whether the programme was effective and also whether it was necessary?
4. Does the evaluation take place in the ‘project silo’ or in the group of projects?
5. When is an evaluation or monitoring accepted by those affected?

2.2 INDICATORS

Initially, smart city projects were basically digitalisation projects. Digitalisation is basically the lowest common denominator of the projects, and the focus is clearly reflected in the Smart City 'brand term'.

In line with the changing thematic focus over time, the approaches to indicators have also changed. Initially, they were essentially a measure of digitalisation for smart cities and instruments for describing technologically designed living spaces.[11] This applies to the digitalisation index of the German Federal Ministry for Economic Affairs and, to a large extent, to the Bitkom Smart City Index or the DIN standards for smart cities.

As part of the Morgenstadt Initiative, the Fraunhofer Institutes developed and tested comprehensive sets of indicators very early on, some of which were still very theoretical at the outset, which led to a significant reduction in the indicators.

With regard to the measurability of the Sustainable Development Goals, numerous and comprehensive sets of indicators have been developed in recent years as a result of the rapidly spreading use of the 17 UN Sustainable Development Goals, some of which relate specifically to municipalities, such as the 'SDG Indicators for Municipalities' guide developed by Bertelsmann with numerous local umbrella associations.

In recent years, the OECD has been heavily involved in measuring sustainable development in regions and cities and has published these results in interactive maps. These lists include both Hesse and the city of Darmstadt as well as other Hessian municipalities. This OECD assessment compares the results and shows municipalities and regions with a similar score – for example, the results for Hesse and Darmstadt.

11 This is where the multifaceted criticism of one-dimensional digital euphoria begins. Bauriedl, S./Strüver, A. (ed.) (2018) provides a good overview of the criticism. Smart City. Kritische Perspektiven auf die Digitalisierung in Städten. Transcript Verlag Bielefeld.

12 https://www.oecd-local-sdgs.org

Overview of Hesse, Germany

- Selected region
- Country average

  – End value for 2030

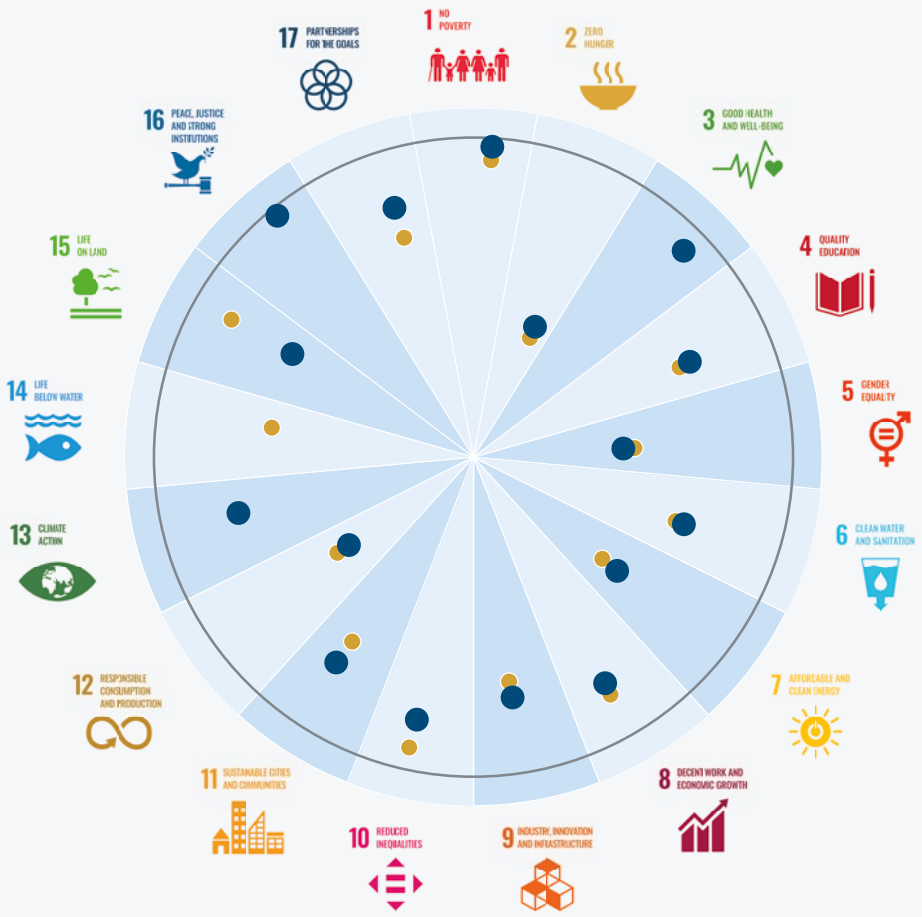

Fig. 7: OECD SDG Index[12]

Numerous projects of the European Commission's latest research framework programme, HORIZON 2020, which dealt with smart city topics, developed corresponding indicator sets for their project. The CITYkeys project, which is also funded as part of HORIZON 2020, made an initial 'meta attempt' to establish a unifying framework for the topic of smart cities.

As part of the development of a smart city performance measurement system, the CITYkeys project has developed a comprehensive system of indicators and metrics in a European comparison, which has included a large number of European indicator collections.

13 https://www.oecd-local-sdgs.org

Overview of Darmstadt, Germany

- Selected city
- Country average

– End value for 2030

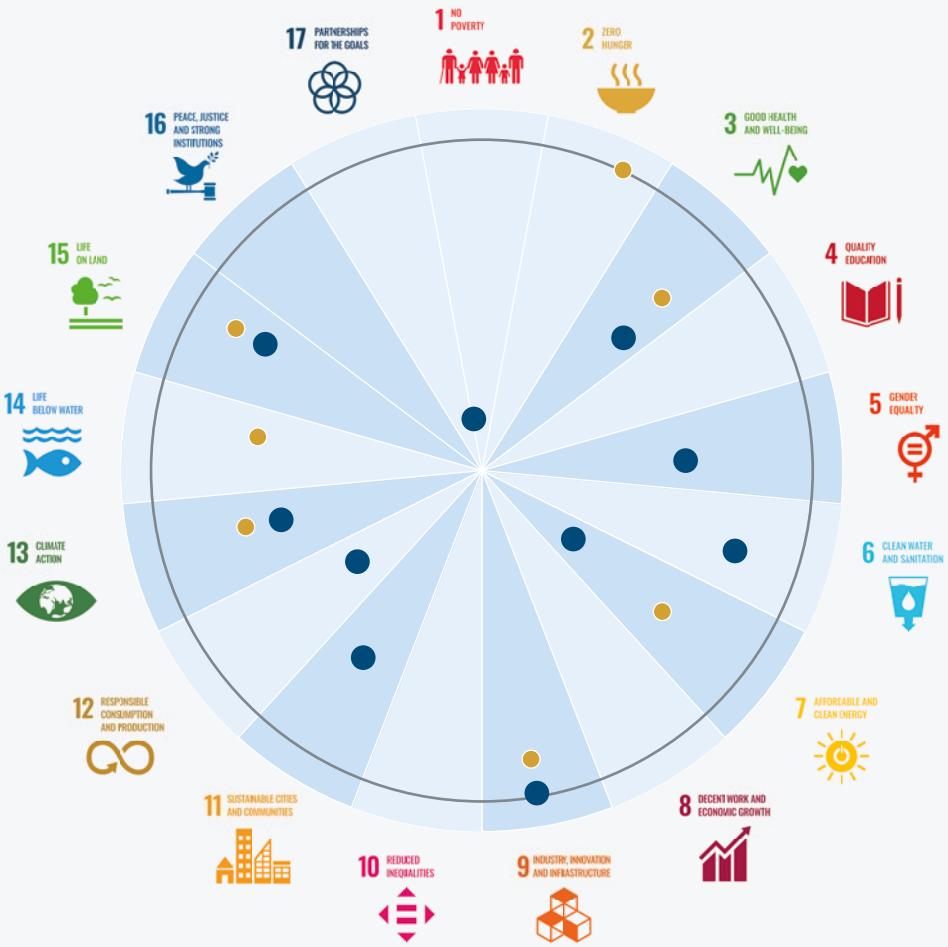

Fig. 8: OECD SDG Index[13]

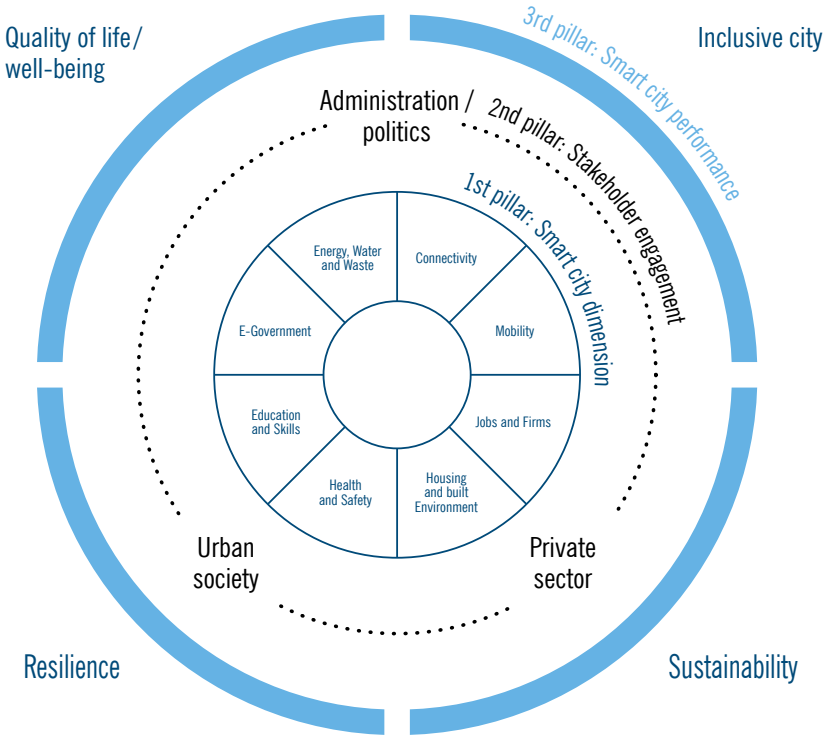

Fig. 9: OECD measurement framework, Own presentation (Die Strategiemanufaktur)

In addition to digitalisation and sustainability, the OECD has been explicitly addressing the topic of smart cities since 2020 and developing a corresponding approach that is derived from the above definition (section 1.2) and focuses strongly on the topics of quality of life and people's well-being. In this context, particular emphasis is placed on citizen participation and stakeholder engagement – see also

As is often the case in the context of smart cities, the city of Vienna has taken an interesting path in the area of indicators, which, on the one hand, underpins the measurement of the desired smart city goals with indicator-based monitoring, but at the same time combines this with a kind of 'development dialogue' with the magistrate's departments.

There is a rich repertoire of relevant indicators in the area of digitalisation and sustainability that can be used and, to some extent, is used, as in the case of the OECD.

2.3 TAXONOMY

Taxonomies are classification systems that bring together, relate and define the different aspects, concepts and dimensions. A smart city taxonomy must take this interconnected multidimensionality into account in terms of content, organisation and participation. The taxonomy developed and used here, based on the systemic smart city approach[15] developed by Die Strategiemanufaktur, creates both an analytical framework for smart city projects and a control framework for the future. This smart city taxonomy brings together the various discussion paths and dimensions, such as digitalisation,

THE FIVE-DIMENSIONAL INDICATOR OF DIGITAL-STADT DARMSTADT

In the evaluation of Digitalstadt Darmstadt, a five-dimensional indicator was used according to the taxonomy. It is made up of:

1. **Technological-economic dimension of the projects**
2. **Social-societal dimension of the projects**
3. **Institutional-organisational dimension of the projects**
4. **Sustainable-ecological dimension of the projects**
5. **Participatory 'co-dimension' of the projects**

sustainability, participation and co-design, into a systemic overview of a smart city. And it adds the dimension of institutional and organisational innovation that smart city projects must generate if they are to be successful in the long term. This holistic perspective on the smart city, smart city funding projects and their evaluation, as well as future monitoring, is new.

3 THE DIGITAL PROJECTS OF DIGITALSTADT DARMSTADT

From the perspective of the Hessian state government, Digitalstadt Darmstadt is a beacon of digital development in Hesse. After having been recognised as a smart city, this development was specifically promoted by the state and the smart city was seen as a space for experimentation without major 'restrictions' or requirements. The heterogeneity of the 20 projects supported by the state is an expression of this freedom and the range of possibilities to test new approaches. Darmstadt is seen as a space for experimentation and learning in Hesse, whose experiences are intended to support and accelerate the digitalisation of other municipalities in Hesse.

Procedures, products and business models developed in Darmstadt are to be adopted by other municipalities and serve as a source of inspiration. Darmstadt is thus a showcase and 'role model' of development for smart cities and regions in Hesse.

One element of this architecture is the exemplary evaluation of digital projects, the procedure and results of which are explained below, as well as the recommendations for action and the easy-to-use, practical guidelines for self-evaluation of smart city projects.

15 The taxonomy used here is based on the model used by Die Strategiemanufaktur since 2014 as part of its smart city evaluations and analyses. It is a systemic approach that not only takes into account the content dimensions of a smart city and the project organisation, but also takes into account the impact on and changes to the structures and processes of the participating organisations.

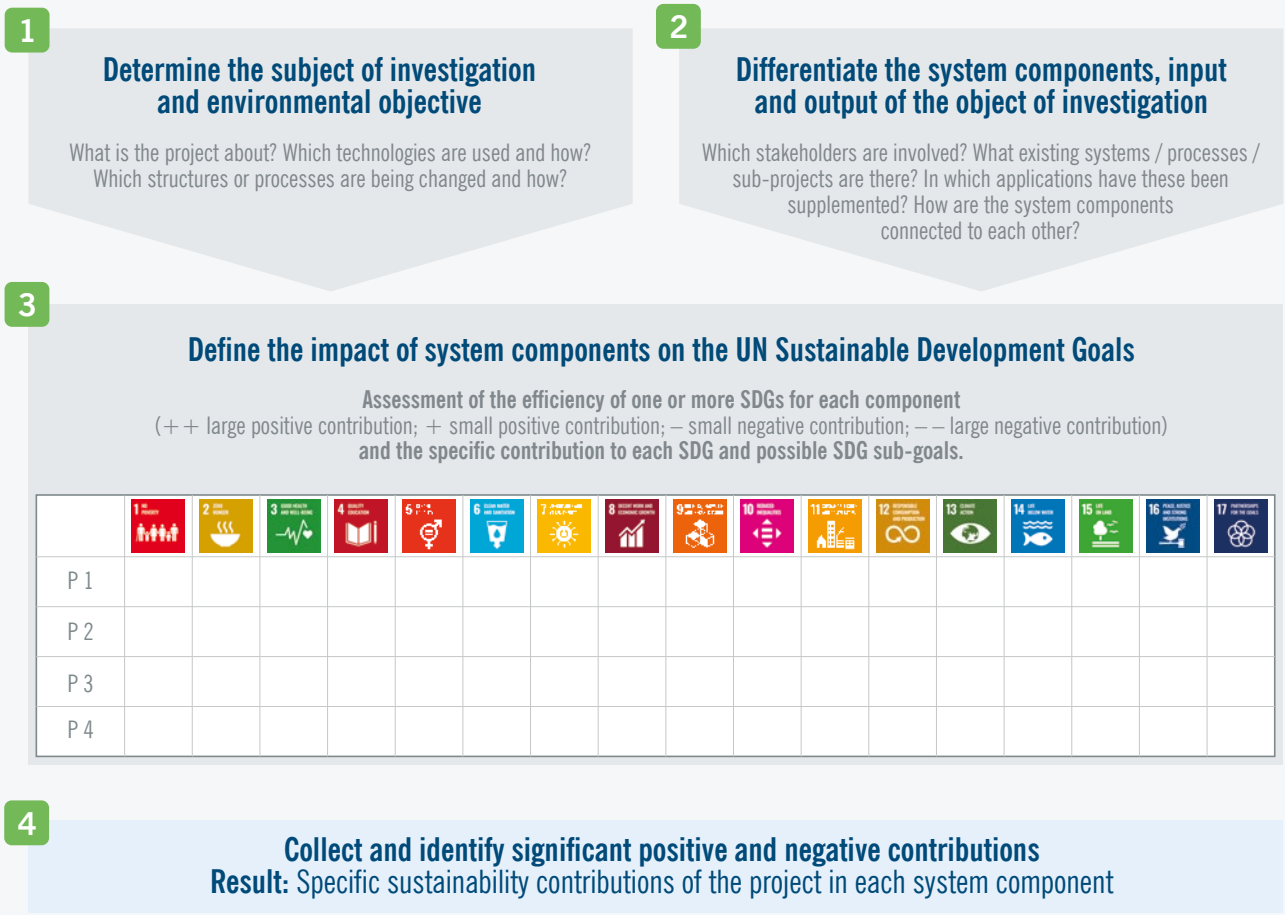

Fig. 10: Documenting the sustainability contribution with a project analysis tool. Own illustration (e-hoch-3) based on Darmstadt University of Applied Sciences and System Innovation for Sustainable Development (undated). Step-by-step procedure for documenting the sustainability contribution of the selected projects.

While stimulating digitalisation and promoting smart city projects have so far been the focus of the efforts of state and federal funding programmes, such as the programme of the Federal Ministry of the Interior (BMI) for Smart Cities Model Projects (MPSC), the impact of the funding measures is now increasingly being questioned.

For the first stage of the Federal Ministry of the Interior's MPSC programme, the Federal Institute for Research on Building, Urban Affairs and Spatial Development published an initial report entitled 'Im Zentrum steht die Nachhaltigkeit' ['Sustainability is at the Heart of Everything'] [16], which, due to the short duration of the programme, can only

describe initial results and some basic programme evaluation principles such as the Logic Chart, a model used in programme evaluation that describes the chain from target definition to impact and was also used in the evaluation of the DDG.[17]

On the one hand, the project descriptions in this chapter offer a concrete insight into the projects and working methods of DDG and describe its content and creation. On the other hand, they summarise the results of the evaluation in the five smart city dimensions (see section 1.3). The contribution to the SDGs is named for the relevant objectives of the 17 SDGs with the respective sub-goals.

The instrument[18] developed by e-hoch-3 as part of the System Innovation for Sustainable Development project (the Federal Ministry of Education and Research's 'Innovative Hochschule' university funding initiative) was used to examine the evaluation of these goals and their effectiveness in more detail within the framework of projects.

For smart city projects, this instrument can be used to assess a fundamental relationship with the SDGs. However, the specific fulfilment of the requirements of the SDGs must be derived from the specific (sub-)goals and the indicators defined for them.

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16 Räuchle, C./Schüle, R. (2021), 'Im Zentrum steht die Nachhaltigkeit' ['Sustainability is at the Heart of Everything'] Smart Cities model projects. BBSR online publication. https://www.bbsr.bund.de/BBSR/DE/veroeffentlichungen/bbsr-online/2021/bbsr-online-12-2021-dl.pdf;jsessionid=4355D95CF5D316CBF4EB4C6BCFBA294C.live11292?__blob=publicationFile&v=2. Last accessed on 21 April 2022.

17 The Logic Chart and Theory of Change are tools used nationally and internationally for project and programme evaluation. They have their roots in the Anglo-Saxon region. In the public sector, Switzerland has developed a highly regarded approach in this area based on the concept of impact-oriented administration (a management model known as 'Wirkungsorientierte Verwaltungsführung' or WOV). On the topic in general: Balthasar, A./Fässler, S. (2017). Wirkungsmodelle: Ursprung, Erarbeitungsprozess, Möglichkeiten und Grenzen. Methodically, the WOV model has numerous overlaps with the impact model and the impact staircase of PHINEO. For example, see: https://www.wirkung-lernen.de/wirkung-planen/wirkungslogik/bestandteile/, last accessed on 21 April 2022.

18 (Darmstadt University of Applied Sciences and System Innovation for Sustainable Development, undated) The project analysis tool supports the identification and assessment of the specific sustainability contribution of projects. On this basis, the tool identifies links between the UN Sustainable Development Goals (SDGs) and the individual system components of the project and identifies strengths, weaknesses and feedback effects.

3.1 PROJECT SELECTION

3.1.1 Fundamental considerations of projects during an evaluation

Innovation projects or programmes are usually developed, started and implemented with the aim of achieving the expected success or achieving the set objectives. This does not automatically address the question of whether the projects and programmes are effective or whether the results are permanent. This is a key issue that is also gaining importance in the general debate on the promotion of smart cities. For example, the Smart City Forum position paper published in March 2022 calls for a stronger focus on reuse.[19]

The challenge of consistency

Projects have several phases that they go through. Two transitions are particularly central to project development and execution: the transition from the preliminary phase that led to the approval and the final transition from the project phase to the routine processes as part of a new standard. Of the three phases of a project, the most significant challenge is the final phase of consolidation or the use of the results after the project has been completed. This applies not only to follow-up

1) Preliminary phase
2) Consolidation
3) Consistency

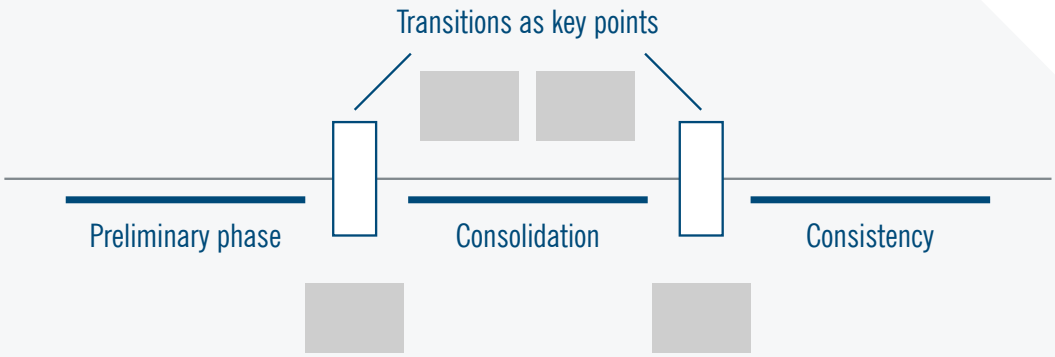


Fig. 11: Transitions of a project process, own presentation.

THE DEFINED CRITERIA GRID

The projects to be evaluated were selected on the basis of a systematic analysis of 20 projects funded by the State of Hesse and based on a pre-defined criteria grid, which includes the following selection criteria:

1. **Representativeness in terms of technological, social and social dimensions**
2. **Transferability to current and future projects**
3. **Adequate data basis for evaluation**
4. **Differentiated project size (selection of both large and small projects)**
5. **Projects in different implementation phases (selection of both ongoing and completed projects)**

financing, but to the utilisation of the results in particular. In addition to project-specific aspects and topics, an evaluation should therefore always focus on the quality of these transitions and the achievement of a final success. This perspective was taken into account in the evaluation of DDG projects, particularly in the case of the Smart City Laboratory.

19 Smart City Forum position paper dated 15 March 2022. Point 2, funding focus more on reuse. The guidelines on smart cities and regions issued by the Ministry of Economic Affairs, Innovation, Digitalisation and Energy of the State of North Rhine-Westphalia also address the challenge of sustainability.

3.1.2 Selection of projects using the example of DDG projects

This strategy comprises three lighthouse topics, five core objectives and 14 fields of action (see section 1.1). In the context of the objectives, projects were selected that ensure the greatest suitability for the transferability of the evaluation to other projects within the framework of DDG and beyond. The basis for the selection was an overview of all 20 DDG projects including a brief project description, the field of activity defined by DDG, the thematic location (technological or social project) as well as information on the budget, duration, data basis, implementation period and partners involved in the projects. The project selection shown in Figure 12 was made on the basis of the aforementioned selection criteria.

3.2 QUESTIONNAIRE DESIGN AND EXPERT INTERVIEWS

3.2.1 General remarks

The analysis of the project documents (concepts, drafts, funding applications, approval decisions, implementation reports and milestones etc.) enabled an initial and intensive overview of the processes in the project. In addition to the document analysis, a comprehensive and as objective as possible impression must also be obtained, in particular by the fact that, in the broad sense of the term, those involved in the project provide important information and assessments about the selected projects from their internal or external perspective. It would have been desirable to have greater involvement of the stakeholder/user perspective in the projects, but this was not possible within the scope of the project and was therefore carried out only in isolated and exemplary fashion. For an appropriate evaluation, interviews require a systematic compilation of specific questions based on the position of the interviewees, their level of knowledge and their role in the project.

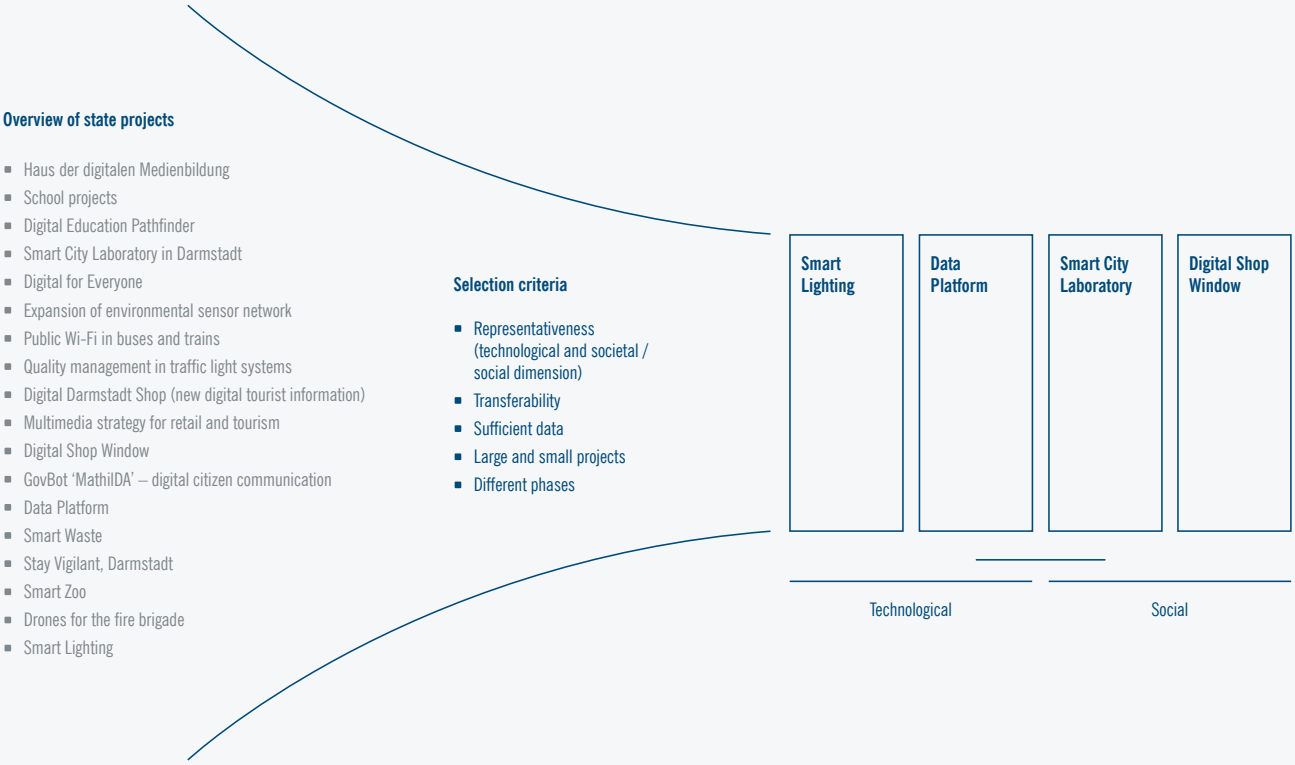


Fig. 12: Project selection using selection criteria, own presentation

3.2.2 Various expert perspectives using the example of DDG projects

A total of 14 experts were selected and interviewed. A distinction was made between the following perspectives:

- Internal perspective of project management (1st level)
- Complementary perspective of external
- project partners (2nd level)
- Informed external perspective (3rd level)
- State perspective (4th level)

For the internal perspective, the project managers of the selected funding projects were interviewed. The complementary perspective refers to individuals who were involved in the projects but do not hold a position at DDG. The informed external perspective and the state perspective were given by experts who were not actively involved in project implementation. A discussion was also held with the Ethics and Technology Advisory Board (3rd level), which plays an advisory role for Digitalstadt Darmstadt. The different perspectives are shown in Figure 13 **(see next page)**.

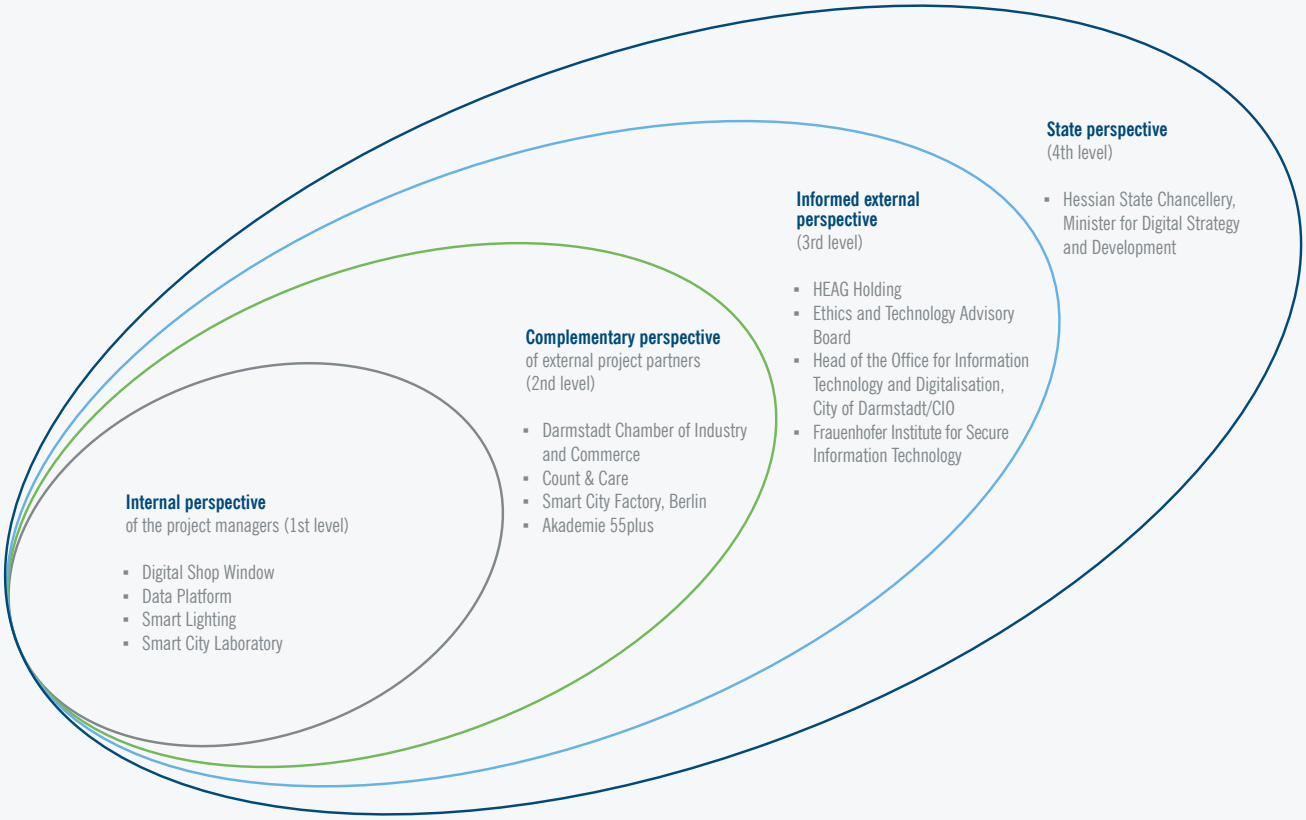


Fig. 13: Experts from four overarching perspectives, own presentation

3.2.3 Questionnaire design

Corresponding interview guidelines were used to ensure the uniformity of the interviews. They define the internal structure of an interview and ensure that all relevant aspects and factors are taken into account and that a systematic and comparative evaluation is possible.

The structure of the interview guidelines for DDG projects was as follows:

1. Project level: Recording of project objectives, description of project content
At this level, the content of the project was screened with questions on the objectives, the approach, the project-specific key figures, the contribution to the Sustainable Development Goals and the implementation of the project (e. g. 'What were the success factors of the project?', 'What were the difficulties in implementing the project?'). In addition, project-specific questions were asked that were still open after the document review.

2. Digitalstadt Darmstadt level: Description of DDG's contribution to the urban strategy
At the level of Digitalstadt Darmstadt, questions were asked about the project's contribution to the smart city, its objectives and fields of action (e.g. 'What DDG goals does the project contribute to?', 'How can the project's contribution to Digitalstadt Darmstadt be described?').

3. Smart city development level: Classification in the context of smart cities
In this part of the interview guidelines, the experts should describe their understanding of smart cities and give their assessments of the project.

4. State level: Contribution to the digital strategy of the state of Hesse
The state level was asked about the implementation and alignment of the project with the digital strategy and funding policy of the state of Hesse in the digitalisation projects of the municipalities.

Depending on the perspective of the interviewees, the structure of the guidelines was supplemented and the structure and detailed questions adapted for the interviews:

- Internal perspective: The interview guidelines for experts with an internal perspective ranged from project-specific questions and the contribution to Digitalstadt Darmstadt to an assessment of the overarching smart city and state perspective.

- Cooperation partners: The survey began with the relationship to the Digitalstadt Darmstadt level. This was followed by an assessment of the project level with a screening of the project's content and detailed questions tailored to the experts and their areas of activity. The survey ended with questions on the smart city and state perspective.

- Informed external and state perspective: The questions focused on the perspective of the person/institution with regard to the projects. It asked about the connection to Digitalstadt Darmstadt and the subsequent course of the selected projects, as well as their impact on Digitalstadt Darmstadt. This was followed by questions about the smart city and the state contribution, which were expanded to include the future prospects of the projects.

3.3 DESCRIPTION OF THE SELECTED PROJECTS

The table below provides key data on the four evaluation projects in terms of the urban strategy, its thematic location and current status.

Project	Field of action	Flagship topics	Technological/ social	Implementation period	Status
Digital Shop Window	Trade & Tourism	Business & Technology		March 2019 – April 2021	Completed
Data Platform	Data Platform	Business & Technology		Since April 2018	Ongoing
Smart City Laboratory	Society	Digital Services & Society		Since July 2018	Ongoing
Smart Lighting	Energy	Mobility & Environment		July 2018 – April 2021	Completed

Fig. 14: Core information on the evaluation projects, own presentation

The four projects are described below with their objectives, project implementation, selected key figures, contribution to sustainability and success factors and barriers to success. A graphic depicts the contribution of each project to the strategy of Digitalstadt Darmstadt and explains the extent to which the each project contributes to the strategic goals of the city.

3.3.1 Digital Shop Window

Project objectives

The Digital Shop Window is intended to contribute to the promotion of a sustainable economic structure, the reduction of private transport and the provision of information to the public.

Economic objectives are to strengthen inner-city retail and catering as well as marketing and promote the image of the location. The environmental objective is to avoid private transport. Social objectives are quality of life and barrier-free accessibility of services. The public service obligation, non-discriminatory and barrier-free access, sovereign citizenship and data protection are central concerns.

Since 2019, the Digital Shop Window has been a central platform for the city of Darmstadt to present gastronomy and retail. In December 2021, around 550 businesses were listed on the website. A partnership with LieferradDA enables goods to be delivered by electric cargo bike. Participants

SELECTED KEY FIGURES

Readily available and meaningful key figures were chosen for the project, which primarily relate to the acceptance and reach of the project:

1. **Number of businesses displayed in the Digital Shop Window**
2. **Number of homepages linked to by the Shop Window**
3. **Number of branches of trade on the platform**
4. **Number of businesses using the LieferradDA delivery service**

include the Darmstadt retail sector, Darmstadt Citymarketing e. V., Darmstadt Marketing GmbH with technical and editorial support, delivery service providers, Darmstadt University of Applied Sciences, the Citizens' Panel, LieferradDA and the Darmstadt Chamber of Industry and Commerce.

Project implementation

Following a workshop at the beginning of 2019, the technical implementation was first carried out, then the data of the acquired companies was collected and the acquisition of additional dealers was carried out. The Digital Shop Window went online in February 2020. At the beginning of the first COVID-19 lockdown in March 2020, all businesses in the city centre were informed via the platform at short notice and intensive press and public relations work was carried out. The participating companies in the Digital Shop Window are now also presented on the website of Darmstadt Marketing GmbH.

The Digital Shop Window contributes positively to the following SDGs:

- Highly positive contribution to SDG 8, especially 8.2: The Digital Shop Window is a technological innovation for Darmstadt's retail sector that supports the local economy and increases productivity.

- Highly positive contribution to SDG 9, especially 9.1, 9.3 and 9.4: The Digital Shop Window provides affordable and equitable access to reliable infrastructure for all citizens

- Including through online information and delivery service (9.1). It increases the visibility of individual local retailers and restaurateurs (9.3) and leads to a modernisation of the infrastructure (9.4).

- Positive contribution to SDG 10: Although the platform is not yet fully barrier-free, the delivery service LieferradDA makes it easier for people with limited mobility to access products.

Success factors

During the lockdown, the Shop Window became a central source of collated information about businesses in Darmstadt from spring 2020. The increased visibility of retail and gastronomy contributed to local value creation. The project has led to new services as well as to the attraction and retention of new customers.

Barriers to success

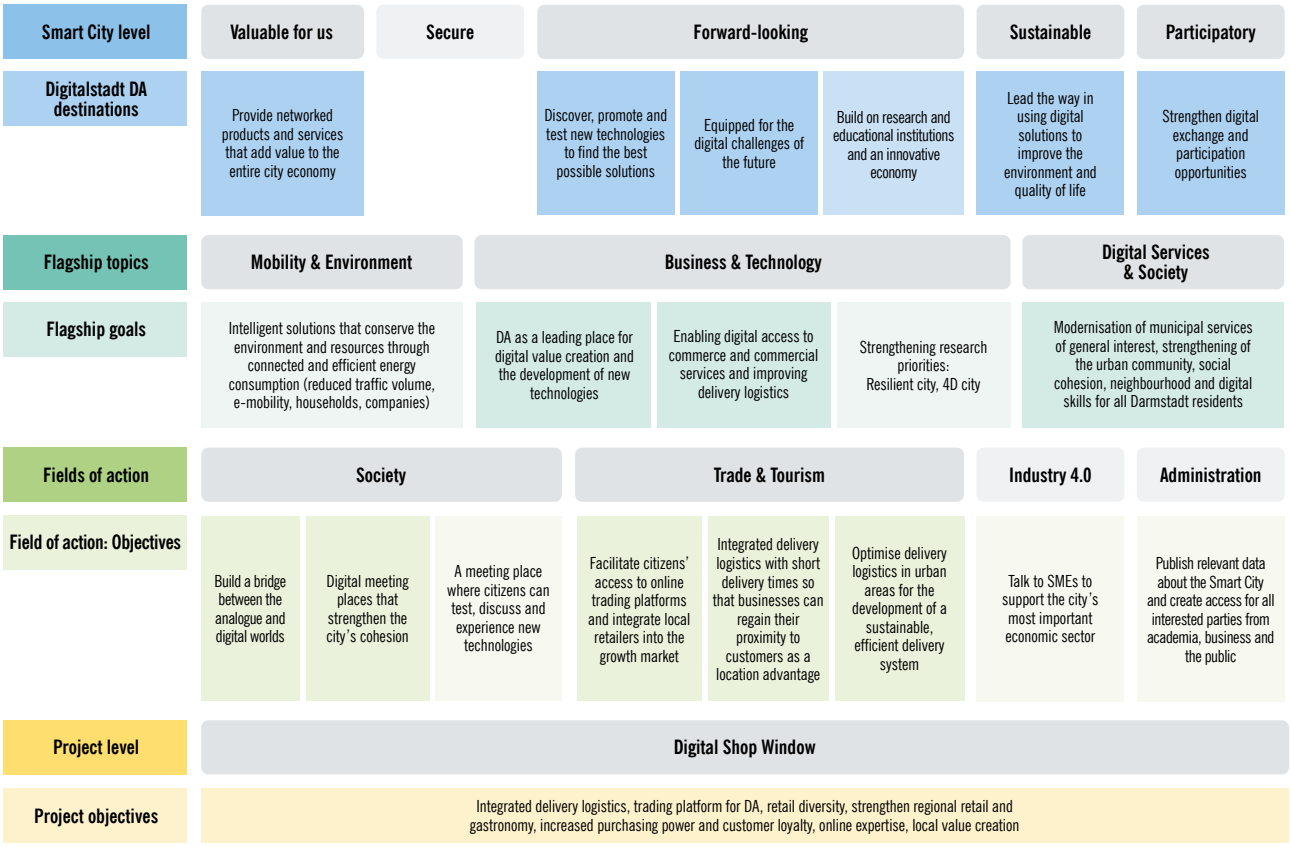
From March 2020, the project benefited primarily from developments during the first COVID-19 lockdown. In this exceptional situation, the project attracted a great deal of attention from retailers and was well known.

The visibility of the Digital Shop Window on the Internet is comparatively low, as it does not have its own website. Its long-term success depends on the number of participating retailers and users, as well as the amount of revenue generated.

Digital Shop Window

Fig. 15: Contribution to sustainability for the 17 SDGs overall

Contribution of the Digital Shop Window to Smart City Darmstadt



Dark target fields =
goals to which the project makes a strong contribution

Light target fields =
goals to which the project contributes in a broader sense

Source: Own illustration based on the Digitalstadt Darmstadt strategy (2020)

3.3.2 Data Platform

The data platform is intended to provide the public in Darmstadt with up-to-date environmental and traffic data, information on the COVID-19 situation, weather data and information on events. The data platform is intended to facilitate networking and communication between citizens, business and the city.

The platform is intended to ensure maximum data security through strong encryption and be a connecting element in Digitalstadt Darmstadt. Its own technical infrastructure is intended to ensure that any data generated remains under the sovereignty of the city and its citizens. In addition to the publicly accessible platform, there is a much more extensive internal administrative management dashboard that is accessible only to employees and the city's CIO. Economic objectives are the promotion of business and cooperation, a sustainable economic structure, location marketing, business establishment and business start-ups. Ecological objectives include climate-friendly urban development and mobility, air pollution control, reduction of energy consumption, increased energy efficiency and the use of renewable energies. Social objectives are people's participation, cohesion, health, quality of life and safety. The Environment & Mobility Office and the Office for Internal Services (IT department)

of Darmstadt as well as city-owned companies (EAD, HEAG, ENTEGA, Nordbad, Count & Care Darmstadt) are involved, as will the Statistical Office be in future. The design and call for tenders ran from late 2018 to late 2019, with implementation taking place in 2020. The platform has been available to the public since February 2021.

Project implementation

The implementation phase served to integrate already planned projects in the fields of transport, environment and waste management. The operating phase began with a duration of 36 months and the possibility of annual renewal. The project was awarded to the company E-kom21 with the subcontractor Urban Institute, who provide the data platform. Digitalstadt Darmstadt supports the implementation of use cases that are implemented on the data platform as well as the basic structure of the data platform. Operational processes were overseen by Count and Care with a focus on cybersecurity.

The publicly available dashboard provided a selection of key information for citizens, including up-to-date COVID-19 and environmental information, traffic data and citizen participation offers.

SELECTED KEY FIGURES

The selection focuses on participation and use by citizens, application by the city administration and the technical components of the data collection:

1. **Number of ideas received about citizen participation**
2. **Number of platform views, length of stay and origin of users**
3. **Number of modules**
4. **Number of measuring points in Darmstadt**
5. **Number of use cases in planning, production and implementation**
6. **Number of installed and active Lora alarm sensors**

The data platform contributes to the following SDGs:

- Highly positive contribution to SDG 9.1: The provision of the data collected contributes to the promotion of innovation and infrastructure. A prerequisite is data analysis and the subsequent use of the data.
- Positive contribution to SDGs 11.2, 11.3 and 11.6: The data platform contributes to efficient urban planning and municipal management. It also enables citizens to participate. The data platform is a driver of climate-friendly urban development by supporting access to safe, affordable, accessible and sustainable transport systems.
- Positive contribution to SDGs 12.5 and 12.8: The data platform contributes to the promotion of resource and energy efficiency and sustainable infrastructure by providing information on waste levels and recycling rates. The provision of information also supports the general awareness of sustainable development.
- Positive contribution to SDG 13.2: The data platform enables the collection, analysis and use of environmental data, e.g. in the area of air pollution control.

Success factors

One of the success factors of the project is the high level of citizen participation. Suggestions regarding traffic volumes, environmental sensors and data presentation on the platform were implemented. Initial steps were also taken to involve municipal economic development.

The project uses new technology, develops a strong innovative character and strengthens Darmstadt's digital presence. The information needs of citizens are met and data can be collected, analysed and applied to the management of processes in the city.

Barriers to success

Implementation was affected by multiple personnel changes in 2021. In addition, it has not yet been possible to collaborate on different documents. The data to be made available on the data platform could not yet be directly integrated into processing due to the different sensor types. Existing legal requirements, a still low willingness to publish data and the sometimes low relevance of data to the economy made it more difficult to use.

Data Platform

Fig. 16: Contribution to sustainability for the 17 SDGs overall

3.3.3 Smart City Laboratory

The project aims to bring the current projects of the Smart City and the digitalisation strategy of the city of Darmstadt to the public. In addition, the Smart City Laboratory will network stakeholders and citizens and promote constructive discourse. Further objectives are to support the transfer of knowledge and skills and the co-creative exchange of ideas about existing projects and new internal projects. It is intended to serve as both a physical and a virtual experimentation space for the discourse on digitalisation topics.

The participants are Science City Darmstadt, Akademie 55+ Darmstadt e. V., Chaos Computer Club Darmstadt e. V., COUNT+CARE GmbH & Co. KG, the following Digitalstadt Darmstadt areas: Culture, Society, Education and Cybersecurity, Digitale Darmstadt e. V., Digitalstadt Darmstadt GmbH, the European Space Agency, the Fraunhofer Institute for Computer Graphics Research IGD, the Fraunhofer Institute for Structural Durability and System Reliability LBF, the Fraunhofer

Contribution of the Data Platform to Smart City Darmstadt

Smart City level	**Valuable for us**	**Secure**	**Forward-looking**	**Sustainable**	**Participatory**	
Digitalstadt DA destinations	Provide networked products and services that add value to the entire city economy	Digital solutions must meet the highest security standards to protect citizens' privacy Maximum transparency in all processes, no compromises at the expense of data security	Discover, promote and test new technologies to find the best possible solutions Equipped for the digital challenges of the future	Lead the way in using digital solutions to improve the environment and quality of life Focus on ecological, social and economic sustainability and sustainable solutions	Strengthen digital exchange and participation opportunities	
Flagship topics	**Business & Technology**		**Mobility & Environment**		**Digital Services & Society**	
Flagship goals	Modern and reliable IT infrastructure for companies, research and education landscape for groundbreaking innovations	Application of the highest cybersecurity security standards to guarantee and further develop the IT infrastructure's defensive capabilities	Intelligent solutions that conserve the environment and resources through connected and efficient energy consumption (reduced traffic volume, electromobility, households, companies	Reduction of energy consumption and CO2 emissions through intelligent control systems		
Fields of action	**Data Platform**		**Cybersecurity**	**Administration**	**Society**	**Culture**
Field of action: Objectives	Enabling access to public data to create transparency and develop new applications (open data principle) Ensuring protection of personal data and increasing the sovereignty of Darmstadt residents in handling data Improving the services offered by DD to improve quality of life		Communication, data storage and network backup must meet the highest security standards that reflect the state of the art	Publish relevant data about Smart City and create access for all interested parties from academia, business and the public	Improving the citizen participation platform to make political and social processes digitally accessible to all citizens	Integration of virtual elements for easy and attractive access to cultural offerings for residents of Darmstadt and tourists
Project level	**Data Platform**					
Project objectives	Connectivity of data, data security and integration of IoT systems, strengthening digital business structures and location, environmentally friendly urban development and mobility, reducing energy consumption, demonstrable energy efficiency, avoiding grid bottlenecks					

Dark target fields =
goals to which the project makes a strong contribution

Light target fields =
goals to which the project contributes in a broader sense

Source: Own illustration based on the Digitalstadt Darmstadt strategy (2020)

SELECTED KEY FIGURES

The choice mainly relates to usage and participation, as well as the number of particularly active people:

1. **Number of users**
2. **Number of participants in the event formats**
3. **Types of work groups and number of participants involved who actively participate in the Smart City Laboratory**
4. **Participation in events (number of people)**

Institute for Secure Information Technology SIT, Haus der digitale Medienbildung, Hessisches Landesmuseum, Darmstadt University of Applied Sciences, Hub31 Technologie- und Gründerzentrum Darmstadt, the Darmstadt Chamber of Industry and Commerce, the special interest group for elderly people in Darmstadt 'Interessenvertretung für ältere Menschen', Kultur einer Digitalstadt e. V., the Kunstforum museum of the Technical University of Darmstadt, Lab3 e. V., Merck Real Estate GmbH, the Schader Foundation, the Technical University of Darmstadt, T-Systems International GmbH and the community education centre vhs Darmstadt. The project has been running since 2020.

Project implementation

In the first design phase, the vision, objectives, values, framework conditions and initial formats were defined for the public. In particular, participants from initiatives for the common good, institutions and companies involved in digitalisation projects in Darmstadt were involved. In digital workshops, the concept was developed with the criteria of openness, sustainability, transparency, common good, networking and creativity. The project ideas gave rise to the following clusters: the Mobile City Laboratory, the Digital Learning Workshop, the participatory Environment/Water project and the digitalRaum.

Initially, public activities only took place digitally due to the COVID-19 pandemic. Analogue services are now also being used. In September 2021, the new concept for the Smart City Laboratory in Darmstadt was anchored in the 'Smart Cities made in Germany' funding programme and secured funding until 2027.

Smart City Laboratory

Fig. 17: Contribution to sustainability for the 17 SDGs overall

The Smart City Laboratory contributes to the following SDGs:

- Highly positive contribution to SDG 4.5 and 4.7: In the services offered by the Smart City Laboratory, citizens can find out more about digitalisation, try out the technologies and acquire digital skills. In particular, the Digital Learning Workshop provides equal access to current educational topics related to digitalisation.
- Highly positive contribution to SDG 10.2: Regardless of age, gender, disability, economic or other status, the Smart City Laboratory integrates all citizens into its services and projects. The events also tried to integrate older people into the increasingly digitised urban society.
- Highly positive contribution to SDG 13.3: In particular, the participatory project with a focus on environment and water ensures improved education and awareness of climate change mitigation.

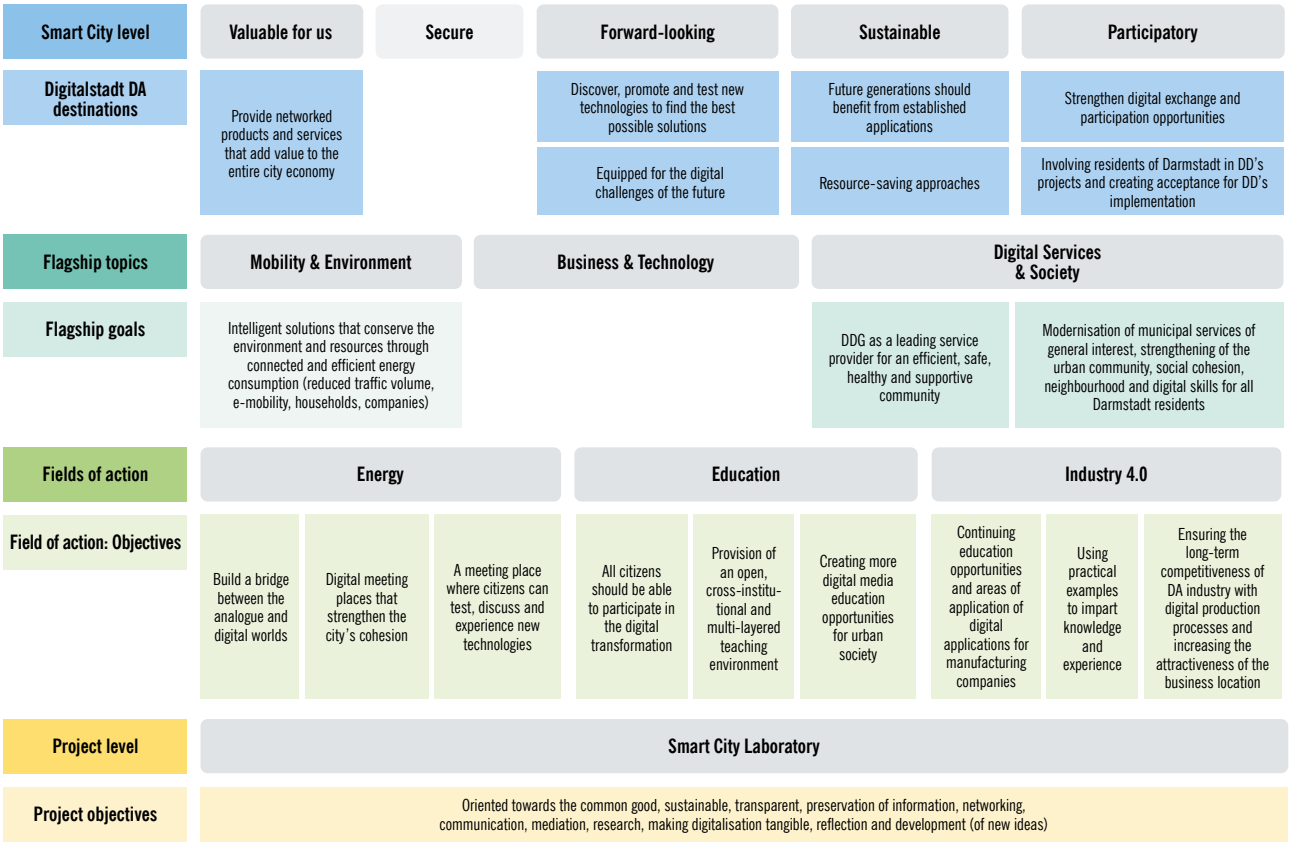
Success factors

The Smart City Laboratory has helped to make the activities of Digitalstadt Darmstadt more visible and more accessible to its citizens. The different perspectives and skills and the participatory process with the citizens provide a clear orientation and build trust for the project amongst the population.

Barriers to success

Bringing people from different contexts, life situations and institutions together presents challenges. In some cases, the highly technical discussions at the events are difficult for the average person to understand. Dependence on external resources is a challenge, as the project is carried out on a voluntary basis and financial and human resources are limited.

Contribution of the Smart City Laboratory to Smart City Darmstadt



Dark target fields = goals to which the project makes a strong contribution

Light target fields = goals to which the project contributes in a broader sense

Source: Own illustration based on the Digitalstadt Darmstadt strategy (2020)

SELECTED KEY FIGURES

The selection was based on the technical infrastructure and the impact of the measures:

1. **Number and location of street lights with adaptive lighting**
2. **Number, location and type of installed sensors**
3. **Use of the collected data**
4. **Degree of reduced accident rate**
5. **Degree of reduced environmental impact**

3.3.4 Smart Lighting

Project objectives

The aim of the project was to establish a technical sensor infrastructure that can be used for smart city applications. The situational lighting control should identify energy-saving potentials and regulate the lighting as needed. As such, the project should also contribute to avoiding light pollution and protect animals and nature at night. The data obtained from the sensors should also help to adjust traffic light circuits according to traffic volume and air quality. The situation-appropriate illumination of dark areas should contribute to an increased feeling of safety.

Project implementation

At the beginning of the project, representatives of Digitalstadt Darmstadt GmbH, the city of Darmstadt, e-netz Südhessen and ENTEGA AG examined the prerequisites for project planning and implementation.

As a pilot measure, street lights were equipped with sensors that record traffic volumes, air quality, noise levels and visitor flows. LED street lights were also equipped with sensors that enable adaptive street lighting. The sensors react to movements in their surroundings and regulate the light. The data from the sensors was also integrated into a data platform, where it could be evaluated and displayed graphically. In addition to the sensors attached to the lights, a ground sensor was installed to record the temperature of the road surface.

Participants included the city of Darmstadt, e-netz Südhessen, ENTEGA as the operator of the network, the Smart City Factory and Vodafone AG. The project ran from the start to the end of 2019 and is now complete.

The Smart Lighting project contributes positively to the following SDGs:

- Highly positive contribution to SDG 9.1: Contributing to sustainable and innovative urban infrastructure.
- Highly positive contribution to SDG 11.2: Adaptive lighting control increases road safety and the feeling of safety for road users.
- Positive contribution to SDG 13: Adaptive lighting control can be expected to save energy and thus contribute to climate action through energy savings (13.2).
- Negative contribution to SDG 13: The production and operation of digital components and data transmission is associated with high energy consumption. The proportion of grey energy contained in the individual modules and the energy required to process the data may exceed the savings and thus reduce positive climate effects.
- Positive + negative contribution to SDG 15.5: The project, in particular adaptive lighting control, contributes to reducing light pollution and thus to protecting biodiversity. However, it must be assumed that the manufacture of the sensors will contribute to the loss of biodiversity.
- Potential positive contribution to SDG 7: if the project is expanded, electricity consumption can be expected to be reduced.

Success factors

With the Smart Lighting project, an infrastructure has been created that can be expanded to include additional smart city applications and at the same time be able to control the light adaptively. Entega AG was a strong local partner who was able to oversee the technical and regulatory requirements and drive the project forward. The project can achieve savings in the area of electricity consumption. The experience and technical framework conditions for scaling and expanding for other smart city applications in urban areas are available.

Barriers to success

The continuous power supply to the sensors on the light poles, even during the day, requires an additional technical solution. In addition, the right luminaires are still cost-intensive, which limits the potential savings. The large number of people involved and those responsible for the project presented itself as a challenge.

3.4 PROJECT INDICATORS

Indicators must be defined for the smart city dimensions of each objective, describing the impact of the project activities and allowing evaluation. They are the qualitative and quantitative key figures for the success and implementation of the project. At the same time, they represent the cross-project indicators that are fundamentally important for a smart city project and to which reference should already be made during project planning.

Comparison with the thematic focus areas and indicators from the current Smart City reference works, e. g. with the impact model as part of the evaluation of the 'go-digital' funding programme of the German Federal Ministry for Economic Affairs and Energy (BMWi), ensures that the set of indicators is highly transferable, meaningful and practical, not only for Digitalstadt Darmstadt and its projects, but also for other municipalities.

Smart Lighting

Fig. 18: Contribution to sustainability for the 17 SDGs overall

Experience gained from the evaluation of DDG projects shows that in addition to the cross-project indicators applicable to many projects, a number of project-specific indicators (e.g. data quality or ongoing project management) can be selected that relate to the specific objectives and measures of the individual projects and, in combination with the cross-project indicators, allow a good assessment of the effectiveness of project implementation. They also form the basis for the necessary data collection as part of the project work. For the smart city taxonomy, see section 2.

Indicators using the example of DDG projects

For the evaluation of the four selected DDG projects, a set of indicators was identified from the data obtained from the sample projects Data Platform and Digital Shop Window. In order to ensure high transferability, relevance and practicality, the indicators were compared with current Smart City reference works and verified using the Smart Lighting and Smart City Laboratory validation projects.

The set of indicators contains cross-project indicators that can be applied to all four selected projects that are both technologically and socially

Contribution of the Smart Lighting to Smart City Darmstadt

Smart City level	**Valuable for us**	**Secure**	**Forward-looking**	**Sustainable**	**Participatory**
Smart City DA destinations	Provide networked products and services that add value to the entire city economy	Digital solutions must meet the highest security standards to protect citizens' privacy Maximum transparency in all processes, no compromises at the expense of data security	Discover, promote and test new technologies to find the best possible solutions Equipped for the digital challenges of the future	Lead the way in using digital solutions to improve the environment and quality of life Resource-saving approaches	
Flagship topics	**Mobility & Environment**		**Business & Technology**		**Digital Services & Society**
Flagship goals	Intelligent solutions that conserve the environment and resources through connected and efficient energy consumption (reduced traffic volume, electromobility, households, companies)	Reduction of energy consumption and CO2 emissions through intelligent control systems	Application of the highest cybersecurity security standards to guarantee and further develop the IT infrastructure's defensive capabilities	Modern and reliable IT infrastructure for companies, research and education landscape for groundbreaking innovations	Use of new technologies to improve prevention, response and public safety
Fields of action	**Energy**	**Environment**	**Data Platform**	**Cybersecurity**	**Administration**
Field of action: Objectives	Efficient & low-emission energy management (development of intelligent energy infrastructure) Energy saving through automatic control of energy consumption (public, households)	Collection and use of environmental data to enable real-time monitoring of urban air quality and to be incorporated into planning and decision-making processes	Ensuring protection of personal data and increasing the sovereignty of Darmstadt residents in handling data Improving the services offered by DD to improve quality of life	Communication, data storage and network backup must meet the highest security standards that reflect the state of the art	Publish relevant data about the Smart City and create access for all interested parties
Project level	**Smart Lighting**				
Project objectives	Process, energy, resource & cost efficiency, data acquisition and use, higher degree of digitalisation, security, experience and participation with new technologies				

Dark target fields = goals to which the project makes a strong contribution

Light target fields = goals to which the project contributes in a broader sense

Source: Own illustration based on the Digitalstadt Darmstadt strategy (2020)

	Dimension	Project	Transferability	Project level	Process level
Cross-project	SDG contribution	All	✓	✓	
	Smart city potential	All	✓	✓	
	Degree of participation	All	✓		✓
	Degree of target achievement	All	✓	✓	
	Project management	All	✓	✓	
	Dialogue with target groups	All	✓	✓	
	Visibility	All	✓		✓
	Data security	All	✓		✓
	Sustainable use of data	All	✓		✓
	Barrier-free website	All	✓		✓

Fig. 19: Overview of the cross-project indicators, own presentation

oriented, as well as three additional project-specific indicators for the individual evaluation of the four selected projects.

In addition, indicators at the project level and indicators at the process level were separated. Indicators at the project level make it possible to evaluate external project areas such as the provision of a barrier-free website or the number of participants per event. Indicators at the process level support the assessment of operational project characteristics (e.g. in the organisational area), that is to say an assessment of internal processes. This includes indicators that serve, for example, to assess the degree of data security or the quality of project management.

The table (Fig. 19) shows how the indicators for the evaluation of both technological and societal projects are applied, and at the same time shows that a high degree of transferability can also be achieved for digital projects of other municipalities.

3.5 EVALUATION OF PROJECTS USING THE EXAMPLE OF DDG PROJECTS

Using the example of the DDG projects, the basic procedure of a project evaluation in the context of a (self-)evaluation can be followed. The evaluation of the DDG projects confirmed that the methodology used makes it possible to assess the project's effectiveness very well.

Initially, DDG's digitalisation projects were evaluated with regard to their cross-project dimensions and the degree of fulfilment of the identified indicators. In addition, there are a larger number of other project-specific dimensions that were also included in the assessment.

The prerequisite was a data basis that was available for almost all indicators per project. Only in the Digital Shop Window and Smart City Laboratory projects was the data basis not sufficient for the evaluation of the data security indicator.

The degree of fulfilment for the cross-project indicators with regard to the categories was determined in a matrix (see also Fig. 20: sample evaluation) with 'green = indicator met', 'yellow = indicator partially met' and 'red = indicator insufficiently met'.

The available key figures for the project-specific indicators were collected by means of data review and analysis as well as expert interviews. However, no quantified objectives were set in the project planning phase. As a result, such key figures could not be included in the valuation.

The assessment was carried out on the basis of the documents reviewed and the expert interviews. The results of the interviews showed a high degree of consistency between the statements and assessments of the interviewees, who had excellent to good project knowledge.

SDG contribution

The SDG contribution indicator, defined by the identification of sustainability contributions, is met by all four projects. Sustainability contributions were identified for the projects. Positive contributions to at least three SDGs and their sub-goals were identified for each of the four projects.

Both technology projects focus on sustainability in the areas of innovation (SDG 9) and sustainable cities (SDG 11). In addition, both projects contribute to climate action (SDG 13) and environmental and species conservation (SDG 12 and SDG 15), although the specific focus of the projects varies. In comparison, the social projects differ significantly in terms of their contribution to sustainability, with a common focus on inclusion and the reduction of inequalities (SDG 10).

The sustainability contributions of each project result in sustainability priorities (sustainability contribution by at least two of the four selected funding projects). Three of the four selected projects contribute to building a resilient infrastructure that promotes widespread and sustainable in-

dustrialisation and supports innovation (SDG 9). The two funding projects with a social focus contribute to reducing inequality within and between countries (SDG 10).

The two funding projects with a technological focus contribute to the design of inclusive, safe, resilient and sustainable cities and settlements (SDG 11). Three of the four selected projects contribute to taking immediate action to combat climate change and its impacts (SDG 13).

With regard to their own monitoring during project implementation and for subsequent (self-)evaluation, it is generally advisable for projects to specify contributions to sustainability in the project planning phase. Extensive sets of indicators for the sustainability contributions of projects are available in reference works, which are suitable for project design.

Smart city potential

The smart city potential indicator with the dimensions described above (see section 2) is met in three out of four projects. For the Digital Shop Window, the potential of the smart city is partly fulfilled. Close relationships and networking between the projects and the areas of Digitalstadt Darmstadt can be seen between the data platform and smart lighting in particular. The Smart City Laboratory also makes a major contribution to networking the areas and stakeholders in the smart city.

In comparison, the Digital Shop Window has less potential, as it is currently used purely as an information and trading platform.

In order to be able to talk about smart city projects in principle, all areas must be closely linked and the data and insights gained from the projects must be examined, used and transferred to other areas. The high potential of the selected projects could be transferred to innovative applications and/or the extension of existing applications, thus creating added value for the entire city.

Degree of participation

The indicator for the degree of participation has been met in the Smart City Laboratory and Data Platform projects. The involvement of business, academia, administration and civil society in the Smart City Laboratory and Data Platform projects is particularly pronounced compared to the other selected Digitalstadt Darmstadt projects. Both projects involve stakeholders from different areas of urban society, and citizens were able to actively contribute ideas. The indicator is partially met for the Digital Shop Window and poorly met for Smart Lighting. The Digital Shop Window was initiated by Citymarketing, supported by the Chamber of Industry and Commerce, and primarily involved the retail sector as the target group for the project. Apart from the stakeholders from the business sector, the Smart Lighting project did not involve any potential users.

Dialogue with target groups

The social projects meet the indicator for dialogue with target groups, whereas Data Platform only partially meets the indicator and Smart Lighting hardly meets the indicator. Both the Digital Shop Window and the Smart City Laboratory attach great importance to involving stakeholders in projects and ensuring a lively exchange of ideas with each other. Through citizen participation, citizens can participate in the design of the public platform. In the case of Smart Lighting, there was no information on a comparable dialogue.

Data security

Due to the weak data base of the Digital Shop Window and Smart City Laboratory projects, the data security indicator could only be considered in the technology projects. The security concept and monitoring of the data platform (encryption, separation and regular audits; GDPR-compliant storage) as well as the use of special software in the Smart Lighting project ensure a high level of data security, also by focusing on sensor data and non-personal data.

Data quality

The cross-sectoral indicator of data quality – defined by the relevance, reliability and transparency of the data and information provided – was considered in the projects with a technological focus. The indicator is met both in the Data Platform and Smart Lighting projects. The up-to-date transmission and provision of the collected data ensures that the data provided is up-to-date, valid and transparent.

Sustainable use of data

Sustainable use of data – defined by the use of data in areas of sustainable urban design, such as traffic management – in social projects takes place within the framework of sub-projects of the Smart City Laboratory or, in the case of goods delivered by LieferradDA, via the Digital Shop Window only in a broad sense.

Visibility

The visibility indicator – defined by the presence of a dedicated website and a social media presence, the recording of the number of visits to the website, the number of links via other websites etc. – is partially met in three out of four projects. Smart Lighting does not meet this requirement, as there is no separate project website apart from the project presentation on the DDG website. Only the data platform has its own website. The Digital Shop Window can be accessed via the website of Darmstadt Citymarketing e. V., while the Smart City Laboratory can be accessed via the Digitalstadt Darmstadt website. Smart lighting is only described on the website of Digitalstadt Darmstadt.

None of the projects has a social media presence. The Smart City Laboratory uses posters in the city centre to draw attention to itself.

Barrier-free website

The website accessibility indicator is poorly met in all projects. None of the four selected projects has a website that provides equal access for people with disabilities thanks to simple language and translation options. In order to reach broader urban society with each service and to contribute to the inclusive focus of the digitalisation strategy of the city of Darmstadt (the core objectives being: valuable for us and participatory), accessibility is very important.

Degree of target achievement

The evaluation of the project's target achievement consisted of the experts' assessment on a scale of 1–5 (1 = low, 5 = high) and comparison with the stated project objectives. The degree of target achievement indicator is met in three out of four projects. In addition to Data Platform, both social projects achieved the goals set. Smart Lighting has not yet fully tapped its potential.

Project management

The project management indicator is met in the social projects. On the other hand, it is poorly fulfilled in projects with a technological focus. Up to now, there has been no change of project management in the two social projects, whereas the technological projects have experienced repeated changes of project management.

3.6 SAMPLE PROJECT EVALUATION

The dimensions used in the evaluation of DDG are summarised here once again in an abstract form in a table and filled out schematically. This overview can also be used for the evaluation of smart city projects and is based on the dimensions of the smart city taxonomy (see also the explanations under section 2).

Dimension	Project A	Project B	Project C
SDG contribution			
Smart city potential			
Degree of participation			
Dialogue with target groups			
Data quality			
Data security			
Sustainable use of data			
Visibility	x	x	
Barrier-free website			
Degree of target achievement			
Project management			

- Indicator met
- Indicator partially met
- Indicator not met sufficiently
- Relevant project-specific indicator
- No relevant project-specific indicator
- x Insufficient underlying data for evaluation

Fig. 20: Sample project evaluation using a set of indicators, own presentation

4 RECOMMENDATIONS FOR ACTION

The dimensions used in the evaluation of DDG are summarised here once again in an abstract form in a table and filled out schematically. This overview can also be used for the evaluation of smart city projects and is based on the dimensions of the smart city taxonomy (see also the explanations under section 2).

Numerous indicators were identified and evaluated from the evaluation of the digital projects funded by the state of Hesse, which in many places have links to smart cities (see also the explanations in section 2). These can also be used to evaluate other regional projects in Digitalstadt Darmstadt.

By placing them in the context of the current general debate and against the background of the knowledge of the challenges posed by sponsors, the following recommendations can be derived, which are divided into three levels:

1. Recommendations for action at the project level, the project partners and the project design

2. Recommendations for action at the level of municipalities and smart city ecosystems

3. Recommendations for action at the programme design level

The manuscript and recommendations for action were completed in May 2022. The recent developments in the funding landscape, e.g. in the context of the criteria in the Smart Cities Model Projects programme, confirm the recommendations.

LEARNING CASE:

SMART CITY EXPERIMENTATION ROOM

Since winning the Bitkom competition, Digitalstadt Darmstadt has been regarded as a pioneer of digitalisation on the road to becoming a smart city. New paths require courage and the testing of possibilities, ideally in an experimental space that makes this possible.

Since 2018, Darmstadt has been an experimental space for digitalisation and smart cities with a total of 20 very different projects in order to make this experience available to other (Hessian) municipalities.

Learning: Digitalisation and smart cities require **areas of experience** and the **sharing of** pioneers' experiences with others in order to accelerate the pace of digitalisation and reduce investment costs through 're-use'.

4.1 PROJECT LEVEL – PROJECT CONSORTIA – PROJECT DESIGN

The recommendations for action are aimed at optimising a smart city in the sense of a networked city (see section 1.3) and the resulting systemic perspective, which must be adopted by all stakeholders and in all project dimensions. This applies not only to the content of the project topic and the composition of the project consortia, but also to the retroactive effect on one's own working methods, the openness of the organisations, their internal processes and work routines.

With this networked view, it is also important to observe the following connecting lines between the levels of the recommended courses of action and the systemic view. The transitions are correspondingly fluid.

RA 1: Clearly describe objectives and metrics
For a comprehensible evaluation of projects, their objectives must be clearly and unambiguously described and correspondingly measurable indicators (KPIs) defined so that the achievement of objectives can be comprehended and evaluated. This also applies in the context of experimentation rooms, as they make it possible to learn from failure without risk.

Numerous sets of indicators are available for all five smart dimensions – technological-economic, social, ecological, participatory and organisational – which can be used accordingly (see also the explanations in section 2 on the smart city taxonomy).

RA 2: Establish project monitoring
The establishment of a project monitoring system makes it easier to manage the project according to the defined key indicators. The monitoring can be further adjusted during the project so that it can be connected and used accordingly in regular operation when it is stable.

RA 3: Strengthen focus on effectiveness
Effectiveness in terms of improving the quality of life of a city or region in a way that is tangible and measurable for the people is the central objective of a funding project. This goes beyond the formal output-outcome orientation and is to be defined in the project proposals (see also the smart city guidelines in the appendix).

RA 4: Carry out project screening
One of the key challenges in smart city projects and smart city funding is to avoid duplicate funding. For this reason, all projects should carry out appropriate screening in the future in order to identify comparable projects in advance and to sharpen their own innovation dimensions.

RA 5: Define climate neutrality as a core objective of the projects
The consideration of climate neutrality in smart city projects systematically combines digitalisation and the topic of sustainability as part of sustainable development.

RA 6: Enable the consolidation and dissemination of project results

Funding is an investment in shaping the future, not a subsidy for the status quo. Consistent project results is a key contribution to the effectiveness of digital and smart city projects. This applies equally to individual product developments,business models or system solutions. Continuity does not follow after the project, but must basically be defined as the final phase of the project itself and created accordingly.

RA 7: Use participation for knowledge management and mobilisation

Participation and co-design through to co-production are key success factors in digital and smart city projects. The full range of citizen participation possibilities should be used in projects: as an element of open innovation, as a knowledge management tool, to increase reach and to mobilise urban society for effective project implementation. The establishment of smart city laboratories offers a sustainable basis for this.

RA 8: Develop project silos into project systems

A key feature of future projects should be their interconnected structure, which factors in the link to other smart city projects and initiatives in the city, thus taking into account the core feature of connectivity – both horizontally and vertically.

LEARNING CASE:

SMART WATER – DIGITALISATION AS A TOOL

The role of digitalisation in the age of the smart city is changing. While the digitalisation of municipalities was often the goal in itself during the first wave, this is now a phase in which digitalisation is seen as a tool. It's all about digitalisation 'without a screen or keyboard.' One example of this is the Smart Water model project in Darmstadt, which, as part of the 'Smart Cities made in Germany' model projects, addresses questions of the future use of water in the city, climate and sustainability with a focus on digitalisation.

Learning: The **next generation of digitalisation and a smart city are using digitalisation to solve future challenges** in the area of climate and city resilience, and not just to digitise the status quo as before.

4.2 MUNICIPALITIES – SMART CITY LEVEL

RA 1: Define your own understanding of a smart city

The successful design of a smart city begins with the definition of one's own understanding of smart city or digital city in terms of content and organisation. It offers clear guidance to all stakeholders in the multi-helix structure (administration, business, academia, civil society) and succinctly describes the purpose and effects of smart city and digital projects.

RA 2: Create an office in the space between

An independent hybrid office whose staff are linked to the different organisations of the smart city allows for the professional management of the various smart city and digital projects. It can perform various functions: Concentration of activities and resources, acceleration and motor functions and, centrally, a continuity function (knowledge and know-how storage) beyond the project durations. Digitalstadt Darmstadt GmbH is a nationwide pioneer in this respect.

LEARNING CASE:
OFFICE OF DIGITALSTADT DARMSTADT GMBH

RA 3: Establish an ethics advisory board and ethics guidelines

The technological and economic orientation of digital projects is key, but not sufficient. The increasing debate over the fundamental ethical issues of digitalisation and artificial intelligence in recent years makes it necessary to systematically integrate this topic into the development of smart city projects. The early establishment of the Ethics and Technology Advisory Board and the adoption of the Ethics Guidelines in Darmstadt can serve as a model here.

Digitalisation and a smart city are interconnected and can be effectively shaped by the cooperation of stakeholders within the city. Darmstadt has set standards here with DDG as the project office, because representatives of the city administration and the municipal utilities work together in independent management and, at the same time, continue to work in their 'posting organisation' – alongside a third full-time member of the management.

This new form of **'intermediate organisation'** prevents parallel procedures and duplication of work.

Learning: The best way to **manage and control smart city projects** is through innovative network structures that give smart city management its own freedom deliberately, without traditional integration into the line organisations, but also without completely breaking away from them.

RA 4: Chief storyteller – shaping a shared vision

A smart city requires a positive vision of the future that provides orientation and gives a sense of meaning to projects that, through their lifeless language, are often technological or digital in nature. Smart cities not only need Chief Digital Officers, but in the future, as a narrative counterpart, Chief Storytellers based on the Scandinavian model.

RA 5: Understand smart cities as ecosystems

Due to their nature as networks, smart cities are collective works of an inclusive urban society. They form an ecosystem of diverse actors. This ecosystem represents the potential of smart cities. It can be connected and used more easily and effectively thanks to new digital instruments and tools.

RA 6: Strengthen connectivity and relationship capital

A basic prerequisite for working in networks is the cooperation skills of the actors in the different sectors, an understanding of the perspectives of others and empathy in dealing with partners in the innovation ecosystem of the smart city or smart region. This cooperation skill is not only needed at the level of top management (C-level), but also, until now underestimated, at the working levels below in order to 'get the show on the road'. Therefore, the lack of relationship capital is a barrier to the development of smart cities as 'multi-helix stakeholder systems'. The relationship capital must be developed and increased by appropriate measures (e. g. Brainport Academy Eindhoven).

RA 7: Drive institutional innovations

A smart city as a networked city is not only developed through the content of the projects, but is only successful in the long term if the type of cooperation and the internal processes and structures of each organisation are aligned with one other. The organisational design must understand and map the attitude and the transformation of the silo organisation into a systemic smart city. A key success factor here is the reorganisation of inter-agency and inter-departmental cooperation within the municipalities and the opening up of the administration to smart city ecosystems.

LEARNING CASE:

ETHICS AND TECHNOLOGY ADVISORY BOARD

For a long time, digitalisation in municipalities was a technological matter that had little or no place in the social and ethical context. This is changing significantly, as this perspective is an increasingly important success factor. The direct collaboration between technology and ethics experts on the advisory board enables the two perspectives to be combined from the very beginning.

This is why the Smart City established an interdisciplinary Ethics and Technology Advisory Board very early on, which adopted nine guidelines for digitalisation projects. These range from public service obligations, democratic control, data protection, transparency, data disclosure, city and citizen sovereignty and accessibility to sustainability and infrastructure security (cyber security).

Learning: The **establishment of an ethics advisory board**is a key success factor for consideration of the bigger picture and analysis, as well as for acceptance within urban society.

RA 8: Drive cultural change

Opening up to the outside world and strengthening cooperation 'across silos' requires a cultural change that takes place through concrete experiences in everyday life. For this reason, the way of working must be changed selectively but specifically by and within smart city projects. One specific approach is the work of the Smart City Laboratory. Another option is the establishment of so-called 'start-ups in residence', which bring a different working culture to life directly in administrative offices.

RA 9: Understand urban and civil society as an anchor of success

Citizen participation is a key success factor for smart city projects. The involvement up to the co-production of urban quality of life anchors technological and social innovations in urban society. It serves to manage acceptance and create the necessary reach of projects within society in all its diversity, thereby promoting effectiveness.

RA 10: Recognise and use time as a key success factor

Projects that are thematically transdisciplinary, organisationally silo-spanning and cross-sectoral require time in terms of learning time. These cannot be accelerated at will. They have to be 'priced in' when building a smart city in the sense of a connected city. If these seemingly decelerated phases are maintained, they will accelerate the speed of implementation even more.

RA 11: Drive the development of data platforms for control

'Cities are real time systems, but rarely run as such.' The development of data platforms for digitally networked city control (environmental, traffic and mobility data etc.) is constantly accelerating due to the expansion of cities into 'sensor cities' and the development of 'digital twins'. The digital data platform of Darmstadt is one of the pioneers in this field in Germany, especially with regard to the internal administrative areas of the project.

LEARNING CASE:

SMART CITY LABORATORY

To be successful, a smart city needs the openness and involvement of key players from science, business and, above all, the urban society itself. This requires new tools and locations. The Smart City Laboratory is both a location – centralised, decentralised and digital – and an instrument for dialogue and openness. This is where new formats such as the Mobile City Laboratory, the Digital Learning Workshop and the participatory Environment/Water project are developed and tested.

A core team of representatives of the individual stakeholder groups, known as 'architects', together with a full-time coordinator, is the driving force behind the Smart City Laboratory and its activities.

Learning: A smart city requires an active urban society and places of dialogue. **The establishment of smart city laboratories creates these places and spaces for dialogue with the city's society** and other relevant stakeholder groups and actors.

LEARNING CASE:

DIGITAL DATA PLATFORM

The digital data platform of Digitalstadt Darmstadt is one of the pioneers nationwide in the processing and visualisation of urban data. The data platform has a publicly accessible dashboard that enables citizens to access and monitor a wide range of up-to-date data – such as the latest environmental data including particulate matter pollution, ozone values for urban areas, traffic and public transport data, climate data and waste data. In addition to this data, citizens receive information on current cultural events. The excellent visual presentation of the data makes orientation easier. The data platform is a new communication channel for smart cities to communicate with their inhabitants.

The more comprehensive internal administrative data platform enables and facilitates the management of key services of general interest (e. g. waste collection) and urban infrastructure (e. g. dynamic traffic management).

Learning: The establishment of a digital data platform makes the use of data and the digitalisation of services of general interest visible to citizens, businesses and administrations, and brings municipalities closer to real-time data management.

RA 12: Connect smart cities with interoperable data

As a sensor city, the smart city must be able to use its data across the board. Therefore, the interoperability of data is a crucial prerequisite for the development and management of the city without reducing data security.

RA 13: Strengthen sustainability through data minimisation

More digitalisation means more energy and resource consumption. Smart city projects themselves should therefore follow the principle of data sufficiency and generally contribute to increasing climate neutrality and resource efficiency.

RA 14: Usher in a new era of cooperation between administration and start-ups

The potential of cooperation between public administration and start-ups has not yet been fully exploited. Smart city projects can become a catalyst for innovation collaborations that give new impetus to digital services of general interest and involve start-ups in the municipal service delivery system. This is where innovative impulses from start-ups, municipal economic development agencies and administration combine to create a new ecosystem of smart services of general interest.

One form is the 'venture client approach', in which the municipality essentially acts as 'venture capital.' As a first/premium customer, the municipality takes advantage of the start-up's business idea. This cooperative relationship can also be thought of the other way around, similar to the 'start-up in residence' programmes, in which start-ups apply with their solution to a municipal challenge and the winners develop the solution together with the municipality.

4.3 LEVEL OF FUNDING PROVIDERS

The results described in the White Book apply not only to individual cities, but also to regions. In addition, there is great potential in inter-municipal cooperation, which is essentially opening up completely new possibilities as a result of digitalisation. It is necessary to shape digitalisation in a smart city or smart region over the previous territorial congestion, because they are inherently 'transterritorial' or, as Rob van Gijzel, one of the founding fathers of the Brainport Eindhoven region, emphasises: Collaboration must be horizontal, inclusive and co-creative.

RA 1: Introduce smart city impact assessment

Funding applications should focus more on the interconnected nature of smart city projects from the outset. This can be done, for example, by introducing a smart city impact assessment as a prerequisite for funding and supplementing or adapting the current funding recommendations in Hesse.

RA 2: Establish comprehensive smart city/ smart region monitoring

The issue of monitoring government resources and their impact is as central to the requirement as it is complex to implement, since Germany does not have the performance measurement tradition of Anglo-Saxon countries and does not have the corresponding acceptance in practice.

By establishing a nationwide and public digital or smart city/region monitoring system, project screening for applicants as well as the potential for the adoption (dissemination) of project results would be facilitated in addition to the political and administrative control potential.

RA 3: Building a Smart Region Virtual Office into a Smart Region Agency

With the bundling of central advisory and support activities in the Smart Region Virtual Office, which is managed by the Hessian Ministry of Digitalisation, the state is well positioned. The further development and consolidation of activities in a digital agency in Hesse and comparison with experiences in Brandenburg and Bavaria should be considered for a next step in development.

LEARNING CASE:

EVALUATION AND SHARING KNOWLEDGE

Digitalstadt Darmstadt is an experimentation space, a learning laboratory from which insights can be derived for the city itself and other municipalities. In order to systematically evaluate the experiences, DDG commissioned an evaluation, the results of which have been incorporated into a White Book Smart City, which is made available to other municipalities.

Another practical application from this is the guideline, which can be used to design smart city projects and self-evaluate smart city projects.

Learning: The **evaluation of digitalisation and smart city projects** is a key element of success. Sharing this knowledge and experience with other municipalities, e. g. by **developing easy-to-use guides**, promotes the shared learning of experiences between municipalities and creates a smart sea of lights instead of individual lighthouses.

RA 4: Describe Smart City Ecosystems

Up to now, the funding of smart city and digitalisation projects has been heavily influenced by path dependencies in science, business, administration etc. The future lies more in a joint perspective. This requires a systemic overall picture as a basis for funding, as well as the funding of 'project groups'.

RA 5: Smart cities and smart regions: promote capacity building

The era of isolated lighthouses is drawing to a close. The challenges are complex, networked and 'wicked'. Solutions can only be achieved through transversal networks, across disciplines, sectors and administrative boundaries (between city and surrounding areas, use of inter-municipal centres etc.). Municipal or regional capacity building is required for smart cities and smart regions.

RA 6: Introduce a utilisation plan for project results as a prerequisite for funding

The dissemination and use of project results is one of the key challenges that is widely discussed under various keywords (including dissemination, replication, scalability and propagation).

The introduction of a plan for the utilisation of project results as part of the project application makes this point easier to discuss between sponsors and recipients.

RA 7: Smart city funding only awarded to consortia with lead and follower cities

The wider dissemination of project results and networking between municipalities can be promoted by introducing and further developing the 'lead and follower cities' approach, as project consortia significantly increase their reach and use is by definition strengthened. This complements Darmstadt's 'showcase of digitalisation' approach, continues it and substantiates it through the cities' increased commitment in the context of funding.

RA 8: Include stability clause in subsidies

The frequent lack of consistency in project results is due not only to the fact that this transition is not sufficiently planned in the routine processes from the outset, or simply to the 'blind spot' of the project partners, but also to a lack of incentive.

Therefore, a certain percentage of the funding should remain blocked as a 'stability bonus' (e.g. 15 % of the total funding) until the transition to the routine process has begun.

SMART CITY WHITE BOOK

Last updated: July 2023

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