Chapter 10
Application to a Case Study

Abstract We present an application of the operational monitoring tool SIPRIUS+ to an ongoing case study representative of urban brownfield regeneration projects: the Pôle Viotte neighbourhood, located in Besançon (France). We start with a description of the brownfield site, followed by the regeneration project. Then, we evaluate 52 indicators linked to the context, project, and governance. Each monitoring result is illustrated by a graph showing the evolution of the performances. Then, we analyse the overall results, which allows us to assess the sustainability strategy of the regeneration project. Through this analysis, we identify four actions to improve sustainability objectives. Finally, we conclude that SIPRIUS+ has the potential to contribute to the integration of sustainability issues into the dynamics of neighbourhoods in transition. The operational monitoring tool is expected to contribute to decision-making in a multi-disciplinary manner, without giving ready-made solutions. Interactions with project stakeholders reveal that, while the use of such a tool would require a change in project management, the evolutions to adopt to include this practice appear not only feasible but realistic and desired.

Keywords Urban brownfield regeneration project · Operational monitoring tool · SIPRIUS+ · Case study · Pôle Viotte neighbourhood · Sustainable neighbourhood · Results reporting · Decision-making support

10.1 Monitoring the Pôle Viotte Neighbourhood in Besançon, France

Chapter 9 explained briefly the functioning of the operational monitoring tool SIPRIUS+. The objective of this chapter is to demonstrate the benefits and limitations of SIPRIUS+, thanks to its application to an ongoing case study representative of urban brownfield regeneration projects: the Pôle Viotte neighbourhood, located in Besançon (France). The monitoring is carried out in a neutral way; as a rule, performance is not compared with other projects and no specific recommendations are made. The first application of the monitoring tool took place during fall 2016, performed by the research team (LAST—EPFL) with the support of the case study's project manager (Direction Urbanisme Projets et Planification, Grand

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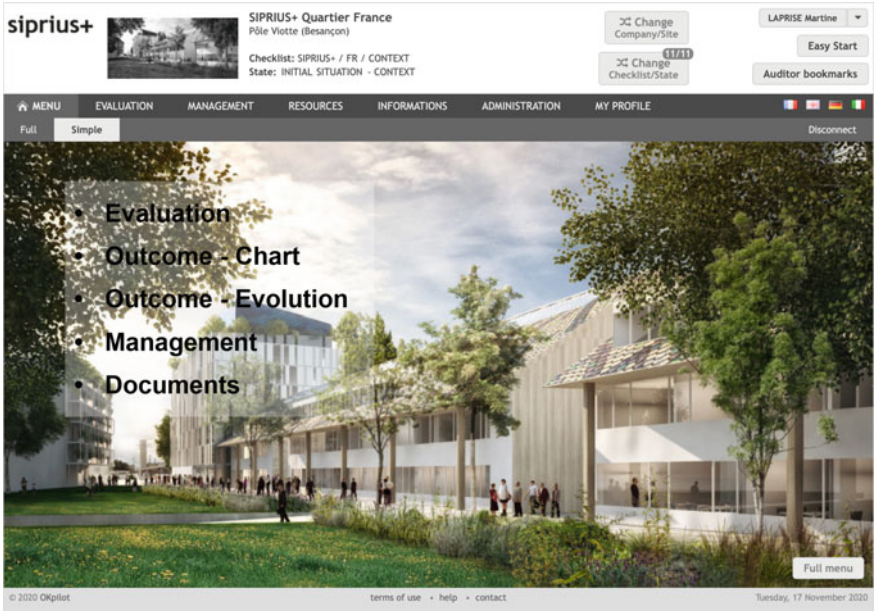

Fig. 10.1 SIPRIUS+ Homepage customized for the Pôle Viotte monitoring

Besançon Metropole) (Laprise 2017). We present here the latest monitoring results. They were obtained with an application of the monitoring tool during fall 2020 and performed by the same team configuration (see Fig. 10.1).

We start with a description of the urban brownfield site, followed by the regeneration project. Then, we present the detailed monitoring results of the context, project, and governance indicators illustrated by the evolution displays of SIPRIUS+. Finally, we show the overall monitoring results using the graph display of SIPRIUS+ as well as an analysis of the monitoring tool's potential to facilitate the integration of sustainability issues into the project dynamics of a neighbourhood in transition.

10.1.1 Description of the Urban Brownfield Site

Railway activities characterize the Viotte site. The railway station was built in 1885 and then rebuilt in 1962 to make room for underground circulation systems, which later became difficult to access and illegible for users. It added to the decline in rail operations throughout the site. More specifically, the closure of the old Sernam Hall (Fig. 10.3) in 2001 caused the loss of several jobs. At the beginning of the twenty-first century, the Viotte site embodied a typical urban brownfield, breaking with its context. The steep drop in level between the northern sector and the southern sector, as well as the lack of vitality of in situ activities, accentuated the barrier created

Fig. 10.2 Aerial view of the brownfield site surrounding Viotte train station (photo: Ville de Besançon, 2007)

by the railways. Only a few jobs linked to the SNCF (the French National Railway Company) remained on site.

The brownfield site has a global hold of 11 hectares in the city, including the surface occupied by railways and various neglected spaces. It is located at the intersection of the Charpais and Saint-Claude neighbourhoods, near the Battant neighbourhood and the *glacis* (paved wall) of Vauban ramparts, which was transformed into a public park in 2013. The Parc des Glacis, listed as a UNESCO World Heritage site, forms a green corridor towards the city centre. The urban brownfield is accessed mainly by Avenue de la Paix to the south and Rue Nicolas Bruand to the north. It benefits from a location that is both privileged—its proximity to the historical city centre—and strategic, due to the expanded transport offer of the Besaçon-Viotte railway station (TGV, regional train, tram, bus, etc.), which can help promote economic development. Figure 10.2 is an aerial view of the brownfield site before the start of the regeneration project. Figures 10.3, 10.4, 10.5, and 10.6 give an overview of the initial situation of the brownfield site. Figure 10.7 locates the brownfield within the city of Besançon.

10.1.2 Description of the Urban Brownfield Regeneration Project

Since 2008, the city of Besançon has been supporting a global project to reclaim the urban brownfield site surrounding the Viotte railway. The Pôle Viotte neighbourhood is designed as a new dense and mixed vibrant sustainable neighbourhood where it will be possible to work, live, do daily shopping, move around, or travel. The trigger

Fig. 10.3 The old Sernam Hall south sector of the brownfield was an emblematic building of railway sites (photo: Martine Laprise, 2016)

Fig. 10.4 View on the brownfield site from Rue Jeanneney showing the steep drop and an SNCF building, 2016 (photo: Martine Laprise, 2016)

Fig. 10.5 The military platform in the northern sector of the brownfield site, 2016 (photo: Martine Laprise, 2016)

Fig. 10.6 A parking in the northern sector of the site next to public access to the multi-modal hub, which was completed during the first phase of development (photo: Martine Laprise, 2016)

Fig. 10.7 Location map of the Viotte brownfield site, Besançon, France

for the regeneration project was the Viotte station's transformation into a 2-ha multi-modal hub. This first phase of development addressed a global mobility issue for the City area, which opened the station to the north and made it accessible to all travel modes. A preliminary consultation file was made public in 2009, following a series of studies carried out by the firm Arep, architects-urban planners, representing a multi-disciplinary group. Work on this first phase—the multi-modal hub—began in November 2012 and ended in October 2014.

The multi-modal hub created in phase 1 serves as an anchor and support for the second phase of development, another urban and metropolitan issue: developing a multi-functional neighbourhood of 3.1 ha to the north and south of the tracks as part of a comprehensive sustainable development approach. As previously described, the sector is a brownfield mainly occupied to the south by the old Sernam Hall and to the north by various abandoned areas impervious to rainwater. At a global cost of 58 M € (excluding tax), 46,535 m^2 of the surface will emerge from the ground creating almost 1,000 jobs and more than 225 housing units. The driving force behind this new neighbourhood is Sernam Hall's replacement by a new tertiary centre (approx. 27,000 m^2, buildings A and B). It will bring together several hundred agents from the state and regional services, currently spread over the territory of Besançon. The project was subject to an architectural competition won in July 2016 by Métra + Associés architects. The tertiary centre project is under the stewardship of SEDIA, a local semi-public company. The developer of the urban brownfield regeneration project is Territoire 25, a local public development and construction's company.

Figure 10.8 shows the masterplan of the Pôle Viotte neighbourhood. The delivery of the first neighbourhood buildings A and B is scheduled for 2021 (see Fig. 10.9). Final delivery of all buildings, landscaping, and exterior facilities is scheduled for 2025.

10.2 Detailed Monitoring Results

From a monitoring point of view, it is especially interesting to focus on the detailed results. Doing so makes it possible to see the effects that some sustainability objectives set by the regeneration project may have on the site's improvement, including the risks, challenges, and opportunities. We present here the detailed monitoring results updated during fall 2020. To do so, we start with the complete checklist of context indicators, followed by the project indicators and the governance indicators. We can retrieve from the datasheet in the appendix the definition of each indicator, the evaluation method, the measurement unit, and the level assigned to the reference values (V_L—limit value, V_A—average value, V_T—target value, and V_B—"best practice" value).

The monitoring focuses mainly on the second phase of development of the project but also takes into account planned improvements of the recent multi-modal hub (phase 1). The documents used for the evaluation are mainly the masterplan, the application file for the EcoQuartier Label—phase 2 (Ville de Besançon 2018), and diverse communications on the project produced by the City and the Arep representatives (Ville de Besançon 2015; Arep ville et al. 2015, 2016). The Grand Besançon website was also regularly consulted. As a complement, we performed site visits, interviews, and working sessions with the city of Besançon projects and planning department to acquire the necessary knowledge and data for the project evaluation.

10.2.1 Checklist—Context Indicators

For these indicators, we evaluate the initial, current, and expected final situations (see Figs. 10.10, 10.11, and 10.12). The initial situation corresponds to that of 2007, before the start of the project. The current situation corresponds to the one closest to the evaluation period (fall 2020) for which the data was available. Since construction work on the southern sector of the site—started in 2018—is still in progress, we note that it is sometimes not relevant to measure the current situation. In these cases, evaluation of the current situation will evolve with the project. Such is the case for the indicators under the sociocultural impact (C5.1 to C7.4). We evaluate these indicators by the various services supplied for the neighbourhood inhabitants within a given radius from their residence place (entrance of the building). For the moment, no existing or new apartment building allows measuring these indicators for the initial and current situation. Only the expected final situation gives an overview of what

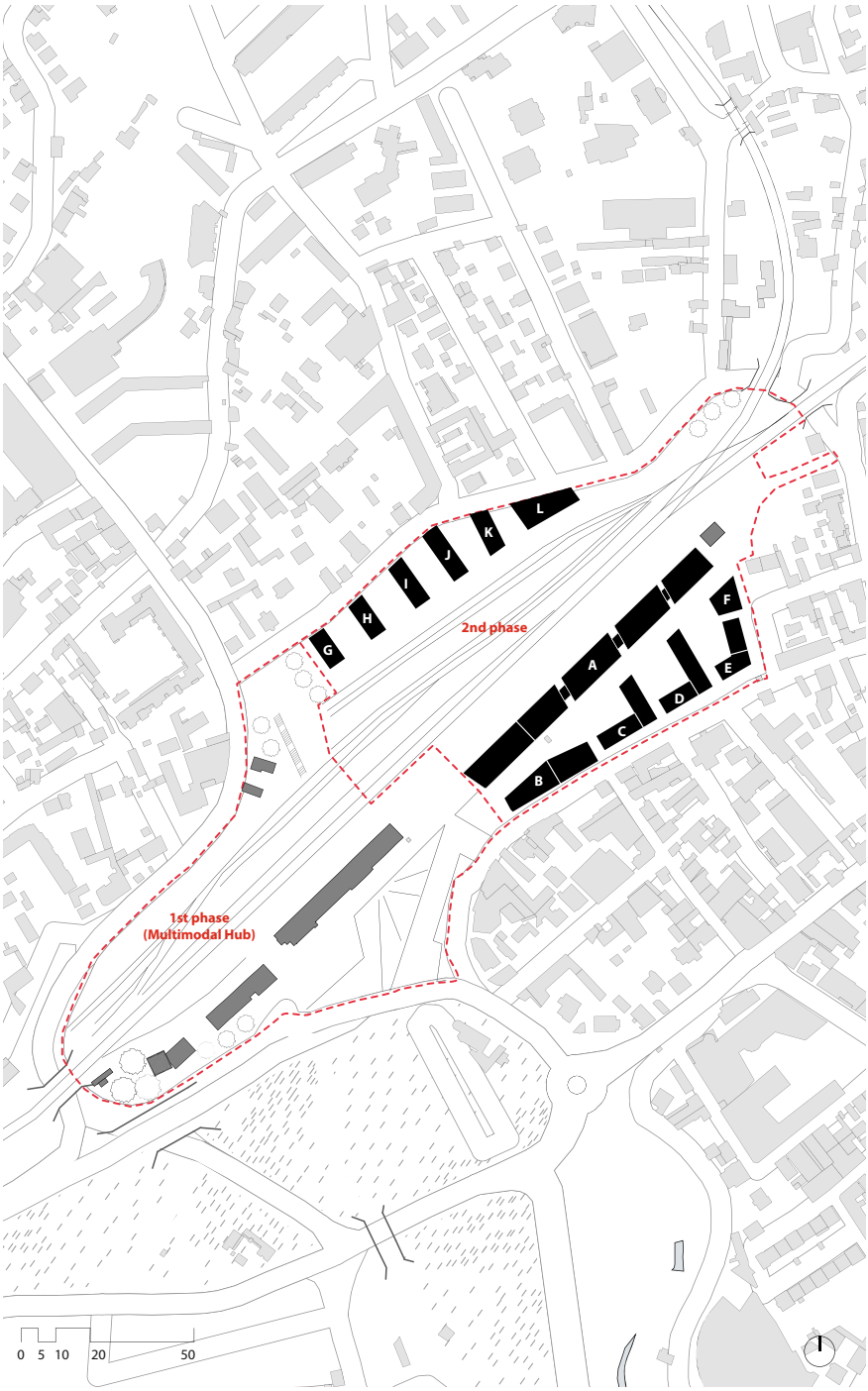

Fig. 10.8 Masterplan of the Pôle Viotte neighbourhood

Fig. 10.9 New tertiary centre under construction (photo: Ville de Besançon, 2021)

can be anticipated; the evaluation of the current situation will be specified as the project progresses. To date, the expected final situation corresponds to the objectives described in the project guidelines used for the assessment.

Moreover, we cannot evaluate indicators *C2. Air pollution—C2.2. Global warming potential (GWP)* and *C2.3. Acidification potential (AP)*—because there are not enough comparable calculations on full lifecycle analysis of buildings to establish reliable reference values.

10.2.1.1 Environmental Impact

C1. Mobility—C1.1. Average distance to a public transport stop

The future neighbourhood will benefit from a real quality of service in public transport, thanks to the multi-modal hub's existence within the Viotte site perimeter. Indeed, the offer includes, for the railway station, the TGV and the main and regional lines, and, for the public transport of greater Besançon, the tramway, the urban and suburban bus network GINKO, and the regional and departmental inter-urban bus network. For the expected final situation, we calculate a weighted average distance of 192 m to the closest public transport stop, which leads to the best practice value (V_B). For the initial situation calculation, the public transport offer was not as complete

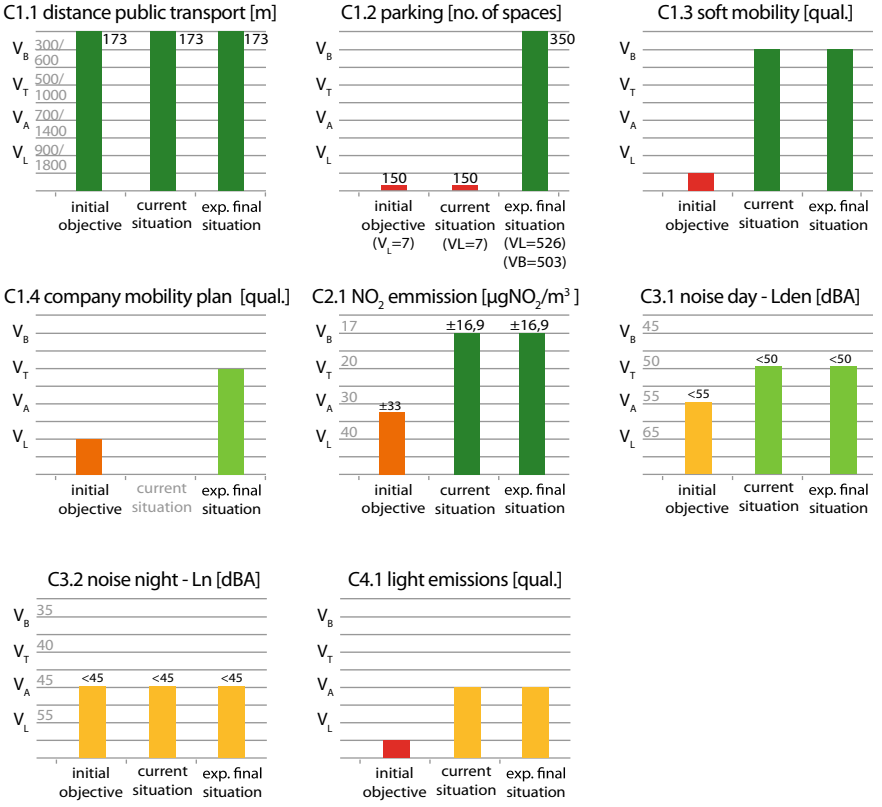

Fig. 10.10 Evolution displays for the context indicators—environmental impact

as it is now: the TGV Rhin Rhône came at the end of 2011, the tramway in 2014. At the same time, very few users worked on the site. However, jobs in the sector were already close to the train station (173 m). Due to this advantageous position, the calculation corresponds to the best practice value (V_B). The evaluation for the current situation is similar to the initial situation (173 m) and gets also the best practice value (V_B).

C1. Mobility—C1.2. Number of parking spaces

Since the new neighbourhood provides numerous jobs – notably within the tertiary sector – and several new inhabitants, parking is an important issue. For this indicator, we limit the calculation to the second phase of development. The parking issue related to the multi-modal hub contains specific and complex requirements that go beyond this indicator.

The initial situation is hard to calculate because the SNCF did not wish to communicate the number of jobs on-site nor its needs for station employees. However, we estimate that some parking lots, spread on the site, offer around 150 spaces used by

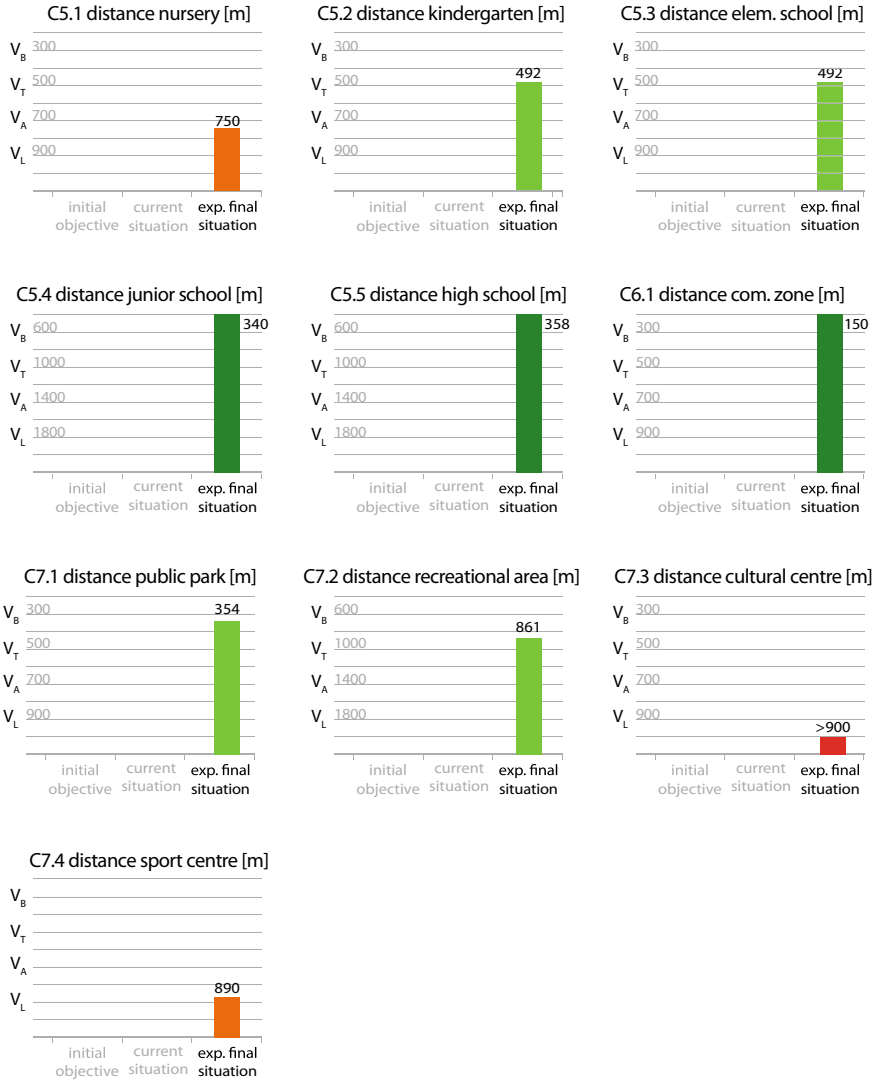

Fig. 10.11 Evolution displays for the context indicators—sociocultural impact

SNCF employees. If we strictly consider the second-phase sector, we calculate the limit value (V_L) at 75 parking spaces. So, we evaluate the initial situation under the limit value (V_L). The evaluation of the current situation is not relevant because there is no activity at the moment in the northern sector, and the southern sector of the site is under construction.

Based on the urban planning code requirements, the future inhabitants' and workers' needs will be 526 spaces for the limit value (V_L) and 503 spaces for

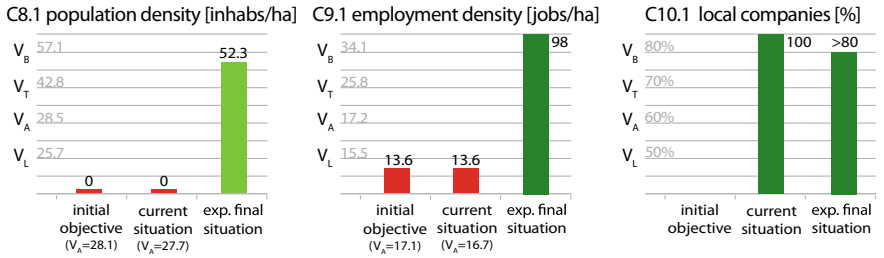

Fig. 10.12 Evolution displays for the context indicators—economic impact

the best practice value (V_B). The new neighbourhood project intends to provide an optimal number of parking spaces. First, we know that no parking spaces will be offered to employees of state services. In the southern sector, the project includes a semi-underground car park with 300 spaces. A shared car park with 150 spaces will probably equip the northern part. Of these spaces, 100 are not taken into account, as they are intended for SNCF agents. With its estimated total of 350 parking spaces, we assign the best (V_B) practice value to the expected final situation.

C1. Mobility—C1.3. Tying status with "soft" mobility networks

For the initial situation, we notice that the Viotte sector made little room for pedestrians and bicycles, particularly because of the rupture between the northern and southern sectors of the site caused by the railways. This observation is one of the triggers that led to the new multi-modal hub's conception. Indeed, one of the objectives was to "get across the station" as well as to create "clear, legible, and secure pedestrian links from the city centre" and "continuity of paths". Another achieved objective was "the accessibility and the provision of bicycle parking". Given the development work completed in 2014, the current situation corresponds to the best practice value (V_B). We evaluate the initial situation as below the limit value (V_L).

Finally, the guidelines for the Pôle Viotte neighbourhood also show strong consideration of soft and sustainable mobility. Indeed, in the neighbourhood's southern sector, a landscaped lane will be accessible only to pedestrians and bicycles. Throughout the site, the project plans a fine-meshed pedestrian and bike network, accompanied by the strong presence of greenery. It will improve the neighbourhood's connectivity to the rest of the city, both in its northern and southern sectors. For these reasons, we assign the best practice value (V_B) to the expected final situation.

C1. Mobility—C1.4. Company mobility plan

A company mobility plan between the tertiary centre's different agencies to promote non-motorized commuting is currently under development. For example, state employees could be offered a 50% reduction in public transport subscriptions. Due to the tertiary centre's strategic localization close to the multi-modal hub and the city centre, we can also expect that a significant proportion of employees will use public transport or other sustainable mobility modes (cycling, walking, etc.). As mentioned

for indicator *C1.2 Number of parking spaces*, no parking space for state employees is granted, representing the vast majority of future jobs in the sector. Besides, the Pôle Viotte neighbourhood will offer an optimal supply of parking spaces, based, among other things, on a pooling strategy. According to this information, the expected final situation is likely to reach the target value (V_T).

Evaluating the initial situation required an examination of the measures formerly in place for SNCF employees. The latter had free use of SNCF transport services. On the other hand, we also know that all employees had a free parking space available, which was used systematically. Faced with this ambiguity and the simplitic offer as an alternative to motorized private transport, we evaluate the initial situation at the limit value (V_L). Evaluating the current situation is not relevant because there is no activity at the moment in the northern sector, and the southern sector is under construction.

C2. Air pollution—C2.1. Average annual emission of NO_2

For the current performance in air pollution, we take into account the measurements of the European Prévoyance station (urban type), located about 500 m from the Pôle Viotte neighbourhood. An average annual emission of 16.9 $\mu gNO_2/m^3$ was measured for the year 2019 (13.2 $\mu gNO_2/m^3$ is currently foreseeable for the year 2020) (ATMO BFC 2020). This measurement corresponds to the best practice value (V_B).

For the initial situation, we must refer to the Mégevand station (traffic type) located in downtown Besançon at a distance of about 1.5 km and an altitude of +246 m. Indeed, the Prévoyance station (+281 m) is only been effective since 2013. The average annual emission for 2007 was 43 $\mu gNO_2/m^3$, which is below the limit value (V_L). However, we note significant differences between the two stations' measurements of the order of 10 $\mu gNO_2/m^3$ from 2013 to 2016. For this reason, we judge the initial situation to be more or less 33 $\mu gNO_2/m^3$, that is to say, the limit value (V_L).

As for the expected final situation, trends observed since 2013 show general improvement, which, however, does not allow us to affirm continuity or stabilization of emissions level. We know from the outset that an increase in site occupancy, including new buildings and increased traffic, will have an impact on the level of NO_2 emissions. That said, the project plans energy-efficient buildings (RT2012 −20%) based on renewable energies, such as geothermal energy. Besides, constant technical development in the automobile and a change in mentality about public transport use can help improve air quality. For these reasons, we give the best practice value (V_B) to the expected final situation, in continuity with the current situation.

C3. Noise pollution—C3.1. Average emissions of noise—day (Lden)

For the initial situation, we consider the cartographic data of rail and road noise from 2012 (Grand Besançon 2016). The current and expected final situations use Type A maps with isophone curves starting at 55 dBA, updated in 2019 (Ministère de la Transition Ecologique et Solidaire and Ministère de la Cohésion des Territoires 2019). For this indicator, we evaluate only the second phase of the development of

the project. Indeed, the multi-modal hub (first phase) has specific requirements, less impacted by noise pollution.

Regarding noise caused by road traffic, 13% of the site is in a 55–60 dBA zone and 9% in a 60–65 dBA zone. These areas are scattered around the site. For railway noise, 12% of the site is in a 55–60 dBA zone, 36% in a 60–65 dBA zone (in the northern part), and 6% of the site reaches levels between 65 and 70 dBA (in the south-eastern part, near Rue du Chasnot, where the free spaces are). The Sernam Hall makes a significant contribution to noise reduction in the south. For the initial situation, there is no building to the north. We estimate through the analysis of these data that most of the occupied site is below 55 dBA, which corresponds to the average value (V_A) for the initial situation.

For the current and the expected final situation, the new measurements show that almost all the buildings will be located outside the noise pollution zones greater than 55 dBA (railways and roads combined). Only the west tip of the tertiary centre (building A) meets a zone of 60 dBA. The noise is mainly around the station, Rue de Vesoul, and Avenue de la Paix. At this stage of the project, there is no indication of specific construction measures to counter noise. Like the Sernam Hall, we expect that the tertiary centre will have a deflecting effect in the southern sector. Based on these data, and for lack of more precise measurement, we evaluate the two situations for the moment at the target value (V_T).

C3. Noise pollution—C3.2. Average emissions of noise—night (Ln)

The evaluation conditions for Ln are similar to the previous indicator Lden. For the initial situation, we consider the cartographic data of rail and road noise from 2012 (Grand Besançon 2016). The current and expected final situations consider Type A maps with isophone curves starting at 50 dBA, updated in 2019 (Ministère de la Transition Ecologique et Solidaire and Ministère de la Cohésion des Territoires 2019).

For the initial situation, concerning road traffic noise, 10% of the site area is in a 50–55 dBA zone. These areas are located around the site. For rail traffic noise, 16% of the site is in a 50–55 dBA zone, 30% in a 55–60 dBA zone (i.e., almost all of the northern portion), and 4% in a 60–65 dBA zone to the north along the Sernam Hall. For the initial situation, there is no building to the north. We estimate through the analysis of these data that most of the occupied site is below 45 dBA, which gives the average value (V_A) for the initial situation.

For the current and expected final situations, the new measurements show that all the buildings will be located outside noise pollution zones greater than 50 dBA (railways and roads combined). The noise is concentrated around the main roads of Rue de Vesoul, Avenue de la Paix, and near the station. The deflecting effect of the tertiary centre has less impact on this indicator since almost no train travels overnight. Based on these data, and for lack of more precise measurement, we evaluate the two situations for the moment at the average value (V_A).

C4. Light pollution—C4.1. Degree of prevention of light emissions

For the initial situation, there is no measure to prevent light emissions. The evaluation is below the limit value (V_L). For the expected final situation, public lighting will be installed according to the city of Besançon's recommendation. Indeed, the city has paid particular attention since 2010 to the right level of public lighting and the energy savings that can be achieved (standby-mode from 10 p.m. to 6 a.m., remote management, low-consumption devices, etc.) (Ville de Besançon 2010). However, the project has not yet developed a more precise lighting plan, which would go beyond these initiatives to the neighbourhood scale. Thus, we assign the average value (V_A) for the expected final situation. Similarly, the current situation (the multi-modal hub) follows the city of Besançon's recommendation, which corresponds to the average value (V_A).

10.2.1.2 Sociocultural Impact

C5. Proximity of school facilities—C5.1. Average distance to a nursery

At the beginning of the project, building F included a nursery to meet the needs of employees and inhabitants with families. Given the limited car access to the building, the programme has evolved into another function, that of urban greenhouse. The closest public nursery stands to the west of the site (Avenue du Commandant Marceau), the weighted average distance to which is 750 m. The expected final situation corresponds to the limit value (V_L). Note that the indicator does not take into account the reception capacity of the nursery.

C5. Proximity of school facilities—C5.2. Average distance to a kindergarten

C5. Proximity of school facilities—C5.3. Average distance to an elementary school

We evaluate these two indicators simultaneously because they involve research concerning buildings accommodating the two functions. For the average distance to a kindergarten and elementary school, the closest school facilities to consider are the Viotte kindergarten and the Viotte elementary school, located about 10 m apart, north of the tracks on the Chemin Français. The weighted average distance is 492 m, which is equivalent to the target value (V_T) for both indicators.

C5. Proximity of school facilities—C5.4. Average distance to a junior high/middle school

For this indicator, the closest establishments are the Collège Stendhal (Avenue du Commandant Marceau) for the northern sector of the site, and the vocational school École des Métiers Artistiques (Rue du Balcon) for the southern sector. Due to the latter's proximity, the weighted average distance is 358 m, which is equivalent to the best practice value (V_B) for the expected final situation.

C5. Proximity of school facilities—C5.5. Average distance to a high school

For this indicator, we take into account the Regional Directorate of Youth and Sports and Social Cohesion (Direction Régionale de la Jeunesse et des Sports et de la Cohésion Sociale—DRJSCS). Located on Rue Nicolas Bruand, this establishment offers various higher education courses. The weighted average distance for the expected final situation is 340 m, which gives the best practice value (V_B) for this indicator.

C6. Proximity of commercial facilities—C6.1. Average distance to a commercial zone

The project guidelines allocate shops on the ground floors along the tertiary centre, notably local services and a brewery in building B. Small convenience stores are also present at the station. In general, for the expected final situation, we can assume that the weighted average distance to a commercial zone will be approximately 150 m, equivalent to the best practice value (V_B.) We note that the neighbourhood benefits from proximity to the Battant district with a varied commercial offer (about 300 m from the station). Also, the city centre is about 900 m from the station.

C7. Proximity of recreational facilities—C7.1. Average distance to a public park

The site of the future Pôle Viotte neighbourhood benefits from proximity to the Parc des Glacis. Finished in 2013, the Parc des Glacis is a public park located within a Vauban fortification. In a wooded environment, equipped with various facilities for users of all ages, and offering a belvedere position over the Doubs valley and the old town, the Parc des Glacis is at a weighted average distance of 354 m, which may correspond to the target value (V_T).

C7. Proximity of recreational facilities—C7.2. Average distance to a recreational green/natural area

It is possible to reach the landscaped banks of the Doubs river relatively quickly from the Pôle Viotte neighbourhood site. The weighted average distance to reach the natural area of the river is 861 m, which is equivalent to the target value (V_T). We note that the evaluation does not take into account the distance from the Doubs banks of an urban walking area.

C7. Proximity of recreational facilities—C7.3. Average distance to a cultural centre

Most cultural facilities such as theatres, movie theatres, museums and exhibition spaces, libraries, or other equivalents in Besançon are in the city centre. The project guidelines do not specifically mention the integration of a cultural programme. In all cases, the weighted average distance is more than 900 m, which is below the limit value for the expected final situation.

C7. Proximity of recreational facilities—C7.4. Average distance to a sport centre

For this indicator, we note that outdoor play areas for children do not specifically fall into this category, nor for small private sports facilities (training rooms, studios, fitness clubs, etc.). Likewise, the swimming pool in building D (retirement home),

which will be open to the public at certain times, is not taken into account either. For the expected final situation, we consider the Denfert-Rochereau gymnasium, which is the closest sports centre to the site. We measure the weighted average distance at 890 m, which places the indicator just above the limit value (V_L).

10.2.1.3 Economic Impact

C8. Population—C8.1. Net population density

The city of Besançon has a territory of 6,505 ha, of which 2,324 ha are green spaces (forests, parks, and natural areas). For this indicator, we estimate the entire city's net population density at 28.1 inhabitants per hectare (inhabs/ha) for the initial situation and 27.7 inhabs/ha for the current situation (Insee 2020a). For the expected final situation, an annual average population increase of 0.32% is forecast until 2025. This makes it possible to estimate the entire city's net population density at 28.5 inhabs/ha.

Following the indicator's logic, the brownfield's entire area is considered for the density calculation for the initial, current, and expected final situations. As already mentioned, the site was uninhabited during the initial and current situations, which in these two cases corresponds to an assessment below the limit value (V_L).

The Pôle Viotte project development principles are to make continuity with the city by creating a new lively, calm, and peaceful neighbourhood estimated at 268 housing units, which can eventually accommodate 575 inhabitants. This is made possible by creating favourable conditions, such as a strong presence of nature. It allows a greater density than that corresponding to the city average in the metropolis centre. Thus, for the expected final situation, the population density is estimated at 52.3 inhabs/ha. This result is above the target value (V_T), set at 42.8 inhabs/ha, which is one-and-a-half times the metropolitan area's net population density.

C9. Employment—C9.1. Net employment density

The calculation for this indicator is similar to that for C8.1 Net population density. For this indicator, we estimate the employment density of the entire city at 17.1 jobs per hectare (jobs/ha) for the initial situation (2007 statistics) and 16.7 jobs/ha currently (Insee 2020a). Regarding the evolution of employment, it is hard to make predictions. The statistics institute expects an average annual population increase of 0.32% until 2025. We use the same rate to estimate the employment density for the expected final situation, which gives 17.2 jobs/ha. It is a balance between the expectations of a late retirement of the older working group and a lower entry of young working people into the job market.

Following the indicator's logic, the brownfield's entire area is considered for the initial, current, and expected final situations. Thus, for the initial and current situation, the net employment density mainly takes into account the SNCF station,

which provides several jobs.[1] For the initial situation, few activities on the site provide employment related to the company. We assume for the current situation that these jobs are relocated to the operating portion of the site (multimodal hub). Despite a generally degraded condition, the site currently provides 13.6 jobs/ha, which remains below the limit value (V_L).

Initiated as a veritable dynamic centre to bring together various government departments under one roof, the tertiary centre plans to accommodate nearly 1,000 agents (state and regional services). If we estimate 1 job/50 m^2 for the rest of the spaces provided for local services and shops, we already know that the Pôle Viotte neighbourhood will reach around 1,075 jobs. This corresponds to an employment density of 98 jobs/ha, which is above the best practice value (V_B) for the expected final situation.

C10. Local economy—C10.1. Proportion of work carried out by local companies

We should first note for this indicator the systematic absence of a value for the initial situation. In fact, the said work begins in principle with the realization of the project.

The current situation first takes into account the work for the multi-modal hub, completed in 2014. For this first phase of development, the project management was provided by the SNCF, which concluded work contracts according to its procedures. All of the companies selected were local. For buildings A and B—as a reminder under the contracting authority of the local semi-public company SEDIA—the law on public contracts does not allow the setting of objectives as to the proportion of the work to be carried out by a local company. Nevertheless, this proportion also amounts to the whole. The current situation is, therefore, evaluated at the best practice value (V_B). The same evaluation goes for the expected final situation, although the proportion may be less because the other buildings will be under the contracting authority of private developers.

10.2.2 Checklist—Project Indicators

For these indicators, we evaluate the objective and the expected final situation, together with the current situation, namely the design, construction, and operating phases. This allows us to monitor the regeneration project in detail (see Figs. 10.13, 10.14, and 10.15).

The evaluation of the initial objective takes its data from the document provided by the city of Besançon's projects and planning department (project guidelines, masterplan, etc.) (Ville de Besançon 2018).

When it is relevant, the operating phase evaluation relates mainly to the multi-modal hub sector (first phase of development). The construction phase evaluation

[1] The SNCF does not wish to disclose the number of jobs on-site. Thus, we hypothesize this number by extrapolating from current parking needs (150 spaces).

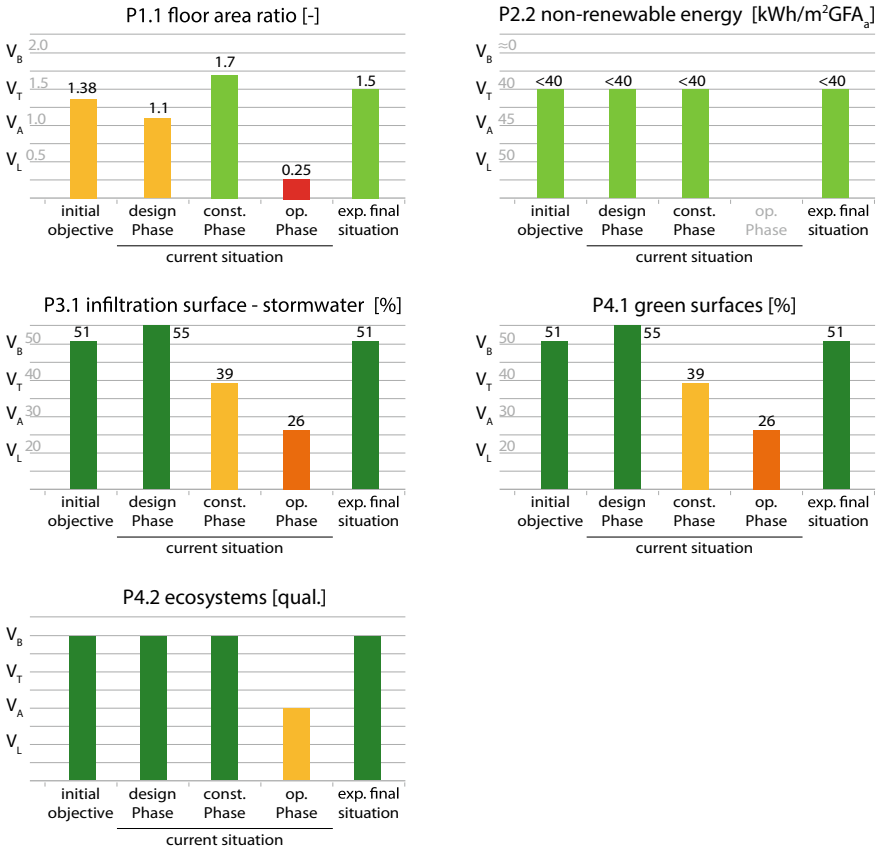

Fig. 10.13 Evolution displays for the project indicator—environmental balance

corresponds to the tertiary centre (buildings A, B, and the underground parking—southern sector). The elements evaluated for the design phase correspond to all the other buildings and planned arrangements described in the project guidelines, mainly the northern sector.

The expected final situation is, at this stage, extrapolated from the objective and the construction phase.

Even if the proximity of SNCF railway lines immediately raises the question of exposure to non-ionizing radiation, the indicator *P5.4 Degree of electrosmog* is considered irrelevant for the Viotte neighbourhood, since the responsibility rests solely with the SNCF. An ANSES report mentions that the SNCF has, for 15 years, carried out various series of measurements on station platforms and in the perimeter

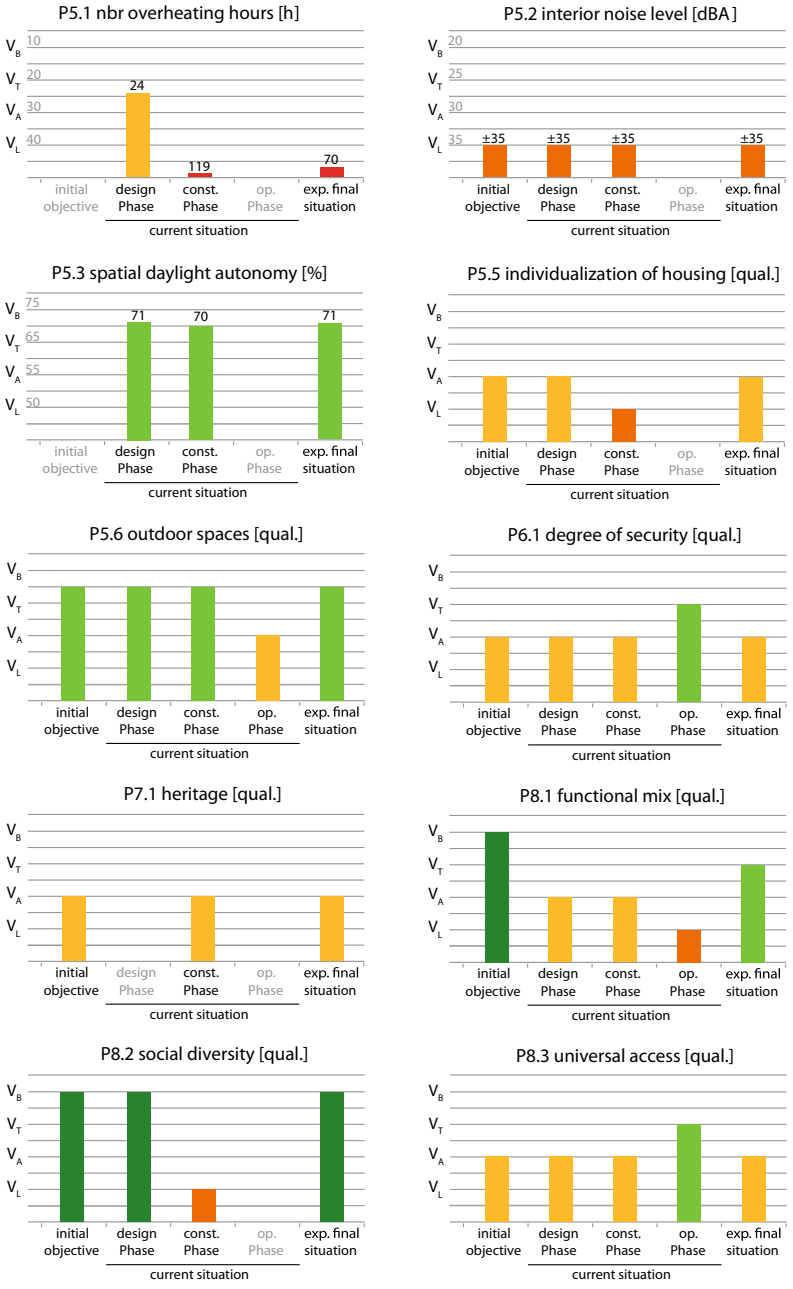

Fig. 10.14 Evolution displays for the project indicator—sociocultural quality

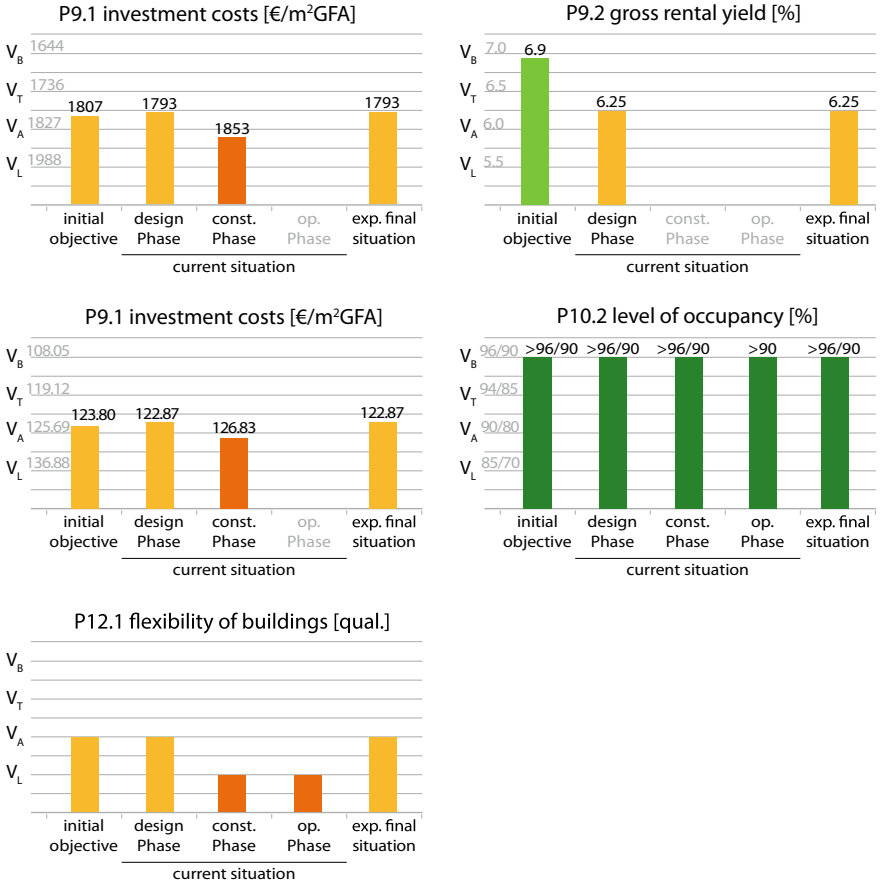

Fig. 10.15 Evolution displays for the project indicator—economic efficiency

of passenger buildings (afsset 2010). The measurement results are below the limit values.[2] That said, the report recommends organizing specific monitoring measures.

Furthermore, the SIPRIUS+ evaluation framework cannot currently provide sufficiently robust reference values for two project indicators: *P2.1. Non-renewable primary energy for construction, renovation, and demolition of buildings* and *P11.1 External costs.*

[2] The exposure limit value recommended by WHO, and adopted by France, is 100 μT. It is a recommended protective value for the public, not the level at which exposure is dangerous.

10.2.2.1 Environmental Balance

P1. Land—P1.1. Floor area ratio

Like most urban brownfield regeneration projects, the new Viotte neighbourhood project allows the densification of a city sector with loose built fabric. For the floor area ratio (FAR) indicator calculation, the portion of the brownfield site taken into consideration corresponds to the perimeter of the second phase of development, i.e., 3.1 ha.

For the initial objective, we consider a programme of 42,712 m^2 of floor area planned for the northern and southern sectors. The FAR is 1.38, which is equivalent to the average value (V_A). It is interesting to mention that the FAR is around 0.25 for this portion of the site in its brownfield state. For the expected final situation, we consider an increase in the planned square meters to 46,535 m^2. The FAR is therefore 1.50, which is equivalent to the target value (V_T).

For the current situation, taking the same data, the design phase (northern sector) plans 10,530 m^2 of floor area, whereas the construction phase (southern sector) provides for 36,005 m^2 of floor area. Reported to their respective sectors, this suggests that the average value (V_A) and the target value (V_T) are 1.1 and 1.7 FAR, respectively. The multi-modal hub centre's operating phase has a 0.25 FAR, below the limit value (V_L). This is explained by the large logistical clearances specific to transportation management.

P2. Energy—P2.2. Non-renewable energy for buildings in operation

The project guidelines state that the buildings will have to reach the RT2012 norm minus 20%, corresponding to the Effinergie + label. The project also commits to a minimum of 40% renewable energy in the energy mix used to heat each building (biomass, solar, geothermal, etc.). Among the possibilities offered to achieve this goal, the developer proposes creating geothermal batteries in the underground level, allowing the immediate development of a naturally renewable potential present on the site.

Our evaluation is equivalent to the target value (V_T) for the initial objective and the expected final situation. We give the same target value (V_T) for the design and construction phases of the current situation. Regarding the operating phase, the SNCF does not wish to communicate information on the energy performance level of their buildings.

P3. Water—P3.1. Infiltration surface and stormwater use

The project plans to discharge only wastewater from the neighbourhood into the network of the city of Besançon. While the site's karstic terrain is conducive to rainwater infiltration, the project will also encourage on-site water reuse (interior—sanitary/exterior—irrigation). Each plot will store its own rainwater, closest to buildings. The creation of green open conduits will make it possible to channel rainwater from public spaces to two retention and infiltration basins in green areas to the neighbourhood's northern and southern sectors. The project will also seek to control the runoff

of surface water by limiting impermeable surfaces through careful management of topography and slopes in the design of public spaces.

For the initial objective and the expected final situation, we estimate about 51% of the surface to be suitable for stormwater infiltration, without counting the green roofs mentioned in the guidelines as a possibility. Some preliminary renderings and the tertiary centre do, however, feature pitched roofs. We give the best practice value (V_B) to these two situations.

For the current situation, taking the same data, the design phase (northern sector) offers about 55% of infiltration surfaces, whereas the construction phase (southern sector) provides 39% of infiltration surfaces, which correspond to the best practice value (V_B) and the average value (V_A), respectively. Finally, for the operating phase (multi-modal hub sector), we estimate that about 26% of the area is suitable for rainwater infiltration. The means used for the harvesting of rainwater and wastewater are not known. We thus grant the limit value (V_L).

P4. Biodiversity—P4.1. Green surfaces

The project guidelines describe the future Pôle Viotte as a natural neighbourhood where vegetation is predominant. The intention is to create generous, open green areas and to favour green roofs. The project also plans to install an urban greenhouse (building F). At this stage of the project, the green areas taken into account are the same as the infiltration areas calculated for the previous indicator.

For the initial objective and the expected final situation, the project plans about 51% of the area as green surfaces, which corresponds to the best practice value (V_B) for both situations.

For the current situation, taking the same data, the design phase (northern sector) offers about 55% of green surfaces, whereas the construction phase (southern sector) provides 39% of green areas, which correspond to the best practice value (V_B) and the average value (V_A), respectively. Finally, for the operating phase (multi-modal hub sector), we calculate about 26% developed as green surfaces, which correspond to the limit value (V_L).

P4. Biodiversity—P4.2. Degree of ecosystem considerations

Reclaiming abandoned landscaped areas is one of the strong intentions of the Pôle Viotte neighbourhood. Hence, the project proposes a development principle emphasizing the natural potential of the site, notably biodiversity. It includes continuous landscaped public spaces to form a green network that fits with the city's great green belt logic (Parc des Glacis among others). In this sense, the project plans for significant embankments around the site to promote biodiversity development at the interface of the surrounding neighbourhoods. Besides, the project provides for the construction of an urban greenhouse allowing social exchanges within the district and other ecological measures such as ponds or nest boxes. Note that the city of Besançon is very attached to the ecological management of green spaces, particularly via the Ecojardin label.

These intentions allow for now to evaluate the initial objective and the expected final situation at the best practice value (V_B). Likewise, the best practice value (V_B)

applies to the design and construction phases of the current situation. Regarding the operating situation, the interventions in the northern part (the belvedere) receive the average value (V_A).

10.2.2.2 Sociocultural Quality

P5. Well-being—P5.1. Annual hours of overheating

The initial project guidelines make no mention of measures taken to ensure summer comfort. The initial objective is, therefore, not evaluated for this indicator. To evaluate the expected final situation and the current situation, we performed a numerical simulation, allowing us to estimate the annual number of overheating hours or hours during which the interior temperature of the buildings is above 28 °C. To do this, we produced a 3D model representing the volumes of the Pôle Viotte neighbourhood's buildings, excluding the urban greenhouse, building F.[3] We obtained in this way the number of overheating hours for each building. It was then extrapolated in proportion to the gross floor area of the entire neighbourhood.

On this basis, we estimated the annual number of hours exceeding 28 °C at 70 for the entire neighbourhood, which is below the limit value (V_L) for the expected final situation. For the construction phase, we estimated the annual number of hours exceeding 28 °C at 119 h for buildings A and B, which is also below the limit value (V_L). We noted that the south orientation, the windows of the two buildings, and mainly the internal gains of buildings dedicated to activities influenced overheating. Evaluating this indicator using digital simulations helps identify a risk to be verified once the buildings are operational. For the design phase (buildings C to L), we estimate that annually 24 h will be exceeding 28 °C, which corresponds to the average value (V_A). We explain this difference in the results mostly by the building type, i.e., housing. It appears that climatic changes, the continental climate condition in the Franche-Comté region, associated with the increasing thermal performances of new buildings, can create overheating pathologies within the new neighbourhood. The guidelines mention thus that the question of thermal comfort should be treated with care when designing new housing buildings.

Finally, the operating phase evaluation is not relevant: no requirement regarding overheating hours applies for the station.

P5. Well-being—P5.2. Interior noise level

In the southern sector, the tertiary centre along the railway tracks is designed to generate a deflecting effect. The intention is to reduce the negative impacts of noise pollution on residential buildings. In the northern sector, the residential buildings will be set back from the railway tracks to minimize noise pollution.

[3] The simulation was performed with Design Builder v5.0. (EnergyPlus). For the working assumptions used to perform the simulation (U values of materials, proportion of glazed surfaces, sun protection, etc.), see Laprise (2017).

Since the buildings are not built yet, we obviously could not give a precise evaluation for the moment. Considering the quite simple measures described above and the relatively high level of railway noise, the initial objective is estimated at the limit value (V_L). For the moment, we gave the same value to the design and construction phases and the expected final situation. The evaluation will evolve following the project's progress. Regarding the operating phase, it would be erroneous to evaluate it because of its eminently noisy function, especially since there is no housing and only a few offices.

P5. Well-being—P5.3. Spatial daylight autonomy (sDA)

The spatial daylight autonomy (sDA) metric is the surface percentage of a given area that reaches a minimum of 300 lx during a given number of hours per year (50% of hours between 8 a.m. and 6 p.m.).

Since the project guidelines made no mention of the amount of natural light desired in the buildings, we did not evaluate the initial objective. We performed a numerical simulation to estimate the sDA of the expected final situation and the current situation. To do this, we produced a 3D model representing the volumes of the buildings of the Pôle Viotte neighbourhood—except the urban greenhouse, building F—assuming that the central spaces of the floors would be occupied by functions that do not need natural light (circulation, technical rooms, etc.).[4] We obtained in this way a specific percentage for each building. It was then reported in proportion to the gross floor area of the entire neighbourhood.

Our simulations revealed that the autonomy in natural light for the entire site would reach 71% of the areas assigned to offices or housing. This estimation gave the target value (V_T) for the expected final situation. It generates similar results to the design phase of the current situation. We can add that buildings A and B of the tertiary centre obtain 74% and 56%, respectively. Extrapolated to their gross floor area yields an sDA of 70%, which corresponds to the target value (V_T) for the construction phase of the current situation. However, this good performance will probably be affected by the use of blinds. An evaluation of the operating phase is not relevant at the moment in the case of this indicator.

P5. Well-being—P5.5. Degree of individualization of housing

At this stage of the project, the guidelines provide little information on the degree of housing individualization. Within the diversity of housing expected, modularity is desired and encouraged to adapt to inhabitants' different life stages. Otherwise, we note that the buildings' shape will follow the natural slope of the terrain. It will provide distant views of the historic centre while minimizing views on the railway tracks. Treatment of the boundaries between public and private spaces will be subject to architectural prescriptions.

[4] We performed the simulation with Diva for Rhino v4.0. For consistency, the fenestration is the same as for P5.1 annual hours of overheating. For the other working assumptions made at this stage of the project, see Laprise (2017).

Thanks to this information, we evaluated the initial objective and the expected final situation at an average value (V_A). For the current situation, the design phase received the same average value (V_A). Buildings A and B provide 14 luxury apartments with a slight degree of individualization. Hence, the construction phase gets the limit value (V_L). As regards the operating phase, here evaluation does not apply because the buildings do not contain accommodation.

P5. Well-being—P5.6. Quality of outdoor spaces

The guidelines include the intention to pay particular attention to the design of the public spaces, which will be mainly free from cars. The project foresees a network of landscaped pedestrian and cyclist paths. The latter will settle around central green alleys in the northern as well as the southern sectors. The treatment of public spaces will follow a logic of sobriety and optimization. A public urban greenhouse managed by the neighbourhood's users will contribute to making the public spaces lively.

Based on these descriptions, we set the initial objective at the target value (V_T). For now, we attributed the same value to the expected final situation and the design and construction phases of the current situation. Regarding the operating phase, the belvedere in the northern sector and the landscaping in the southern sector improved the initial situation to a level that corresponds to the average value (V_A).

P6. Security—P6.1. Degree of security

The guidelines recommend the implementation of passive measures to ensure general safety within the neighbourhood. More specifically, the project plans to secure public outdoor spaces through several means. It will promote pedestrian and cyclist paths and mutualized parking to avoid cars on the neighbourhood's roads and on-street parking. Also, the mix of functions (offices, housing, and shops) combined with the quality of outdoor spaces will generate a neighbourhood that is "lively, calm, and peaceful" for several hours of the day throughout the week.

These few elements allowed us to assign the average value (V_A) to the initial objective, to the expected final situation, and to the design phase of the current situation. For the construction phase, security measures congruent with the requirements of the state and regional services are put in place (e.g., video surveillance). Hence, the average value (V_A) is also assigned.

The station and its surroundings are secured by standard measures for this type of building (security agents, adequate public lighting, surveillance cameras, etc.). The multi-modal hub's facilities also contribute to clarifying motorized and non-motorized traffic on-site. We evaluated the operating phase at the target value (V_T).

P7. Heritage—P7.1. Degree of enhancement of existing heritage

None of the brownfield buildings is officially listed as historic monuments. However, some of them attest to the old railway activity of the site, which has marked the Besançon urban space since the mid-nineteenth century (military platform to the north, Sernam Hall to the south). The Pôle Viotte neighbourhood project does not preserve any specific buildings. However, the tertiary centre's principal building (building A) will faithfully evoke Sernam Hall's morphology through its location

along the railway tracks and its size. Moreover, the construction principle will evoke the original wooden frame of the Sernam Hall. The tinted tiles of the pitched roof are a reinterpretation of the "Blue City", which highlights the stone of Chailluz, typical of Besançon.

Based on these considerations, we give an average value (V_A) to the initial objective, the expected final situation, and the construction phase of the current situation. The design and operating phases are not affected by heritage considerations. We note the presence of a significant Gallo-Roman archaeological heritage site, mainly in the northern sector, that will be investigated before construction begins. But these aspects are not taken into account by this indicator.

P8. Diversity—P8.1. Degree of functional mix

By developing a mixed-use district near the station, the Pôle Viotte neighbourhood project, with the various urban functions offered, strengthens the role of the extended urban city centre. In other words, functional diversity is at the centre of project planning. By bringing together several complementary functions, it transforms the monofunctional past of the site dedicated to rail activities.

From the initial objective comprising a 54% ratio activities/housing—best practice value (V_B)—the project evolved to a 66% ratio activities/housing for the expected final situation—target value (V_T). For the construction phase of the current situation (southern sector), we estimated the ratio of activities/housing at 77%, which corresponds to the average value (V_A). On the contrary, for the design phase of the current situation (northern sector), the ratio of housing/activities was estimated at 70%, which also corresponds to the average value (V_A). The operating phase, mainly occupied by the multi-modal hub activities, corresponds for its part to the limit value (V_L).

P8. Diversity—P8.2. Potential of social diversity

The Pôle Viotte neighbourhood aims at a strong integration of social diversity. Indeed, among the 230 housing units planned, 20% will be public housing (including 10% social housing) and 15% low-cost housing, reserved for first-time buyers. Additionally, the guidelines recommend an extended typology of housing. That means spacious apartments intended for families and others adapted to inter-generational needs. Building D will accommodate a retirement home. Some self-promotion opportunities will also be possible.

This information is sufficient to assign the best practice value (V_B) to the initial objective, the expected final situation, and the design phase of the current situation. As for the construction phase, buildings A and B are making way for 14 luxury apartments, which limits the potential for social diversity. Hence, we temporarily evaluate this phase at the limit value (V_L). Evaluation of the operating phase is not relevant for the moment.

P8. Diversity—P8.3. Degree of universal access

Because of the steep slope of the site (more than 17 m difference between the north and south sectors), it is relevant to consider accessibility for users with impaired

mobility throughout the various exterior developments. Therefore, gently sloping facilities and lifts are planned where necessary to allow universal access to the whole site. However, the guidelines do not mention particular measures regarding the design of the different buildings.

The average value (V_A) is given to the initial objective, the expected final situation, as well as to the construction and design phases of the current situation. For the operating phase, all the multi-modal hub's facilities are accessible to users with reduced mobility, including the underpass, which constitutes a clear improvement in terms of freedom of movement for these users. Here, the target value (V_T) is assigned.

10.2.2.3 Economic Efficiency

P9. Direct costs—P9.1. Investment costs

To evaluate this indicator, we need to know the average construction cost of buildings in the Besançon area. However, the most reliable data available is from the construction cost index for residential buildings calculated by the INSEE. The latter is estimated at 1,765 €/m^2 for the third semester of 2020 (Insee 2020b). We also needed to know the average constructible land price within a radius of 5 km from Besançon city centre, which is 93 €/m^2 (Terrain-construction.com 2016, 2020). With an average floor area ratio of 1.5, we obtained for this indicator an investment cost of 1,827 €/m^2, which was the reference for the average value.

At this stage of the project, when work with the various public and private developers is not yet underway, it is hard to precisely evaluate this indicator for the entire neighbourhood. Besides, the guidelines do not set any formal objective in this area. The gross amount communicated on land acquisitions (1.3 M €, excl. tax) tells us, at least, about land price, which is equivalent to 42 €/m^2. Hence, for the initial objective, we estimated the investment cost at 1,807 €/m^2, i.e., the addition of the average construction cost and the actual cost of the land (floor area ratio of 1.38), which corresponds to the average value (V_A).

For the construction phase of the current situation (the tertiary centre, buildings A and B), it is estimated that the construction costs will be around 50 M € (private investment). With a floor area of 27,458 m^2, this equates to a cost of 1,828 €/m^2. When we add the actual cost of the land (floor area ratio of 1.7), we obtain an investment cost of 1,853 €/m^2, which corresponds to the limit value (V_L). However, this is only a partial view of the entire Pôle Viotte neighbourhood project; the tertiary centre (two office buildings with 14 luxury apartments) is designed as signature buildings.

Because the other constructions will be more standard ones, the costs will likely be lower. For the moment, therefore, we situate the design phase of the current situation as well as the expected final situation at around 1,793 €/m^2, i.e., the addition of the average construction cost and the cost of the land (floor area ratio of 1.5). It corresponds to the average value (V_A).

Regarding the operating phase of the current situation, we know that the multi-modal hub represented an investment of 15.3 M € excl. tax. However, because

we cannot rely on robust comparable costs to establish the reference values, the evaluation of this phase is currently irrelevant.

P9. Direct costs—P9.2. Gross rental yield

For this indicator, we did not consider data concerning offices and commercial premises. Hence, at this stage of the project, we made a theoretical calculation of this indicator based on the spaces allocated to housing, which corresponds to a gross floor area of 15,399 m^2. As a reminder, we previously estimated the construction cost at 1,827 €/m^2. A minimum income of around 28 M € is thus required. In Besançon, around the Pôle Viotte neighbourhood, the average monthly rent fluctuates between 12.30 €/m^2 (Battant district), 11.80 €/m^2 (St-Claude district), and 11.50 €/m^2 (Charpais district) (SeLoger.com 2020). We considered an average monthly rent of 11.90 €/m^2. Besançon has rental profitability that oscillates between 4.07 and 7.97% (OuInvestir 2019). Thus, we considered an average gross rental yield at 6.02% for the reference value.

According to the preliminary calculation of the initial objective, the gross rental yield was set at 6.9%, i.e., the target value (V_T). The construction phase of the current situation is not relevant to this indicator. 14 luxury apartments (15% above the price market) are offered for sale. The design phase of the current situation and the expected final situation follows the same calculation. We estimated the net living area at 12,319 m^2 or 20% less than the gross floor area. Thus, we estimated a gross rental yield at 6.25%, which corresponds to the average value (V_A).

Concerning the operating phase, the evaluation is not relevant because the multimodal hub does not include housing.

P10. Indirect costs—P10.1. Annual operating costs

We estimated the heat and energy consumption costs according to the results obtained for indicator P2.2 and the investments and maintenance costs of buildings according to the results obtained for indicator P9.1. Together, these results determine an indication of the annual operating costs.[5] For the investment costs, we assumed an interest rate on the capital of 2.0% amortized over 25 years, i.e., a coefficient of 0.051 for the calculation of annuities. For maintenance costs, we used an average rate of 1.5% (the annuity by the amortization period) (SIA 2004). For heat costs, the assumption used to establish the average reference cost was heat production running 100% on natural gas, costing 8.43 cents/kWh (Le médiateur national de l'énergie 2020). The price change takes into account an average increase of 5% over the next 25 years, i.e., a coefficient of 1.78 (Müller and Walter 1994). Finally, the average reference cost for electricity in Besançon is 14.25 cents/kWh (Le médiateur national de l'énergie 2020). The price change takes into account an average increase of 3% over the next 25 years, i.e., a coefficient of 1.39 (Müller and Walter 1994).

For the initial objective, the expected final situation as well as the design phase of the current situation, the same assumptions applied for the costs of investment,

[5] We based the calculation on the 2016 reference values, the launch year of the second phase of the project following the architecture competition.

maintenance, heating, and electricity, even if other sources of energy supply are considered (such as geothermal). We know that the investment costs are equivalent to 1,807 €/m^2, 1,793 €/m^2, and 1,793 €/m^2, respectively. For the buildings' operation primary energy, we estimated performance to be equivalent to RT2012 −20%. The sum of the various operating costs amounts to 123.80, 122.87, and 122.87 €/m^2 GFA annually, which is below the average value (V_A).

For the construction phase of the current situation (the tertiary centre, buildings A and B), we have estimated an investment cost of 1,827 €/m^2. Similarly, we expect an RT2012 −20% energy performance. The calculation for operating costs turns out to be 126.83 €/m^2 GFA annually, which corresponds to the limit value (V_L).

The evaluation of the operating phase is not relevant because of the complexity and specificity of the multi-modal hub's installations.

P10. Indirect costs—P10.2. Level of occupancy

As with the previous economic indicators, we based the evaluation of this indicator on estimations. Indeed, the project sets no official objective for this indicator. That said, interviews with the project team revealed that strong demand for office rental exists, which would already exceed the current supply planned by the project. Furthermore, we know that the project carried out conclusive pre-marketing tests based on urban planning studies and the real estate market reality (unfortunately not disclosed). Finally, built to accommodate the state and regional agents of Besançon, the tertiary centre will be fully occupied.

Based on this information, we gave the initial objective and the expected final situation the best practice value (V_B). We assigned the same value for the moment to the construction and design phases of the current situation. For the operating phase, we know that the multi-modal hub rental spaces are all occupied and that the occupation intensity of the SNCF offices increased due to the restructuring on-site. The best practice value (V_B) was therefore also attributed.

P12. Flexibility—P12.1. Degree of building flexibility

At this stage of the project, it is hard to judge the concrete means implemented to promote flexibility. Only the intention to "encourage modular housing to cope with the different life stages of the inhabitants" is mentioned in the project guidelines.

Given this meagre information, we considered the degree of building flexibility for the initial objective equivalent to the average value (V_A). By extrapolation, we assigned the same value to the expected final situation and the design phase of the current situation. It is interesting to note that the car park is designed with reversibility measures to eventually minimize its capacity and respond to new uses for this sector ideally served by public transport. However, the tertiary centre (buildings A and B) contains no specific flexibility measures. Thus, we evaluated the construction phase of the current situation at the limit value (V_L). For the operating phase, which mainly concerns the station, the evaluation is also at the limit value (V_L), because the building typology with construction features specific to its function leaves little room for flexibility.

10.2.3 Checklist—Governance Indicators

For these indicators, we evaluate three situations: the initial objective, the current situation, and the expected final situation (see Figs. 10.16 and 10.17). Although the project guidelines set no clear objective for some indicators, observation of the project progress makes an evaluation possible. It incidentally reveals the risks or opportunities associated with a given indicator. As a reminder, we divide governance indicators into two dimensions: management and process. While the indicators under the process dimension may extend to the entire regeneration project, indicators under the management dimension often refer to a specific project phase and may be limited in timespan.

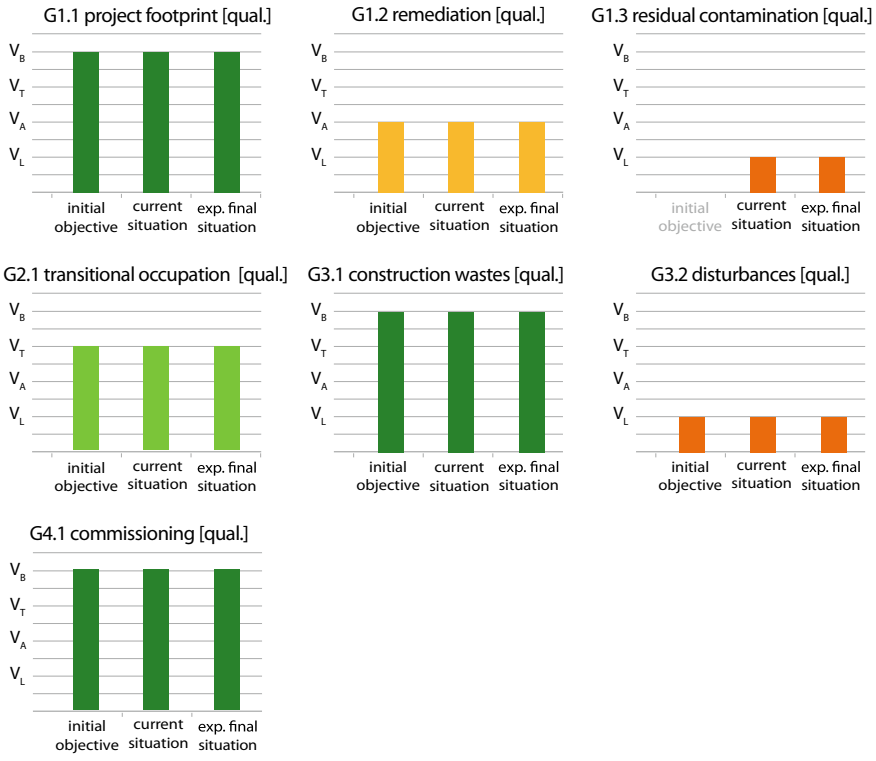

Fig. 10.16 Evolution displays for the governance indicators—management

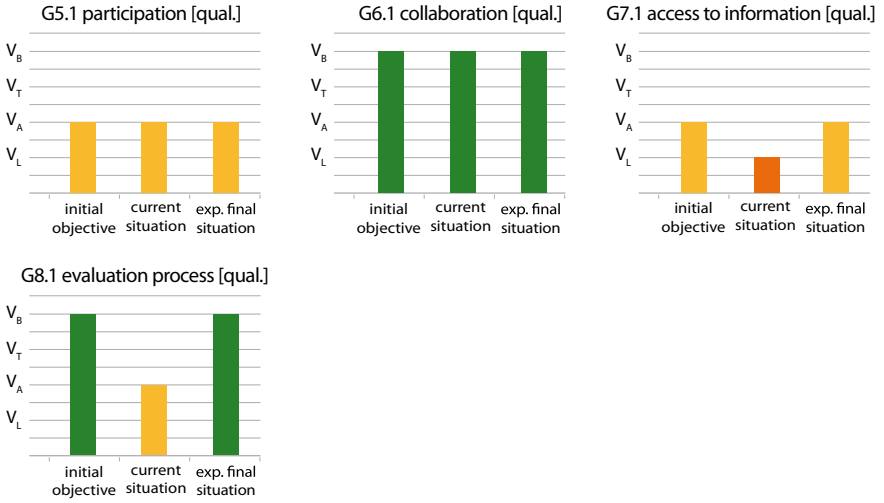

Fig. 10.17 Evolution displays for the governance indicators—process

10.2.3.1 Management

G1. Remediation—G1.1. Logic of project footprint

The environmental impact assessment, which includes an investigation of health risk, revealed some soil pollution traces. For the southern sector, moderate pollution gradients were measured (3,200 m^3), mainly coming from old landfills linked to the nineteenth-century railway activities and located on the first layers of soil near the Sernam Hall. The organization of the public spaces and the programming of urban functions—notably the parking and building A location—deal with this pollution presence, which is compatible with the project. Thus, the project provides for an optimized and economic management plan for contaminated soil (excavation and backfill) to limit the risks. For the northern part, the investigation reveals a small amount of contaminated soil (80 m^3) that will be evacuated to a treatment centre. In any case, the masterplan is flexible enough to evolve based on the unlikely discovery of soil pollution. Based on this information, we evaluate the initial objective, the current situation, and the expected final situation at the best practice value (V_B).

G1. Remediation—G1.2. Degree of site remediation

As mentioned in the evaluation of the indicator G1.1, the brownfield site has 80 m^3 of contaminated soil in the northern sector, which will be evacuated to a treatment centre, and 3,200 m^3 of contaminated soil in the southern sector. The treatment of this latter pollution is to correlate with the use of the site. A pedestrian ramp to the east of the site will use around 1,200 m^3 of contaminated soil to consolidate the foundations. The ramps will serve to connect the new neighbourhood with its surrounding. The remaining contaminated soil (2,000 m^3) will be confined inside a

geotextile membrane under the self-ventilated car park, which is used as a buffer. These ongoing remediation measures make it possible to evaluate the initial objective, the current situation, and the expected final situation at the average value (V_A).

G1. Remediation—G1.3. Degree of residual contamination

For now, management of the residual contamination is limited to the obligation of a mention in the deeds of sale to keep records. We give thus the limit value (V_L) to the current situation and expected final situation. No initial objective was set for this indicator.

G2. Temporary use—G2.1. Transitional occupation initiatives

There were initially some activities related to SNCF jobs in the southern sector of the site, such as a canteen for employees' children, an activity room, and a small library. The new neighbourhood project planned to combine these services within new programmes (e.g., a company restaurant could serve the canteen meals), or to relocate them within the surroundings of the site. We evaluated the initial objective at the target value (V_T). The project evolved slightly differently along with the initial objective. Only the SNCF library is reconstituted in building A. The previous canteen users have contracted with nearby company restaurants, although an inter-agency restaurant is also available in building A. We evaluate the current situation and the expected final situation at the target value (V_T).

G3. Construction site—G3.1. Management of construction waste

The guidelines mention the implementation of a "Green Charter" for the construction site annexed to the works contract. It aims at limiting the carbon footprint of the works. It includes, notably, recommendations on waste sorting, a limitation on outsourced backfill, and on-site reuse of material from excavation and demolition. The "Green Charter" also requires a certain percentage of waste recovery (sorting, recycling, reuse, and reduction). Moreover, a "Green Charter" manager is appointed before the construction works begin to ensure its application by all companies and workers on the site. Currently, no detailed data as to the share of waste reused are available yet. We know that various public landscaping and installations include a certain percentage of recovered waste. Since buildings are being demolished, the products resulting from the demolition work are reused in road fill. Besides the on-site remediation measures (see indicator G1.2), the making of public spaces will reuse 8,000 m^3 of clean soil from the 17,000 m^3 excavation material.

Based upon this information, we give the initial objective, the current situation, and the expected final situation the best practice value (V_B).

G3. Construction site—G3.2. Management of construction disturbances

The neighbourhood site is surrounded to the north, south, and east by residential areas. However, the steep slope between the site and the south area creates a buffer. In the west, the multi-modal hub is quite crowded in the daytime. This observation highlights the importance of taking into account disturbances during the construction

phase. However, no specific mention is made to this effect in the guidelines, nor during the tertiary centre construction.

Given this lack of measures, we give the limit value (V_L) to the initial objective and the current situation. By extrapolation, the expected final situation obtains the same evaluation.

G4. Commissioning—G4.1. Commissioning plan for buildings

The new neighbourhood project provides for the establishment of workshops called "Ateliers Viotte". The workshops aim to transmit and share the project's spirit with the different building developers, including, notably, energy issues. The guidelines also specify that the "Ateliers Viotte" must integrate future building managers. Additionally, a prescription book for each building will make users aware of the issues linked to climate change, mainly summer overheating management, as soon as they arrive in the neighbourhood. Finally, monitoring by an environmental expert and ex-post evaluation questionnaires will be put in place to take advantage of any performance gaps between the design and the construction of buildings and improving the project along the way.

These various measures allow us to evaluate the initial objective, the current situation, and the expected final situation at the best practice value (V_B).

10.2.3.2 Process

G5. Participation—G5.1. Degree of participation of population

Since 2008, the city of Besançon has initiated consultation for the entire regeneration of the brownfield.[6] The public consultation closed at the end of the neighbourhood pre-operational studies, i.e., at the end of 2015. A series of more specific public meetings with various associations (surrounding neighbourhood, transport users, cyclists, etc.) are closely associated with the project throughout the different stages. The city of Besançon projects and planning department is available at any time to collect requests for information and suggestions. Finally, the "Ateliers Viotte" provides the opportunity to exchange views with all stakeholders, including future site managers, and to take into account the practices of future end-users.

These elements lead our evaluation of the initial objective at the average value (V_A). The current situation and the expected final situation follow this evaluation.

G6. Collaboration—G6.1. Degree of collaboration of professionals

Our evaluation of this indicator is also based on the workshop principle, the "Ateliers Viotte". In addition to the city of Besançon and future users, as described above, the "Ateliers Viotte" involves the developer and the project team (urban project management) from the pre-operational studies phase. During the design phase, it is expected that the building projects proposed by the different developers will be optimized and

[6] Complies with provisions L 300-2 of the Urban Planning Code (Code de l'urbanisme).

finalized within the framework of these workshops with the support of the consultant architect of the urban project management. The same will apply to the supervision of construction work. These interactive workshops allow co-construction, that is to say, a project that is negotiated and shared between all professionals while opening a permanent and effective dialogue between urban and built spaces. The "Ateliers Viotte" also aims to convey and share the project's spirit with the different operators, as recently experienced for the choice of buildings C, D, and E's architects and developers.

We set the initial objective at the best practice value (V_B). The current situation and the expected final situation obtain the same evaluation.

G7. Information access—G7.1. Degree of access to information

According to the project guidelines, a dedicated website for the Pôle Viotte neighbourhood will be online with the first arrivals. A testimonial book retracing the entire development is being produced. The website will include an exchange platform between users, which will facilitate, among other things, the organization of client groups or local economy initiatives. However, the degree of access to information is currently limited to the few downloadable presentation documents on the city of Besançon website.

In light of this information, we evaluate the initial objective and the expected final situation at the average value (V_A) and the current situation at the limit value (V_L).

G8. Evaluation—G8.1. Degree of integration of an evaluation process

The Pôle Viotte neighbourhood has initiated a certification process since 2014: the EcoQuartier Label. Currently, the project has the label for step 2 (four steps: design, construction, delivery, and post-occupation). The project guidelines mention that all the commitments related to the EcoQuartier Label process are integrated into a spreadsheet. The aim is to facilitate their monitoring, like a sustainable development dashboard. Annually, a global update on this dashboard is produced and available to the various stakeholders upon request. Moreover, the guidelines prescribe post-occupancy performance monitoring of all buildings, performed through an online questionnaire available on the neighbourhood's website. With the intent of providing feedback and continuous improvement opportunities, private developers will be required to communicate the results.

For these reasons, we evaluate the initial objective and the expected final situation at the best practice value (V_B). Because all these measures are not yet in place, we evaluate the current situation at the average value (V_A).

10.3 Overall Monitoring Results

We have just carried out the one-by-one monitoring of the indicators related to the context, the project, and the governance of the Pôle Viotte neighbourhood project

using the SIPRIUS+ monitoring tool, which represents a total of 52 out of 57 indicators. One indicator was deemed irrelevant (*P5.4 Degree of electrosmog)* and four indicators were not evaluated due to the current lack of robust reference values *(C2.2. Global warming potential (GWP), C2.3. Acidification potential (AP)*, *P2.1. Non-renewable primary energy for construction, renovation and demolition of buildings,* and *P11.1 External costs*).

We argue that, from the perspective of integrating sustainability issues into the dynamics of the urban brownfield regeneration project, communicating the overall results of the monitoring is just as important as the monitoring itself. The latter is the source of iterations aimed at continuous improvement of the project. In that regard, SIPRIUS+ allows the different actors involved in the project to visualize the overall results in several forms. As a rule, the tool is not designed to compare projects in different locations, nor to rate projects, as some labels do. Nevertheless, as can be seen in Figs. 10.18, 10.19, and 10.20, the Chart displays make visible and comparable the overall monitoring results for specific stages of the project. Figure 10.21 provides a synoptic view of all the indicators for the expected final situation according to the performance achieved at the moment of the evaluation.

These visualizations of the results allow the actor who consults them to make some general observations. First, for the context indicators, the expected final situation is generally better than the initial and current situations. The comparison between these different situations allows assessing the efforts undertaken by the brownfield regeneration project in terms of sustainability issues improvement. For project indicators, the initial objective and the expected final situation are very similar. Only two indicators get different results (*P1.1 Floor area ratio* and *P8.1 Degree of functional mix*). This fact can be explained by the progress level of the project; the expected final situation is still a transposition of the initial objective. However, variations appear in the evaluation of the current situation (especially the construction phase). It can be an opportunity to pay attention to certain aspects that could potentially affect project performances. For governance indicators, the initial objective and the expected final situation are also similar. However, the current situation indicates possible trends that the project may take. Finally, through the Evolution display (Fig. 10.21), we note in general that the evaluation results of the expected final situation are quite favourable, with more than half being above the target value (V_T). However, it is interesting to underline that the environmental dimension is more efficient than, in particular, the social dimension. As mentioned in Chap. 5, this is typical of new sustainable neighbourhood projects, where a focus is often on energy or ecological aspects.

By looking more closely, the three Chart display comparison makes it possible to identify four critical aspects of the project that deserve special attention from the project stakeholders. This is where SIPRIUS+ can best play its decision-support role.

- The first is to identify the indicators that are not taken into account by the brownfield regeneration project and, ideally, integrate them into new objectives. In the case of the Pôle Viotte neighbourhood, little consideration is given to *P5. Well-being—P5.1. Annual hours of overheating* and *P5.3. Spatial daylight autonomy (sDA).*

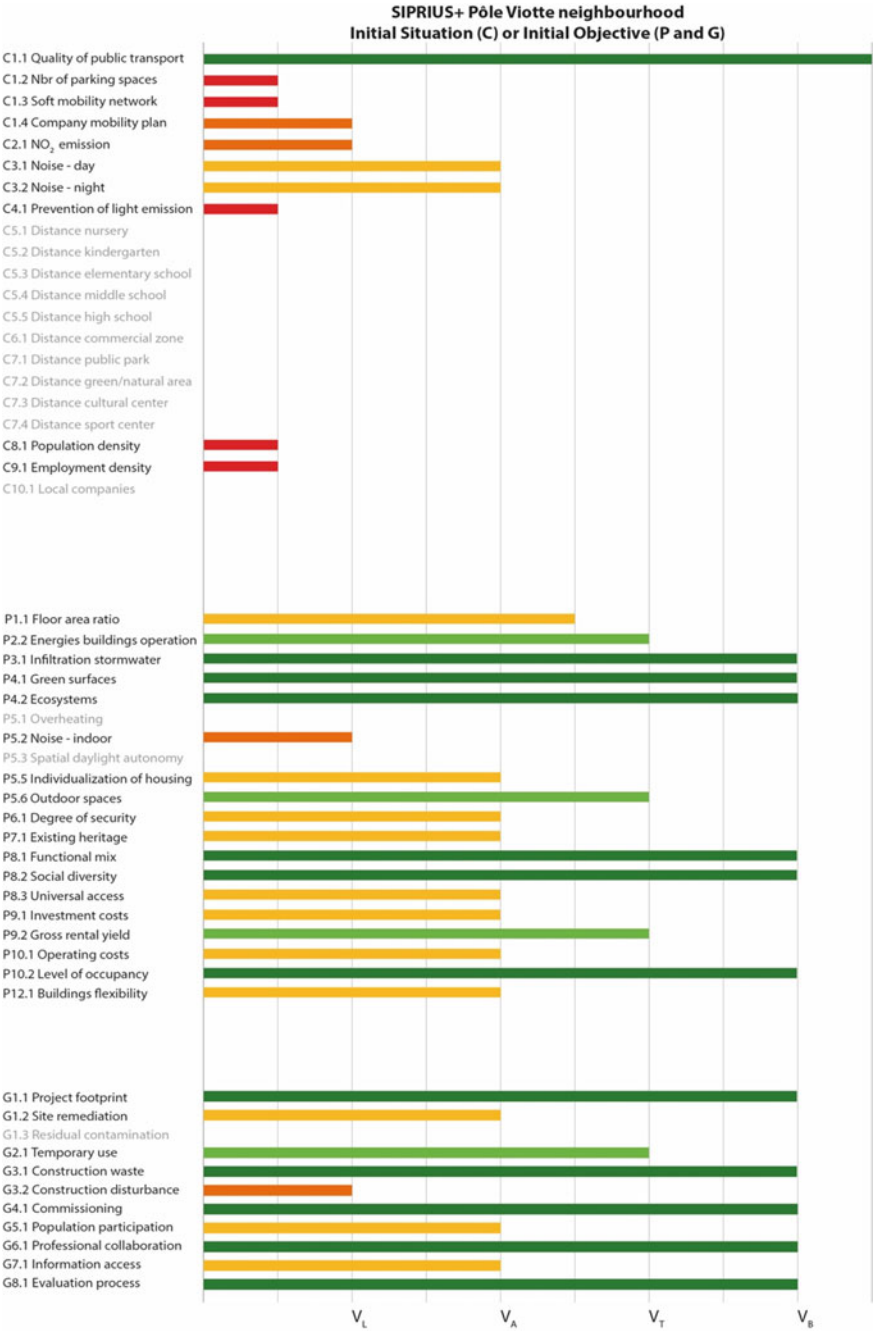

Fig. 10.18 Overall results of the initial situation (context indicators) and the initial objective (project indicators and governance indicators)

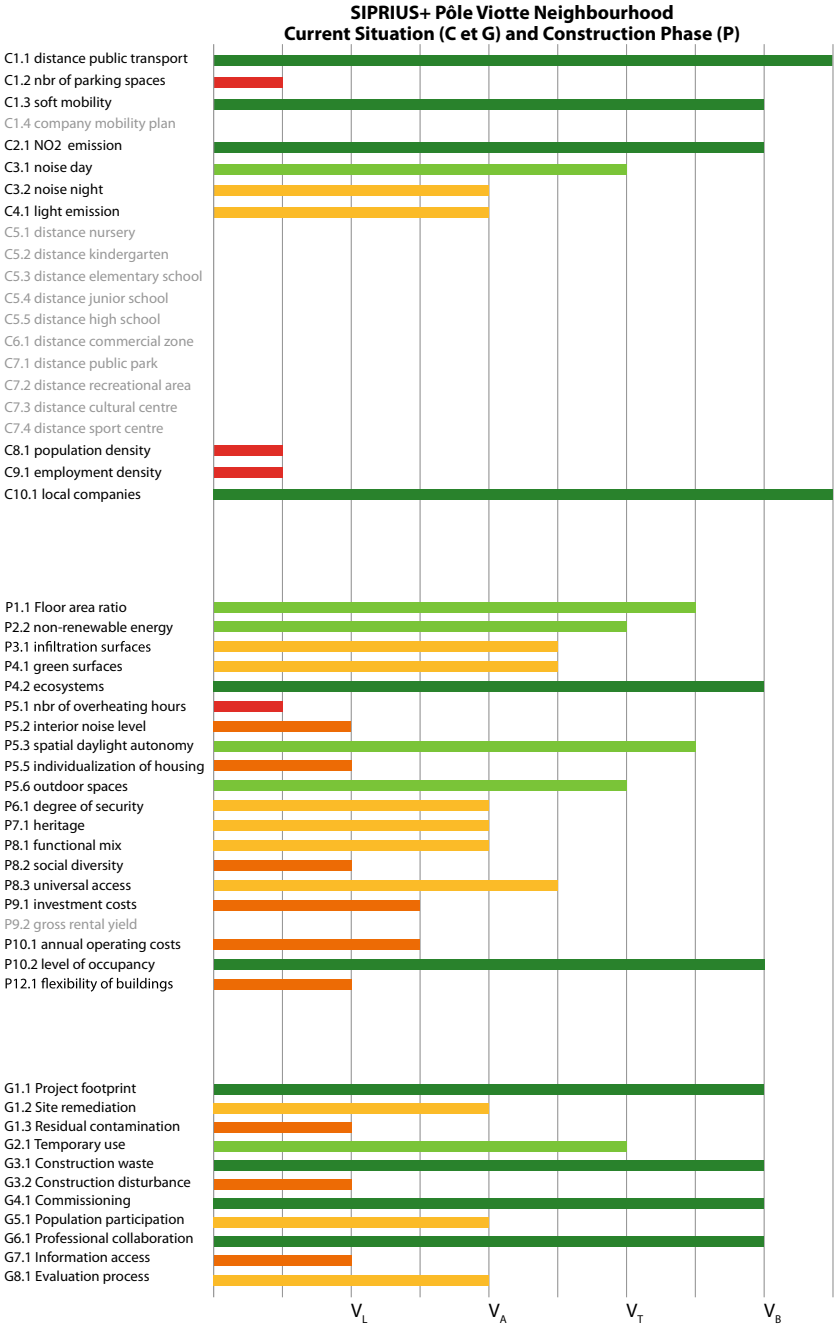

Fig. 10.19 Overall results of the current situation (context and governance indicators) and the construction phase of the current situation (project indicators)

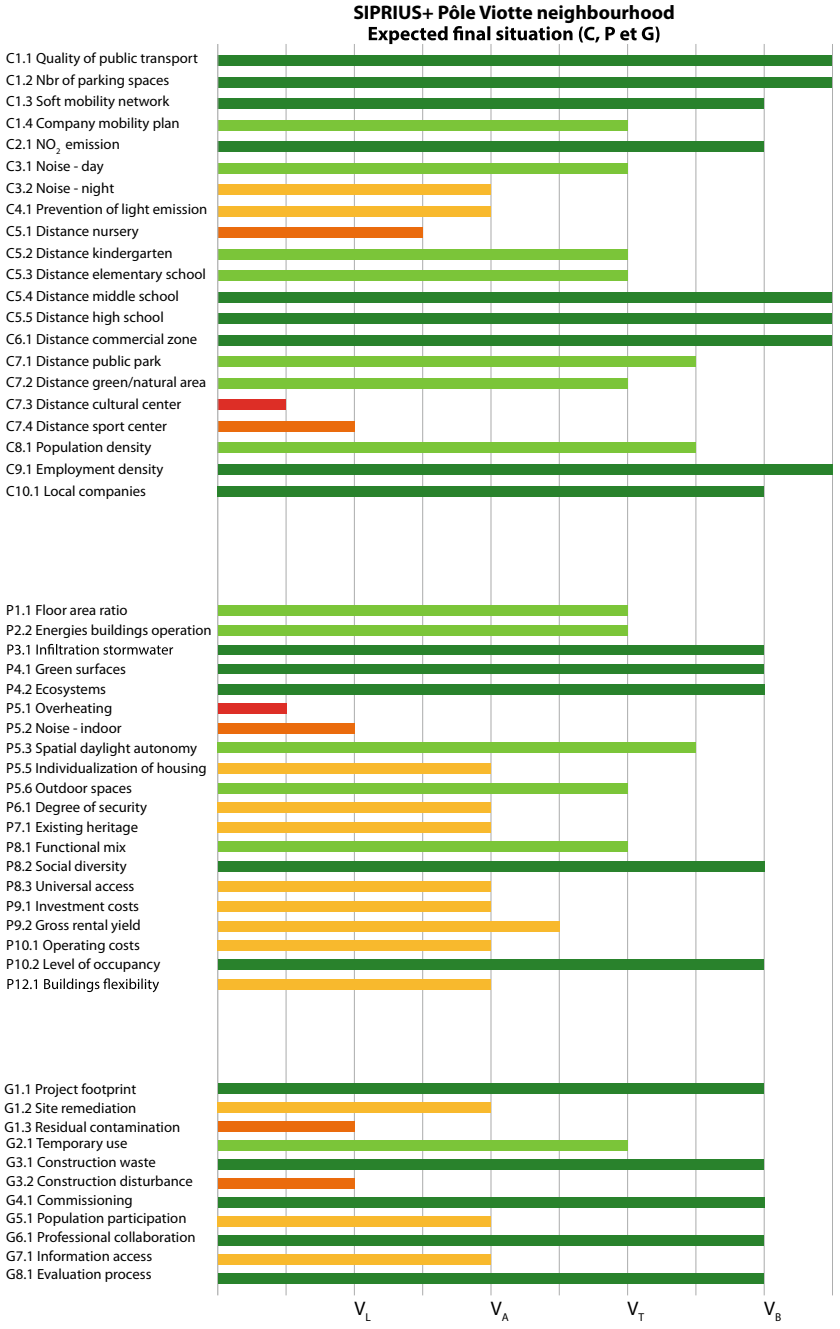

Fig. 10.20 Overall results of the expected final situation (context, project, and governance indicators)

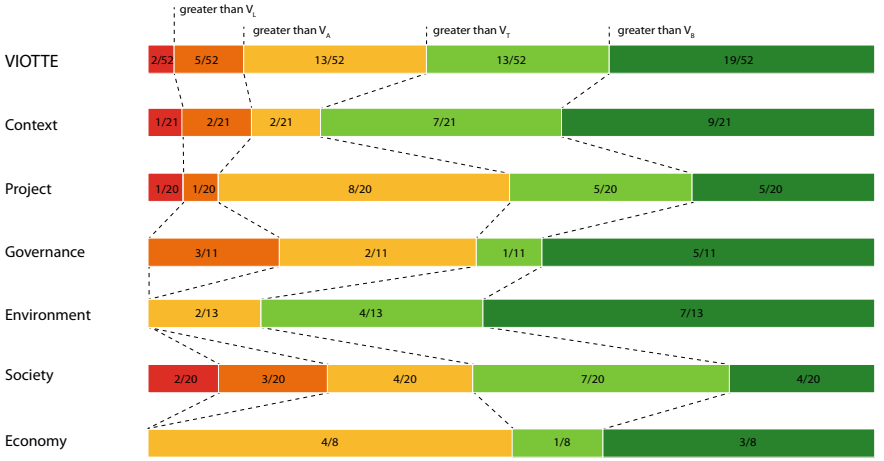

Fig. 10.21 Evolution display showing the distribution of all indicators' performances based on the values obtained for the expected final situation. The figure also shows the breakdown by sustainability dimension: environmental, sociocultural, and economic impact

- The second is to focus on the expected final situation results that would be below the limit value (V_L), or in other words, a veto value. Indeed, two indicators of the Pôle Viotte neighbourhood project deserve to be improved: *C7.3. Average distance to a cultural centre* and *P5.1. Annual hours of overheating*.
- The third is to pay particular attention to the indicators whose expected final situation result is lower than the initial situation or the initial objective. For the Pôle Viotte neighbourhood project, this is the case for indicator *P8.1 Degree of functional mix*.
- Finally, stakeholders involved in the project can look for indicators whose performance could be improved, such as those evaluated at the limit value (V_L). As an example, indicator *G3. Construction site—G3.2. Management of construction* disturbances could be better considered during the next upcoming work.

Essentially, taken together, the indicators embody different urban strategies used by the brownfield regeneration project to promote the transition towards more sustainable cities. The monitoring of sustainability—using evaluation of indicators and management functionalities—makes it possible to transcribe these various urban strategies and to visualize their performance through time. With the monitoring results and following the above considerations, SIPRIUS+ can support, in their decision-making, the stakeholders who are concerned about greater integration of sustainability into their regeneration project.

10.4 Towards Integration of Sustainability Issues into the Project Dynamics of a Neighbourhood in Transition

These monitoring results using SIPRIUS+ are, by definition, the portrait of a situation at a given moment. Hence, they are subject to change according to the evolution of the projects. In other words, the monitoring makes visible urban changes within the neighbourhood in transition. It provides useful information to integrate and pursue sustainability objectives throughout the regeneration process, thanks to global and detailed results. It can be used to iteratively compare different options, especially during the preliminary phases when the project is the most flexible and offers room for the integration of high-sustainability targets.

It is interesting to mention that the Pôle Viotte neighbourhood project is currently subject to considerable change that, unfortunately, could not be included in the present monitoring. Indeed, the development of the northern sector is on hold in the aftermath of the municipal team change after the election of 2019. Because the neighbourhood project is an important method of exploration to implement sustainable urbanistic and architectural solutions, the new political team wants to improve its sustainability objectives (reduce built density to increase green spaces, make a car- and parking-free area, etc.). In this case, the monitoring update promises to be interesting.

As a reminder, this monitoring was performed by the research team (LAST—EPFL) with the support of the case study's project manager (Direction Urbanisme Projets et Planification, Grand Besançon Metropole). To verify the potential of SIPRIUS+ as a support for the practical integration of sustainability in the Pôle Viotte neighbourhood project, we presented and discussed the previous monitoring results with different stakeholders of the development team (Laprise et al. 2018). The stakeholders agreed that SIPRIUS+ could contribute to maintaining sustainability objectives over the long term, much like a dashboard. They also agreed that SIPRIUS+ could be a relevant tool to build a shared vision on sustainability for the neighbourhood. In that sense, it could facilitate multi-disciplinary communication about this vision within the internal and external teams of the project. It could also facilitate communication with a broader audience, such as the population. However, divergences appeared among stakeholders about the level of information to communicate to the public. In the end, the stakeholders agreed that the monitoring provided by SIPRIUS+ could stimulate a willingness to improve and optimize the sustainability parameters of their project.

Ultimately, what emerges from these interactions is that, whereas the use of such a tool would imply a change in the management of the projects, the evolutions to adopt to include this practice appear not only feasible but realistic and desired. In this sense, the operational monitoring tool is expected to contribute to decision-making by facilitating unavoidable trade-offs in a multi-disciplinary manner, without giving ready-made solutions. However, at present, the monitoring tool is still not used regularly. It could be consulted on a yearly basis, for example, coinciding with the annual reviews. In any case, concretizing a sustainability vision and maintaining the objectives will always depend on the stakeholders' motivation and genuine involvement.

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