Indicators for capital and finance needs and replication potential

Deliverable D2.8

Version N°2

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Table of contents

List of figures

This project has received funding from the H2020 Research and Innovation Programme under the grant agreement n°101036519.

Abbreviations and acronyms

Acronym	Description
CAPEX	Capital Expenditures: money spent to buy, maintain, or improve fixed assets, such as buildings, vehicles, equipment, or land
OPEX	Operating Expenses: an ongoing cost for running a system

Summary

The indicators for capital and finance needs described below will form an important part for the Net Zero Cities for their Cost, Impact & Capital Planning as well as their Impact Monitoring Framework as part of the Investment Plan.

The economic case looks different for different climate mitigation measures; some provide great savings while others carry significant costs. In general, mitigation measures require substantial upfront investments, coupled with capital costs over time, whilst the savings arise from reduced costs of operations.

Usually there is an uneven distribution of costs and benefits among stakeholders which can be a a key barrier to the transition.

Keywords

Indicators, capital, finance needs

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1 Aim and Scope of the Deliverable

Identify relevant indicators for capital and finance needs for cities in their climate mitigation and the indicators replication potential

2 Introduction

The economic case looks different for different climate mitigation measures; some provide great savings while others carry significant costs. In general, mitigation measures require substantial upfront investments, coupled with capital costs over time, whilst the savings arise from reduced costs of operations. This holds true for a variety of measures across the different impact domains, such as new investments in renewable power generation, grid improvements that reduce transmission and distribution losses, electric vehicles that replace internal-combustion vehicles, energy efficiency measures in the stationary environment as well as some investments that improve the circularity of waste management.

The financial case looks to maximize the use of public and private investment capital towards accelerating the transition to net zero for cities. It will scope out the applicability of funding mechanisms across national and local programs, as well as sustainable financial instruments such as green bonds, green mortgages, revolving funds and others.

The purpose of financial indicators is to assess the need for capital sources, to monitor their effective use throughout the journey to reach climate neutrality, and to optimize their allocation over time to maximize impact. The indicators will form an important aspect of the Cost, Impact & Capital Planning as well as the Impact Monitoring Framework as part of the Investment Plan currently in development. Such indicators can include the ratio between public and private capital allocated towards climate neutrality, or percentage of capital allocated towards climate neutrality over total budget. The set of indicators will allow financial and funding stakeholders to monitor the cities' success in their use of climate capital over time.

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3 Indicators

3.1 Economic Indicators

In order to measure change in a city's decarbonization policy today, indicators of the required initiatives are more valuable than projecting the eventual emissions reduction. Most cities track carbon emissions. However, this data is often available a few years after the emissions have taken place and is by nature a measurement of the result of actions rather than a measurement of the activities themselves. Relevant activities for decarbonization are categorized into transportation, electricity and buildings. There are four main economic indicators a city can use:

- Energy Generation/Electricity
- Transportation and Mobility
- Stationary Environments/Buildings
- Circular Economy/Waste

1. Energy Generation/Electricity - Direct Costs and Savings

Decarbonised electricity is a powerful solution for reducing energy-related emissions and a key enabler for emissions reductions in other sectors as they electrify over time. This solution includes various demand-side measures that decrease the scope-2 emissions from electricity use, including increased adoption of distributed renewable generation (such as solar PV) and increased purchasing of certified green electricity from utility-scale wind/solar-PV farms. For some cities, electricity use stands for 50% or more of their total greenhouse gas emissions

Capital costs to decarbonize energy generation and distribution are mainly related to the electricity grid. Savings can come from renewable energy generation, e.g. large-scale utility solar/wind, are getting cheaper and cheaper, and OPEX are lower than for fossil alternatives in many cases.

Costs from transitioning the energy generation to green energy can be estimated by taking the CAPEX and OPEX per kWh energy shifting from fossil to green generation and multiplying it with the total amount of energy (in kWh) that is shifting.

2. Transportation and Mobility - Direct Costs and Savings

Reduced passenger transportation need has great potential in reducing both CO_2 emissions and externalities (air pollution, accidents, noise) from passenger transportation by passenger cars and public transport. This primarily occurs through urban planning to reduce transportation by placing residential homes and work close to each other as well as the increased digitisation of work and meetings.

A shift to public and non-motorised transport favouring public transport, walking, or cycling can significantly decrease travel emissions. Cities may achieve this by enhancing the appeal of alternative means of travel, for example, by improving roads and routes for bicyclists and pedestrians and improving the availability, quality and cost of public transportation options. This tends to be a very cost-effective solution for society as it, like the previous one, reduces both CO2emissions and externalities (air pollution, accidents, noise) and thereby generates significant health benefits, especially when switching to active mobility (walking/cycling).

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Increased carpooling would increase the utilisation of cars (average number of passengers per car) independent of the transportation need and thus reduce the overall vehicle kilometres and the associated emissions and negative externalities. In addition to the benefits to society, carpooling reduces the up-front investment need for car users on average, as more people share the same cars.

Electrification of passenger cars is one of the most promising solutions in the long term. Electrification eliminates 100% of the tailpipe emissions (CO2, NOx, and PM) that come from the combustion of fossil fuels. It is, therefore, a solution with enormous co-benefits. However, the total abatement potential also depends on the carbon intensity of the electricity used and the carbon footprint of producing the vehicle (mainly the battery). Taking these factors into consideration is essential when evaluating electrification as a decarbonisation solution.

Electrified buses eliminate 100% of the tail-pipe emissions and come with comparable benefits to passenger cars. Some co-benefits may even be higher per tonne of CO2abated, for example, PM emissions and noise.

Optimised logistics is one of the solutions that can reduce the negative impacts of freight transport in cities. By improving the utilisation of trucks (tonnes transported goods per truck) and optimising their routes, it is possible to greatly reduce the total vehicle kilometres and thereby the CO2emissions, air pollution and noise.

Electrified trucks could reduce most of the externalities associated with freight transport. Similar to the electrification of cars and buses, this solution eliminates tailpipe emissions when trucks shift from internal combustion engines to electric engines and batteries.

Capital costs can increase from investing in e.g., new electric vehicles and charging infrastructure. Savings on the other hand, can come from e.g., the generally lower fuel and maintenance costs of electrified vehicles compared to ICE (internal combustion engine) vehicles depending on the price of electricity.

Calculation methodology depends on the type of implemented action. For example, cost of electrifying the vehicle fleet can be calculated as the number of vehicles that shift to electric multiplied by the cost increase of buying an EV compared to an ICE. Savings could then be calculated as the number of vehicles electrified multiplied by the average distance travelled per vehicle, and then multiplied by the average savings per kilometre travelled (from driving on electricity compared to fossil fuels)

3. Stationary Environment/Buildings - Direct Costs and Savings

Building envelope renovations help deal with the significant emissions of CO2and air pollution in cities by reducing the large amount of energy needed for heating. With this solution, the heat demand for space heating and domestic hot water is reduced for the existing building stock by addressing heat losses (excluding heat supply) via extensive heating renovations (e.g., windows, insulation, etc.). The aggregated CO_2 reduction potential of envelope renovations are great as Europe has many old and poorly insulated buildings. Still, it can also be very costly, with some renovation cases much more expensive than others.

Energy-efficient new buildings are costlier than their counterpart but offer meaningful energy savings over a long period. New buildings already have to align with the minimum building standards. Still, improvements that raise the energy performance to higher standards than required can come with many benefits in cost savings and CO2emissions reduction over time.

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With this solution, the heat demand for space heating and domestic hot water is reduced building new buildings.

Efficient lighting and appliances are both important as old units use much more energy on average than the latest efficiency standards, are relatively easy to upgrade and even have negative abatement costs in many cases. Instead, the challenge for cities lies in identifying how the costs and benefits can be appropriately redistributed, as citizens now bear the cost but stand little to gain from spending extra money on lighting and appliance efficiency.

Fossil-free heating is, in many cases, one of the most critical steps to reduce a city's emissions since the aggregated energy demand and the associated emissions can be substantial. Heating in cities is often produced through a mix of fossil fuels, electricity (e.g., heat pumps), and biobased fuels. The heating can either be produced locally or centralised as district heating. Eliminating fossil fuels from the heating system is a solution with high CO2abatement potential, which also positively impacts air quality if generation shifts to, e.g., heat pumps with low-CO2electricity.

Capital costs can stem from retrofitting/renovating buildings/facilities to increase energy efficiency, as well as building new buildings/facilities more energy efficient. Cost savings come from reduced energy consumption in the retrofitted/renovated or new energy efficient buildings/facilities.

Costs can be estimated by taking the cost in EUR per square meter for renovations/new energy efficient buildings and multiply it with the total number of square meters.

Savings can be estimated by taking the difference in energy consumption per square meter renovated/built energy-efficient and multiply it by the total amount of square meters renovated/built, and then times the cost of energy (in EUR/kWh).

4. Circular Economy / Waste - Direct Costs and Savings

Increased costs can be generated from increased waste collection, sorting, and recycling. On the opposite, increased recycling can generate revenues from re-selling materials that would otherwise be landfill/incinerated. Furthermore, improved waste management can help the city to avoid penalties.

Costs can be estimated by taking the cost of waste collection/sorting/recycling (in e.g., EUR per tonne waste) and multiplying it by the increased amount of waste collected/sorted/recycled (in tonnes).

Overall, the challenge is to incentivize different stakeholders to do the investments required to decarbonize as some may need to invest more than others and savings are spread unevenly across the different stakeholders.

Examples of indicators for capital investments in city decarbonisation are shown in Figure 1 below.

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EXAMPLE

Category	Indicator	CapEx (MEUR 2020-2030)	Indicator unit	Indicator in 2020	Indicator in 2030	CO_2 reduction (Mt CO_2 2020-2030)	Description
Transportation	Electrification of cars	xx	% of total vehicle-kilometers electrified (alternatively % of fleet electric vehicles)	xx	xx	xx	Fleet of internal combustion engines increasingly replaced with battery electric vehicles
	Electrification of trucks	xx		xx	xx	xx	
	Electrification of buses	xx		xx	xx	xx	
	Shift to public & non-motorized transport	xx	% of passenger-kilometers as public transport or walking/cycling	xx	xx	xx	Public transport includes shift to buses and trains
Buildings	Major renovations[1] (excluding district heating)	xx	% of building stock deep energy retrofitted between 2020-2030	xx	xx	xx	Low CO_2 heat generation includes shift to electrical heat pumps
	Low CO_2 heat generation including district heating	xx	% of total heating demand supplied by renewables	xx	xx	xx	New buildings and renovation indicator based on EU Taxonomy
	Efficient lighting & appliances	xx	% of building stock retrofitted	xx	xx	xx	For example, washing machines
	New nearly zero-energy buildings (NZEB)[2]	xx	% of building stock composed of new NZEB[2] 2020-2030	xx	xx	xx	New buildings and renovation indicator based on EU Taxonomy
Electricity	Low CO_2 electricity generation	xx	% of total electricity production coming from renewables	xx	xx	xx	Shift from fossil to renewables such as wind and solar
Total		xx				xx	

1. EU Taxonomy Report: Technical Annex, EU Technical Expert Group on Sustainable Finance, March 2020, Page 380
2. Taxonomy Report: Technical Annex, Page 375 , "net primary energy demand of the new construction must be at least 20% lower than the primary energy demand resulting from the relevant nearly zero-energy buildings (NZEB)" requirements.

Figure 1: Leading Indicators for Capital Investments in City Decarbonization

Investment needs for cities

As a start, a city can look at a similar "sample" city based on previous work with cities, to identify where the majority of climate investments have taken place, either in the area of electricity, transportation or buildings. The sample city is selected by geographic location, inhabitants and GDP/capita and can be used as a first indication. Later the city can do a more accurate analysis based on their own local data.

The investment needs are categorized within electricity, transportation and buildings.

Electricity Cities with high fossil electricity typically require large investments in grid decarbonization. Investments in the electrical grid are in large proportional to the difference in renewables share projected for 2030 and that of 2020, with additional costs when the renewables share approaches 100% in 2030.

Transportation investments tend to be large for cities with a current vehicle fleet with high emissions per vehicle km, but also for cities who aim to push total fleet electrification above 90% by 2030.

Buildings typically represent the largest share of total emissions, and therefore also the largest share of total investments. Building investments are predominantly driven by investment in low CO_2 heat generation but in cities with already relatively low emissions per m^2, the investments shift towards renovation and in certain cases to construction of new very energy efficient buildings.

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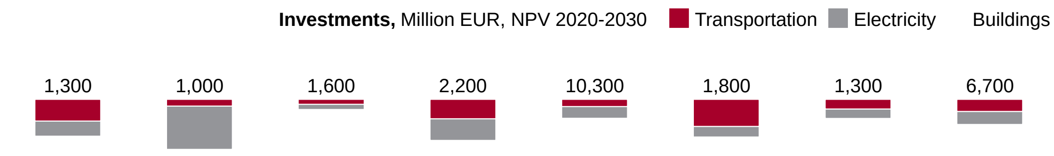

City	A[1]	B	C	D	E	F	G	H
Inhabitants (million)	<0.5	<0.5	<0.5	0.5-1.0	>1.0	0.5-1.0	<0.5	>1.0
Geography	Eastern Europe	Northern Europe	Western Europe	Eastern Europe	Southern Europe	Eastern Europe	Western Europe	Central Europe
GDP per capita	9,000 EUR	46,000 EUR	50,000 EUR	7,000 EUR	37,000 EUR	22,000 EUR	38,000 EUR	52,000 EUR
Invest. per capita	5,260 EUR	2,740 EUR	5,410 EUR	3,930 EUR	3,170 EUR	560 EUR	12,430 EUR	4,850 EUR
	• Very ambitious scenario • Focus on reducing building emissions through investments in low CO2 heat generation	• Large focus on electricity emissions bringing renewable share from 48% to 92%	• Very large focus on residential building emissions through extensive renovation	• Even spread of emissions reduction initiative • Large focus on transportation emissions as almost 95% electrification reached	• Only 12% of heating demand in buildings supplied by renewables resulting in investments in low CO2 heat generation in buildings	• Large transportation emissions due to large share of high- emissions trucks	• Large focus on building emissions driven by investments in low CO2 heat generation	• Large focus on building emissions driven by investments in building renovations and new energy-efficient buildings

1) City A exemplifies a very ambitious decarbonization scenario (vehicle electrification is almost 100% in 2030 for passenger cars, truck and buses and renewable share in electricity and heat generation also almost reaches 100% in 2030. This scenario should therefore be interpreted as a theoretical "visionary" pathway where deep decarbonization is carried out in all sectors.

Figure 2: Investment Needs for Sample Cities

A more detailed investment need for the sample cities can be found in the appendix.

3.2 Stakeholders

Investment costs and benefits may vary significantly across stakeholders. Uneven distribution of costs and benefits between stakeholder groups is a key barrier to the transition and need to be addressed in order to create a successful green transition.

Property owners are significant investors, but also yield some benefits from decarbonising local heating and electricity (e.g., through rooftop solar).

Citizens receive benefits from the investments they make, investments in infrastructure made by property owners, as well as health benefits from better air quality and increased walking/cycling. However, they might invest in electric cars.

Utilities will need to pay for investments in the country's energy systems, but also receive the benefits of lower operational costs from renewable energy sources

Healthcare providers receive indirect benefits from a healthier population without requiring any specific investments other than in renovations of their own properties

Transport operators reduce costs through optimised logistics and reduced transportation need, but must invest in/maintain new vehicles and an expanded public transport system

National/municipal governments typically cover costs for expanding transport infrastructure, lower land costs for developers building energy efficiently, and retrofits of publicly owned buildings.

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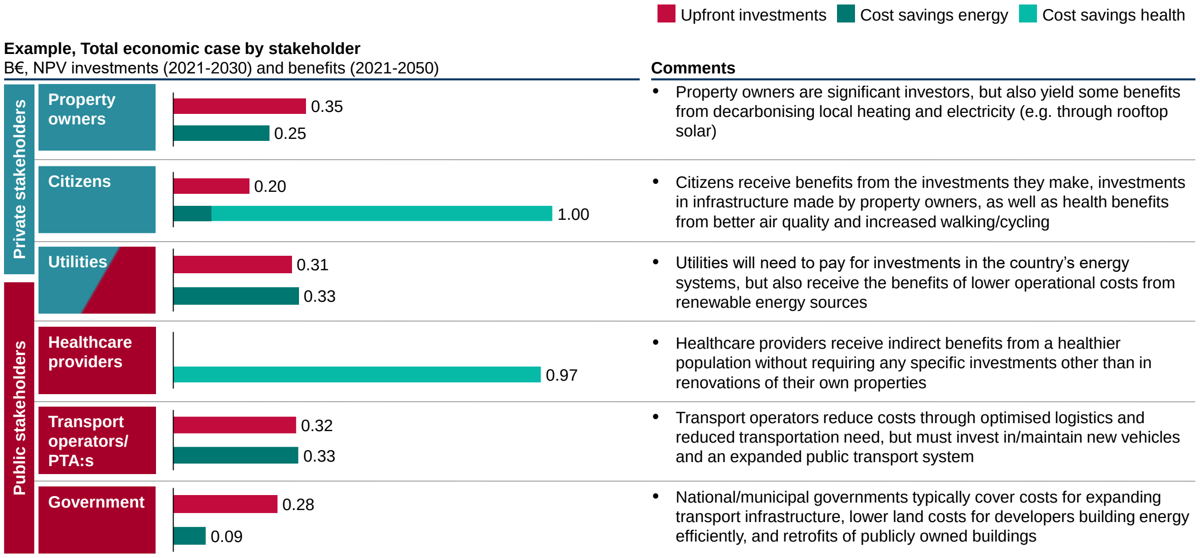

Figure 3: Uneven distribution of costs and benefits among stakeholders

3.3 Financial Indicators

The financial indicators created as part of the NetZero Cities Mission project, will act as key performance indicators (KPI) for financing actors within a city to optimize capital towards the city. Initially described in Deliverable 2.4, the below section explicitly identifies and describes the indicators selected for cities to optimise towards through their transition to carbon neutrality.

Four financial indicators have been identified to be applied in all sectors and at city-wide level. By aligning with the framework and applying them to the key emitting sectors within a city, actions taken to generate impact can be monitored, verified, and optimized over time towards the 2030 climate neutrality goal. These 4 indicators should be applied to every sector taken into consideration by the city (transportation, buildings, green infrastructures, energy, etc.).

The indicators are as follows:

(i) **Proportion of Green Capital invested by sector** - % of capital invested in a specific green sector in comparison to the total capital invested in that corresponding sector. The sectors taken into consideration in the Investment Plan are: “Transportation”, “Built Environment”, “Energy Systems”, “Green infrastructure and Nature-based solutions”, and “Waste and Circular Economy”.

This first indicator is the percentage of capital invested into climate-related projects within a specific sector as a percentage of the city’s overall spend within that sector. This is intended to measure the degree to which local financing actors (both public and private) are investing in the transition to climate neutrality. It can then act as a catalyst for additional investment to facilitate the transition.

Calculation: Capital invested in green activities in a specific sector/total capital within that sector

(ii) **Proportion of Green Capital invested overall** - % of capital invested in specific green aspects/activities of the following sectors taken into consideration in the Investment Plan: “Transportation”, “Built Environment”, “Energy Systems”, “Green infrastructure and Nature-based solutions”, and “Waste and Circular Economy”.

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This second indicator is the capital invested into climate-related projects as a percentage of the city's overall budget. It will enable the city to take a more macro view of its climate investment programme and the transition.

Calculation: Total capital invested in green activities within the 6 IP sectors/Total capital invested in the 6 IP sectors

(iii) **Private-to-Public Capital** - % of green private capital over total capital invested in the same sectors

The third indicator is the ratio of private capital to public capital allocated towards climate neutrality. Over time, the city should aim to optimize this multiple, which subsequently maximizes the allocation of investment capital raised towards the climate neutrality goal. Cities have found that the overall investment needed for net zero is higher and this indicator should highlight the different financial sources that are working towards this goal.

Calculation: Private capital in the 6 IP green sector/ total capital within the 6 IP green sector

Note: Cities may wish to consider this indicator on one-to-one sectorial base

(iv) **Carbon x Capital Invested** - Unit of carbon abated per unit of currency spent

The fourth indicator is how much of a single unit of carbon is abated per unit of currency spent by the city. The purpose of this indicator is to maximize the carbon reduction within key emitting sectors to accelerate the climate transition to net zero. The intended outcome of this indicator is to make public and private capital spending towards climate neutrality more efficient over time.

Calculation: Total carbon abated/total capital invested within the 6 IP sectors

Category	Indicator	Indicator unit
Transportation	Capital Investment	% of capital invested in green transportation (over the all-city budget)
	Private-to-Public Capital	% private capital to public capital ratio in green transportation
	Carbon x Capital Invested	Unit of carbon abated per unit of currency spent in green transportation
Buildings	Capital Investment	% of capital invested in green buildings (over the all-city budget)
	Private-to-Public Capital	% private capital to public capital ratio in green buildings
	Carbon x Capital Invested	Unit of carbon abated per unit of currency spent in green buildings
Electricity	Capital Investment	% of capital invested in green energy (over the all-city budget)
	Private-to-Public Capital	% private capital to public capital ratio in green energy
	Carbon x Capital Invested	Unit of carbon abated per unit of currency spent in green energy

Figure 4: Financial Indicators of Capital Investments in City Decarbonisation

4 Data Collection

Within the curation of an Action and Investment Plan, there will be a request to cities for data. The single data collection request will be structured in a way which initially allows cities to curate a series of actions to generate climate positive impacts, and then cost up those impacts and source the relevant sources of capital. Therefore, the alignment between data collection

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as part of the Climate City Contract (CCC) process and the economic and financial indicators is vitally important in generating action and impact towards climate neutrality 2030 targets.

An important vector of data which needs to be collected as part of the Action Plan, is the CO_2 emission inventory. This will allow cities to identify emitting sectors and select relevant actions to maximize impact. The emission inventory collected will then link to the Investment Plan, which aims to quantify the cost and capital required to generate the impact.

This interaction between emissions inventory as part of the Action Plan, and the cost and capital quantification within the Investment Plan will evolve and iterate over time. Within this dynamic, the indicators created above will act as optimizing figures that a city would look to maximize over time.

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5 Replication Potential

The financial and economic indicators should be replicable geographically and easily be used by other cities. The indicators are fully replicable for different cities, but the absolute values will differ for different cities depending on the structure of the transportation and energy system and current building stock. But with adaptations based on city-specific circumstances, the indicators can be effectively used to assess and track improvements across the city.

One thing to be keep in mind is that the aggregate abatement within one segment is usually less than the sum of the parts due to interactions. E.g. modal shifts, electrification and fuel blending impact should be quantified in relation to each other rather than standalone, to avoid double counting.

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6 Appendix

Below are the leading indicators for capital investments for two sample cities.

Category	Indicator	CapEx (MEUR 2020-2030)	Indicator unit	Indicator in 2020	Indicator in 2030	CO_2 reduction (Mt CO_2 2020-2030)	Description
Transportation	Electrification of cars	xx	% of total vehicle-kilometers electrified (alternatively % of fleet electric vehicles)	xx	xx	xx	Fleet of internal combustion engines increasingly replaced with battery electric vehicles
	Electrification of trucks	xx		xx	xx	xx	
	Electrification of buses	xx		xx	xx	xx	
	Shift to public & non-motorized transport	xx	% of passenger-kilometers as public transport or walking/cycling	xx	xx	xx	Public transport includes shift to buses and trains
Buildings	Major renovations[1] (excluding district heating)	xx	% of building stock deep energy retrofitted between 2020-2030	xx	xx	xx	Low CO_2 heat generation includes shift to electrical heat pumps
	Low CO_2 heat generation including district heating	xx	% of total heating demand supplied by renewables	xx	xx	xx	New buildings and renovation indicator based on EU Taxonomy
	Efficient lighting & appliances	xx	% of building stock retrofitted	xx	xx	xx	For example, washing machines
	New nearly zero-energy buildings (NZEB)[2]	xx	% of building stock composed of new NZEB[2] 2020-2030	xx	xx	xx	New buildings and renovation indicator based on EU Taxonomy
Electricity	Low CO_2 electricity generation	xx	% of total electricity production coming from renewables	xx	xx	xx	Shift from fossil to renewables such as wind and solar
Total		**xx**				**xx**	

1. EU Taxonomy Report: Technical Annex, EU Technical Expert Group on Sustainable Finance, March 2020, Page 380
2. Taxonomy Report: Technical Annex, Page 375 , "net primary energy demand of the new construction must be at least 20% lower than the primary energy demand resulting from the relevant nearly zero-energy buildings (NZEB)" requirements.

Category	Indicator	Indicator unit	Description	Calculation of cost			Calculation of savings				
Transportation	Electrification of cars	% of total vehicle-kilometers electrified (alternatively % of fleet electric vehicles)	Fleet of internal combustion engines increasingly replaced with battery electric vehicles	Number of vehicles shifted to electric	X	Increased cost of buying an EV compared to an ICE.	Number of vehicles electrified	X	Avg distance travelled/ vehicle	X	Avg savings/km travelled (driving on electricity)
	Electrification of trucks										
	Electrification of buses										
	Shift to public & non-motorized transport	% of passenger-kilometers as public transport or walking/cycling	Public transport includes shift to buses and trains	vv							
Buildings	Major renovations[1] (excluding district heating)	% of building stock deep energy retrofitted between 2020-2030	Low CO_2 heat generation includes shift to electrical heat pumps	Cost/ $meter^2$ for renovation	X	Total number of $meters^2$ renovated	Difference in energy consumption/ $meter^2$ renovated energy-efficiently	X	Total number of $meters^2$ renovated	X	Cost of energy (EUR/kWh)
	Low CO_2 heat generation including district heating	% of total heating demand supplied by renewables	New buildings and renovation indicator based on EU Taxonomy	xx							
	Efficient lighting & appliances	% of building stock retrofitted	For example, washing machines	xx							
	New nearly zero-energy buildings (NZEB)[2]	% of building stock composed of new NZEB[2] 2020-2030	New buildings and renovation indicator based on EU Taxonomy	Cost/ $meter^2$ for new building	X	Total number of $meters^2$ built	Difference in energy consumption/ $meter^2$ new built	X	Total number of $meters^2$ new built	X	Cost of energy (EUR/kWh)
Electricity	Low CO_2 electricity generation	% of total electricity production coming from renewables	Shift from fossil to renewables such as wind and solar	CAPEX per kWh energy shifting from fossil to green generation	X	Total amount of energy (in kWh) that is shifting					
Total											

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