young cities

Developing Urban Energy Efficiency
Tehrān-Karaj

Young Cities Research Briefs | 13

CO_2 Balance for Buildings and Transportation in Hashtgerd New Town and Tehran Region

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Abstract

Due to the very high energy consumption in the Tehran region, CO_2 emissions are also very high, with the residential and commercial buildings making up the largest share of 41% by 2008 and for transportation up to 25%.

This publication tries to estimate the results of different planning fields in New Town Hashtgerd and Tehran-Karaj region in Iran regarding the development of CO_2 emissions. Concerning this goal the expressiveness of the paper is limited to emissions caused by mixed-use-buildings, office-buildings and transportation.

In order to evaluate the project's impact in terms of CO_2 reduction, the emission savings through the implementation of Young Cities' project findings and recommendations are estimated. The CO_2 emissions of buildings and transportation are calculated based on their energy consumption, based on energy simulation, and the CO_2 emission factors for different energy carriers. First the specific CO_2 emissions are balanced for the project area of Hashtgerd New Town and then they are extrapolated for the whole former Tehran province.

The CO_2 emissions per capita and year are estimated and compared using two forecast scenarios for the year 2027 based on the preliminary results of the residential and office building as well as transport planning within the Young Cities project. The first scenario "business as usual 2027" visualizes the CO_2 emissions in 2027, with the development following the current trends in Iran. The second scenario "planning scenario 2027" forecasts the CO_2 emissions for 2027 assuming that two per cent of all new buildings are built according to the results of the Young Cities project and the suggested transportation system is implemented.

The comparison of these two scenarios indicates the possible reduction of CO_2 emissions for 2027 achieved through the implementation of the Young Cities' research findings. All areas monitored show significant potentials of possible emission savings which have been developed in the Young Cities project. It therefore appears that the implementation of the developed measures could lead to eminent energy and emission savings in comparison with conventional planning, construction and behavior approaches. Anyway it needs to be born that the results provided in this paper is based on simulation algorithms trying to represent real conditions as far as possible. As long as those estimations are based on various assumptions meanderings can

therefore not be excluded. To fulfill the requirements of an overall CO_2 balance in Hashtgerd additional energy intensive fields like industry, agriculture and power plant need to consider as well. Nonetheless the results of this paper underline the effectiveness of the developed approaches and emphasize ways of future development in the Tehran-Karaj region.

Conceptual Formulation

The aim is to calculate the CO_2 emissions per capita caused by mixed-use-buildings, office-buildings and transportation in Hashtgerd New Town and Tehran Region. Thereby different scenarios should be compiled and compared with each other.

1 Framework Conditions and Assumptions

1.1 Region

The calculation applies to the former Tehran Province, which has been divided in new Tehran and Alborz Provinces in August 2010 (Figure 1, the red colored space represents the former Tehran Province). The Region covers 18,909 km² including the Tehran-Karaj region with nearly 13.2 million inhabitants, which is the area with the highest population density in Iran. Approximately 86.5 % of the population lives in cities and 13.5 % in rural parts of the Region.

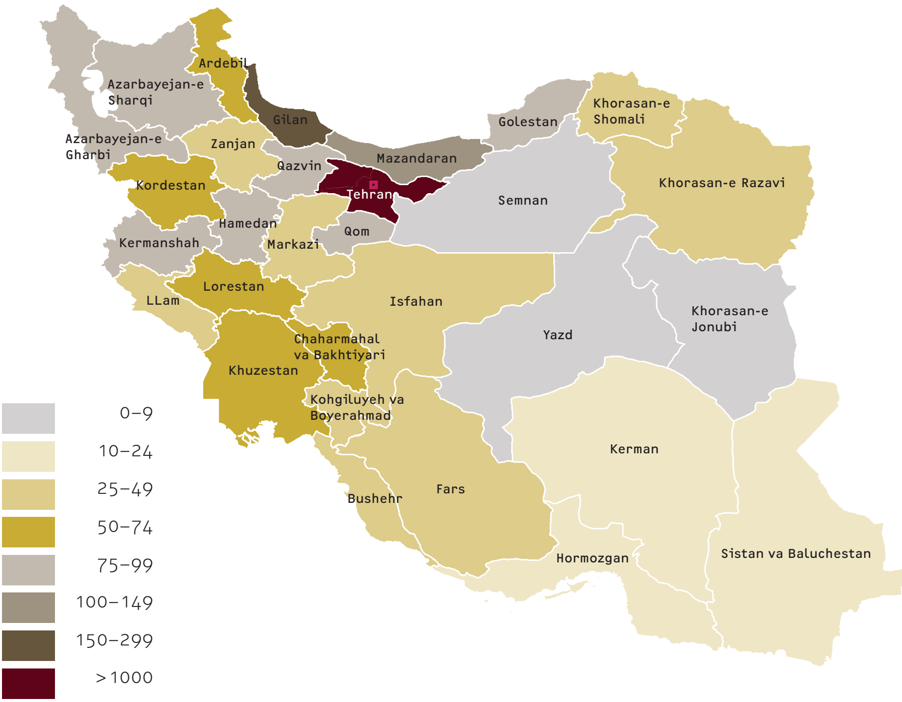


Fig. 1: Regions and Population Density in Iran

Cartography: N. Döge
GIS map base: http://thematicmapping.org/downloads/world_borders.php and National Cartographic Center of Iran
Thematic data source: Wikipedia.org

County Shahrestan	Area km² 2008				Population 2008				Population density inhabitants/km2 2008			
	A) Tehran Region with Counties above 1,000 inh./km²	B) Tehran-Karaj Region with Counties above 600 inh./km²	C) Tehran-Karaj Region with Counties above 200 inh./km²	D) Tehran-Karaj Region with all Counties	A) Tehran Region with Counties above 1,000 inh./km²	B) Tehran-Karaj Region with Counties above 600 inh./km²	C) Tehran-Karaj Region with Counties above 200 inh./km²	D) Tehran-Karaj Region with all Counties	A) Tehran Region with Counties above 1,000 inh./km²	B) Tehran-Karaj Region with Counties above 600 inh./km²	C) Tehran-Karaj Region with Counties above 200 inh./km²	D) Tehran-Karaj Region with all Counties
Islamshahr	205	205	205	205	437,300	437,300	437,300	437,300	2,133.17	2,133.17	2,133.17	2,133.17
Pakdasht			670	670			268,900	268,900			401.34	401.34
Tehran	1,601	1,601	1,601	1,601	7,300,000	7,300,000	7,300,000	7,300,000	4,559.65	4,559.65	4,559.65	4,559.65
Damavand				1,997				87,998				44.07
Robat Karim	549	549	549	549	613,000	613,000	613,000	613,000	1,116.58	1,116.58	1,116.58	1,116.58
Shahre Rey			2,295	2,295			640,000	640,000			278.87	278.87
Savojbolag				2,258				210,600				93.27
Shemiranat			1,111	1,111			335,100	335,100			301.62	301.62
Shahriar		1,321	1,321	1,321		949,400	94,9400	949,400		718.70	718.70	718.70
Firouzkoh				2,261				40,000				17.69
Karaj		2,466	2,466	2,466		1,586,299	1,586,299	1,586,299		643.27	643.27	643.27
Nazarabad			576	576			136,700	136,700			237.33	237.33
Varamin			1,775	1,775			594,900	594,900			335.15	335.15
total	**2,355**	**6,142**	**12,569**	**19,085**	**8,350,300**	**10,885,999**	**12,861,599**	**13,200,197**	4,622.50	**1,772.39**	**1,023.28**	**691.65**

Tab 1: 4 different constraints of Tehran-Karaj Region based on population density (own calculation based on Tehran Municipality, Tehran Statistical Year Book 2008–09, p. 48)

This spatial scale was chosen because the area includes the whole functional Region around the 2 linked Megacities Tehran and Karaj. Furthermore the availability of data for this area is much better than on other spatial scales. The Region also includes areas with very low density near the Alborz mountains in the north and the east as well as in the desert in the south and the west.

A calculation of inhabitants, space and density based on the different settlement densities in the 13 old and new counties ("Shahrestan") is visualized in table 1.

Constrain A) and B) don't include Hashtgerd New Town and the other New Towns which are aimed at discharging the Urban Growth Center Tehran-Karaj. Therefore the following descriptions refer to a constraint between Tehran and Karaj Provinces (shortened as "Tehran Region").

1.2 Spatial Scale of Calculation

First of all the CO_2 emissions are balanced for Shahre Javan Community (building sector) and Hashtgerd New Town (transportation) because of better database. Following this there is an upscaling to the whole Tehran Province based on relative emissions per capita calculated in the first step.

1.3 Demographic Development

It is estimated that the present 13,5 million inhabitants of Province Tehran and Province Alborz (2006) will grow up to 23,2 million in 2027 (Figure 2). The forecast is based on the average growth rates for Tehran Region from 1996 to 2006.

	1996 1375	2006 1385	Growth Rate (%)	2020 1399	2027 1406
Iran	60,055,488	70,472,846[1]	1.48[2]	86,578,178	95,962,546
Tehran Province	10,343,000	13,413,348[2]	2.63[3]	19,301,192	23,153,018
Tehran City	6,758,845	7,705,036[4]	1.32[3]	9,56,306	10,145,402

Tab. 2: Demographic development of Iran, Tehran Province/Region and Tehran City (Self calculation of Farshad Nasrollahi based on data from Statistical Center of Iran, http://www.amar.org.ir/)

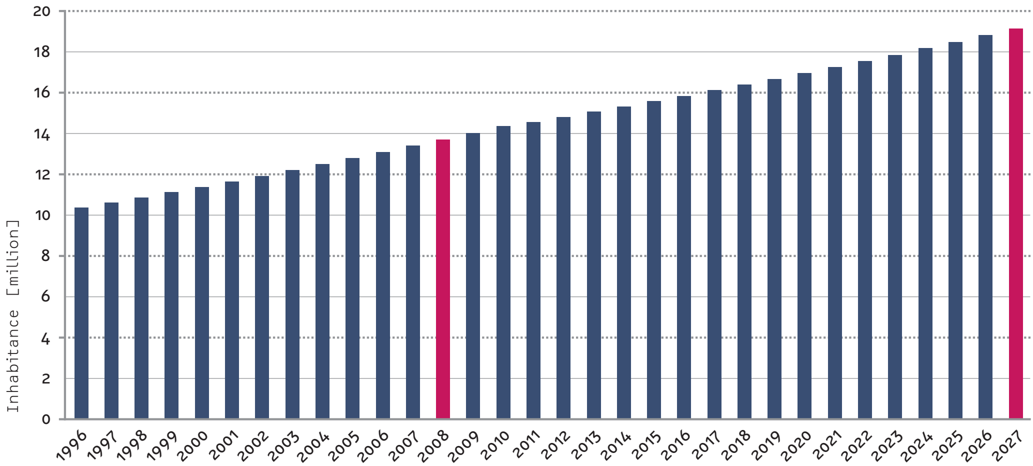


Fig. 2: Demographic development of the province Tehran

1.4 Emissions in Iran

Primary Energy

In the year 2008, Iran has 453,235,562 tons CO_2 emission, which is about 6,318 tons CO_2 per capita. The following graph shows the share of CO_2 production by different sectors in Iran. Power Plant and Building sector with respectively 29% and 26.4% have the highest CO_2 emission concerning primary energy in Iran.

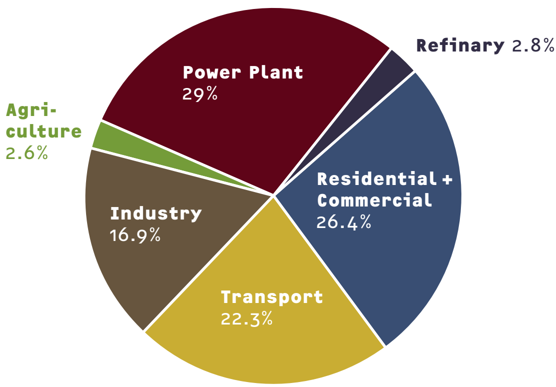


Fig. 3: Share of CO_2 Emission by Sector (Primary Energy) (Ministry of Energy, Energy Planning Department, Energy Balances of Islamic Republic of Iran, 2005)

Final Energy
The current CO_2 emission per capita and annum (2008) in Tehran Region concerning final energy is about 4.14 tons. The residential and commercial sector has the highest CO_2 emissions (41%).

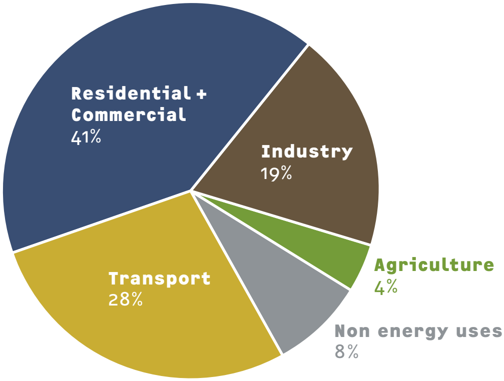


Fig. 4: Share of Final Energy by Sector (Ministry of Energy, Energy Planning Department, Energy Balances of Islamic Republic of Iran, 2005)

The carbon emission is related to the energy consumption because of mainly using of fossil energy sources in Iran.

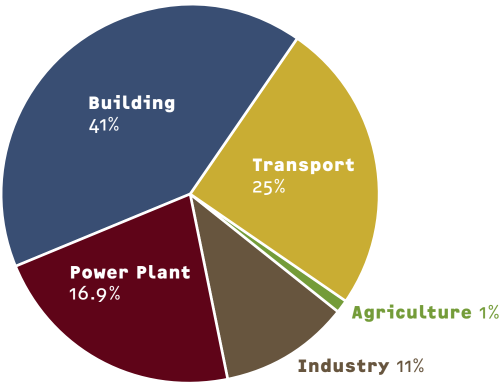


Fig. 5: CO_2 Emission by sectors in Tehran Province (Farshad Nasrollahi)

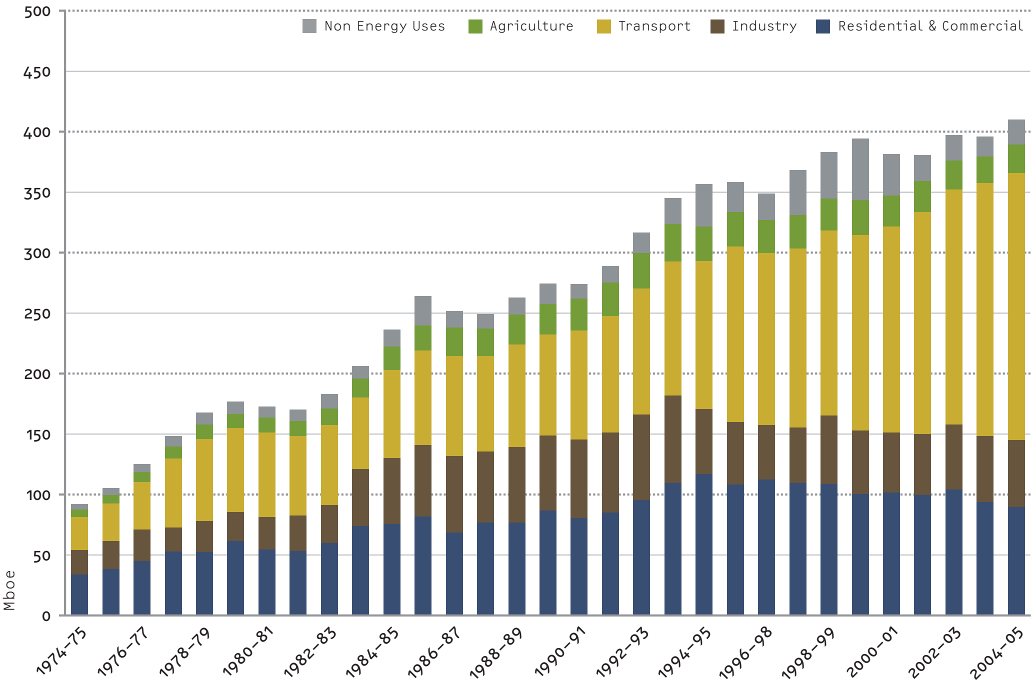


Fig. 6: Share of Petrol Products Consumption by Sector (Energy Balances of Islamic Republic of Iran, Ministry of Energy, Energy Planning Department, Tehran 2006.)

Figure 6 shows the development of consumption of fossil fuels per sector. The highest and fastest growing share is the sector transportation.

1.5 Weather

It is assumed that the weather won't change within the considered period. Consequently a consistent dataset can be used.

1.6 Inclination

Relating to Master plan 2008 the average inclination of the streets is about (+/-) 5%. To nearly come up with this parameter the modelling in the transportation segment will calculate with (+/-) 4% which is pre-defined in the database of the European "Handbook of Emission Factors" (HBEFA 3.1).

1 http://www.aftabnews.ir.
2 http://www.asien-auf-einen-blick.de/iran/regionen.php
3 Between 1996 and 2006.
4 http://en.wikipedia.org/wiki/List_of_Iran_cities_by_population

2 Scenarios

2.1 Scenario "BAU 2008"

In this scenario the CO_2 emissions per capita and annum for transportation, residential and non-residential buildings are calculated for the current situation (base year 2008) in Hashtgerd New Town and Tehran Region.

2.2 Scenario "BAU 2027"

The scenario "business as usual 2027" visualizes the CO_2 emissions in the year 2027 as estimated if the development follows the current tendencies in Iran.

2.3 Planning Scenarios in 2027

This planning-scenario should point out the potentials to reduce CO_2 emissions of the Young Cities Project to 2027. In the transportation segment the scenario is additionally divided in 2 sub-scenarios. The first named "basic" includes the new concept of public transport (BRT/LRT, city-bus and minibus) and the share of bicycles. The second named "optimum" supplementary includes soft policies and traffic optimized settlement pattern.

3 Modelling Approach

3.1 Introduction

Residential and Non-Residential buildings

The possibility to reduce the emissions of Greenhouse gases is in the sector "Residential & Commercial" very excellent, because it is the sector with the highest CO_2 emissions in the province Tehran. There are different possibilities to safe the emissions, for example usage of better technologies, other materials, other constructions, different user behavior, etc.

Transportation

Approximately 1.16 t of 3.14 t CO_2 emitted by capita and annum concerning final energy are generated by the transportation-sector. With nearly 28% it is the second largest part after "residential and commercial". The aim of CO_2 reduction in the transportation-field is directly connected to the emissions caused by motorized traffic. In relation to this the main-goal in this segment is to reduce the use of private cars by sustaining public-transport. To visualize the impact of the planned measures the emissions caused by the present and future Iranian car-fleet has to be modeled.

3.2 Modelling Approach of the different Fields

3.2.1 Residential and Non-Residential Building

First Method

Calculation of CO_2 emission rates for office building is based on the amount of energy consumption of this building and CO_2 emission factor of different energy carriers. The energy consumption of this building is calculated through building energy simulation.

The energy consumption of residential and office building depends on the climate and the building. The climate of Hashtgerd New Town will be defined for the simulation software tool with an Hourly Weather Data.

Different components and elements of buildings and their characteristics will affect the energy consumption of this building and thus its CO_2 emission. Building characteristics have a big variety from the architectural design up to physical characteristics of building elements and to building users and their activities.

Through simulation, the energy consumption of the building will be calculated. The amount of energy consumption will be calculated by type of fuel.

The buildings will consume different energy carriers including renewable energies, electricity and natural gas for cooling, heating, hot water, lighting, and household appliances. The total fuel consumption of building calculating through energy simulation includes:

For the office building, the consumption is the following:
Natural Gas
1. Heat Generation
2. Demand Hot Water

Electricity
1. Space Cooling
2. Room Electricity
3. Lighting
4. Household Appliances

The use of renewable energies to cover some of the building's energy demand means that the building produces less CO_2 from fuel combustion. Therefore, if solar thermal (heating) panels are used to provide hot water, or if photovoltaic panels are used to cover some of the building's electricity demand, the amount of renewable energies generated by the building must be subtracted from the natural gas and electricity demands. The following figure presents the method used for calculating the building's CO_2 emissions. The following figure represents the method of calculation of CO_2 emission of the buildings.

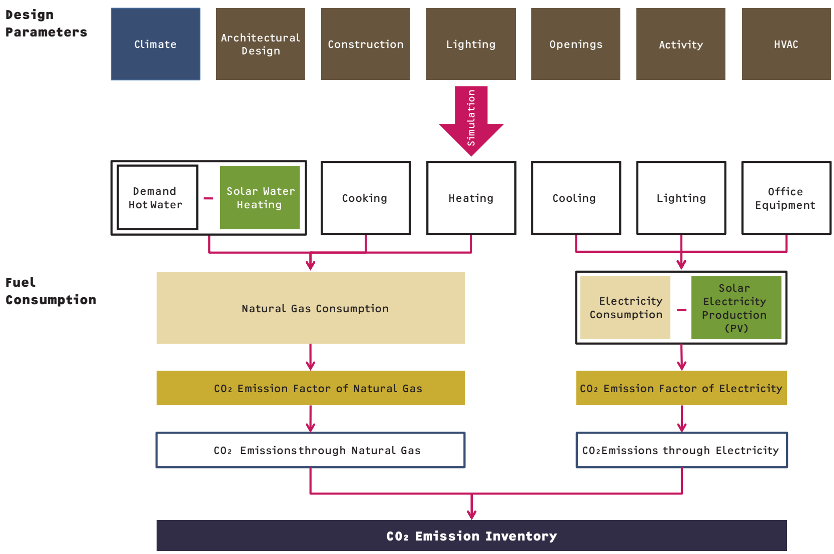


Fig. 7: CO_2 calculation method for the office building

Second Method

The second method for the calculation of CO_2 emission rates of buildings is the simulation. Some building energy simulation software tools can calculate the CO_2 emission rate of buildings too. Most of these software tools use the same method of calculation of CO_2 production based on the amount of energy consumption and the CO_2 emission factor of different energy carriers, which is represent in the first method.

3.2.2 Transportation

Background

As mentioned above the transportation sector produces approximately 28% of the whole CO_2 emissions. The main-initiator of this is the use of private cars which has a share of 40% of the modal split and is responsible for the highest CO_2 emissions in the transport segment. To reach a sustainable reduction of CO_2 emissions there has to be a change in traffic behavior resulting in a consolidation of public transport by reducing the use of private cars.

Prearrangements

To reach this aim at first as visualized in figure 7 the current and future situation of emissions by the Iranian car-fleet has to be modeled. Therefore in the first step (blue fields in figure 7) important inputs like technical information on the present Iranian car-fleet (including buses, trucks, taxis etc.), configuration of the car-fleet sub-segments, GIS-based surface data (course

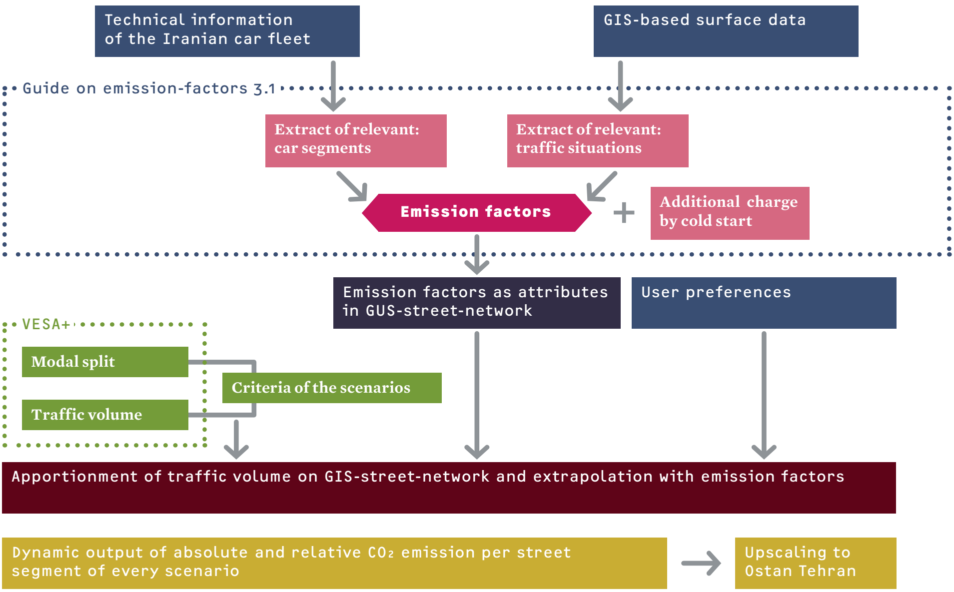


Fig. 8: Calculation of emissions by traffic in Hashtgerd New Town

of the streets, inclination etc.) and preferences of the users in Hashtgerd have to be gathered. These information lead to emission-factors for every subsegment of the car-fleet (magenta fields) by using the German "guide of emission-factors" ("Handbuch der Emissionsfaktoren 3.1") to link car-data and street-data. These emission-factors (gCO_2 per km) have to be attached as attributes on every street-segment of GIS-street data by using ARCGIS (ocher field).

Calculation approach
The basis of the calculation of traffic based CO_2 emissions is an innovative transport model built up by the Technical University Dresden. Comparing to common traffic models the new approach of VISEVA+ includes informal traffic modes like different kinds of taxis which have a big share regarding the overall traffic volume in Iran.

The results of the traffic model have been delivered as georeferenced shapefiles providing an excellent basis to be handled accurately in geoinformation systems. Within the shapefiles the traffic volume (private cars: cars per day, all other modes: passenger per day) has been provided on lines representing streets and divided to the different transport modes. For the further calculation of CO_2 emissions only motorized transport modes such as private cars, taxis and buses will be considered. While the calculation procedure differs between the different traffic modes figure 9 visualizes in detail the approach for motorized private transport.

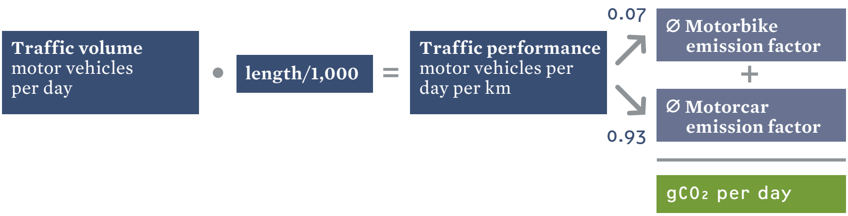


Fig. 9: Emission calculation approach for motorized individual traffic

At first the traffic performance needs to be calculated for all modes. Due to the deviant provision of traffic volume for private vehicles (vehicles per day) it only needs to be multiplied by the length of corresponding street segment. It results in vehicle × kilometers. The traffic volume of all other motorized modes (passenger per day) first needs to be distributed to the corresponding average vehicle capacities. Afterwards number of vehicles per day is also multiplied by the length of street segment. Regarding the different shares of different vehicle types the traffic performance needs to be distributed to them. In case of private motorized vehicles approximately 93% are accounted by cars and 7% by motorbikes.

Following this calculation the traffic performance for each vehicle type simply needs to be extrapolated by the specific emission factors resulting of the certain traffic situations. In conclusion the calculation approach initially results in an absolute value of CO_2 emissions for a regular working day for each street segment and vehicle type. Summing up all values finally results in an overall value of traffic related CO_2 emissions in Hashtgerd. On the other hand the results for each street segment can be related to the length of the segment resulting in relative emission values (gCO_2 per day and km).

3.3 Results

3.3.1 Residential Building and Non-Residential Building

Scenario "BAU 2008"

Approximately 1.697 t of 4.14 t CO_2 emitted by capita and annum in the region Tehran concerning final energy are generated by the "Residential & Commercial" sector (see Figure 4). With 41% it is the largest part.

Scenario: "BAU 2027"

The assumption for this scenario was that 2%of the Inhabitants (for example in 2009 from about 14.0 million inhabitants are 2% 290,000 persons) move annually from existing buildings into a building with a 10% reduced CO_2 output. You can see in figure 10 the distribution of the inhabitants of "old" and "new" buildings. These new buildings are the buildings with the reduced CO_2 emission.

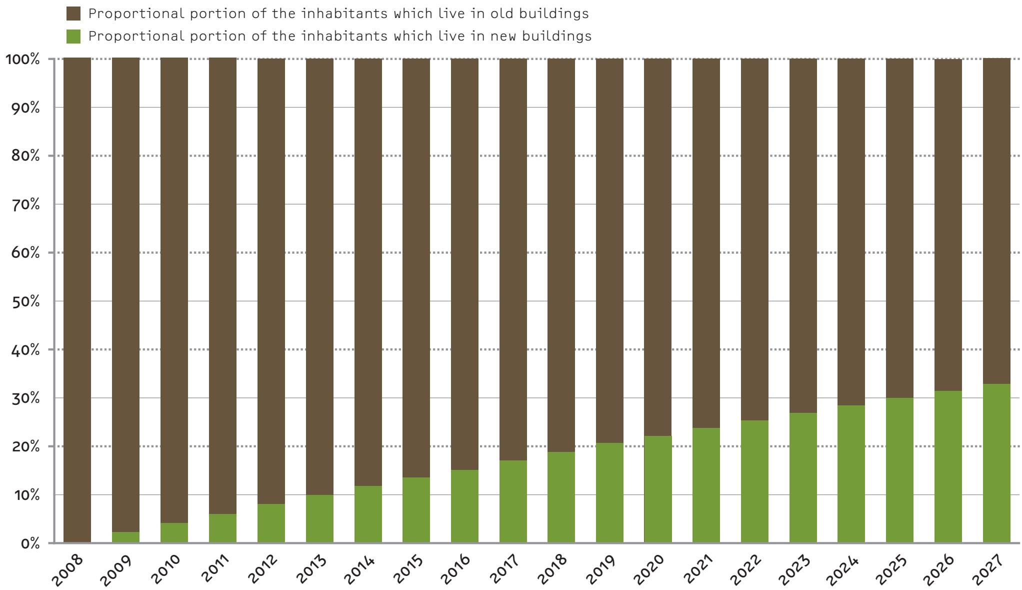


Fig. 10: Inhabitant distribution which live in "new" and "old" buildings

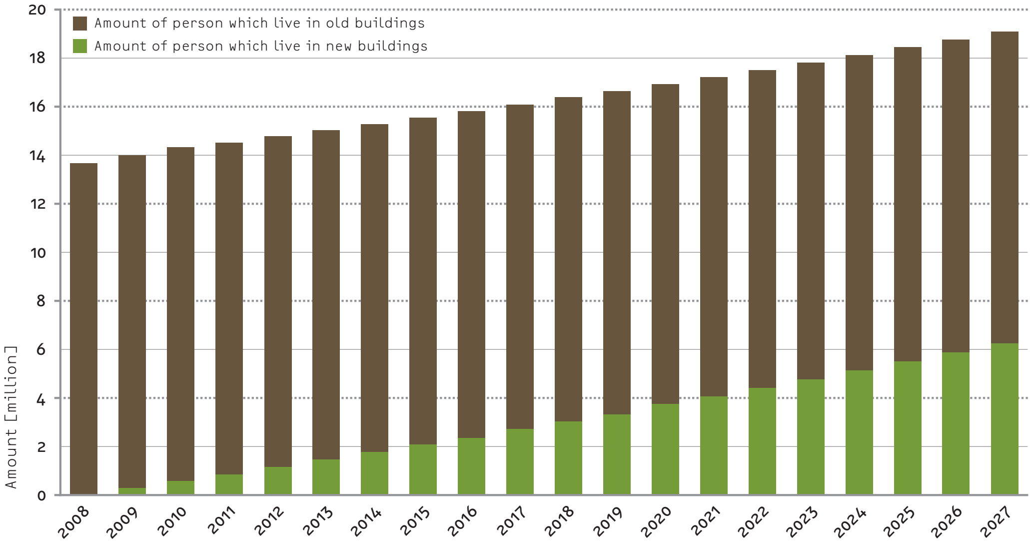


Fig. 11: Amount of the Inhabitants which live in "new" and "old" buildings

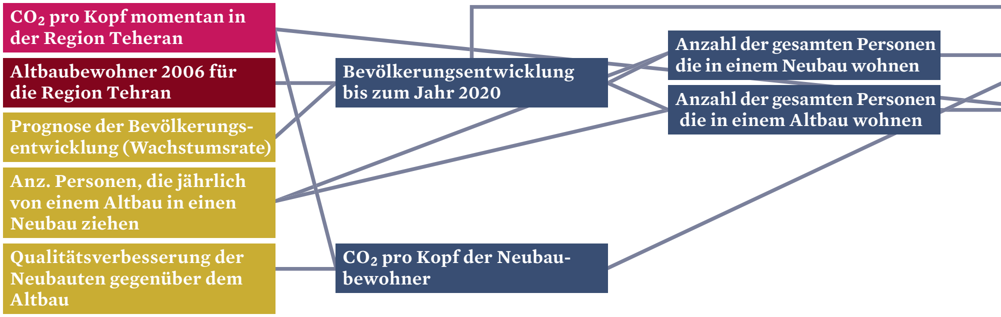


Fig. 12: CO_2 calculation method for the Scenario "BAU 2027"

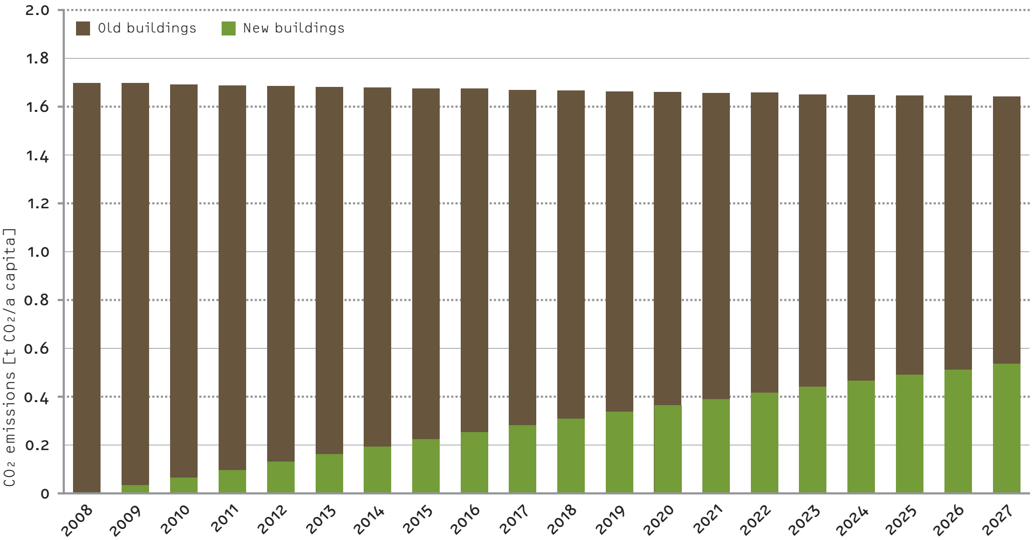


Fig. 13: CO_2 emission per capita and year in the province Tehran, Scenario "BAU 2027"

The CO_2 emissions per capita and annum was in 2008 1.697 t CO_2. With this scenario, the emissions per capita and annum for 2027 will be reduced to 1.642 t CO_2 (see Figure 13). This is a natural reduction per capita of about 3.3%. The entire amount of CO_2 in the region Tehran rises in relation to the value of 2008 from 24 million tons CO_2 per annum up to 31.3 million tons CO_2 per annum. This is an increase of about 35% (see Figure 14) because of the demographic development of the province Tehran.

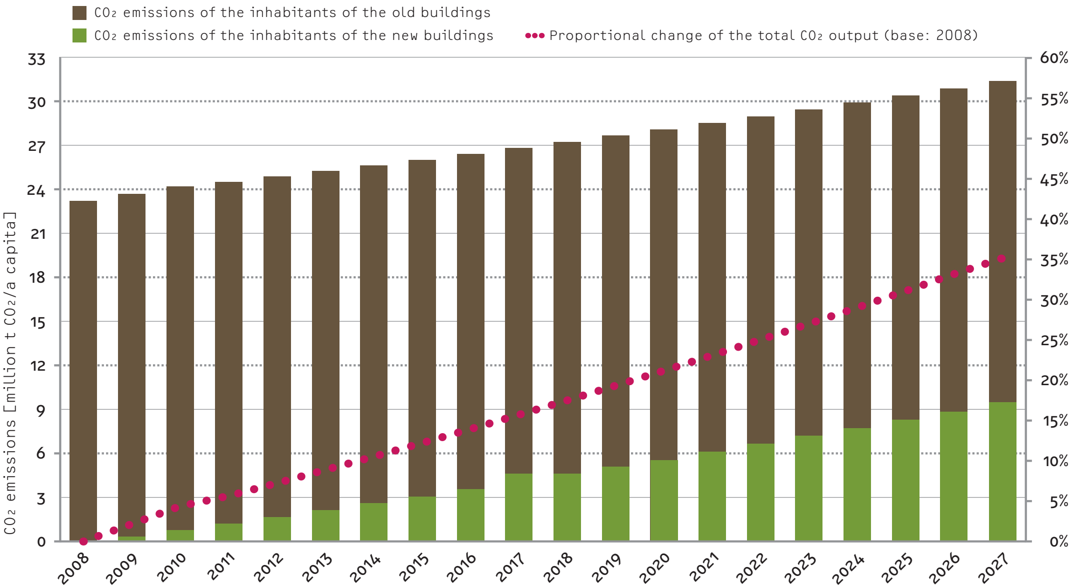
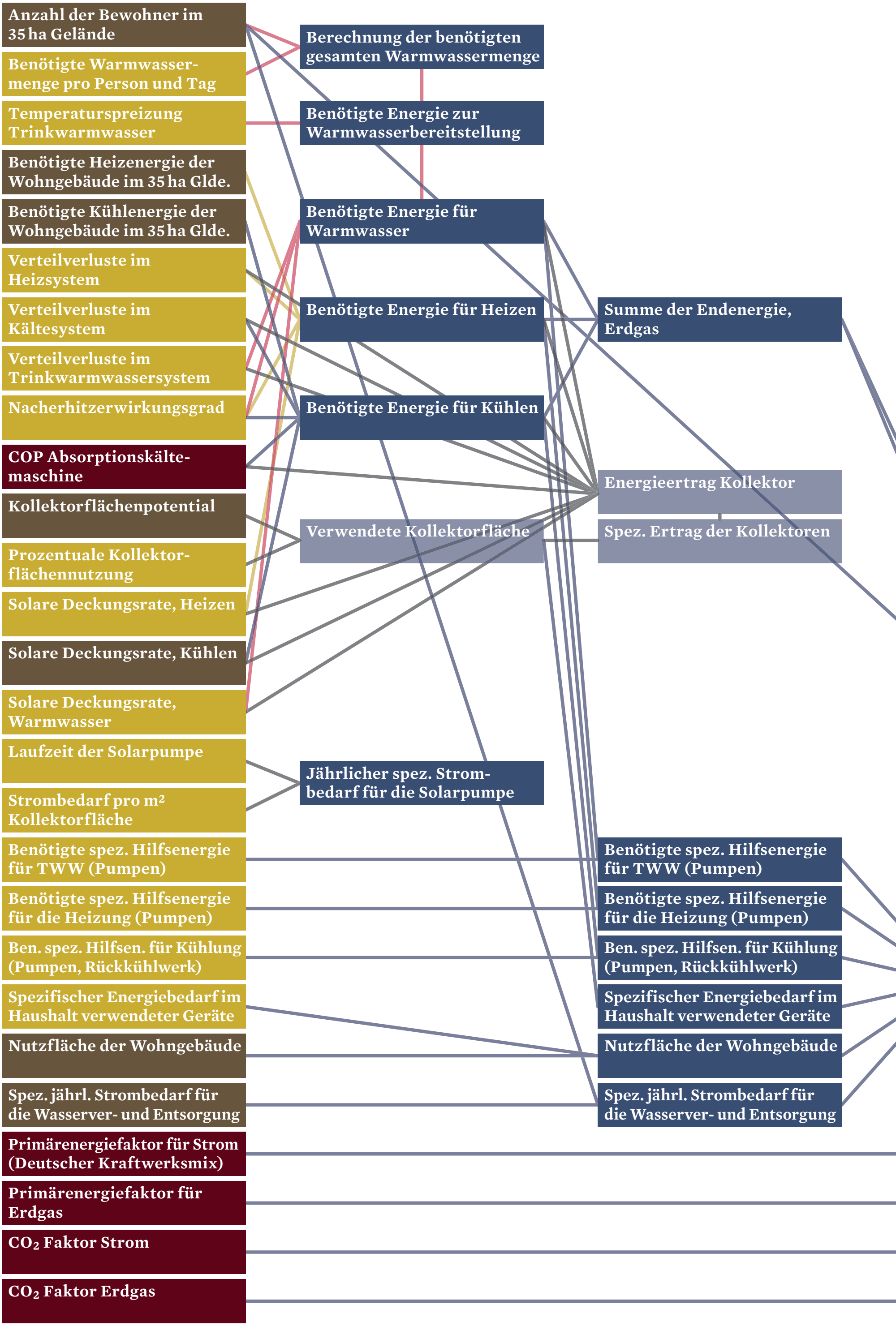


Fig. 14: Entire CO_2 emission per year in the province Tehran, Scenario "BAU 2027"


Anzahl der Bewohner im 35 ha Gelände
Benötigte Warmwassermenge pro Person und Tag
Temperaturspreizung Trinkwarmwasser
Benötigte Heizenergie der Wohngebäude im 35 ha Glde.
Benötigte Kühlenergie der Wohngebäude im 35 ha Glde.
Verteilverluste im Heizsystem
Verteilverluste im Kältesystem
Verteilverluste im Trinkwarmwassersystem
Nacherhitzerwirkungsgrad
COP Absorptionskältemaschine
Kollektorflächenpotential
Prozentuale Kollektorflächennutzung
Solare Deckungsrate, Heizen
Solare Deckungsrate, Kühlen
Solare Deckungsrate, Warmwasser
Laufzeit der Solarpumpe
Strombedarf pro m² Kollektorfläche
Benötigte spez. Hilfsenergie für TWW (Pumpen)
Benötigte spez. Hilfsenergie für die Heizung (Pumpen)
Ben. spez. Hilfsen. für Kühlung (Pumpen, Rückkühlwerk)
Spezifischer Energiebedarf im Haushalt verwendeter Geräte
Nutzfläche der Wohngebäude
Spez. jährl. Strombedarf für die Wasserver- und Entsorgung
Primärenergiefaktor für Strom (Deutscher Kraftwerksmix)
Primärenergiefaktor für Erdgas
CO₂ Faktor Strom
CO₂ Faktor Erdgas
Berechnung der benötigten gesamten Warmwassermenge
Benötigte Energie zur Warmwasserbereitstellung
Benötigte Energie für Warmwasser
Benötigte Energie für Heizen
Benötigte Energie für Kühlen
Verwendete Kollektorfläche
Jährlicher spez. Strombedarf für die Solarpumpe
Summe der Endenergie, Erdgas
Energieertrag Kollektor
Spez. Ertrag der Kollektoren
Benötigte spez. Hilfsenergie für TWW (Pumpen)
Benötigte spez. Hilfsenergie für die Heizung (Pumpen)
Ben. spez. Hilfsen. für Kühlung (Pumpen, Rückkühlwerk)
Spezifischer Energiebedarf im Haushalt verwendeter Geräte
Nutzfläche der Wohngebäude
Spez. jährl. Strombedarf für die Wasserver- und Entsorgung

Planning Scenario in 2027

This planning-scenario should point out the potentials to reduce CO_2 emissions of the Young Cities Project to 2027. In this scenario, the persons who move into new buildings move in buildings, which are designed from the Young Cities Team with lower CO2 emissions (only 0.8 t CO_2 per capita and annum). This is a reduction of about 53% compare to the emissions from 2008 (16.97 t CO_2 per capita and annum). Figure 15 shows the calculation method for the Planning Scenario 2027.

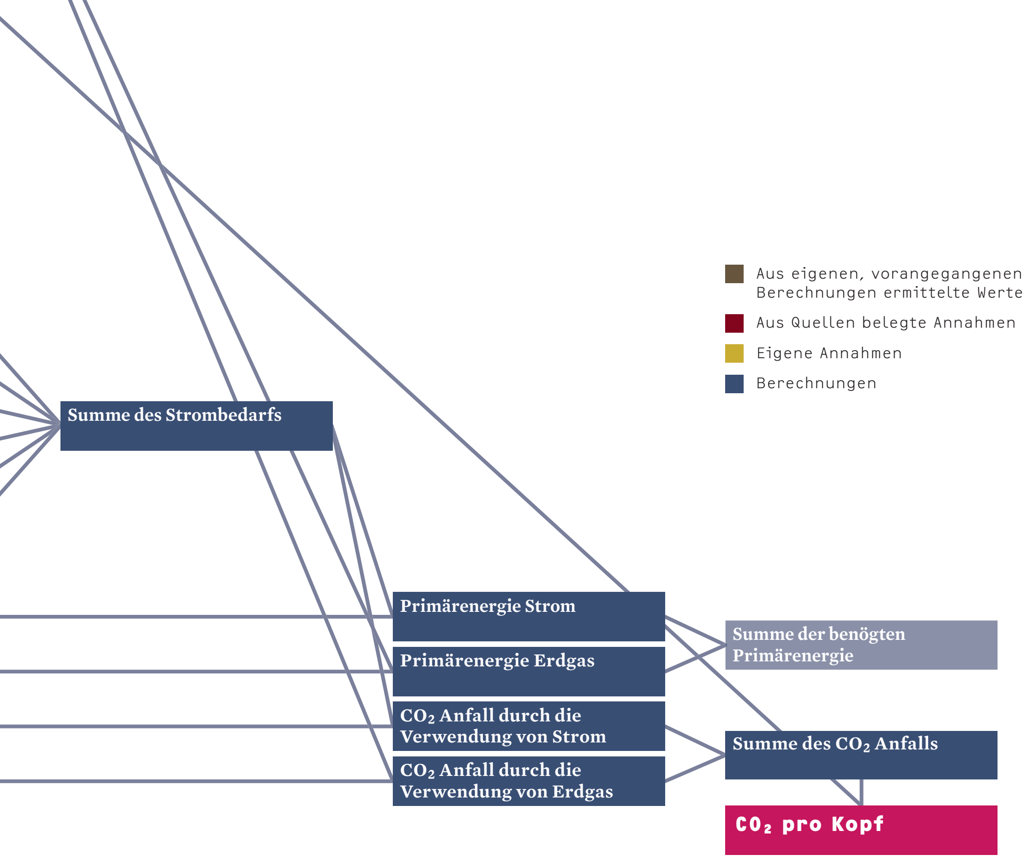


Fig. 15: Calculation method for the CO_2 emission per capita of the designed residential buildings from Young Cites

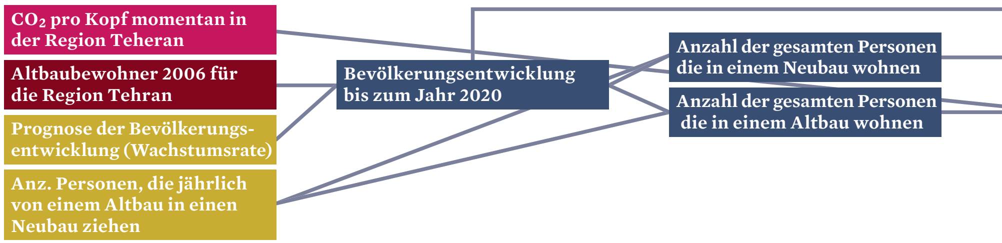


Fig. 16: Entire CO_2 emission per year in the province Tehran, Scenario "BAU 2027"

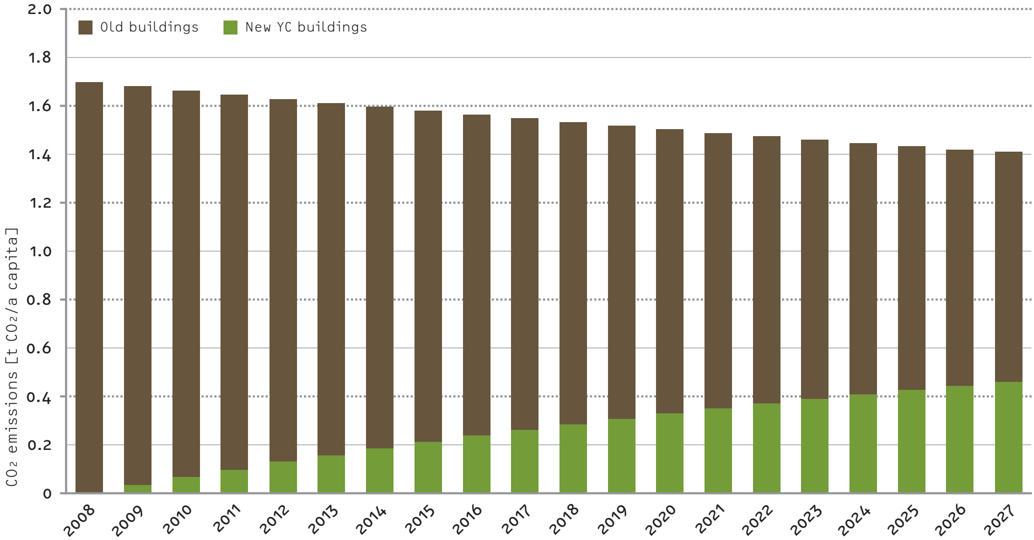


Fig. 17: CO_2 emission per capita and year in the province Tehran, "Planning Scenario 2027"

The CO_2 emission per capita and year in the province Tehran amounts in 2027 1.36 t CO_2 (see Figure 17). These are per capita 17% fewer emissions than 2008. The entire amount of CO_2 in the region Tehran rises in relation to the value of 2008 from 23.98 million tons CO_2 per annum up to 26.8 million tons CO_2 per annum (4.5 million tons CO_2 less than scenario "BAU 2027"). The increase constitutes 15.7% compared to the entire emissions in 2008 (see Figure 18).

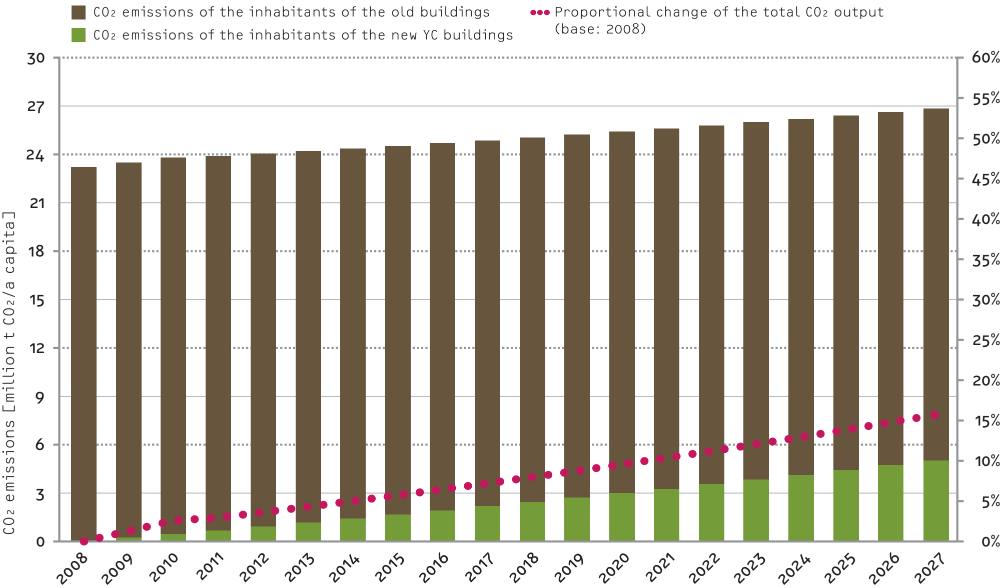


Fig. 18: Entire CO_2 emission per year in the province Tehran, "Planning Scenario 2027"

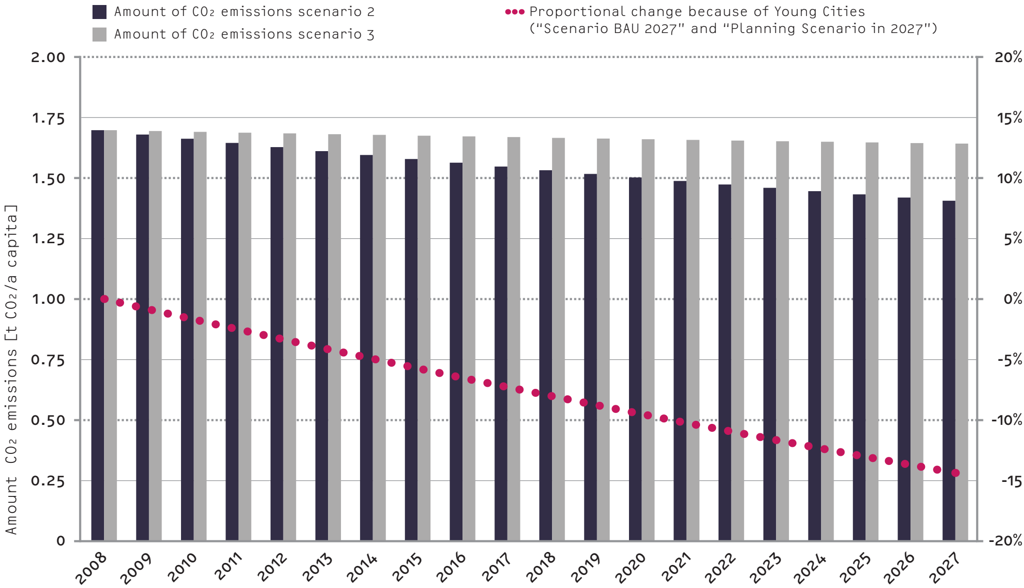


Fig. 19: Comparison per capita between "Scenario BAU 2027 (Scenario 2)" and "Planning Scenario in 2027 (Scenario 3)"

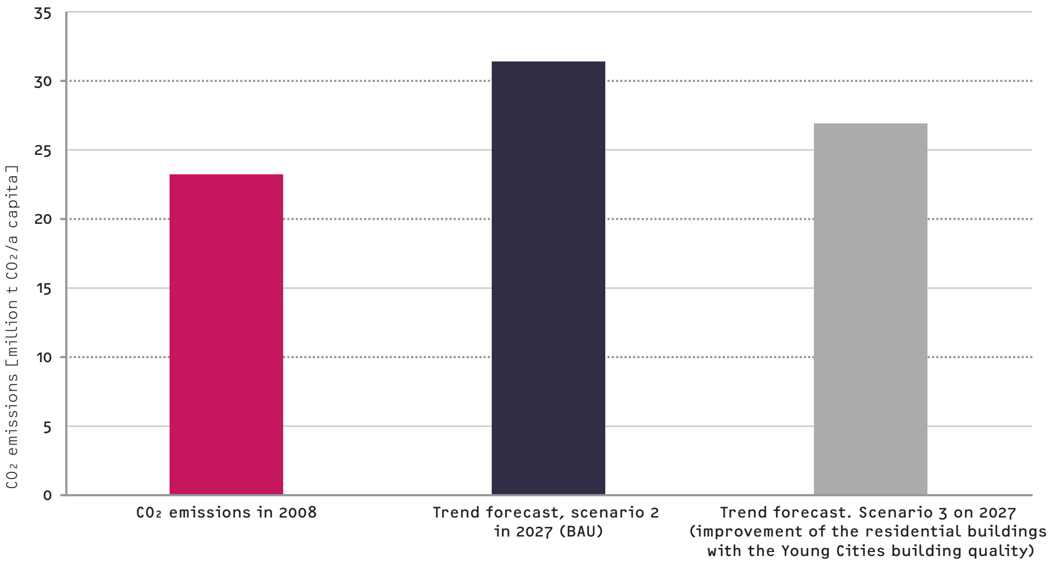


Fig. 20: Comparison between "Scenario BAU 2027 (Scenario 2)" and "Planning Scenario in 2027 (Scenario 3)"

Comparison between "Scenario BAU 2027" and "Planning Scenario in 2027"
In the comparison for the year 2027 between "Scenario BAU 2027" and "Planning Scenario in 2027" one recognizes a difference of the CO_2 emissions about 14.4% (see Figure 19). The entire amount between the different scenarios is presented in figure 20.

Transportation
Due to the reason that the emission of CO_2 in transportation is influenced by various factors (e.g. usage of slow-modes) a more detailed view needs to be demonstrated as possible with the 3 scenarios mentioned above. Especially the planning horizon of more than 15 years leaves space for speculations on the development of the modal share. Therefore the future scenarios BAU 2027 and the planning scenario have been calculated in terms of 2 subscenarios to show up possible tendencies. The subscenarios mainly differ in terms of bicycle speeds (in *b scenarios bicycle are 10% faster than in *a scenarios). Anyway it must be kept in mind that this simulation does not consider the commercial transport which has a big share regarding the CO_2 emissions of the transport segment.

Scenario "BAU 2008"
This scenario follows the prerequisites made in the master plan 2008. The corresponding settlement structure as well as the vehicle fleet of 2008 has been considered. The supply of public transport services was limited to a basic bus service on the main tracks (no minibuses and BRT has been considered). Following these conditions the traffic and CO_2 emission modelling resulted in 0.57 t CO_2 per capita and annum for individual traffic for Hashtgerd in 2008. As figure 21 points out, the motorized individual traffic (MIT) accounts 0.38 t CO_2 per capita and annum which is the biggest share with around 65%.

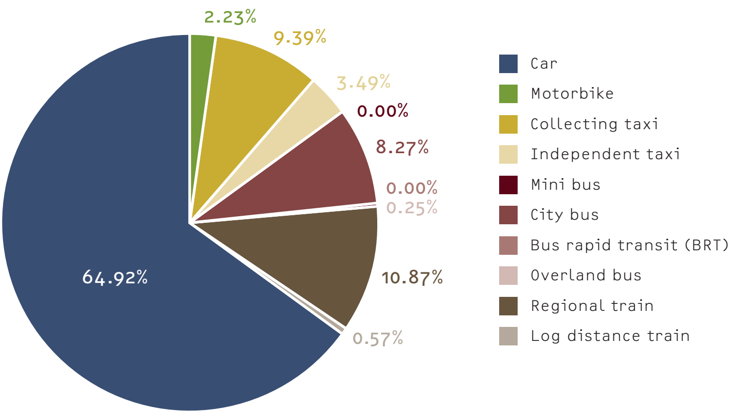


Fig. 21: Traffic related CO_2 emissions in 2008

Scenario "BAU 2027"

The scenario "business-as-usual 2027" mainly differs from the one for 2008 in the development of the vehicle fleet. As experienced in the past, 19 years will lead to an important change in the technical properties of motor vehicles especially regarding CO_2 emissions. As mentioned above the scenario has been divided into to subscenarios. Scenario A considers the common properties of bicycles while scenario B emphasizes the attractiveness of bicycles by increasing the travel speed by 10%. This results in 0.54 t CO_2 per capita and annum. In this way the change in the technical properties of motorized vehicles leads to a decrease of CO_2 emissions of 4.9 percent. As figures 22 and 23 point out, the share of motorized individual transport will increase from 65% in BAU 2008 to 66% in BAU 2027. Furthermore the increased attractiveness of bicycles does not affect the distribution of CO_2 emissions of all motorized traffic modes.

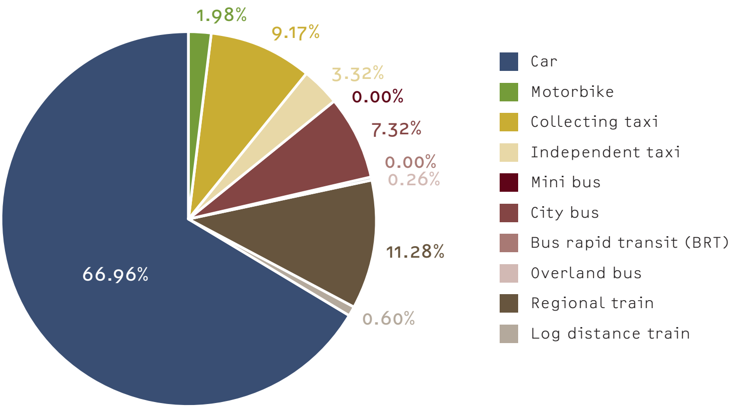


Fig. 22: Traffic related CO_2 emissions in 2027 (BAU)

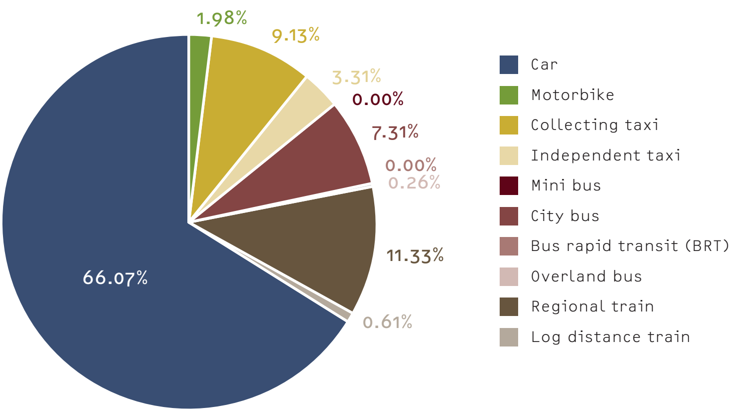


Fig. 23: Traffic related CO_2 emissions in 2027 (BAU) with increased bicycle share

Planning Scenario in 2027
This scenario includes the overall traffic approach for Hashtgerd. This includes the settlement structure as mentioned in the master plan 2008 as well as the estimated vehicle fleet of 2027. The main difference comparing to the other scenarios is the overall public transport system which includes neighborhood buses (mini buses), city buses as well as a bus rapid transit system. While in the beginning especially short ways will be substituted by the high quality bus system, the increased share of buses will mainly result by a decrease of pedestrians. Therefore the CO_2 emission of 0.54 t per capita and annum remain constant. Nonetheless as figure 24 and 25 point out the share of private cars is decreasing constantly due to an increased attractiveness of public transport.

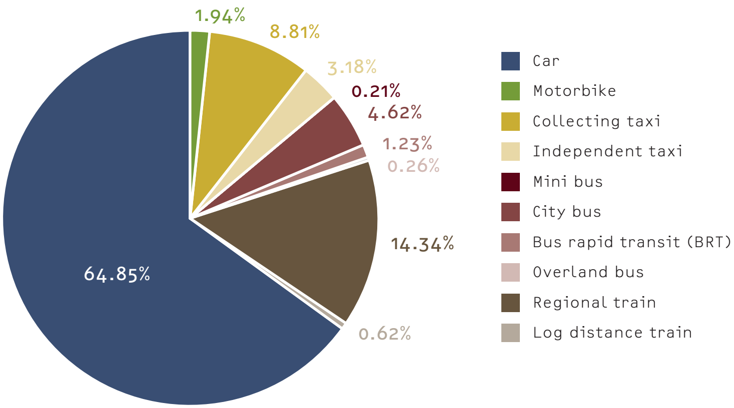


Fig. 24: Traffic related CO_2 emissions in 2027 (planning scenario)

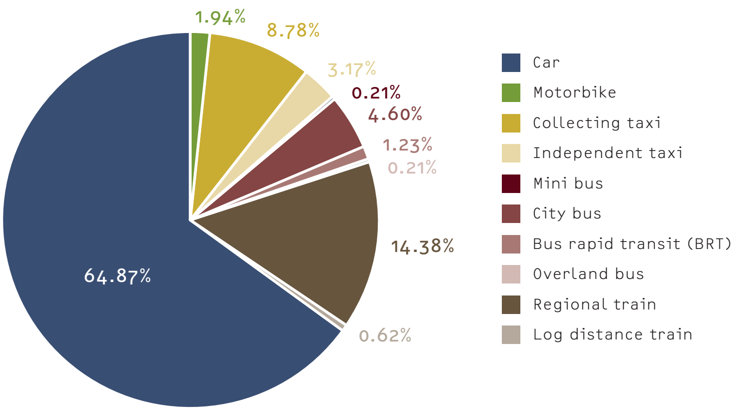


Fig. 25: Traffic related CO_2 emissions in 2027 (planning scenario) with increased bicycle share

Comparing to scenario BAU 2008 the CO_2 emissions have been decreased by -5.27%. Within the subscenarios (2a/b) the increased attractiveness of bicycles causes only minor changes in the distribution of emissions. While the emissions of taxis and city buses decrease due to a modal shift for short ways, the share of private cars is rising slightly.

Comparison of the scenarios

The description of the scenarios as mentioned above firstly visualizes that the share of private cars regarding the overall private traffic related CO_2 emissions would increase by 1.15% until 2027 if the approach of the master plan 2008 would be implemented. Regarding the planning scenario this trend could be stopped. As visualized in figure 26 even the absolute number of CO_2 emissions will be decreased consequently from scenario 0 (BAU 2008) to 2 (planning scenario).

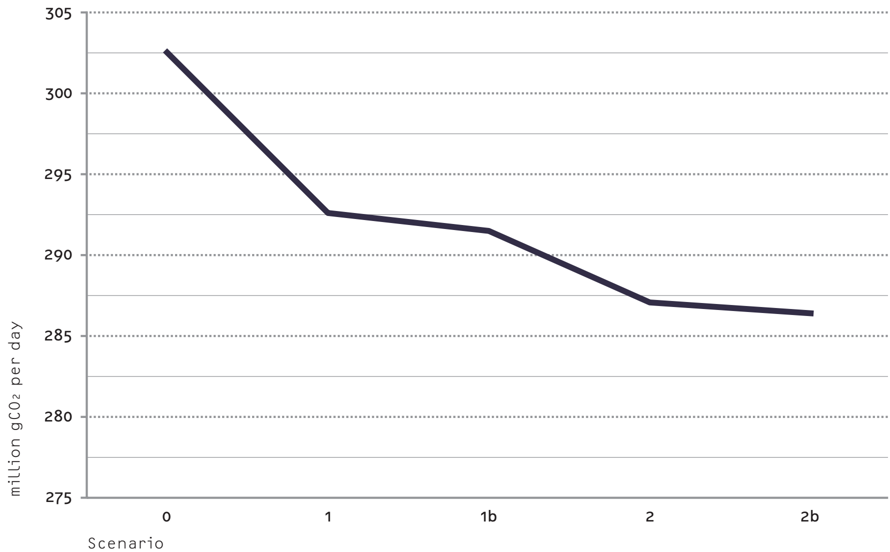


Fig. 26: Development of CO_2 emissions of private cars

While the reduction from scenario 0 to 1 (BAU 2027) is due to engineering progress in the automobile industries, the additional decrease is the result of the implementation of the measures for an overall public transport supply.

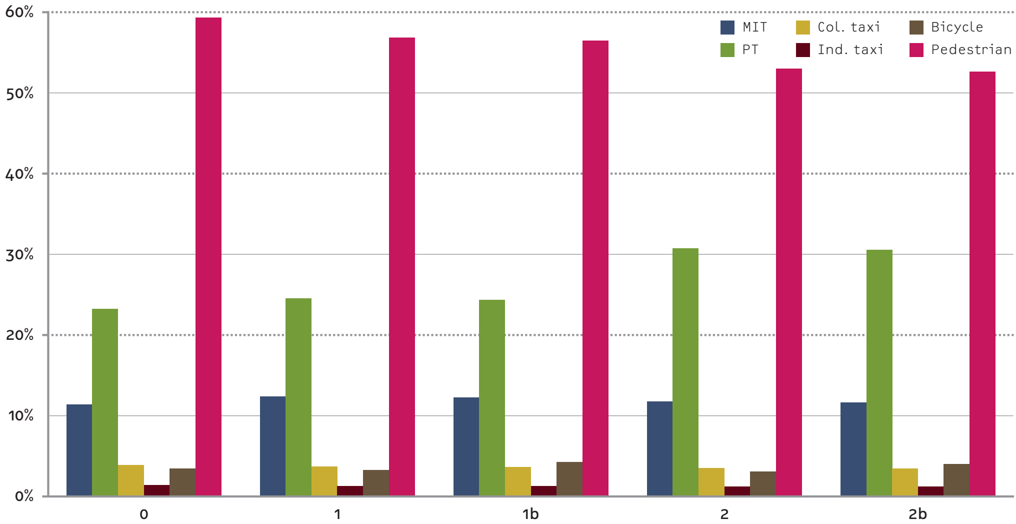


Fig. 27: Development of modal split (number of ways)

Especially regarding the number of ways pointed out in figure 27 a small decrease of private car usage becomes manifested while the use of public transport modes is consequently increasing. Additionally the implementation of the neighborhood buses reduces the share of walking. Due to the safety problems for pedestrians in Iran this could also lead to a decrease of accidents.

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Imprint

Design/Typesetting büro-d | Communication Design Berlin

Publisher
Universitätsverlag der TU Berlin
Universitätsbibliothek
Fasanenstr. 88
10623 Berlin | Germany

ISSN 2196-517X (Print)
ISSN 2196-6583 (Online)
ISBN 978-3-7983-2583-8 (Print)
ISBN 978-3-7983-2584-5 (Online)

www.univerlag.tu-berlin.de

Simultaneously published online on the Digital Repository of the Technische Universität Berlin
URL http://opus.kobv.de/tuberlin/volltexte/2013/4064/
URN urn:nbn:de:kobv:83-opus-40640
[http://nbn-resolving.de/urn:nbn:de:kobv:83-opus-40640]

All texts are based on scientific research performed within the Young Cities Project. All pictures, tables and graphics are courtesy of the respective article's authors, unless otherwise mentioned.

The volume before you results from the federal funded research project “Young Cities – Developing Urban Energy Efficiency”. It has been written by

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