Pryazovskyi State Technical University

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Lecture on "Energy parameters of risks"

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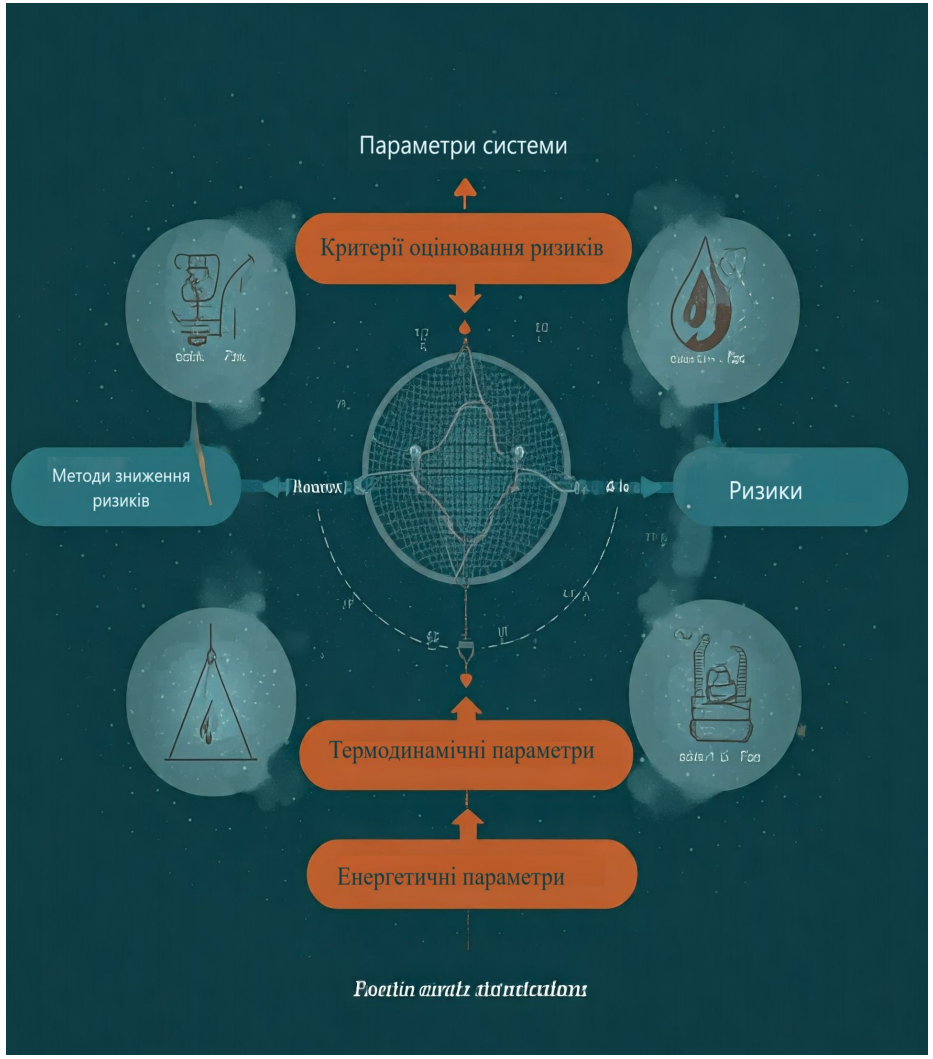
The purpose of the lecture

To consider the concept of risk assessment through the prism of energy parameters, apply concepts from thermodynamics and demonstrate the practical application of this approach



Plan

1. Understanding the energy component of risks

1.1 Thermodynamic approach to risk assessment

1.2 The concept of entropy as a measure of uncertainty and risk

1.3 Application of basic thermodynamic parameters in risk assessment

2. Temperature, as an important energy parameter that must be taken into account when assessing risks.

2.1 Effect of temperature on changes in the physical properties of substances

2.2 Effect of temperature on the reduction of strength of materials

2.3 Effect of temperature on environmental risks.

2.4 Measures to prevent risks from temperature changes

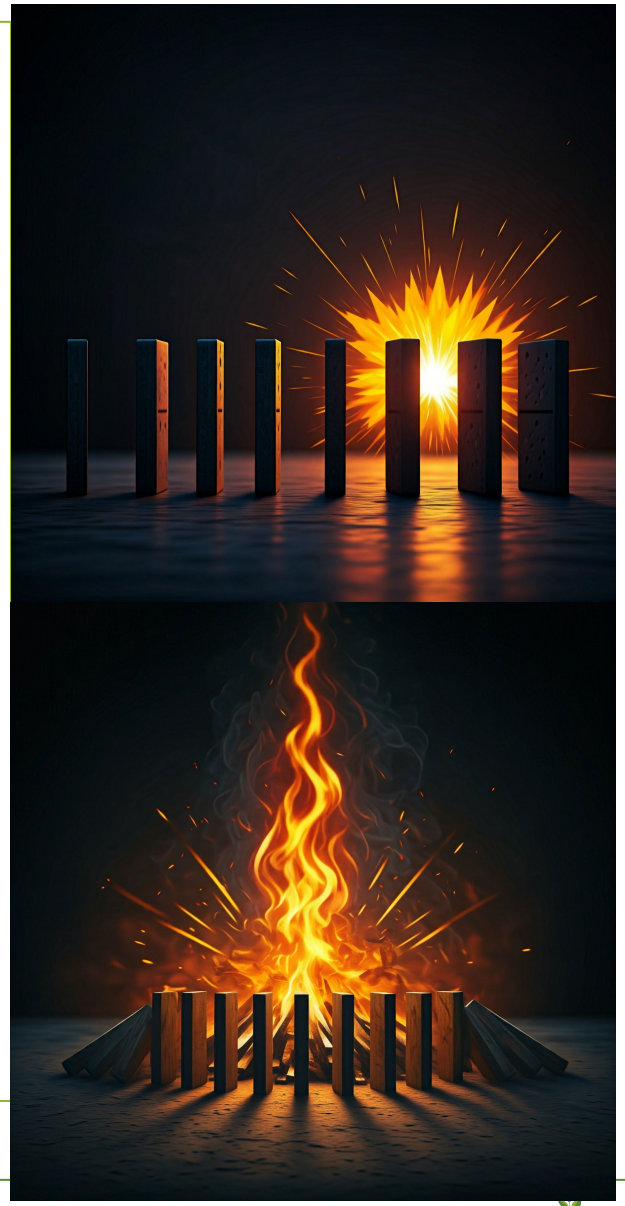
3. Directions for applying the energy approach to risk assessment

nderstanding the energy component of risks

1.1. Thermodynamic approach to risk assessment

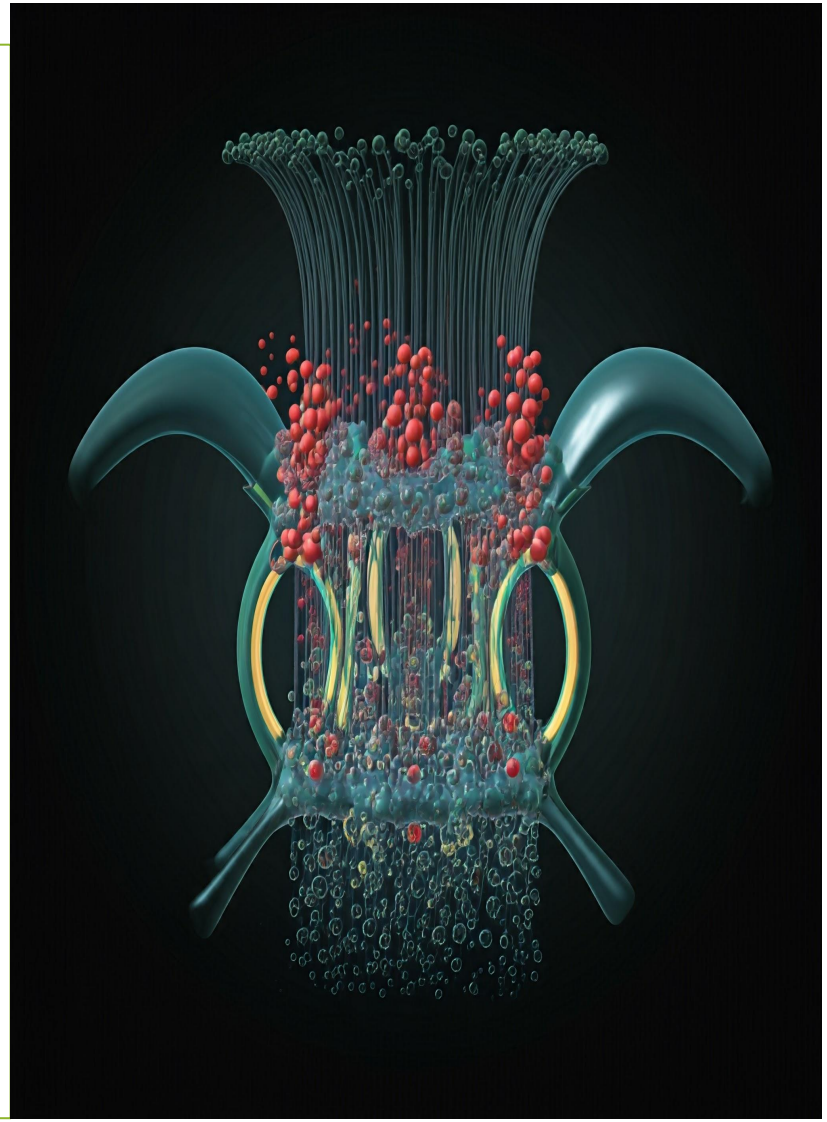
Energy is a risk driver. Different types of energy (thermal, chemical, nuclear, electric, etc.) can be sources of risks.

The higher the energy concentration in the system, the greater the potential for hazardous situations to occur. For example, high gas pressure in a cylinder creates a potential explosion threat.



1. Understanding the energy component of risks

Thermodynamics, as a science of energy and its transformation, provides us with an understanding of risk formation processes from the standpoint of energy, entropy, and thermodynamic equilibrium. Systems in thermodynamic equilibrium are usually more stable and less prone to risks



. Understanding the energy component of risks

1.2. The concept of entropy as a measure of uncertainty and risk

Changes in the energy state of the system can lead to unpredictable consequences.

Entropy is a measure of how evenly distributed energy is in a system.

Understanding the energy component of risks

Effect of increasing entropy in different systems

Technical systems

- An increase in the entropy of technical systems can indicate wear of parts, overheating, leakage of substances and other problems that can lead to accidents.

Social systems

- High entropy in social systems can manifest itself in the form of social conflicts, economic instability and other negative phenomena.

Ecological systems

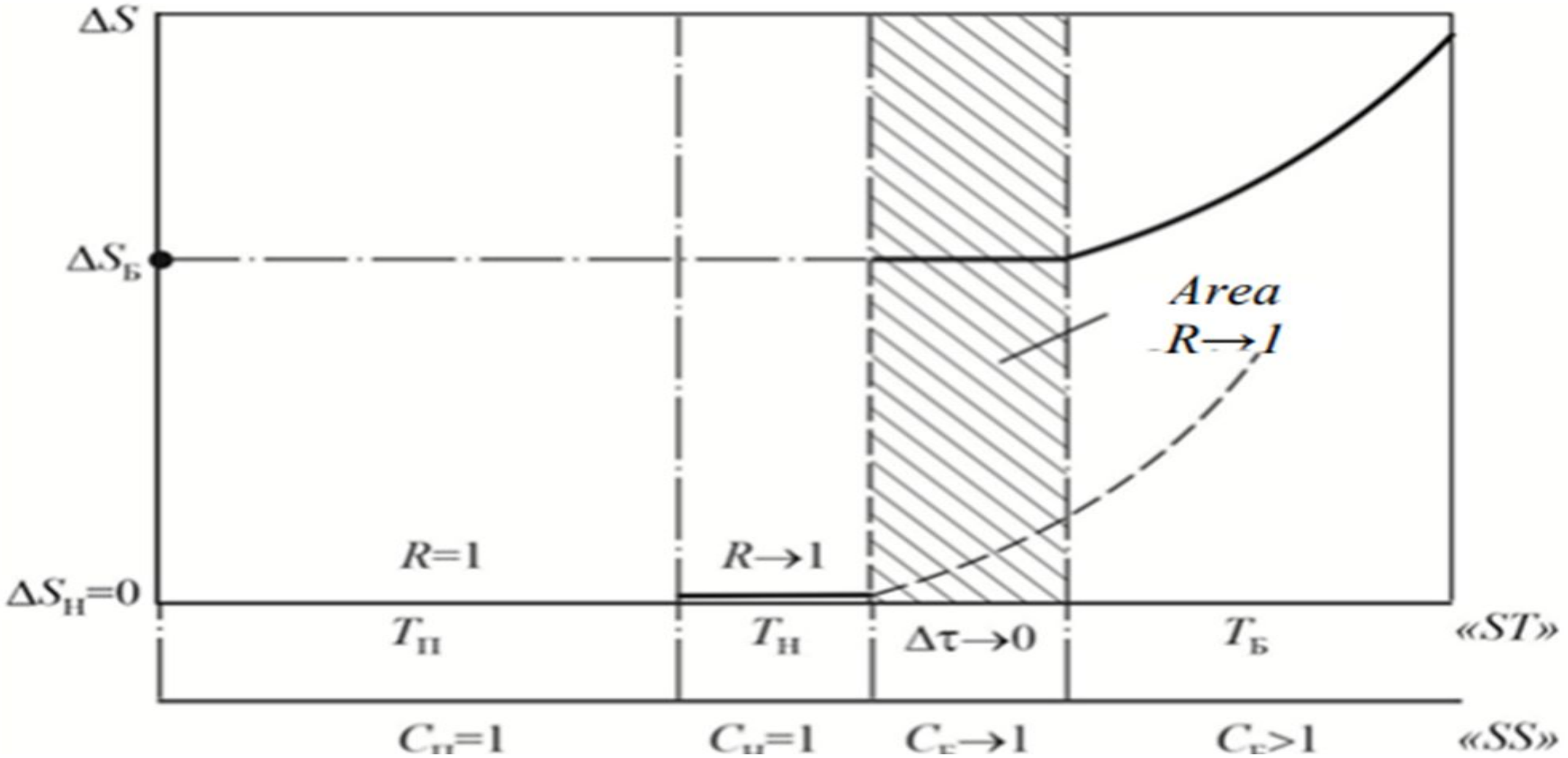
- High entropy in social systems can manifest itself in the form of social conflicts, economic instability and other negative phenomena.

1. Understanding the energy component of risks

The higher the entropy of the system, the less predictable it is.

Systems with high entropy are more prone to unpredictable changes and, therefore, carry more risk.

1. Understanding the energy component of risks



Estimated risk entropy in relation to time "ST" and event "SS" measurements

. Understanding the energy component of risks

Shannon's formula [3] is most often used to estimate system entropy:

$$S = -\sum p(x) * log_2 p(x) , \quad (1)$$

where S - is the entropy of the system (J/K), which measures the amount of energy that is distributed in the system when the temperature changes by one kelvin;

$p(x)$ – the probability that the system is in state x.

1. Understanding the energy component of risks

Example: Imagine a glass of hot water. Water molecules move chaotically, which corresponds to the high entropy of the system. If we add cold water, the system will try to reach equilibrium, which can lead to unpredictable temperature fluctuations. This process can be considered as an analogue of the development of an event that can lead to a dangerous situation (for example, a burn).

1. Understanding the energy component of risks

Thermodynamic parameters are physical quantities that describe the state of the system.

They are interconnected and can be used to predict system behavior in various conditions.

This relationship is key in risk assessment as it allows you to predict potential hazards and design safety measures

1. Understanding the energy component of risks

Basic thermodynamic parameters that can be used in risk assessment

Parameter	Description of the parameter	Impact on risk
Temperature (T)	Shows how strongly the particles of matter move. The higher the temperature, the faster the particles move.	An increase in temperature can lead to deformation of materials, explosions, fires and other dangerous phenomena.
Pressure (P)	The force with which a substance acts on a unit area	A change in pressure can lead to the destruction of structures, explosions, leaks of harmful substances
Volume (V):	The space occupied by a substance	In combination with other parameters
Internal energy (U):	The total kinetic and potential energy of the particles that make up the system.	A change in the system's internal energy can lead to phase transitions, chemical reactions, and other processes that carry risks.
Entropy (S):	A measure of disorder in the system. The greater the entropy, the less we know about the state of the system.	The high entropy of the system indicates its instability and increased risk.

. Understanding the energy component of risks

Knowing the thermodynamic characteristics of the system, we can predict how it will behave in different conditions, even predict possible accidents, disasters and other negative events. For example, to prevent explosions in chemical industries, it is necessary to control the temperature and pressure of the reaction mixture.

2. Temperature as an important energy parameter

Risks of accidents and catastrophes depending on the temperature

Let's consider examples of how temperature can affect risks.

•Fires: An increase in temperature can lead to spontaneous combustion of combustible materials, especially in conditions of insufficient ventilation.

• Explosions: When heated, many substances decompose with the release of gases, which can lead to an increase in pressure in a closed volume and an explosion.

• Deformations of materials: A change in temperature can lead to the expansion or contraction of materials, which can cause deformations of structures and equipment.

•Disturbance of technological processes: A change in temperature can disrupt technological processes, lead to a decrease in product quality or equipment failure.

• Natural disasters: A change in temperature can affect climatic conditions, contributing to the occurrence of extreme weather events, such as droughts, floods, hurricanes.

2 Temperature as an important energy parameter

The influence of temperature on environmental risks

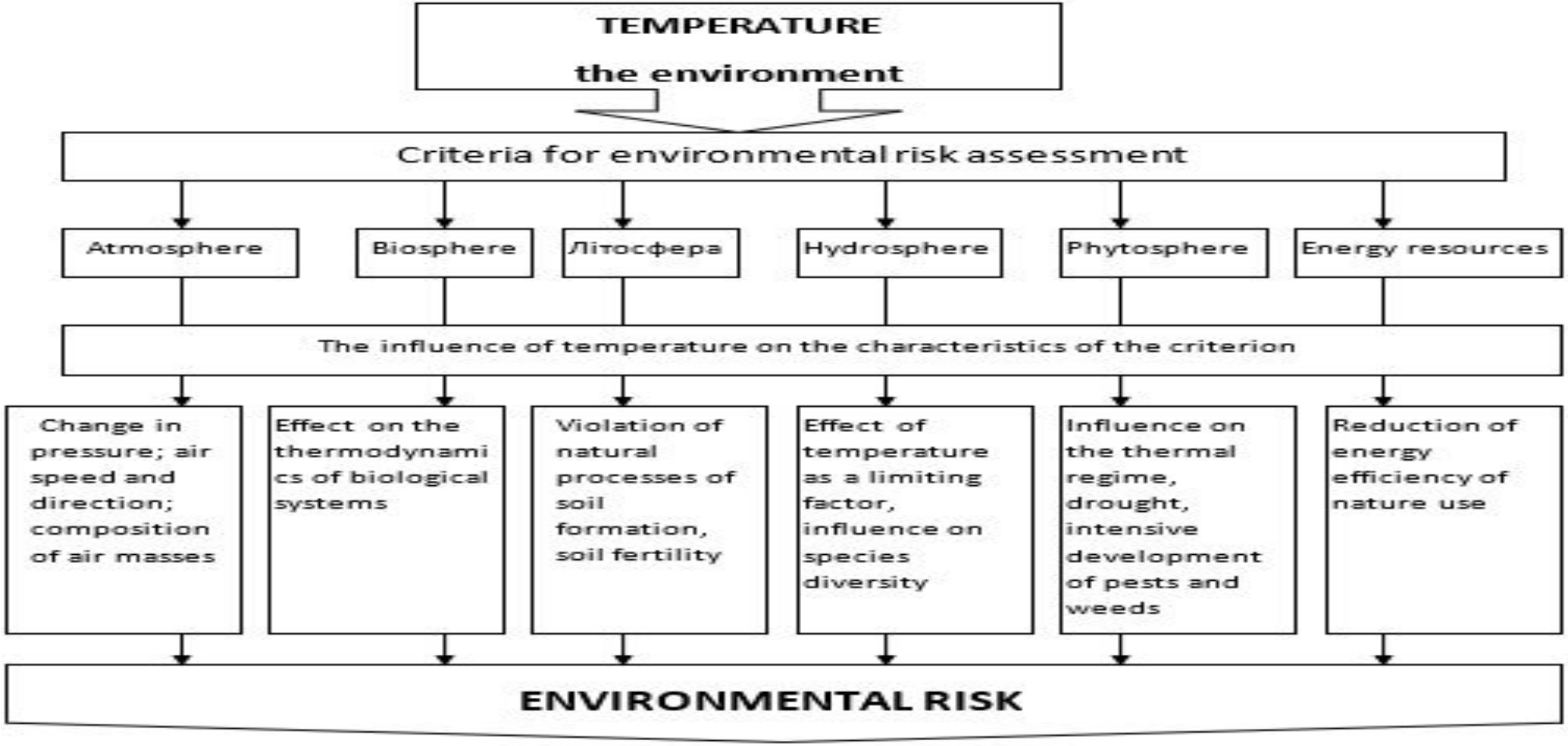
Temperature is one of the important energy parameters that can be used in risk assessment, and which directly or indirectly affects both individual technological processes and the environment as a whole.

An increase in the temperature of the environment as a result of anthropogenic activity on the natural environment leads to an increase in environmental risks.

Temperature, as an energy parameter of risk, is a limiting abiotic factor for many components of ecosystems

2. Temperature as an important energy parameter

The influence of temperature as an abiotic factor of the environment on the assessment of environmental risk of transport and technological systems



Temperature as an important energy parameter

Risks related to temperature can be prevented by understanding the nature and direction of their action

- It is necessary to control the temperature with thermosensors and automatic regulation systems to maintain the optimal temperature in technological processes.

- The use of heat-insulating materials reduces heat loss and prevents equipment overheating.

- Provision of sufficient ventilation to remove thermal energy and prevent the accumulation of combustible gases.

- Compliance with fire safety rules, use of fire extinguishers and other means of extinguishing fire reduces possible damage from fires.

3. Directions for applying the energy approach to risk assessment

It is appropriate to determine the level of risk using energy parameters when applying an expert approach. It consists in the application of modeling on a multi-criteria basis of the probability of risk occurrence under the influence of changes in the energy parameters of processes, taking into account the internal connections between various objects and processes with the participation of an expert, that is, an experienced decision-maker

3. Directions for applying the energy approach to risk assessment

When using energy parameters for risk assessment, it is necessary, first of all, to create a mathematical model of the process that takes into account all relevant thermodynamic parameters. Then it is necessary to analyze the sensitivity of process or technology indicators, to determine how a change in a certain energy parameter affects the probability of an emergency situation. Next, we determine the boundary conditions, the values of the parameters at which the system becomes unstable.

3. Directions for applying the energy approach to risk assessment

Type of risk	Analysis of influencing energy parameters
Explosion risk assessment	Analysis of changes in temperature, pressure and internal energy in the system allows to estimate the probability of an explosion
Fire risk assessment	Analysis of thermal processes occurring in materials allows to determine the conditions under which a fire may occur
Assessment of the risk of chemical reactions	Analysis of changes in enthalpy and Gibbs free energy allows predicting the possibility of spontaneous chemical reactions
Environmental disaster risk assessment	Analysis of thermodynamic processes occurring in natural systems allows to assess the risk of such disasters as floods, earthquakes, volcanic eruptions

Analysis of the impact of energy parameters on risk assessment

Examples of using energy parameters for risk assessment

Object of research	Energy parameters for risk assessment
Nuclear power plants	The assessment of the risk of a nuclear accident is based on the analysis of such parameters as the temperature of the coolant, the pressure in the circuit, and the speed of neutrons.
Explosions in mines	Analysis of temperature, concentration of combustible gases and sources of ignition allows to assess the risk of an explosion
Fires	The assessment of the fire hazard of materials is based on the analysis of their thermophysical properties, auto-ignition temperature and flame propagation speed

Conclusions

1. Understanding energy processes is key to risk assessment. Thermodynamics provides us with a powerful toolkit for analyzing the causes of risks, their development and consequences. The application of thermodynamic principles allows for the development of more effective risk management strategies in various spheres of human activity. The use of energy parameters for risk assessment is a promising direction of research that allows obtaining a more complete and objective picture of risks.

2. Thermodynamics can be a powerful tool for risk assessment, especially in industries where energy processes play an important role. However, its application requires a comprehensive approach and consideration of other factors, such as social, economic and political.

3. Although entropy is not a direct measure of risk, it is a useful tool for assessing it. By combining entropy analysis with other methods, you can get a more complete picture of potential threats and develop effective security measures.

Resources and literature

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