

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE  
Kyiv National University of Construction and Architecture

**STRATEGIES FOR MITIGATING THE EFFECTS  
OF CLIMATE CHANGE AND ADAPTATION TO IT  
FOR THE CONSTRUCTION INDUSTRY OF UKRAINE**

Methodical instructions  
for practical work for applicants for the second (master's)  
level of higher education in the specialties E2 “Ecology”,  
G2 “Environmental Protection Technologies”

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**Strategies** for mitigation and adaptation to climate change for the construction industry of Ukraine [Electronic resource]: methodological instructions for practical work / comp. L. O. Vasylenko and others. – Kyiv : KNUBA, 2025. – 24 p.

Contains practical works and solutions to them, theoretical information, basic concepts, a list of recommended reading. Designed for applicants for the second (master's) level of higher education in the specialties E2 "Ecology", G2 "Environmental Protection Technologies.

**Стратегії** пом'якшення наслідків зміни клімату і адаптації до неї для будівельної галузі України [електронний ресурс] : методичні вказівки до виконання практичних робіт /уклад. Л.О. Василенко та ін. – Київ : КНУБА, 2025. – 24 с.

Містить практичні роботи та їх розв'язання, теоретичну інформацію, основні поняття та список рекомендованої літератури.

Призначені для здобувачів другого (магістерського) рівня вищої освіти спеціальностей E2 «Екологія», G2 «Технології захисту навколишнього середовища».

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## GENERAL PROVISIONS

The environment is heavily influenced by various factors, among which the development of production, the use of machinery, industry, transportation, and construction play a key role. The impact of man-made factors creates challenges for natural ecosystems, changing their balance. At the same time, mitigating the negative effects, particularly through the introduction of environmentally friendly technologies and adaptation to climate change, opens up opportunities for sustainable development and the preservation of the biosphere for future generations.

The tasks are designed to develop analytical thinking, the ability to assess climate risks, and to develop effective solutions for the urban environment.

The primary goal is to teach students to evaluate the impact of climate change on urban systems, including water resources, temperature, and energy consumption, through the use of mathematical calculations, models, and forecasting methods.

Climate change is a global challenge that requires adaptation at all levels, from international strategies to local actions. Cities are most affected by these changes due to rising temperatures, changing precipitation patterns, increased extreme weather events, and increased stress on infrastructure. Studying the impact of climate change is key to ensuring the sustainable development of urban areas.

After completing the tasks, students should:

- Master the methods of climate data analysis and change forecasting.
- Master the basics of modeling climate impacts on urban systems.
- Learn to assess the risks associated with rising temperatures, increased precipitation, and other changes.
- Develop practical recommendations for urban adaptation to climate change.

*Analyze the initial data.* Utilize up-to-date information on climatic conditions, which can be obtained from scientific sources or based on specified scenarios. This will ensure the objectivity and accuracy of your calculations.

*Mathematical calculations.* Follow the given formulas and conditions of the problem to ensure that the results obtained are as accurate as possible and correspond to the original data.

*Reasoned conclusions.* The results of the calculations should be explained, with an argument on how climate change affects urban systems and why the proposed adaptation measures are appropriate.

Data visualization. For clarity, use graphs, tables, or diagrams to clearly illustrate dependencies, modeling results, and key conclusions. This will simplify the perception of the material and improve its understanding.

Assignments will be evaluated according to the following criteria:

- *Accuracy of calculations.* Correct application of formulas and mathematical dependencies.

- *Reasonableness of conclusions.* Logic and consistency of the analysis of climate change impacts.

- *Practicality of recommendations.* Development of realistic measures to improve urban resilience.

- *Paper presentation.* Clarity, structuredness, and visibility of the information presented.

## Case Study № 1

### ANALYSIS OF THE CITY'S VULNERABILITY TO CLIMATE CHANGE

**Objective:** to assess the risks to the city due to climate change and propose adaptation measures.

**Stages of implementation:**

1. *Identify threats:* identify climate risks for your city (floods, heat, water shortages, etc.).

2. *Infrastructure analysis:* assess how well the city's infrastructure is prepared for these threats (stormwater management, water supply, green areas).

3. *Suggestions:* develop 2-3 ideas for increasing resilience (green spaces, modernization of the drainage system, creation of rainwater tanks).

4. *Result:* a specific action plan for the city's adaptation to climate change.

#### 1. Theoretical information

*Climate change and its impact.* Climate change has a significant impact on the natural environment, infrastructure, and quality of life in cities. Its effects are manifested in the form of extreme weather events that pose significant challenges to urban systems and communities.

Rising average temperatures and an increase in the number of hot days affect:

- Human health: heat causes heat stress, cardiovascular disease, and increased mortality among vulnerable populations.

- Energy consumption: increased demand for air conditioning, which overloads energy systems and increases greenhouse gas emissions.

- Ecosystems: urban plants and animals suffer from high temperatures, which leads to a decrease in biodiversity.

- Transportation and buildings: heat can damage roads and urban infrastructure, such as melting asphalt or damaging railroad tracks.

Uneven distribution of precipitation leads to more frequent rainstorms and floods, which have the following *consequences*:

- damage to infrastructure: flooding of roads, homes, and businesses;

- soil erosion: destruction of river banks and pollution of water resources due to soil washout;

- public transportation: interruptions in public transportation due to flooding of roads and stations;

- public health: stagnant water after floods can cause outbreaks of infectious diseases.

Prolonged droughts are becoming more frequent, threatening the availability of water for:

- water supply: the amount of available water resources for the population, industry, and agriculture is decreasing;

- agriculture: droughts reduce yields, which can lead to higher food prices;

- urban greenery: reduced water for irrigation of green areas reduces their effectiveness in regulating temperature and purifying the air.

Climate change also causes:

- sea level rise: this threatens coastal cities, which may lose significant areas to flooding;

- strong winds and storms: they destroy buildings, infrastructure, and put residents' lives at risk;

- loss of biodiversity: urbanized areas are losing natural ecosystems that help to adapt to climate change.

To minimize the impact of climate change, cities should implement adaptation measures. This includes developing sustainable infrastructure, improving water supply and sewage systems, expanding green areas, and integrating modern technologies to reduce vulnerability to climate threats.

### **Key concepts:**

- *Vulnerability*: the ability of a city or region to adapt to climate change or to counteract its impact.

- *Adaptation*: actions aimed at reducing the negative effects of climate change.

- *Resilience*: the ability of a city to recover quickly from climate disasters.

### **Main approaches to the analysis:**

#### 1. *Risk assessment*:

- Identification of natural hazards that pose a threat.

- Assessment of the frequency and magnitude of potential hazards.

#### 2. *Infrastructure analysis*:

- Assessment of the state of transportation, water supply, energy, and other systems.

- Identification of weaknesses that may be most affected.

#### 3. *Development of adaptation measures*:

- Improving infrastructure, applying the latest technologies.

- Integration of nature-based solutions, such as green roofs or wetlands.

### **Examples of adaptation measures:**

- Establishment and modernization of a stormwater drainage system.
- Expansion of green areas to mitigate the heat island effect.
- Implementation of rainwater harvesting systems for technical needs.
- Developing emergency response plans for the population.

For the analysis, it is recommended to choose a specific city where the student lives or is familiar with. This will enable you to consider real local conditions and issues. If it is difficult for the student to choose a city, it is suggested to consider one of the following:

- Kyiv (a capital city with a large population and high urbanization).
- Odesa (a coastal city facing sea level rise).
- Kharkiv (a large industrial city with relevant environmental challenges).
- Lviv (a city with historic buildings that faces flood risks).

*It is necessary to collect basic information about the city that will be needed for the analysis:* climatic conditions (average temperature, precipitation, drought periods); population (number of residents, population density); features of local infrastructure (water supply, transport network, green areas); and current environmental problems of the city.

#### *Additional information:*

1. Examples of successful adaptation solutions: how other cities are implementing climate change measures (e.g., Berlin, Copenhagen).

2. Regulatory framework: laws and programs on climate change adaptation available in your country.

## **2. Example of solving case study №1**

City for analysis: Kyiv, Ukraine.

### *1. Identification of the main climate threats for the region*

Kyiv is situated in a temperate climate zone, but due to global climate change, the risks are on the rise. The main threats are:

- Floods: due to floods on the Dnipro River and heavy precipitation, which are becoming more frequent due to climate change;
- heat: an increase in the average temperature in summer, an increase in the number of extremely hot days;
- water shortages: drying up of rivers and lower groundwater levels due to prolonged periods of drought;
- severe storms: increased storm activity that damages buildings and urban infrastructure.

## *2 Analysis of the existing urban infrastructure*

### 2.1. Flood resilience:

- Existing dams and levees on the Dnipro River: partially effective, but in many places outdated and in need of reconstruction;
- stormwater drainage system: overloaded during heavy rains, leading to flooding of streets and residential areas.

### 2.2. Ability to withstand heat:

- green areas cover about 25% of the urban area, which partially helps to mitigate the impact of heat, but the pace of urbanization is reducing the area of these zones.
- insufficient level of green roofs and use of reflective materials in buildings.

### 2.3. Water resources management:

- water supply is provided mainly from rivers and underground sources, but there is a lack of rainwater collection systems for further use;
- outdated water intake equipment leads to significant water losses.

## *3. Suggested improvements and adaptation measures*

### 3.1. Flood management:

- modernization of hydraulic structures: reconstruction of dams and dikes and strengthening of the Dnipro River banks;
- improvement of stormwater drainage: creation of new drainage systems and tanks for temporary storage of rainwater;
- restoration of natural wetlands: to absorb excess water during floods.

### 3.2. Adaptation to heat:

- expansion of green areas: creation of new parks, squares, and greening of streets;
- use of modern technologies in construction: introduction of reflective materials for roofs and walls, installation of natural ventilation systems;
- green roofs: implementation of support programs for the arrangement of green roofs on high-rise buildings.

### 3.3. Water resources management:

- rainwater harvesting systems: installation of tanks for storing rainwater that can be used for irrigation or technical needs;
- modernization of water supply: replacement of old pipes and reduction of water losses.

### 3.4 Educational and organizational measures:

- conducting information campaigns among the population about climate threats and adaptation measures;
- development of an emergency response plan in case of floods or other climate disasters.

*Conclusion.* The proposed measures will mitigate the risks associated with climate change and enhance Kyiv's resilience to its impacts. The main emphasis should be placed on upgrading infrastructure and increasing the area of green areas.

### **Checklist questions**

1. What climatic phenomena are most commonly observed in your city (droughts, heavy rains, strong winds)?
2. What consequences have these phenomena already had for the city (destruction of roads, flooding of buildings, water shortages)?
3. Are there any areas of the city that are particularly vulnerable to climate threats?
4. Does the drainage system work during heavy rainfall?
5. Is there enough green space in the city to help regulate the temperature?
6. What measures are already being taken by local authorities to counter climate threats?
7. What resources and budget are available to modernize the city's infrastructure?

## Case Study №2

### DEVELOPMENT OF AN ENERGY-EFFICIENT BUILDING CONCEPT

**Objective:** To create a building concept that reduces energy consumption, minimizes greenhouse gas emissions, and is resilient to climate change.

**Tasks:**

1. *Research modern technologies and solutions in the field of energy-efficient construction.* In particular:

- renewable energy sources (solar panels, wind turbines);
- innovative materials with high thermal insulation;
- water collection and reuse systems;
- green roofs and vertical gardening.

2. *Develop a house design that takes into account:*

- orientation of the building on the ground for optimal use of sunlight.
- materials to reduce heat loss;
- energy-efficient ventilation and air conditioning systems;
- use of local resources to reduce transportation costs for construction.

3. *Assess the environmental impact:*

- calculate approximate energy savings compared to conventional buildings;
- determine the reduction of greenhouse gas emissions;
- show long-term benefits for residents and the ecosystem.

*Format of execution:*

- presentation in the form of slides or a text document with graphs, illustrations and comparative analysis;
- modeling (optional) in visualization programs such as SketchUp, AutoCAD or other available tools.

*Indicative questions for analysis:*

- Which energy sources are most efficient for a given region?
- How can building design contribute to reducing energy consumption?
- What are the best materials to use to reduce environmental impact?
- How can green technologies be integrated into the building's appearance?

*Results:*

Students are required to present an innovative and practical project that illustrates how technology can ensure energy efficiency and sustainability in construction.

## 1. Theoretical information

*An energy-efficient building* is one that consumes a minimal amount of energy to ensure the comfort of its occupants. Such buildings are developed using innovative technologies aimed at reducing energy consumption, reducing greenhouse gas emissions, and increasing resilience to climate change.

### ***The main principles of energy-efficient construction are:***

1. Energy saving:
  - use of materials with high thermal insulation properties (e.g., expanded polystyrene, mineral wool);
  - installation of energy-efficient windows and doors to reduce heat loss.
2. Renewable energy sources:
  - solar panels for electricity generation;
  - heat pumps for heating and cooling;
  - wind turbines in appropriate regions.
3. Design optimization:
  - orientation of the building to maximize the use of natural light and solar heat;
  - use of passive cooling systems, such as external curtains, awnings or green spaces.
4. Rational water use:
  - installation of rainwater collection systems for technical needs;
  - use of devices with low water consumption (economical taps, shower systems).
5. Integration of green technologies:
  - green roofs to increase thermal insulation and carbon dioxide absorption;
  - vertical greening to reduce overheating of facades.
6. Automation:
  - use of smart lighting, heating and ventilation control systems.

### ***Economic and environmental benefits:***

1. Reduced energy costs: an energy-efficient house can reduce energy consumption by 30-50% compared to traditional housing.
2. Reducing greenhouse gas emissions: the use of renewable energy sources minimizes the environmental impact of building construction and operation.
3. Improved comfort: energy-efficient heating and ventilation systems provide an optimal indoor climate.
4. Durability: the use of quality materials increases the service life of the building and reduces the need for repairs.

Examples of innovative solutions:

- Passive house: a building that requires almost no energy for heating or cooling due to effective insulation and proper location.
- «Zero-emission» buildings: buildings that generate as much energy as they consume through solar panels and other technologies.
- Eco-villages: communities with homes designed to minimize environmental impact.

*Sources of information for in-depth study:*

- Websites of manufacturers of energy-efficient materials. - Research on green building.
- Webinars or courses on green building.
- Building modeling programs such as SketchUp or AutoCAD.

## **2. Example of solving case study №2**

*Project name:* "Solar House of the Future"

*Location:* Ukraine, temperate climate.

*Goal:* to create a house that consumes 50% less energy than traditional buildings.

*Architectural solutions:*

1. Location of the house:

- the main facade is oriented to the south to maximize the use of solar heat;
- minimization of windows on the north side to reduce heat loss.

2. Materials:

- walls with multilayer thermal insulation (aerated concrete + mineral wool insulation);

- roof with sun protection coating and green spaces to reduce overheating.

3. Design:

- large triple-glazed windows on the south side.
- use of external blinds to protect against summer overheating.

*Engineering solutions:*

1. Renewable energy sources:

- solar panels on the roof to generate electricity (up to 10 kW);
- solar systems for water heating.

2. Heating and cooling:

- Heat pump system for heating in winter and cooling in summer;
- Underfloor heating with low-temperature operation.

3. Ventilation:

- heat recovery system that recovers up to 70% of the heat from the exhaust air.

4. Water supply:

- rainwater harvesting system for plant irrigation and technical needs;
- economical water mixers and cisterns.

*Environmental solutions:*

1. Green roof:

- Plants that absorb CO<sub>2</sub> and improve thermal insulation.

2. Vertical gardens on the facade:

- reduce the impact of solar radiation and promote natural cooling.

*Comparison with a traditional house (Table 1).*

*Table 1*

**Comparative characteristics of traditional and energy-efficient buildings**

Parameter	Traditional house	Energy efficient house
Energy consumption	200 kWh/m <sup>2</sup> /year	90-100 kWh/m <sup>2</sup> /year
The level of CO <sub>2</sub> emissions	High	Low
Initial cost of construction	Medium	15-20% higher
Payback	None of the above	5-7 years

*Results and conclusions:* this house saves up to 50% of energy, reduces emissions, and ensures comfort and sustainable development.

**Control questions**

1. What factors should be considered when choosing a location for an energy-efficient building?
2. How do climatic conditions affect the choice of materials for the construction of an energy-efficient building?
3. What are the features of using solar panels in different climatic zones?
4. How does the orientation of the house affect its energy efficiency?
5. What are the advantages of multilayer walls with insulation compared to traditional materials?
6. How to choose the right type of windows to reduce heat loss in winter?
7. How does a heat pump work, and why is it beneficial to use it in an energy-efficient house?
8. What factors influence the choice of a ventilation system for such a house?

### Case study № 3

## ASSESSMENT OF THE IMPACT OF TEMPERATURE INCREASE ON ENERGY CONSUMPTION

**Objective:** To assess the impact of rising temperatures on energy consumption for cooling buildings and to determine the overall increase in energy consumption during the period of high temperatures.

### 1. Theoretical information

*The Impact of Temperature on Energy Consumption.* As air temperature rises, the need for cooling in buildings increases, which in turn increases energy consumption. The following relationship is used to estimate this impact: For every 10C increase in temperature, the average energy consumption increases by 10%.

*Daily energy consumption after temperature increase:* if consumption increases by 10% for each degree, then energy consumption at a temperature increase of X°C can be determined by the formula (3.1):

$$E_x = E_0 \times (1 + 0,1X) \quad (3.1)$$

where  $E_0$  - is the initial energy consumption at a temperature of 25 °C (100 Wh/day).

The additional energy consumption for the period is:

$$\Delta E_{total} = (E_x - E_0) \cdot T \quad (3.2)$$

*Baseline data:* the city has a tendency to increase in temperature, which can reach X°C (table of options). Your task is to estimate how this temperature increase will affect the energy consumption for cooling buildings. Consider that for every 1 °C increase in temperature, the average energy consumption for cooling increases by 10%. Calculate the amount of energy that will be used for cooling if the average energy consumption before the temperature increase was 100 kWh per day. What is the total increase in energy consumption for 30 days of increased temperature?

### 2. Example of solving case study №3

*Assumption:* the city tends to experience a temperature increase, which can reach 35°C. Note that with each 1°C increase in temperature, the average energy consumption for cooling increases by 10%. The initial cooling energy consumption at 25°C is 100 kWh per day.

*Solution:*

1. *Total temperature change calculation:* initial temperature is 25 °C; final temperature X = 35 °C; temperature difference is 35 °C - 25 °C = 10 °C; time T = 30 days; initial energy consumption  $E_0$  at 25 °C (100 kWh/day).

That, the temperature is increased by 10 °C.

2. *Change in energy consumption:* Every 1 °C increase in temperature results in a 10% increase in energy consumption. Therefore, if the temperature increases by 10 °C, the energy consumption will increase by 10 % for every degree.

*General coefficient of increase of energy consumption:*

- after the increase of temperature by 1 °C: energy consumption will be increased on 1,1 times;

- after the increase of temperature by 10 °C: the energy consumption will increase by 1,1<sup>10</sup>.

3. *Calculation of new energy consumption:* the initial energy consumption for cooling at 25 °C is 100 kWh per day.

Let's calculate the daily energy consumption at a temperature of 35 °C: substitute the values into formula (3.1):

$$E_x = 100 \times (1 + 0,1 \times 10) = 100 \times 2,1 = 210 \text{ kWh/day.}$$

The additional energy consumption for the period is determined by the formula (3.2):

$$\Delta E_{total} = (210 - 100) \cdot 30 = 3300 \text{ kWh.}$$

*Conclusion:* When the temperature rises to 35 °C, the energy consumption for cooling increases from 100 kWh to 210 kWh per day. Thus, if the temperature rises to 35 °C, the energy consumption for cooling will increase by more than two and a half times. The total increase in energy consumption per month is 3300 kWh, which indicates a significant additional load on the city's power system.

Such an increase in temperature can cause overloading of power networks, especially during peak periods, which requires:

- implementation of measures to increase the energy efficiency of buildings;
- transition to renewable energy sources to reduce the impact on the environment;
- resource planning to meet increased energy demand. Thus, climate change has a significant impact on the energy sector, and this needs to be taken into account in long-term planning.

**Case study № 4**  
**ESTIMATING TEMPERATURE INCREASE DUE TO**  
**THE "URBAN HEAT ISLAND" EFFECT**

**Objective:** to estimate the temperature increase in urban areas caused by the "urban heat island" effect by analyzing its causes and using calculation methods to quantify the impact of various factors on temperature increase.

**1. Theoretical background**

«The Urban Heat Island Effect» (UHI) is the phenomenon where temperatures in urban areas are significantly higher than in suburban or rural areas. The main causes of this phenomenon are:

- high building density, which reduces air circulation;
- heat accumulation from asphalt, concrete and other building materials, which absorb and retain heat;
- reduction in the number of green spaces, which limits natural cooling through evaporation;
- heat emissions from vehicles, industry and air conditioners.

The formula for calculating the temperature in a city (4.1):

$$T_{city} = T_{suburb} + \Delta T_{city} \quad (4.1)$$

where  $T_{city}$  - is the temperature in the city,

$T_{suburb}$  - temperature in the suburbs,

$\Delta T_{city}$  - temperature difference (°C).

Estimate the temperature increase in urban areas due to the «urban heat island effect». Given: the average temperature in the urban environment is 3°C higher than the average temperature in the suburbs. The temperature increase is predicted to be A°C.

**Example of solving case study №4**

**Objective:** to estimate the increase in temperature in urban areas due to the "urban heat island" effect.

*Input:* nitial data indicate that the average temperature in urban environments is 3 °C higher than in suburban areas. The temperature increase is predicted to be 2 °C.

*Solution:*

According to formula (4.1), we have:

$$T_{city} = 25^{\circ}C + 3^{\circ}C + 2^{\circ}C = 30^{\circ}C$$

Climate change could cause temperatures in the city to rise to 30 °C. This increase in temperature leads to more frequent and intense hot days, which have serious impacts on the health of residents, the energy needs for cooling buildings, and the city's ecosystems. High temperatures can exacerbate health problems, including heatstroke and stress, and increase energy use for air conditioning, which further strains energy resources.

*Table 2*

**Initial data for case study № 3 and № 4**

№ Option number	<b>Case study № 3</b>	<b>Case study № 4</b>
	<i>X°C</i>	<i>Temperature increase by A°C</i>
1	30	1
2	31	1,5
3	32	1,8
4	33	2,1
5	34	2,3
6	35	2,4
7	36	2,5
8	37	2,6
9	38	2,7
10	39	3

**Case study № 5**  
**THE IMPACT OF THE CIRCULAR ECONOMY ON REDUCING**  
**THE CARBON FOOTPRINT IN CONSTRUCTION**

**The purpose of the work:** to investigate the impact of implementing the circular economy on reducing the carbon footprint in construction by comparing the traditional approach and the circular model of material use, assessing the environmental benefits, and calculating the savings in CO<sub>2</sub> emissions.

**1. Theoretical background**

*Input:* A construction company is planning to build a new facility and is considering two approaches:

Traditional approach: using 1200 tons of new concrete. The carbon footprint of new concrete production is 0.9 tons of CO<sub>2</sub> per ton of material.

Circular model: using 65% new concrete and 35% recycled concrete (i.e., 780 tons of new concrete and 420 tons of recycled concrete). The carbon footprint of recycled concrete is 0.3 tons of CO<sub>2</sub> per ton of material.

*Task:*

1. Calculate the total carbon footprint for each option.
2. Determine by what percentage the carbon footprint will be reduced when switching to the circular model.
3. Calculate how many CO<sub>2</sub> emissions will be saved when implementing the circular model.

Hint: to solve the problem, use the formulas: The total carbon footprint is determined by formula (5.1):

$$E_{\text{total}} = E_{\text{new concrete}} + E_{\text{recycled concrete}} \quad (5.1)$$

The percentage of carbon footprint reduction is calculated using the formula:

$$\Delta E\% = \frac{E_{\text{tradits}} - E_{\text{krugova}}}{E_{\text{tradits}}} \times 100\% \quad (5.2)$$

CO<sub>2</sub> emission savings:

$$\Delta E = E_{\text{tradits}} - E_{\text{krugova}} \quad (5.3)$$

**2. Example of solving case study № 5**

*Input:* A construction company is considering two options for the project:

1. *Traditional option:* using 1000 tons of new concrete. The carbon footprint of producing new concrete is 0.8 tons of CO<sub>2</sub> per 1 ton of material.

2. *Circular model*: using 70% new concrete and 30% recycled concrete (i.e., 700 tons of new concrete and 300 tons of recycled concrete). The carbon footprint of recycled concrete is 0.2 tons of CO<sub>2</sub> per 1 ton of material.

Calculate the total carbon footprint for each option.

1. By what percentage will the carbon footprint be reduced by switching to a circular model?
2. How many CO<sub>2</sub> emissions will be saved?

*Solution:*

1. Calculation of the total carbon footprint:

*Traditional version:*

$$E_{\text{traditional.}} = 1000\text{T} \times 0,8\text{CO}_2\text{T} = 800\text{T CO}_2$$

*Circular model:*

Carbon footprint of new concrete:

$$E_{\text{new.}} = 700\text{T} \times 0,8\text{CO}_2\text{T} = 560\text{T CO}_2$$

Carbon footprint of recycled concrete:

$$E_{\text{recycled..}} = 300\text{t} \times 0,2\text{CO}_2\text{t} = 60\text{t CO}_2$$

The total carbon footprint for the circular model is calculated using the formula (5.1):

$$E_{\text{circular.}} = 560\text{t} + 60\text{tCO}_2 = 620\text{t CO}_2$$

- 2, Percentage of carbon footprint reduction, formula (5.2):

$$\Delta E\% = \frac{800\text{tCO}_2 - 620\text{tCO}_2}{800\text{tCO}_2} \times 100\% = 22,5\%$$

We calculate the CO<sub>2</sub> emission savings using the formula (6.3):

$$\Delta E = E_{\text{tradits}} - E_{\text{krugova}} = 800\text{tCO}_2 - 620\text{tCO}_2 = 180\text{tCO}_2$$

*Answer:*

1. Total carbon footprint:
  - for the traditional option: 800 t CO<sub>2</sub> ;
  - for the circular model: 620 t CO<sub>2</sub> .
2. The reduction in carbon footprint is 22.5%.
3. Amount of CO<sub>2</sub> emissions saved: 180 t CO<sub>2</sub> .

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OF CLIMATE CHANGE AND ADAPTATION TO IT  
FOR THE CONSTRUCTION INDUSTRY OF UKRAINE**

Methodical instructions

for practical work for applicants for the second (master's)  
level of higher education in the specialties E2 “Ecology”,  
G2 “Environmental Protection Technologies”

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