Inhabitable Infrastructures: A scenario towards sustainable energy in Berlin

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**Abstract.** Following the pattern of several megacities and European large cities, Berlin grows and changes at a fast rate. The fast transformations that cities are undergoing can no more be considered only a local phenomenon, since they have global implications: large agglomerations and megacities are drivers of climate change. Nevertheless, the increased tempo of transformations and technological innovation also triggers the city to regenerate its systems, opening a path for the emergence of new sustainable models. If these models succeed, their impact can be bold and effective on the reduction of global CO2 emissions and climate change, aiming to achieve Sustainable Development Goals (SDGs) such as affordable and clean energy, industry, innovation and infrastructure and sustainable cities and communities.

The fast growth has overloaded Berlin’s housing stock. In order for it to keep pace and relieve the real-estate market, the senate released the development plan “Berlin-2030”, which aims to create 200,000 new dwellings on the affordable housing sector by then.

Cities consume 80% of the energy produced worldwide and produce approximately 85% of global emissions of greenhouse gases. According to the Energy and Climate Protection Program developed by the Senate, Berlin aims to become climate neutral by 2050. By now the city is far behind in its tempo for achieving its ambitious goals.

This paper investigates a scenario for Berlin involving housing co-operatives and stakeholders from the energy sector joining efforts. It explores a system that operates with a building kit for housing developments with optimized elements for energy generation in order to increase production of new socially sustainable affordable housing and a energetic production – consumption simulation. This scenario explores the creation of the housing co-operatives 4.0 and simultaneously the establishment on a long-term basis of an ecologically sustainable virtual-power-plant grid driven by renewable energy sources and a pumped hydroelectric energy storage (PHES) system.
1. Introduction

Germany and mainly the city of Berlin are currently undergoing crises in the energetic and housing sectors and have set big challenges towards a more resilient and sustainable future and in order to achieve several of the sustainable development goals (SDGs). Due to rapid population growth and the effects of digitalization, the speed of changes in these sectors is also growing and the city needs to react fast in order to catalyze these changes.

This paper describes the current situation on the housing and energy sectors in Berlin and approaches the topic from an architectural perspective. It addresses these challenges by speculating on future scenarios through the construction of new buildings can foster and direct the development of the city in the right direction, the one that makes it possible to overcome the challenges in a collective and resilient way by combining following SDGs 7, 9 and 11: affordable and clean energy; industry, innovation and infrastructure; and sustainable cities and communities.

1.1. Problem statement

Germany is determined to reduce its carbon dioxide (CO2) emissions complying with the Paris Agreement and COP21 and following the SDGs. Despite the current investments in renewable energy sources and research in green technologies, the country’s Total Primary Energy Supply (TPES), which is the full amount of primary energy that is at the disposal for consumption, is in its great majority generated by fossil fuels. In Berlin the TPES is also predominantly composed by fossil fuels, such as coal, natural gas as well as primary and secondary oil. This scenario hasn’t yet changed significantly in the last decade, according to the International Energy Agency (2019).

On a regional level, city of Berlin plans to be climate neutral by reducing its CO2 emissions by 85% until 2050 (Senate Department for Urban Development and the Environment, 2014). Another big challenge is in the housing sector. The fast population growth has overloaded Berlin’s housing stock and in order for it to keep pace and relieve the real-estate market, the Berlin Senate released the development plan “Berlin-2030”, which aims to create 200.000 new dwellings on the affordable housing sector by then, around 20.000 per year (Senate Department for Urban Development and the Environment, 2013).

In order to approach these two important challenges towards social and environmental resilience in the sectors of housing and the energy generation, this paper will later focus on a design scenario and energy simulation that can help accelerate initiatives that are already partly taking place through the energy transition from fossil fuels to renewable sources as well as through the construction of housing by joining efforts of these two sectors in Berlin. How are these massive foreseen transitions going to take place in this tempo? How will they be implemented in Berlin? Before that, the current housing and energy situation in Berlin will be addressed.

Furthermore this paper shows the ongoing simulation of a scenario that quantifies, analyses and discusses electricity generation by renewable sources within a distributed grid and is integrated in the scale of an eight-stories building, serving as nodes of the electrical grid. The proposed system is balanced by a small scale system of pumped-hydroelectric-energy-storage (PHES), integrated at the scale of a building as water reservoir.

1.2. Methodology: scenario constrains and simulation

For this study a simulation was done to compare and evaluate the electricity usage to the generation potential of a small scale PHES system within a grid of renewables.

For the residential electricity usage in Berlin, a generic building was created in order to generate a consumption profile and consumption values. Beyond that, design strategies that influence energy consumption values can also be tested this way and geometric rules can be easily stipulated and tested. For this part of the simulation a virtual 3D-model of the building was created using the software REVIT. The add-in Sefaira was used for the estimation of electricity usage in kWh and light incidence, using climatic data for Berlin and the definition of energy-relevant configurations, such as residential usage profile, wall material, window material, building orientation, light incidence area, heating technology and area of photovoltaic panels.

The Energy analysis shows the average consumption of electricity in kWh for every month. For this study the consumption of January and July were considered, as referential for winter usage and summer usage.

In order to ascertain how effective the proposed system with a PHES would be, the energetic potential of an upper reservoir above a building was also calculated and compared to its consumption through the following formula (Hendrick & Silva, 2016):
Amount of energy (Joule) = \( E = p \cdot V \cdot g \cdot h \)

Where \( p \) is the density of the water (kg/m\(^3\)), \( V \) is the volume of the reservoir (m\(^3\)), \( g \) is the gravitational acceleration (m/s\(^2\)) and \( h \) is the head, related to the height of the tower (m). The constant \( p \) is 1,000mk/m\(^3\) and the constant \( g \) has the value of 9.81m/s\(^2\).

2. Housing and energy

2.1. Current state: housing co-operatives

Berlin and Germany have a long tradition of building cooperatives as a local real-estate development model generating co-housing projects, many of them being in the affordable sector. According to Ache & Fedrowitz (2012) “Co-housing is not just a physical form, but a certain form of daily practice. Additional characteristics are the strong involvement of the future inhabitants during the conceptual and planning phase, a kind of contract that formulates the sense of community, or communal spaces in addition to individual units.” The housing co-operatives play an important role on the social resilience in the city by producing affordable housing on a local scale and contributing to the creation of communities and neighborhoods. The inhabitants of co-housing projects usually have a closer commitment and social life. The co-housing projects in Germany vary in a size range of single small buildings with less than 10 housing units or even sometimes three or four buildings together to the scale of city districts with for example 300 households and about 800 inhabitants (Ache & Fedrowitz, 2012).

2.2. Current state: the energy transition

In past years, the city of Berlin sold considerable part of its land. Due to the lack of cheap land and therefore affordable housing units, about 80 housing co-operatives in Berlin are currently actively organized in order to claim towards the Berlin Senate either more financial incentives from the city for buying land or for direct offers to buy land from the city in order to develop housing projects in the affordable sector. These cooperatives represent right now around 600,000 inhabitants in 200,000 housing units in Berlin, around one fifth of the whole population of the city (Jürgens, 2019).

On the other hand, CO\(_2\) emissions in Berlin by fields of action on the year 2010 were predominantly expended on the operation of buildings by almost the half and due to consumption in households Senate Department for Urban Development and the Environment, 2014). Compared with the same statistics for the whole country, the buildings and households in Berlin account for more than double as much as the German average of energy consumption. Other fields of the total consumption included traffic and economy.

For the two predominant fields, the origin of the emissions are due to two main factors: on the one hand the consumption of electricity by electrical appliances such as computers, servers, dish washers, refrigerators, hair driers, among others, and on the other hand the generation of heat for daily uses such as for the personal hygiene and room heating. Main energy carriers for energy consumption in Berlin are fossil fuels, and it is above the country average.

The grid infrastructure of the city is constructed and maintained due to a concession since the 1997 made by the city and since 2001 with vast majority by the Swedish energy producer Vattenfall. The subsidiary company that operates the distribution grid in Berlin is called Stromnetz-berlin. After the infrastructural connection with the grid, 514 electricity suppliers in Berlin provide the 2,350,000 registered final users with electricity, being them households, businesses or industries. (Stromnetz Berlin, 2019). The vast majority of the power plants located in Berlin and surrounding area are owned by the Swedish company Vattenfall, followed by the German company EnBW. They are the biggest suppliers of the city and the energy generated by these power plants is predominantly out of fossil fuels. (Fraunhofer ISE, 2019)

The electricity generated by them is then distributed through a linear grid. The length of the grid in Berlin accounts for more than 35,000km and has an annual cost for its maintenance and expansion of more than EUR 187,000,000. In Berlin the grid is fed in average with 13.6TW per hour. Within the grid, there are at least two types of conversions necessary from the generation until the consumer is reached. The grid is divided in 3 sub-grids with different voltages, depending on the generation origin of the energy and distance of transmission and distribution. The electricity is transformed from a maximum of 380,000Volt by the generation until the low voltage sub-grid that supplies households of 400Volt. (Stromnetz Berlin, 2019) For the conversion between the sub-grids, a transformer that operates with direct current (DC) is used. This is the same current type
produced by most types of generators. Due to the high voltage and demand to overcome high distances with a high voltage, the current used is alternated (AC).

The following future scenario for Berlin speculates on two paths: on the one side by actively operating on the construction of new buildings (through the implementation of smart building components) by the housing co-operative 4.0 towards new forms of commons and furthermore rethinking the housing typology towards a new relation between humans and energy.

3. New commons: living in a power plant

In order to increase and distribute the amount of generators of renewable energies and multiply its impact on the TPES, the scenario of inhabitable infrastructures speculates on an architectural approach towards the energy transition. Energy generators that use renewable energy sources are incorporated in fundamental parts of the architecture of housing units and introduced in the construction market as a designed building kit. The several active power-producing components are connected and create a circular energetic system. A virtual power plant for instance is by definition “[...] a cluster of dispersed generator units, controllable loads and storages systems, aggregated in order to operate as a unique power plant. The generators can use both fossil and renewable energy source. The heart of a VPP is an energy management system (EMS) which coordinates the power flows coming from the generators, controllable loads and storages. The communication is bidirectional, so that the VPP can not only receive information about the current status of each unit, but it can also send the signals to control the objects.” (Saboori & Mohammadi & Taghe, 2011).

Everyday activities of households and buildings assimilate and include sources of energy that can be transformed into electricity and heat for their own use. One of the energy sources is for instance geothermal, which is in the building kit directly implemented in fundaments of buildings. Berlin is located in the area of the North German Basin, which is a region with hydrothermal resources, which can be used for space heating and even generation of electricity (Agemar & Weber & Schulz, 2014). Solar energy is captured by photovoltaic panels, which are incorporated in facade elements as well as roof elements and is a great potential of energy generation. The amount of solar energy in zettajoules that reaches the surface of the Earth in a period of less than five days is equivalent to the amount of latent energy stored in all known reserves of fossil fuels of the planet. Furthermore the amount of solar energy incidence every day is extremely high in comparison to the total consumption of humanity. If 0.1% of the total daily incidence could be captured, all this energy would still be six times bigger than the daily consumption of the whole world. And this is achieved without emissions of carbon dioxide (Naam, 2019). A latent potential is wind energy, which is captured by small turbines integrated on facade panels and on rooftop tiles, where they can be are activated through wind corridors. Another source of energy is biomass, resulting from the burning of waste and excrements in order to generate electricity and heat. Most buildings use water as carrier of heat spaces, which is why hydropower is also one of the renewable sources incorporated in the building kit. The vertical movement of water (pumped or released by gravity) activates small turbines combined in water channels and generates power.

3.1. Simulation results and Discussion

As a strategy of simplification of the computer simulation only photovoltaic panels were incorporated to the simulation of the virtual power plant. For this analysis, solar panels were integrated with optimized orientation and inclination of -30 degrees south. The stipulated area for this study is 1000sqm.

For this scenario, the profile of electricity usage for the city of Berlin was calculated using the add-in Sefaira for the software Revit and is based on a specific typology of a solitary building. The typology has a variable number of stories. Its volume is divided in a massive core and a habitable ring around. For the PHES system an elevated water reservoir is needed. The core is formed by the vertical circulation structure (staircase and lifts), supports the water upper water reservoir as well as its necessary infrastructure of pipes, turbines, electricity generators and cables from the roof to the underground. The outer ring hosts the housing units, facade and roof. Each floor has 12 habitation units and an area of 970sqm. There are two sizes of units: 35sqm and 65sqm. On the facade and roof energy collectors were placed. The openings on the facade have different sizes, varying between 3,50m-4,50m wide and 1,90m high (see figures 1 and 2).
Annually most of the area of the housing units for this specific building is naturally underlit and has an annual average energy consumption of 30 kWh per sqm. The total electricity usage can be seen in the following table and diagram and is of approx. 345,000 kWh per year (see table 1).

| ENERGY RESULTS - MONTHLY USE BREAKDOWN                        | Heating (kW) | Cooling (kW) | Heat Reject (kW) | Fans (kW) | Interior (kW) | Pumps (kW) | Other (kW) | Total (kW) |
|---------------------------------------------------------------|--------------|--------------|------------------|-----------|---------------|------------|------------|------------|
| Month, AHU, Humidificant Zones                                | AHU          | AHU          | AHU              | AHU       | AHU           | AHU        | AHU        | AHU        |
| January                                                       | 67           | 12018        | 66               | 85        | 1691          | 452        | 13750      | 6875       | 1063       | 0           | 30687      |
| February                                                      | 56           | 10083        | 73               | 94        | 1537          | 390        | 12485      | 6342       | 960        | 0           | 31900      |
| March                                                         | 27           | 4897         | 172              | 222       | 1768          | 273        | 14259      | 7129       | 1063       | 0           | 29830      |
| April                                                         | 6            | 997          | 439              | 565       | 1537          | 166        | 12650      | 6325       | 1029       | 0           | 23734      |
| May                                                           | 1            | 220          | 1257             | 22        | 1620          | 234        | 14259      | 7129       | 1063       | 0           | 27573      |
| June                                                          | 0            | 1            | 1860             | 65        | 2399          | 1691       | 325        | 13667      | 6834       | 1029       | 0           | 27871      |
| July                                                          | 0            | 5            | 2061             | 88        | 2657          | 1614       | 359        | 13241      | 6621       | 1063       | 0           | 27709      |
| August                                                        | 0            | 0            | 2243             | 88        | 2892          | 1768       | 387        | 14259      | 7129       | 1063       | 0           | 29829      |
| September                                                     | 0            | 24           | 1127             | 11        | 1454          | 1614       | 189        | 13159      | 6579       | 1029       | 0           | 25186      |
| October                                                       | 3            | 535          | 546              | 0         | 704           | 1691       | 158        | 13750      | 6875       | 1029       | 0           | 25325      |
| November                                                      | 30           | 5405         | 145              | 0         | 187           | 1691       | 279        | 13667      | 6834       | 1029       | 0           | 25257      |
| December                                                      | 52           | 9324         | 91               | 0         | 117           | 1614       | 381        | 13241      | 6621       | 1063       | 0           | 32504      |
| Annual Total                                                  | 242          | 43489        | 10080            | 274       | 12996         | 19984      | 3593       | 162387     | 81193      | 12517      | 0           | 346755     |

The usage in the winter (for January) is of ca. 35,000 kWh and 25,000 kWh in the summer (for July), mostly due to cooling efforts. These values account for the average power (kW) that is running through the grid every hour in order to supply the housing units with electricity (considering heating).
The monthly energy mix for the 1000sqm of photovoltaic panels varies between the seasons (see diagrams 1 and 2). The prototype building used in this study has a facade area of approx. 610sqm (south orientation) and a roof area of 1.150sqm. Therefore the implementation of 1000sqm as proposed here is a suitable and realistic area. The numeric amount of energy produced by the panels can be seen in the table 2, as following. Its power generation covers approximately 5-10% of the usage in the winter and approximately 40-45% of the usage in the summer.

Table 2: energy results from simulation by plug-in Sefaira. (source: author)

| Month   | Electricity | Gas | Solar PV | Non-renewal | Renewable (i Total) (kWh) |
|---------|-------------|-----|----------|-------------|--------------------------|
| January | 27734       | 8332| 2296     | 38362       |                          |
| February| 24069       | 6931| 4668     | 36568       |                          |
| March   | 26926       | 2884| 8374     | 38184       |                          |
| April   | 23472       | 242 | 16122    | 39836       |                          |
| May     | 27573       | 0   | 20978    | 48551       |                          |
| June    | 27870       | 0   | 21098    | 48968       |                          |
| July    | 27708       | 0   | 22115    | 49283       |                          |
| August  | 29828       | 0   | 18864    | 48692       |                          |
| September| 25186      | 0   | 11430    | 36616       |                          |
| October | 25325       | 0   | 6804     | 32129       |                          |
| November| 25954       | 3311| 3381     | 32648       |                          |
| December| 26243       | 6262| 1775     | 34280       |                          |
| Annual Total| 318788   | 27964| 137905 | 484657      |                          |

3.2. Sizing the Reservoir
Considering that the building has 6 floors, the head of the reservoir is in this case is 20m. Therefore the Volume of a reservoir that has the same perimeter as the building and a height of 1m can be calculated as following:

\[
\text{Volume} = V = 34m \times 34m \times 1m = 1156m^3
\]

\[
E = 38.259.000 \text{ Joule}
\]

Since 1kWh is equivalent to 3.600.000 Joule, then:

\[
E = 10,6275\text{kWh}.
\]

For this study, two sizes of reservoirs were considered, the height of 1 story and of 3 stories, which accounts for 3m and 6m respectively. Their volume and amount of energy saved in it would be as following:

Volume V = 34m × 34m × 3m = 3468m³

\[
E = 680.421.600 \text{ Joule} = 189\text{kWh}
\]

Volume = V = 34m × 34m × 6m = 6936m³

\[
E = 1.360.843.000 = 378\text{kWh}
\]

If the head of the reservoir increases, as in the case of a building with 8 stories, to the value of 30, the amount of energy saved would be as following:

Volume = V = 6936m³

\[
E = 2.041.265.000 = 567\text{kWh}
\]

In order to define an appropriate dimension for this system in the scale of a building, a selection of turbines with generators was also taken into consideration form two different producers. Pico hydropower turbines usually have can generate power between 100W and 1,1kW each unit. On the other hand, micro hydropower turbines can generate power between 1kW and 50kW per unit. Therefore between 20 and 50 pico-turbines with generators would manage to produce power in the total or maximum capacity of the reservoir and building PHES. At the same time, one or two of these micro-turbines with generators would be able to operate the system in its full capacity. If less turbines, pipes and generators are necessary to implement the system with the same capacity, then there will be fewer losses in the energy saved in the water due to friction.
3.3. Production chain of building components

The local production allows energy to be generated, stored and consumed locally; avoiding the usual waste caused by voltage and current (direct/alternated) conversions due to long term transmissions and centralized generation and supply systems. For the fabrication of the building kit, research institutes and power companies, which have a strong market presence in Berlin and Germany should potentially be involved as stakeholders due to their investment in research and technological know-how for energy generation. This way housing cooperatives benefit from economies of scale for the building components. The integration of the technical fit-out (conventional cables, wires and pipes) directly on the building components allows the construction prices to decrease, eliminating the subsequent addition of the infrastructural layer to walls and structural components. Studies also foresee that the technologies for harvesting energy from renewable sources in small scale will be as cheap as laptops in the next 10 years. After establishing the grid, the costs of producing energy in a circular way almost reaches zero, since the sources are renewable and coexist with the environment (Rifkin, 2015).

3.4. Supply and management: housing co-operative 4.0

These single strategies of energy generation need to be implemented in a larger scale in order to allow its operation, work therefore effectively and have a bold impact achieving SDGs. They do not work as isolated entities due to the need of balance in the energy production and consumption, therefore fostering the formation of a collective, a new common between the inhabitants. For this reason their implementation is significantly interconnected to housing cooperatives in Berlin, more specifically to the concept of the housing cooperative 4.0.

The virtual power plant ultimately allows housing units and buildings of the cooperatives 4.0 to create a new form of commons and consume their own renewable energy or trade it with other inhabitants, buildings, co-operatives or the general grid in Berlin. It is relevant for the operation of the virtual power plant to rely on the generation of energy by different renewable sources, since they are usually conditioned to natural (predictable to a certain degree) factors such as weather seasons and can complement each other in combination with batteries, balancing therefore the smart grid and supplying the consumers with energy. The grid also benefits from a greater number of generating and consuming units connected to it in order to ensure its stability. The generation of energy is not constant, but happens on demand, avoiding energy peaks as well as waste of potential thanks to the smart responsive peer-to-peer grid and its management through blockchain.

The ability of managing the grid and energy generation transforms the inhabitants of the cooperatives into shareholders that produce, retail and consume energy. From consumers they become prosumers (Läpple, 2016). Each inhabitant decides whether and how the energy produced by their habitual unit should be used or for instance traded to their neighbors while they are on holidays during the summer for example. Not necessarily wasted or switched off, as it would happen in an isolated case of power generation by renewable sources.

In order to allow prosumers to trade their energy between each other, the housing co-operative 4.0 benefits from the computer platform based on blockchain. Smart contracts are self-operating and regulate in this case the exchange and sharing of energy in the network through the use of interactive applications and user interfaces. The decentralized grid is also more reliable, as can be understood in the following quote. “In this model, computing power aggregated form that of individual machines becomes immanent to the network itself. [...] It serves as a platform for networked applications that run on a decentralized, peer-to-peer basis, rather than the more conventional client-server model. With such distributed applications (or, cloyingly, “dapps”) there is not a central server, not only one physical place where the program resides, and therefore no single point of failure.” (Rifkin, 2015).

Related to these alterations in the architectural components, the spatial arrangement of living can be reorganized by the human interaction with energy (heat and electricity), which will be able to fulfill human needs in always lower and lower voltages in the future. There is a commercial push toward smaller, higher performance portable systems for computing, communication and lighting. Energy will therefore have another meaning, incorporated in the new housing typologies for the housing co-operatives 4.0. A new understanding and relation to energy emerges with time, not based on the fear of the electrical current, but rather on the immaterial character, lightness and responsiveness that the lower voltage in combination with sensors and Internet of Things (IoT). On a smaller scale, responsive surfaces and small electrical devices can harvest their energy from the environment around them, as for instance using piezoelectric elements, thermoelements (body heat as an energy source) or using radio frequency (emitted by phones and Wi-Fi) for power production, not necessarily depending on batteries or energy supply from cables (Twentyman, 2019).
3.5. Results of the simulation and considerations
The generated amount of 567kWh is much lower than the average usage in the building in general. According to the analysis in Sefaira, the average annual energy consumption for this building is 30kWh per sqm. As a comparison: according to the Deutsche Energie-Agentur, the annual average energy consumption in Germany lays currently at approx. 85 kWh per sqm. This high value is mainly due to the building stock in the city that was in big part built until 1979. In absolute values, an apartment of around 20sqm could be operated by this reservoir, which would mean one of the planned smaller housing units in this building.

On the other hand, once the reservoir would not be able to supply the whole building as a standalone source of electricity generation, it should be although considered as an alternative to overcome and balance the generation of electricity between different renewable sources.

On a daily basis, the solar energy directly prevenient from photovoltaic panels can only be retrieved during the day in occasion of a sunny day and clear sky. Other sources would definitely play an important role in complementing the generation and allowing for covering the usage during the nights as well as during the winter months or cloudy days. Other sources include geothermal, wind turbines and energy generated from biomass in the several points where waste is being burned to ashes in the city. When a surplus of energy is generated by these sources, the grid does not need to shut some sources down in order not to overload, but it would instead use this surplus to pump the water to the upper reservoirs.

Concerning the building geometry, architectural design measures such as increasing the openings, changing the materiality of the external walls and integrating a heat-pump system can improve the performance of the building, resulting in lower average annual energy consumption.

Other typologies could also be implemented in order to decrease even more the usage. The consideration of different renewables and their balance during the time-frame of a day or of a week would also be of great relevance in order to discuss whether the PHES system in a building scale can be a considerable and reasonable strategy for balancing fluctuations in the generation and usage of these sources of energy (such as the ones listed above). It would also be valid to test the average generation for a case in winter and in summer.

4. Conclusion
Following up the results of the simulations and comparison of the magnitude of electricity usage and production, a timeframe and some constrains for a scenario were more accurately determined. Furthermore, other changes in the building design would generate other simulation results to be considered and compared as a next step. Systemic changes in the building infrastructure and on a network of buildings would also contribute to the viability of this kind of system within the framework of the housing cooperative 4.0.

Changes in the infrastructure usually require large scale and large capital requirements and small business might not have the capacity to engage to the project and the process of building it, which is many times undertaken by state collaborations with/and large corporations. These changes do though modify the economic landscape that small entrepreneurs operate within. The co-operative 4.0 creates another business ecosystem and expands the notion of commons by creating a decentralized grid, which contributes to the achievement of both “sustainable cities and communities” and “affordable and clean energy” SDGs. Besides that, production of several everyday low-voltage electrical devices and small renewable power generators is growing and their price is getting lower as times passes by. Their incorporation in everyday life might also relieve the energy consumption in households and open space for living typologies. It is ultimately a different and smarter understanding and approach to the resources on earth.

Once the cooperatives can offer something back to the city, their contribution should be rewarded in a regulated form of currency, therefore create incentives towards the city, in order for example to secure cheap and strategically positioned land for affordable housing. It opens a potential to finance new projects when selling energy back to the city, when contributing strategically to reduce carbon dioxide emissions, multiplying the city’s potential to contribute and achieve its established goals for climate change mitigation.

Rebuilding and completing the energetic infrastructure in a smaller scale for a new use through housing initiatives accelerates the energy transition to renewable sources in Berlin. It is a scenario for an update of the established energetic system by adapting the role of the energy industry. The technology allows energy and information to be distributed for all in a distributed system at almost no (operational) cost, since it is available in nature and the industrial production costs are falling
very fast due to scalability. The cost for the maintenance of a smaller grid is also lower, because the bigger distances that electricity needs to travel, the bigger amount of losses and the more expensive the whole grid becomes.

This scenario is a basis for discussion on how these transitions could take place in Berlin by specifically helping the city achieve SDGs. The creation and strengthening of collaborative commons combined with the energetic transition and the distributed operation of the infrastructure using technological innovation contribute for social and environmental sustainability in Berlin and can help the city maintain its goals.

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