

Henrique Ajuz Holzmann  
João Dallamuta  
(Organizadores)

# ENGENHA- RIAS: Pesquisa, desenvolvimento e inovação

Henrique Ajuz Holzmann  
João Dallamuta  
(Organizadores)

# ENGENHARIA- RIAS: Pesquisa, desenvolvimento e inovação



Atena  
Editora  
Ano 2022

**Editora chefe**

Profª Drª Antonella Carvalho de Oliveira

**Editora executiva**

Natalia Oliveira

**Assistente editorial**

Flávia Roberta Barão

**Bibliotecária**

Janaina Ramos

**Projeto gráfico**

Bruno Oliveira

Camila Alves de Cremo

Daphynny Pamplona

Luiza Alves Batista

Natália Sandrini de Azevedo

**Imagens da capa**

iStock

**Edição de arte**

Luiza Alves Batista

2022 by Atena Editora

Copyright © Atena Editora

Copyright do texto © 2022 Os autores

Copyright da edição © 2022 Atena Editora

Direitos para esta edição cedidos à Atena Editora pelos autores.

Open access publication by Atena Editora



Todo o conteúdo deste livro está licenciado sob uma Licença de Atribuição *Creative Commons*. Atribuição-Não-Comercial-Não-Derivativos 4.0 Internacional (CC BY-NC-ND 4.0).

O conteúdo dos artigos e seus dados em sua forma, correção e confiabilidade são de responsabilidade exclusiva dos autores, inclusive não representam necessariamente a posição oficial da Atena Editora. Permitido o *download* da obra e o compartilhamento desde que sejam atribuídos créditos aos autores, mas sem a possibilidade de alterá-la de nenhuma forma ou utilizá-la para fins comerciais.

Todos os manuscritos foram previamente submetidos à avaliação cega pelos pares, membros do Conselho Editorial desta Editora, tendo sido aprovados para a publicação com base em critérios de neutralidade e imparcialidade acadêmica.

A Atena Editora é comprometida em garantir a integridade editorial em todas as etapas do processo de publicação, evitando plágio, dados ou resultados fraudulentos e impedindo que interesses financeiros comprometam os padrões éticos da publicação. Situações suspeitas de má conduta científica serão investigadas sob o mais alto padrão de rigor acadêmico e ético.

**Conselho Editorial****Ciências Exatas e da Terra e Engenharias**

Prof. Dr. Adélio Alcino Sampaio Castro Machado – Universidade do Porto

Profª Drª Alana Maria Cerqueira de Oliveira – Instituto Federal do Acre

Profª Drª Ana Grasielle Dionísio Corrêa – Universidade Presbiteriana Mackenzie

Profª Drª Ana Paula Florêncio Aires – Universidade de Trás-os-Montes e Alto Douro

Prof. Dr. Carlos Eduardo Sanches de Andrade – Universidade Federal de Goiás

Profª Drª Carmen Lúcia Voigt – Universidade Norte do Paraná



Prof. Dr. Cleiseano Emanuel da Silva Paniagua – Instituto Federal de Educação, Ciência e Tecnologia de Goiás  
Prof. Dr. Douglas Gonçalves da Silva – Universidade Estadual do Sudoeste da Bahia  
Prof. Dr. Eloi Rufato Junior – Universidade Tecnológica Federal do Paraná  
Profª Drª Érica de Melo Azevedo – Instituto Federal do Rio de Janeiro  
Prof. Dr. Fabrício Menezes Ramos – Instituto Federal do Pará  
Profª Dra. Jéssica Verger Nardeli – Universidade Estadual Paulista Júlio de Mesquita Filho  
Prof. Dr. Juliano Bitencourt Campos – Universidade do Extremo Sul Catarinense  
Prof. Dr. Juliano Carlo Rufino de Freitas – Universidade Federal de Campina Grande  
Profª Drª Luciana do Nascimento Mendes – Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Norte  
Prof. Dr. Marcelo Marques – Universidade Estadual de Maringá  
Prof. Dr. Marco Aurélio Kistemann Junior – Universidade Federal de Juiz de Fora  
Prof. Dr. Miguel Adriano Inácio – Instituto Nacional de Pesquisas Espaciais  
Profª Drª Neiva Maria de Almeida – Universidade Federal da Paraíba  
Profª Drª Natiéli Piovesan – Instituto Federal do Rio Grande do Norte  
Profª Drª Priscila Tessmer Scaglioni – Universidade Federal de Pelotas  
Prof. Dr. Sidney Gonçalo de Lima – Universidade Federal do Piauí  
Prof. Dr. Takeshy Tachizawa – Faculdade de Campo Limpo Paulista



# Engenharias: pesquisa, desenvolvimento e inovação

**Diagramação:** Camila Alves de Cremo  
**Correção:** Mariane Aparecida Freitas  
**Indexação:** Amanda Kelly da Costa Veiga  
**Revisão:** Os autores  
**Organizadores:** Henrique Ajuz Holzmann  
João Dallamuta

## Dados Internacionais de Catalogação na Publicação (CIP)

E57 Engenharia: pesquisa, desenvolvimento e inovação /  
Organizadores Henrique Ajuz Holzmann, João  
Dallamuta. – Ponta Grossa - PR: Atena, 2022.

Formato: PDF

Requisitos de sistema: Adobe Acrobat Reader

Modo de acesso: World Wide Web

Inclui bibliografia

ISBN 978-65-258-0481-1

DOI: <https://doi.org/10.22533/at.ed.811220208>

1. Engenharia. I. Holzmann, Henrique Ajuz  
(Organizador). II. Dallamuta, João (Organizador). III. Título.  
CDD 620

Elaborado por Bibliotecária Janaina Ramos – CRB-8/9166

**Atena Editora**

Ponta Grossa – Paraná – Brasil

Telefone: +55 (42) 3323-5493

[www.atenaeditora.com.br](http://www.atenaeditora.com.br)

contato@atenaeditora.com.br



**Atena**  
Editora  
Ano 2022

## DECLARAÇÃO DOS AUTORES

Os autores desta obra: 1. Atestam não possuir qualquer interesse comercial que constitua um conflito de interesses em relação ao artigo científico publicado; 2. Declaram que participaram ativamente da construção dos respectivos manuscritos, preferencialmente na: a) Concepção do estudo, e/ou aquisição de dados, e/ou análise e interpretação de dados; b) Elaboração do artigo ou revisão com vistas a tornar o material intelectualmente relevante; c) Aprovação final do manuscrito para submissão.; 3. Certificam que os artigos científicos publicados estão completamente isentos de dados e/ou resultados fraudulentos; 4. Confirmam a citação e a referência correta de todos os dados e de interpretações de dados de outras pesquisas; 5. Reconhecem terem informado todas as fontes de financiamento recebidas para a consecução da pesquisa; 6. Autorizam a edição da obra, que incluem os registros de ficha catalográfica, ISBN, DOI e demais indexadores, projeto visual e criação de capa, diagramação de miolo, assim como lançamento e divulgação da mesma conforme critérios da Atena Editora.



## DECLARAÇÃO DA EDITORA

A Atena Editora declara, para os devidos fins de direito, que: 1. A presente publicação constitui apenas transferência temporária dos direitos autorais, direito sobre a publicação, inclusive não constitui responsabilidade solidária na criação dos manuscritos publicados, nos termos previstos na Lei sobre direitos autorais (Lei 9610/98), no art. 184 do Código Penal e no art. 927 do Código Civil; 2. Autoriza e incentiva os autores a assinarem contratos com repositórios institucionais, com fins exclusivos de divulgação da obra, desde que com o devido reconhecimento de autoria e edição e sem qualquer finalidade comercial; 3. Todos os e-book são *open access*, *desta forma* não os comercializa em seu site, sites parceiros, plataformas de *e-commerce*, ou qualquer outro meio virtual ou físico, portanto, está isenta de repasses de direitos autorais aos autores; 4. Todos os membros do conselho editorial são doutores e vinculados a instituições de ensino superior públicas, conforme recomendação da CAPES para obtenção do Qualis livro; 5. Não cede, comercializa ou autoriza a utilização dos nomes e e-mails dos autores, bem como nenhum outro dado dos mesmos, para qualquer finalidade que não o escopo da divulgação desta obra.



## APRESENTAÇÃO

Um dos grandes desafios enfrentados atualmente nos mais diversos ramos do conhecimento, é o do saber multidisciplinar, aliando conceitos de diversas áreas. Hoje exige-se que os profissionais saibam transitar entres os conceitos e práticas, tendo um viés humano e técnico.

Neste sentido este livro traz capítulos ligados a teoria e prática em um caráter multidisciplinar, apresentando de maneira clara e lógica conceitos pertinentes aos profissionais das mais diversas áreas do saber.

Apresenta temas relacionados as áreas de engenharia, como civil, materiais, mecânica, química dentre outras, dando um viés onde se faz necessária a melhoria continua em processos, projetos e na gestão geral no setor fabril. Destaca-se ainda a busca da redução de custos, melhoria continua e automação de processos.

De abordagem objetiva, a obra se mostra de grande relevância para graduandos, alunos de pós-graduação, docentes e profissionais, apresentando temáticas e metodologias diversificadas, em situações reais.

Aos autores, agradeço pela confiança e espírito de parceria.

Boa leitura

Henrique Ajuz Holzmann

João Dallamuta



## SUMÁRIO


### **CAPÍTULO 1..... 1**

#### **AVALIAÇÃO DA TEMPERATURA, TEMPO DE DISSOLUÇÃO E CONCENTRAÇÃO DE DTPA NA DISSOLUÇÃO DE INCRUSTAÇÃO DE SULFATO DE BÁRIO**

Geizila Aparecida Pires Abib

Georgiana Feitosa da Cruz

Alexandre Sérvulo Lima Vaz Junior

 <https://doi.org/10.22533/at.ed.8112202081>


### **CAPÍTULO 2..... 18**

#### **PROCESSAMENTO CERÂMICO DE COMPÓSITOS DE ALUMINA E CA6**

Daniele Rodrigues Freitas

José Manuel Rivas Mercury

Antonio Ernandes Macêdo Paiva

 <https://doi.org/10.22533/at.ed.8112202082>


### **CAPÍTULO 3..... 25**

#### **ANÁLISE DE MECANISMOS**

Gabrieli Mesquita de Araujo

Hermano Ranieri Quirino Kubaski

Wesley Costa Bueno

 <https://doi.org/10.22533/at.ed.8112202083>

### **CAPÍTULO 4..... 39**

#### **SELECTIVE DISPERSION OF STYRENE-BUTADIENE CROSS-LINKED WASTE IN THE POLYSTYRENE MATRIX: A TRANSMISSION ELECTRON MICROSCOPY (TEM) RESEARCH**

Carlos Bruno Barreto Luna

Elieber Barros Bezerra


Divânia Ferreira da Silva

Eduardo da Silva Barbosa Ferreira

Edcleide Maria Araújo

Amanda Dantas de Oliveira

Renate Maria Ramos Wellen

 <https://doi.org/10.22533/at.ed.8112202084>

### **CAPÍTULO 5..... 53**

#### **ENERGY AND COVID-19 – ANALYSIS OF THE IMPACT ON THE GLOBAL ENERGY MATRIX**

Luiz Antonio Ferrari


Leni M. P. R Lima

Elaine A. Rodrigues

Maria Aparecida M. G. Pereira

Jamil M. S. Ayoub


José A. Seneda

 <https://doi.org/10.22533/at.ed.8112202085>

**CAPÍTULO 6..... 67**

**CERVEJA ESTILO CATHARINA SOUR: UMA BREVE REVISÃO DA LITERATURA**


Isabella Tauchert da Luz  
Vicente Damo Martins da Silva  
Janayne Sander Godoy  
Cristiano Reschke Lajús  
Gustavo Lopes Colpani  
Josiane Maria Muneron de Mello  
Francieli Dalcanton

 <https://doi.org/10.22533/at.ed.8112202086>

**CAPÍTULO 7..... 77**

**AGUAPÉ: UMA ALTERNATIVA SUSTENTÁVEL PARA O TRATAMENTO DE ÁGUA E SANEAMENTO**


Kaio Machado Santos  
Pedro Lúcio Bonifacio

 <https://doi.org/10.22533/at.ed.8112202087>

**CAPÍTULO 8..... 88**

**MELHORAMENTO DE RODOVIAS DE TERRA: UM ESTUDO DE CASO**


Rafael Pacheco dos Santos

 <https://doi.org/10.22533/at.ed.8112202088>

**CAPÍTULO 9..... 105**

**ANÁLISE DE METODOLOGIAS DE ENSINO E APRENDIZAGEM APLICADAS NO EGRESSO DA GRADUAÇÃO DE ENGENHARIA DE PRODUÇÃO – PARTE 1**


Fabiola Silva Bezerra  
Wallace Rodolfo Lopes da Silva  
Karina Silva Campos  
Camila Figueiredo Vasconcelos Vidal

 <https://doi.org/10.22533/at.ed.8112202089>

**CAPÍTULO 10..... 117**

**PLANEJAR PARA OTIMIZAR RECURSOS: APLICANDO A METODOLOGIA DA APRENDIZAGEM BASEADA EM BRINQUEDOS (ABB)**

Fabiola Silva Bezerra  
Alaine Cardoso Silva  
Luciano Guimarães Garcia


 <https://doi.org/10.22533/at.ed.81122020810>

**CAPÍTULO 11 ..... 126**

**CLOUD QOX: ARQUITECTURA DEL SISTEMA DE RECOGIDA DE INFORMACIÓN. APROXIMACIÓN EN EDUCACIÓN**

Rosa Mora  
Julián Fernández-Navajas  
José Ruiz-Mas

Ana Cebollero  
Patricia Chueca  
Marta Lampaya

 <https://doi.org/10.22533/at.ed.81122020811>

**CAPÍTULO 12..... 145**

**UTILIZAÇÃO DE APRENDIZAGEM BASEADA EM PROBLEMAS NO ENSINO DE  
MODELAGEM APLICADA A CONTROLADORES LÓGICOS PROGRAMÁVEIS**


Rafael Garlet de Oliveira  
Thiago Javaroni Prati  
Luan Cizeski de Lorenzi  
Antonio Ribas Neto

 <https://doi.org/10.22533/at.ed.81122020812>

**CAPÍTULO 13..... 156**

**OSTEORRADIONECROSE MANDIBULAR APÓS IMRT PARA CÂNCER DE CABEÇA E  
PESCOÇO**


Maria Cândida Dourado Pacheco Oliveira  
Danilo Viegas da Costa  
Caio Fernando Teixeira Portela  
Tarcísio Passos Ribeiro Campos  
Arno Heeren de Oliveira

 <https://doi.org/10.22533/at.ed.81122020813>

**CAPÍTULO 14..... 168**

**ANÁLISE PARA ATENUAÇÃO DE RISCOS DE CHOQUE ELÉTRICO E INCÊNDIOS  
EM INSTALAÇÕES ELÉTRICAS EM MORADIAS DE BAIXA RENDA EM CIDADE  
UNIVERSITÁRIA**

Márcio Mendonça  
Marta Rúbia Pereira dos Santos  
Fábio Rodrigo Milanez  
Wagner Fontes Godoy  
Rodrigo Henrique Cunha Palácios  
Marco Antônio Ferreira Finocchio  
Carlos Alberto Paschoalino  
Francisco de Assis Scannavino Junior  
Vicente de Lima Gongora  
Lucas Botoni de Souza  
Michele Eliza Casagrande Rocha  
José Augusto Fabri

 <https://doi.org/10.22533/at.ed.81122020814>

**CAPÍTULO 15..... 181**

**A RESIDÊNCIA EM SOFTWARE NO BRASIL**

Alessandro Silveira Duarte  
José Augusto Fabri  
Alexandre L'Erario

Rodrigo Henrique Cunha Palácios  
José Antonio Gonçalves  
Marta Rubia Pereira dos Santos  
Márcio Mendonça  
Michelle Eliza Casagrande Rocha  
Emanuel Ignacio Garcia

 <https://doi.org/10.22533/at.ed.81122020815>

<b>SOBRE OS ORGANIZADORES .....</b>	<b>197</b>
<b>ÍNDICE REMISSIVO .....</b>	<b>198</b>

## ENERGY AND COVID-19 – ANALYSIS OF THE IMPACT ON THE GLOBAL ENERGY MATRIX

*Data de aceite: 04/07/2022*

### **Luiz Antonio Ferrari**

Nuclear and Energy Research Institute – IPEN/  
CNEN  
São Paulo-São Paulo

### **Leni M. P. R Lima**

Nuclear and Energy Research Institute – IPEN/  
CNEN  
São Paulo-São Paulo

### **Elaine A. Rodrigues**

Instituto de Pesquisas Ambientais - IPA  
São Paulo – São Paulo

### **Maria Aparecida M. G. Pereira**

Nuclear and Energy Research Institute – IPEN/  
CNEN  
São Paulo-São Paulo

### **Jamil M. S. Ayoub**

Nuclear and Energy Research Institute – IPEN/  
CNEN  
São Paulo-São Paulo

### **José A. Seneda**

Nuclear and Energy Research Institute – IPEN/  
CNEN  
São Paulo-São Paulo

**ABSTRACT:** Ancient pandemics reverberated through their times, changing social and economic contexts, prompting and redirecting changes in social ties, business, and education, and restructuring the world that generated them. In this context, this study aims to assess the

impact of the COVID-19 pandemic on the global energy matrix from January 2019 to June 2021. The energy balance showed variations in this period, with the incremental use of wind, solar and nuclear energies, which is positive for the environment. The participation of different sources in the final energy mix changed during the pandemic period evaluated, although these changes appear to not be lasting.

**KEYWORDS:** COVID-19, global energy matrix, nuclear energy.

## 1 | INTRODUCTION

The great pandemics that devastated humanity allowed the analysis of their historical impacts in the human, social, and economic fields. But one aspect, the impact on the area of consumption and generation of energy, was not specifically explained, which in a way it is understandable because, until the 18th century, thermal energy consumption was mainly coal – mineral and natural, and wood to firewood, another source was negligible. Between the 19th century and the middle of the 20th century, even though humanity used energy, its complexity and impact on human life was low, especially compared to what is seen from the second half of the 20th century until today.

This paper aims to answer the following question of whether the health and sanitation crisis affect or alter the use, demand, and consumption of present and/or future energy, and how so. To carry out a correlation, it is

important to define the scope of the areas of analysis and the time of their application.

## 2 | METHODS

For the paper, there was a search for systematic literature review, bibliographic and documental survey [1,2]. The following electronic databases were selected as a source of scientific data: Web of Science, INIS, Google Scholar and databases from IEA, IFM and others. The query strategy consisted in the use of search tools for keywords related to the topic, with the main descriptors «pandemics and society», «Covid-19», «energy consumption and economy», «energy matrix» and «electricity », as well as others to expand the themes. Other materials from different sources also served as support, such as the content expressed in books, interviews with scientists, and reports.

The research was carried out from December 2019 to July 2021, from the content analysis, and information in the bibliographic references. When the references presented the same objective approach of this study, they were systematized and correlated to obtain data about change in the world energy matrix.

## 3 | RESULTS AND DISCUSSION

Diseases, or rather the germs that cause them, are not prejudiced of any kind; they are indifferent to people and their well-being, and thus should be respected as skilful opponents and of great strength and resilience. They have been present in the world for a long time, before humanity even existed.

### 3.1 Pandemic

The germs cause individual diseases that afflict us, and in certain situations, those diseases are classified in regards to their proliferation [3,4]: a) endemic - an outbreak of disease that is consistently present but limited to a particular region; b) epidemic - an unexpected increase in the number of disease cases in a specific geographic area; and c) pandemic - when the growth of the disease is exponential; this means that the growth rate of cases soars and that a virus covers a wide area, affecting many countries and populations;

The difference between an epidemic and a pandemic is not the severity of the disease but the degree to which it has spread. A pandemic crosses international borders, as opposed to regional epidemics. The three biggest pandemics that ravaged the world, classified by their estimated mortality, are presented in Table 1.

Classification	Disease	Date	Deaths Global(1)	Affected Regions	Notes
1 <sup>st</sup>	Justinian Plague	541 - 549	15 – 100	Europe and Asia	(c), (d)
2 <sup>nd</sup>	Black Death	1346 – 1353	75 – 200	Europe, Asia, and North Africa	(a), (b), (c)
3 <sup>rd</sup>	Spanish Flu	1918-1920	17 - 100	All World	(c), (e)

(1) Millions of individuals.

(a) Damen, 10; (b) Santamaria, 08. (c) Carpenter, 09. (d) Atkinsons, 02. (e) CDC, 19

Table 1: Biggest pandemics in the modern world.

The studies carried out on the effects of the mentioned pandemics on society highlight their negative effects at the time of their occurrence, foreseen for this type of event.

The Justinian's Plague contributed to the political and economic weakening of the Byzantine Empire by decimating its population, likely causing labor shortages and increasing the price of labor. Trade was disrupted, the agricultural sector was devastated, prices soared, and tax revenues fell, which contributed to reducing the ability to resist enemy invasions. Barbarian hordes invaded and divided northern Italy, and North Africa and the Near East were invaded by Arabs [5].

The Black Fever shook 14th-century European society, and caused the cessation of wars and a sudden drop in trade. There was a drastic reduction in the amount of cultivated land, due to the death of so many workers. The shortage of labor forced the aristocracy to replace labor services with wages or cash rents, helping to eradicate serfdom and the development of a new economic system. New social systems developed, as well as modern economic, religious, and scientific ideas [6,7]. On the other hand, outbreaks of violence occurred in communities, mainly aimed at some groups accused of being responsible for the spread of the disease [8].

The Spanish Flu pandemic took place during World War I and authorities discouraged social interaction, which fuelled rumors of enemies spreading the virus and created a climate of suspicion and mistrust that characterized the period and much later. Researchers estimate that, in a typical country, the pandemic reduced real GDP per capita by 6% and private consumption by 8%. The flu was particularly deadly for young adults without pre-existing conditions, which increased its economic and social impacts. The inefficiency of governments in managing the crisis provoked a wave of workers' strikes and anti-imperialism, a reaction to growing inequality, noting that in 1917 the Russian revolution had taken place [9,10].

COVID-19 is the disease of the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). The COVID-19 is the pandemic of the 21st century. It was first identified in Wuhan, Hubei province in December 2019, China. The main hypothesis of its transmission is regarded to the live animal market, where there is an interaction between humans, pigs,

birds, and other animals, which favored the spread of this virus between species. It produced variables for which man has no immunity, and is transmissible in the incubation period, before the onset of symptoms, which is a critical condition. It started in December 2019 with atypical cases of pneumonia and quickly spread. The WHO identified the 2019 coronavirus on February 11, 2020, and declared the outbreak as a global pandemic on March 11 [11,12].

In just over a year and a half since the declaration of the COVID-19 pandemic, the disease, its consequences and sequelae remain mainly out of control, even with the beginning of vaccination. Its rapid evolution and expansion have drastically altered people's lives, with direct and severe impacts on the global and local economy, in the public and private sectors. Massive blockages, economic recession, tourism stoppage, reduced agricultural production, decline in the financial sector, intense reductions in the supply and demand aspects of the economy at the international level[11,13], significant expansion of home office activities, high demand for medical, hospital and funeral services, expansion of social inequality and poverty to extreme levels in a short period, are all aspects of the pandemic that have come to dominate the daily scene in global level.

After 14 months of the WHO declaration, the world accumulated 164 million cases, with 3.40 million lives lost to COVID-19, affecting 191 countries [14,15].

### **3.2 World Energy Demand and the Energy Matrix**

Energy comes from a set of sources, and the combination of all these sources is the energy matrix. It represents the set of sources available in a country, state, or in the world, to supply the demand of energy. The energy matrix represents the set of energy sources available to move vehicles, planes and ships, to cook food, and generate electricity. The electrical matrix is formed by the set of sources available only for the generation of electrical energy, being a part of the energy matrix [16].

The composition of the energy matrix varies greatly from one country or region to another, and can change significantly depending on the period. Variables include the availability of usable resources in the domestic market or the possibility of importing them; the range and type of energy that needs to be met; and policy choices determined by historical, economic, social, demographic, environmental and geopolitical factors [17].

Energy is fundamental for human development, and its availability determines access to health, food, education, safety, and the well-being of the population [17]. This relation became evident after the British Industrial Revolution in 1760. It sourced energy from coal, which became an important production factor [18]. Figure 1 shows the inflection of the World Gross Domestic Product (GDP) curve, starting mid-18th century.



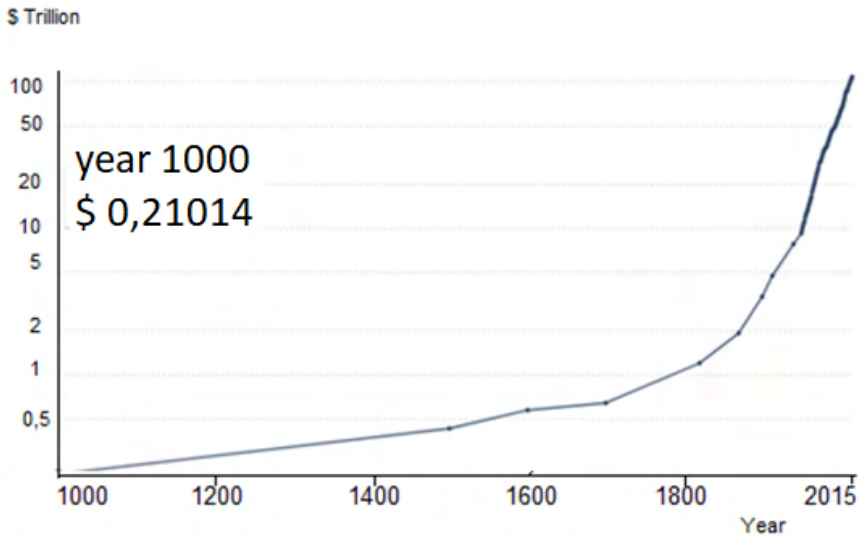


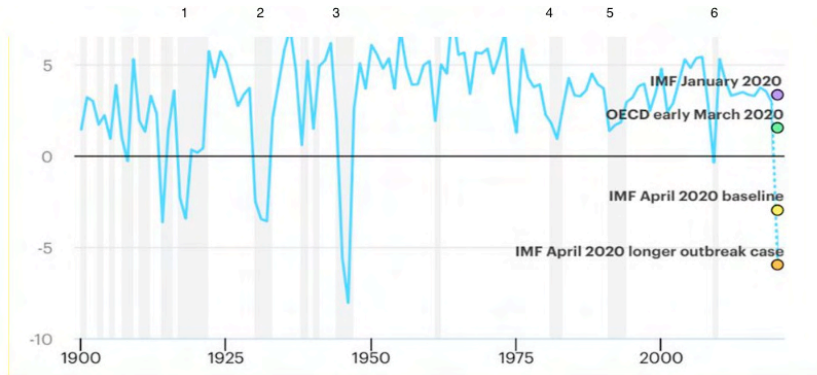
Figure 1: World GDP in the last millennium – (ROSER, 2013)

Sources: World GDP - Our world in data based on World Bank and MADDISON (2017); OurWorldInData.org/economic-growth.

Energy is identified as an economic commodity, and because it is poorly distributed, it is expensive and subject to price fluctuations that are often unpredictable. It is also an indicator of inequalities between countries, when analyzed by their relation with the Gross Domestic Product (GDP) of their economies, or by the per capita energy consumption of their inhabitants [19].

Energy drives economic productivity and industrial growth and is fundamental to the functioning of any economy [20]. Ensuring universal access to electricity, especially for billions of people in developing countries, who do not have access to services or whose consumption levels are far below industrialized countries, is a crucial goal that can spur growth and transformation in the world (UNDP, 2000).

Barney and Franzi argue that energy is responsible for at least half of the industrial growth in a modern economy, while representing less than a tenth of the cost of production [21]. To show the relation between the world economy and energy, Figure 2 shows the variation in the World GDP over the 20th and 21st century, and Figure 3 shows the variation in energy demand (global consumption) during the same period, where it is verified that positive or negative variations in GDP correspond to variations in the same module of demand.



1 – Spanish Flu, 2 – 29' Crash, 3 – II War, 4 – 1° Oil Chock, 5 – 2° Oil Chock, 6 – Financial Crises.  
2020 values are predictions.

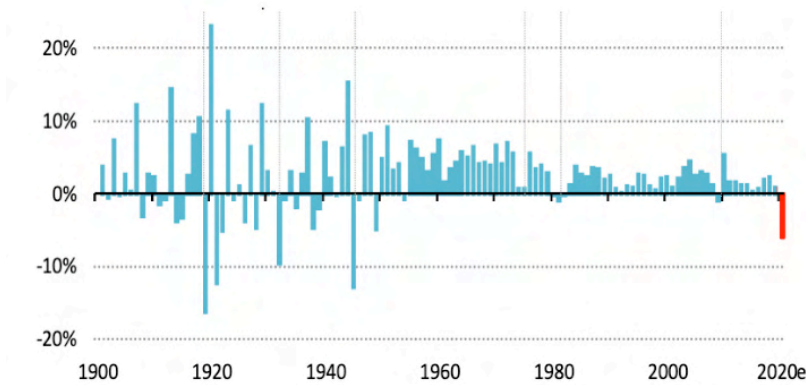
Sources: IEA based on IMF World Economic Outlook (January and April 2020), OECD Interim Economic Outlook Forecasts (March 2020) and MADDISON Project Database (2018).

Figure 2: Global annual change in real GDP - 1900-2020 – IEA Sustainable Recovery (2020)

Currently, as shown in Figure 4, fossil fuels dominate the energy matrix at a global level, accounting for more than 80% of the total needs. The total energy production (2018) was 583.9 EJ or 1621.9 x 10<sup>3</sup> TWh, and in the generation of electric energy, it accounts for the consumption of fossil sources in about 64% of the total needs. It is necessary to note that the format of the matrix shown is not static; it will necessarily undergo changes, seeking to meet extremely important priorities.

Most governments, faced with the pandemic, declared a national emergency and introduced in their countries measures of generalized physical distancing for the population, including confinement, with strong restrictions on transport systems and logistical services globally, and the mandatory use of masks, implementing efforts to flatten the curve of COVID-19 cases.

The effects of the new coronavirus pandemic go beyond health, economic, political, and environmental areas. Specifically, the energy, electrical and thermal supply sector, both for transport and production, or for services and related and for social use, suffered notable impacts [21].



1 – Spanish Flu, 2 – 29' Crash, 3 – II War, 4 – 1º Oil Chock, 5 – 2º Oil Chock, 6 – Financial Crises.

Notes: 2020e predicted fall due COVID-19

Figure 3: World Energy Demand – Base IEA Sustainable Recovery (2020)

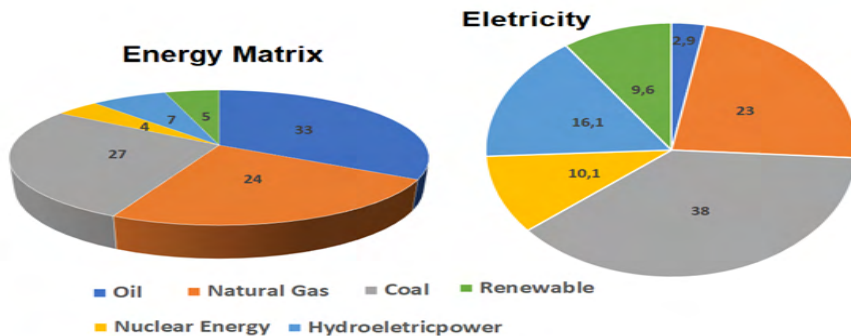


Figure 4: Global Energy Matrix (bp, 2020)

Source: bp. Plc – Statistical Review of World Energy 2020 | 69th edition

The measures of physically distancing the population and interrupting trade and travel can't stop the pandemic, only mitigate the mortality rates. It's important to note that several countries have passed or are going through the second and third waves of contamination. The solution, which was developed by science in historical time, is focused on the vaccine. Its offer is, however, currently limited to a few countries, although the World Health Organization expects that by the second half of 2022 the whole world will have access to vaccines [12].

### 3.3 Post-pandemic Energy Matrix

The economic crisis caused by COVID-19, mainly due to the quarantine applied by several countries, is comparable to that generated by World War II [22]. Due to its magnitude, it generated impacts on the daily lives of people all over the planet, which resulted, based on the analysis of the studies presented, in a significant reduction in the generation of

greenhouse gasses, especially CO<sub>2</sub> (Figure 5).

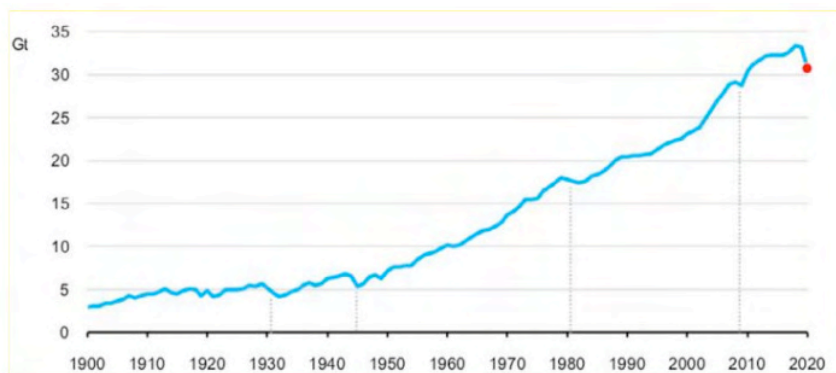


Figure 5: Global Energy-Related CO<sub>2</sub> Emissions 1900 to 2020 (Gigatons CO<sub>2</sub>)

Source: International Energy Agency (2020). Global Energy Review 2020.

To alleviate the socio-economic implications generated by the pandemic, the world's largest economies are taking unprecedented fiscal and monetary actions. According to the International Monetary Fund's analysis in 2021, the global economy is ready to start the most robust post-recession recovery in 80 years [23]. Governments hope that economically aggressive actions will result in rapid recovery for their countries, even though COVID-19 will cause permanent or at least long-term economic damage to poor or emerging countries [23,24].

The World Bank predicts that the global economy should recover by 5.6% in 2021, while 2020 brought a reduction of 3.5%. The recovery will occur mainly in a few important economies. The global GDP will grow by more than 2% from 2019 levels [25], and this will increase global energy demand by around 4.6% in 2021, offsetting the 2020 contraction and surpassing 2019 demand by 0.5% [26].

Even with the main environmental indicators worldwide showing that human activities must reduce the consumption of energy from fossil fuels [26], demand for all fossil fuels is expected to grow significantly in 2021, and the greatest increase in demand will occur in emerging markets and developing economies. The predictions for more advanced economies is a small reduction in demand due to policies of increasing energy efficiency and reducing emissions [27].

With the increased consumption of fossil fuels, there will be a reversal in the CO<sub>2</sub> emissions drop that occurred in 2020 (which amounts to 20% less), with emissions in 2021 reaching values slightly below or at the same levels of emissions from 2019 [26]. Figure 6 shows the variation in CO<sub>2</sub> emissions generated by the major financial crises that occurred in recent decades. The data indicates that during the crisis there is a reduction in CO<sub>2</sub>

emissions, but that just after the emissions curve returns to its growth trend [28].

The pandemic impacted the energy supply, something that extended the time for the return to regular conditions in the society, and generated an increase in inequality in the world. The pandemic has not been stopped, although most developed countries have been able to reduce its impact and return to almost normal living conditions. An energy crisis, however, has now set in and is also spreading across the world.

This spread is biasedly only correlated with the pandemic. Analyzing some of the causes, there is a confluence of several factors, whether related to the pandemic or the climate crisis [29-31]. Winter in much of the northern hemisphere, especially in Asia, was exceptionally cold in early 2021, followed by a cold spring in Europe, which increased demand for heating and impacted both the demand and supply for gas. The intense cold in Texas also hampered US gas production, resulting in lower US liquefied natural gas (LNG) exports to Asia and elsewhere during the beginning of the year.

Unusually severe summer heatwaves and droughts in China, Europe, and the United States, as well as in some other parts of the world have increased gas demand to produce electricity for cooling. Potential sources of electricity generation were harmed. Wind generation (Europe and China) has been far below averaged this year due to long periods with below-average wind speeds.

Demand for gas and coal increased to offset the reduction in renewable energy production, pushing up prices [32]. Drought conditions in China and South America have reduced hydropower production, attracting globally traded gas supplies to these markets.

The producers of gas, oil, and coal, in response to the record drop in prices and consumption at the height of the pandemic, have not increased, or are having trouble increasing, their production in the face of the growing demand.

The “green inflation” is due to governments restrictions on traditional energy sources to encourage renewable energy to meet global emissions targets [32]. China has promised an aggressive 65% reduction in its emissions by 2030 and cut coal mining sharply. The UK already relies on wind power to supply a quarter of its electricity needs, and Germany has pulled another three nuclear reactors off the grid this year. The push towards the adoption of renewable energy has led investors to divest into traditional energy sources. The amount of divestment from 2014 to 2021 reached US\$14.5 trillion [33-35].

The situation demonstrated is not something foreign to the energy market; supply or demand crises are relatively frequent. Governments should avoid that in the future, as people have a perception that reaching the targets for emission of greenhouse gasses has a high economic cost. Renewable energy sources such as wind and solar can be unreliable, especially during winters, and countries are forced to depend on traditional fossil fuels. Hence the need for governments to rethink their energy policy.

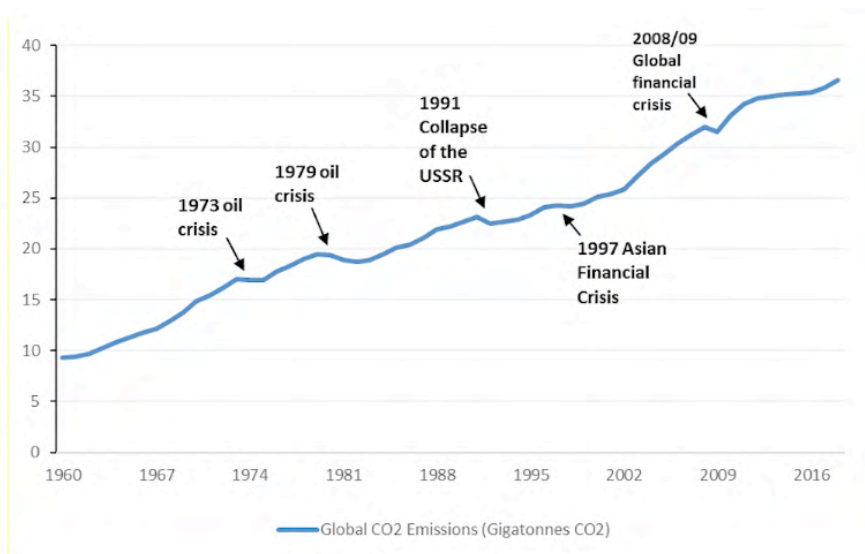
There is no dispute, however, that climate change generated by greenhouse gasses is the reason for more extreme temperatures: hotter summers and polar cold waves. Climate

change aggravates droughts and reduces hydroelectric energy, which is now prevalent in the generation of clean electricity.

Confusing or uncorrelated actions can lead to price volatility of carbon-based fuels, which, in turn, feeds energy price volatility, creating a feedback loop instead of pushing alternatives that can reduce the gap between energy generated by non-renewable and renewable sources.

The current situation and future prospects (see Figures 2, 3, and 6), whether originated from pandemics or social or political processes, highlights the urge to accelerate the pace of transition to clean energy. The transition process will demand unpredictable adjustments in the economy, society and policies, but also in individual decisions about what kind of car to buy, electricity to generate, housing to build, or production industry.

To supplement and maintain the reliability of a clean energy system, the maintenance, and even implementation of energy production from nuclear plants that guarantee against climate change and are not a source of CO<sub>2</sub> emission, is essential.



(1) – 1st Oil Crisis; (2) – 2nd Oil Crisis; (3) – Collapse of the Soviet Union; (4) – Financial Crisis in Asia; (5) - Global Financial Crisis

Figure 6: CO<sub>2</sub> Emissions and Previous Economic Crises (OECD, 2020)

Source: Adapted from The Economist (2020), based on CO<sub>2</sub> emissions data from the Global Carbon Project. CO<sub>2</sub> emissions from the use of coal, oil, and gas (combustion and industrial processes).

Nuclear plants are compatible with the need for energy sources which are not based on fossil fuels. This reaffirms the importance of nuclear energy production, which has already been presented and defended in numerous studies, regarding its efficiency. It is enough to analyze that in the USA, more electricity is produced with zero carbon via nuclear

power plants than with wind turbines and photovoltaic panels combined [36-42].

## 4 | CONCLUSION

The verification of the permanent growth of CO<sub>2</sub> emissions, even after economic crises, confirms that the energy matrix will not present a permanent shift due to the COVID-19 pandemic. The changes lasted only during the economic slowdown brought by the acute phase of the pandemic, and were not a structural change in how the world fuels its cars or produces the electricity it consumes.

The current IPCC indicators demonstrate that consumption of energy based on fossil fuel will have to decrease and that this depends on a policy that develops new technologies and takes advantage of existing ones to bring the changes needed. Humanity must show efficiency mitigating impacts of the energy transition. Thus, nuclear energy has an important position in the portfolio of energy generation sources for the future of the world.

## REFERENCES

- [1] FIOCRUZ, 2020. Online Course in Scientific Research Methodology. Fiocruz Virtual Campus Classroom Platform (in Portuguese). Available in: <https://cursos.campusvirtual.fiocruz.br/>. Accessed: May 2020.
- [2] SEVERINO, A.J. Methodology of scientific work (in Portuguese). 24th ed. rev. and wide São Paulo: Cortez, 2018. 320 p.
- [3] CDC – Centers for Disease Control and Prevention (CDC). Lesson 1: Introduction to Epidemiology. (May 2012) <https://www.cdc.gov/csels/dsepd/ss1978/lesson1/section11.html>
- [4] WHO – World Health Organization. Bulletin of the World Health Organization: The elusive definition of pandemic influenza. (2011). <https://www.who.int/bulletin/volumes/89/7/11-086173.pdf>
- [5] HORGAN, John. Justinian's Plague (541-542 CE). World History Encyclopaedia. World History Encyclopaedia, Dec 2014. [https://www.worldhistory.org/article/782/justinians-plague-541-542-ce/#citation\\_info](https://www.worldhistory.org/article/782/justinians-plague-541-542-ce/#citation_info)
- [6] FRANKE, C. The Black Death, an Unforeseen Exchange: Europe's Encounter with Pandemic Sparked an Age of Exploration. (Jun, 2016). National History Day. [https://www.nhd.org/sites/default/files/Franke\\_Senior\\_Paper.pdf](https://www.nhd.org/sites/default/files/Franke_Senior_Paper.pdf)
- [7] BROWN UNIVERSITY. Decameron Web. Social and Economic Effects of the Plague. (March, 2010). Italian Studies Department's Virtual Humanities Lab at Brown University. [https://www.brown.edu/Departments/Italian\\_Studies/dweb/plague/effects/social.php](https://www.brown.edu/Departments/Italian_Studies/dweb/plague/effects/social.php)
- [8] WINKLER, A. The Medieval Holocaust: The Approach of the Plague and the Destruction of Jews in Germany, 1348-1349. (2005) Brigham Young University. Faculty Publications. 1816. <https://scholarsarchive.byu.edu/facpub/1816>

- [9] BARRO, R. J., URSÚA, J. F., WENG, J. The coronavirus and the great influenza pandemic: Lessons from the “spanish flu” for the coronavirus’s potential effects on mortality and economic activity. 2020 - National Bureau of Economic Research (nber.org.) [https://www.nber.org/system/files/working\\_papers/w26866/w26866.pdf](https://www.nber.org/system/files/working_papers/w26866/w26866.pdf)
- [10] RILEY, R. A Review of the Impacts of the 1918 Spanish Flu Pandemic. ( Jun, 2020) City Region Economic and Development Institute. University of Birmingham. <https://blog.bham.ac.uk/cityredi/a-review-of-the-impacts-of-the-1918-spanish-flu-pandemic/>
- [11] ANAND, K.B., et al. Review Article. SARS-CoV-2: Camazotz’s Curse. (Coronaviruses: origin and evolution). Medical Journal Armed Forces India. (April 2020). DOI:10.1016/j.mjafi.2020.04.008
- [12] WHO - WORLD HEALTH ORGANIZATION. WHO-convened global study of origins of SARS-CoV-2: China Part. (March 2021). <https://www.who.int/publications/i/item/who-convened-global-study-of-origins-of-sars-cov-2-china-part> .
- [13] CHANG, D-S. and WU, W-D. Impact of the COVID-19 Pandemic on the Tourism Industry: Applying TRIZ and DEMATEL to Construct a Decision-Making Model. Sustainability 2021, 13, 7610. <https://doi.org/10.3390/su13147610>
- [14] WHO - WORLD HEALTH ORGANIZATION. WHO Coronavirus (COVID-19) Dashboard. (updated daily). <https://covid19.who.int/>
- [15] JOHNS HOPKINS UNIVERSITY. COVID-19 Data Repository by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University. <https://github.com/CSSEGISandData/COVID-19>
- [16] EPE – Empresa de Pesquisa Energética – ABCDEnergia – <https://www.epe.gov.br/pt/abcdenergia/matriz-energetica-e-eletrica>, Acesso em 2020.
- [17] LA FONDATION d’entreprise TOTAL. Planète Énergies - WHAT IS THE ENERGY MIX?. last update jul. 2020. <https://www.planete-energies.com/en/medias/close/what-energy-mix>. Access 2021
- [18] STEVENS, P. A brief history of the role of energy in the global economy. The last 25 years. (2017). UNU-WIDER United Nations University World Institute for Development Economics. <https://www.wider.unu.edu/publication/brief-history-role-energy-global-economy>.Access2020
- [19] PARAVANTIS, J. et al. A Geopolitical Review of Definitions, Dimensions and Indicators of Energy Security. Conference: 2018 - 9th International Conference on Information, Intelligence, Systems and Applications (IISA). DOI:10.1109/IISA.2018.8633676
- [20] ASGHAR, Z. Energy–GDP relationship: a causal analysis for the five countries of South Asia. Applied Econometrics and International Development Vol. 8-1 (2008). <https://www.usc.gal/economet/reviews/aeid8114.pdf>
- [21] BARNEY .F, FRANZI .P The future of energy From Future Dilemmas: Options to 2050 for Australia’s population, technology, resources, and environment. CSIRO Sustainable Ecosystems.pp157 – 189, (2002). <https://publications.csiro.au/rpr/pub?list=BRO&pid=procite:b2d81791-52f0-4f60-9f33-5fe09454b63c>
- [22] NICOLA, M. et al. The socio-economic implications of the coronavirus pandemic (COVID-19): A review. International Journal of Surgery Volume 78, June 2020, Pages 185-193. <https://doi.org/10.1016/j.ijso.2020.04.018>



[23] IMF – International Monetary Fund. World Economic Outlook Reports (April, 2021). <https://www.elibrary.imf.org/view/books/081/29821-9781513575025-en/29821-9781513575025-en-book.xml?code=imf.org>

[24] CFR – Council on Foreign Relations. Coronavirus: How Are Countries Responding to the Economic Crisis? (2020) <https://www.cfr.org/background/coronavirus-how-are-countries-responding-economic-crisis>

[25] WBG (1) - World Bank Group – IBRA – IDA. The Global Economy: on Track for Strong but Uneven Growth as COVID-19 Still Weighs (JUNE, 2021). <https://www.worldbank.org/en/news/feature/2021/06/08/the-global-economy-on-track-for-strong-but-uneven-growth-as-covid-19-still-weighs>

[26] IPCC – Intergovernmental Panel on Climate Change 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press. [https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC\\_AR6\\_WGI\\_Full\\_Report.pdf](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf)

[27] IEA - International Energy Agency. Global Energy Review 2020. Global energy and CO2 emissions in 2020. <https://www.iea.org/reports/global-energy-review-2020/global-energy-and-co2-emissions-in-2020>

[28] OECD – Organization for Economic Co-operation and Development. COVID-19 and the low-carbon transition: Impacts and possible policy responses. <https://www.oecd.org/coronavirus/policy-responses/covid-19-and-the-low-carbon-transition-impacts-and-possible-policy-responses-749738fc/>

[29] BORDOFF, J. Why This Energy Crisis Is Different. Center on Global Energy Policy at Columbia University SIPA. <https://foreignpolicy.com/2021/09/24/energy-crisis-europe-gas-coal-renewable-prices-climate/>

[30] FLEMING, S, Lessons for the energy transition from the 2021 energy crisis. World Economic Forum. <https://www.weforum.org/agenda/2021/10/energy-transition-risks-crisis/>

[31] Blackmon, D. Winter Is Coming: Can Energy Catastrophe Be Averted? 2021 Forbes Media. <https://www.forbes.com/sites/davidblackmon/2021/10/03/winter-is-coming-can-energy-catastrophe-be-averted/?sh=4521904536bd>

[32] Prashanth P. J. Explained | How bad is the world's energy crisis? The Hindu, OCTOBER 05, 2021. <https://www.thehindu.com/business/expained-how-bad-is-the-worlds-energy-crisis/article36834452.ece>

[33] NAUMAN, B. Sharp rise in number of investors dumping fossil fuel stocks. Financial Times. <https://www.ft.com/content/4dec2ce0-d0fc-11e9-99a4-b5ded7a7fe3f>

[34] IEA, INTERNATIONAL ENERGY AGENCY. Net Zero by 2050. IEA Reporter, 2021. <https://www.iea.org/reports/net-zero-by-2050>

[35] Fossil Free. Full List of Divestment Commitments. Fossil Free is a project of 350.org. 2021. <https://gofossilfree.org/divestment/commitments/>

- [36] Sekimoto, H. (Guest Editor) Special Issue «Sustainable Nuclear Energy». Published Papers (15 papers). Sustainability Journal (ISSN 2071-1050). Multidisciplinary Digital Publishing Institute (MDPI). 2012. <https://www.mdpi.com/si/sustainability/sne>
- [37] Brook, W. B., Alonso, A. et al. Why nuclear energy is sustainable and has to be part of the energy mix. Sustainable Materials and Technologies. Volumes 1–2, December 2014, Pages 8-16. <https://www.sciencedirect.com/science/article/pii/S2214993714000050>
- [38] EIA, US Energy Information Administration. Electricity in the United States is produced (generated) with diverse energy sources and technologies. (2021). <https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php>
- [39] IAEA, International Atomic Energy Agency. Nuclear Power and the Clean Energy Transition. (2020). <https://www.iaea.org/bulletin/61-3>
- [40] U.S. Department of Energy. RESTORING AMERICA'S COMPETITIVE NUCLEAR ENERGY ADVANTAGE. 2020. <https://www.energy.gov/sites/prod/files/2020/04/f74/Restoring%20America%27s%20Competitive%20Nuclear%20Advantage-Blue%20version%5B1%5D.pdf>
- [41] E.C. - European Commission. Technical assessment of nuclear energy with respect to the 'do no significant harm' criteria of Regulation (EU) 2020/852 ('Taxonomy Regulation') 2021. [https://ec.europa.eu/info/sites/default/files/business\\_economy\\_euro/banking\\_and\\_finance/documents/210329-jrc-report-nuclear-energy-assessment\\_en.pdf](https://ec.europa.eu/info/sites/default/files/business_economy_euro/banking_and_finance/documents/210329-jrc-report-nuclear-energy-assessment_en.pdf)
- [42] IEA, INTERNATIONAL ENERGY AGENCY. Nuclear Power in a Clean Energy System. (2019). <https://www.iea.org/reports/nuclear-power-in-a-clean-energy-system>

## ÍNDICE REMISSIVO

### A

ABB 117, 118, 120

Aguapé 77, 78, 80, 81, 83, 85, 86, 87

Alumina 18, 19, 20, 21, 23, 24

Aprendizagem baseada em problemas 105, 107, 111, 112, 114, 120, 145, 146, 148

### B

Barita 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 16

### C

CA6 18, 19, 20, 21, 22, 23, 24

Câncer de cabeça e pescoço 156, 158, 159, 161, 163, 165

Cervejas ácidas 67, 70, 71, 74, 75

Cervejas frutadas 67

Compósito 18, 19, 20, 24

Controladores lógicos programáveis 145, 146, 147, 148

### D

Dano 1, 4, 8, 11, 12, 13, 14, 15, 19

### E

Efluentes 7, 8, 12, 13, 77, 78, 79, 80, 82, 83, 85, 86

Engenharia de Produção 105, 106, 107, 108, 112, 113, 114, 115, 116, 117, 118, 120, 124, 185, 197

Estradas de terra 88, 89, 90, 91, 103

### I

Incrustação mineral 1, 3, 7, 13

### L

LEGO 117, 122, 123

### M

Macadame seco 88, 89, 91, 92, 98, 99, 103, 104

Melhoramento de vias 88, 95, 97, 98, 102, 103

Metodologias ativas 117, 118, 119, 120, 125, 174

Metodologias de ensino e aprendizagem 105, 112, 114

Modelagem de sistemas a eventos discretos 145, 146

## **O**

Osteorradiocrose 156, 158, 160

## **P**

Parâmetros físico-químicos 67, 69

## **R**

Radioterapia de intensidade modulada 156, 158

Reservatório de petróleo 1

## **S**

Saneamento 77, 78, 79, 86, 87, 170, 171

Sistemas a eventos discretos 145, 146, 147, 148

## **T**

Teoria de controle supervisorio 145, 147, 148, 150

🌐 [www.atenaeditora.com.br](http://www.atenaeditora.com.br)  
✉ [contato@atenaeditora.com.br](mailto:contato@atenaeditora.com.br)  
📷 @atenaeditora  
📘 [www.facebook.com/atenaeditora.com.br](https://www.facebook.com/atenaeditora.com.br)

# ENGENHARIA- RIAS: Pesquisa, desenvolvimento e inovação



**Atena**  
Editora  
Ano 2022

🌐 [www.arenaeditora.com.br](http://www.arenaeditora.com.br)  
✉ [contato@arenaeditora.com.br](mailto:contato@arenaeditora.com.br)  
📷 @arenaeditora  
📘 [www.facebook.com/arenaeditora.com.br](https://www.facebook.com/arenaeditora.com.br)

# ENGENHA- RIAS: Pesquisa, desenvolvimento e inovação

**Atena**  
Editora  
Ano 2022