10th German-Brazilian Dialogue on Science, Research and Innovation

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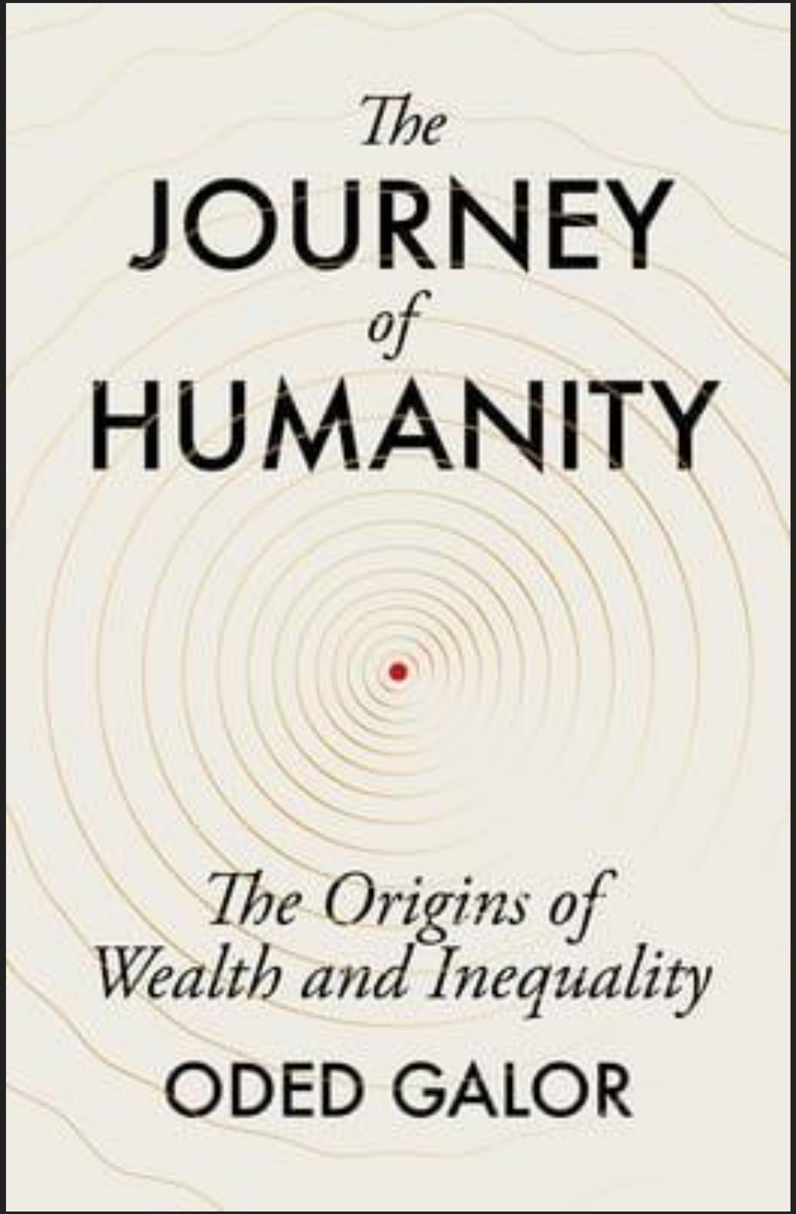
Education for Innovation and Sustainable Energy Consumption

José Roberto Cardoso

May 2023


The
JOURNEY
of
HUMANITY
The Origins of
Wealth and Inequality
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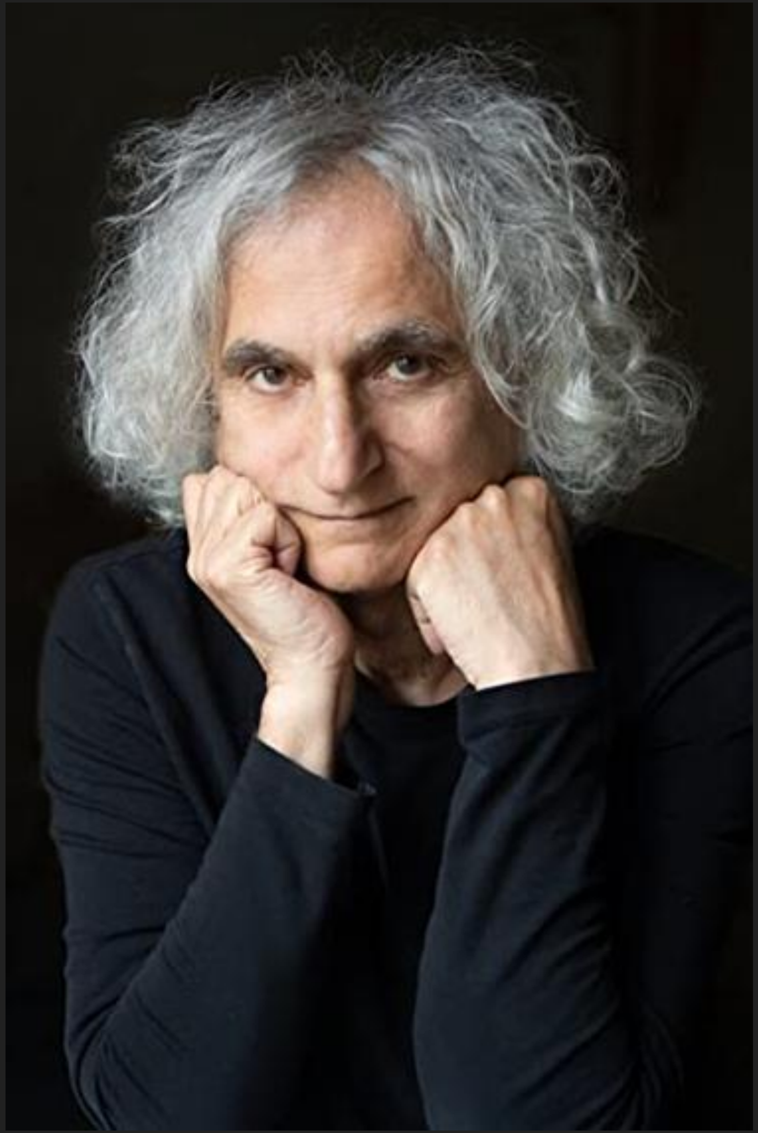
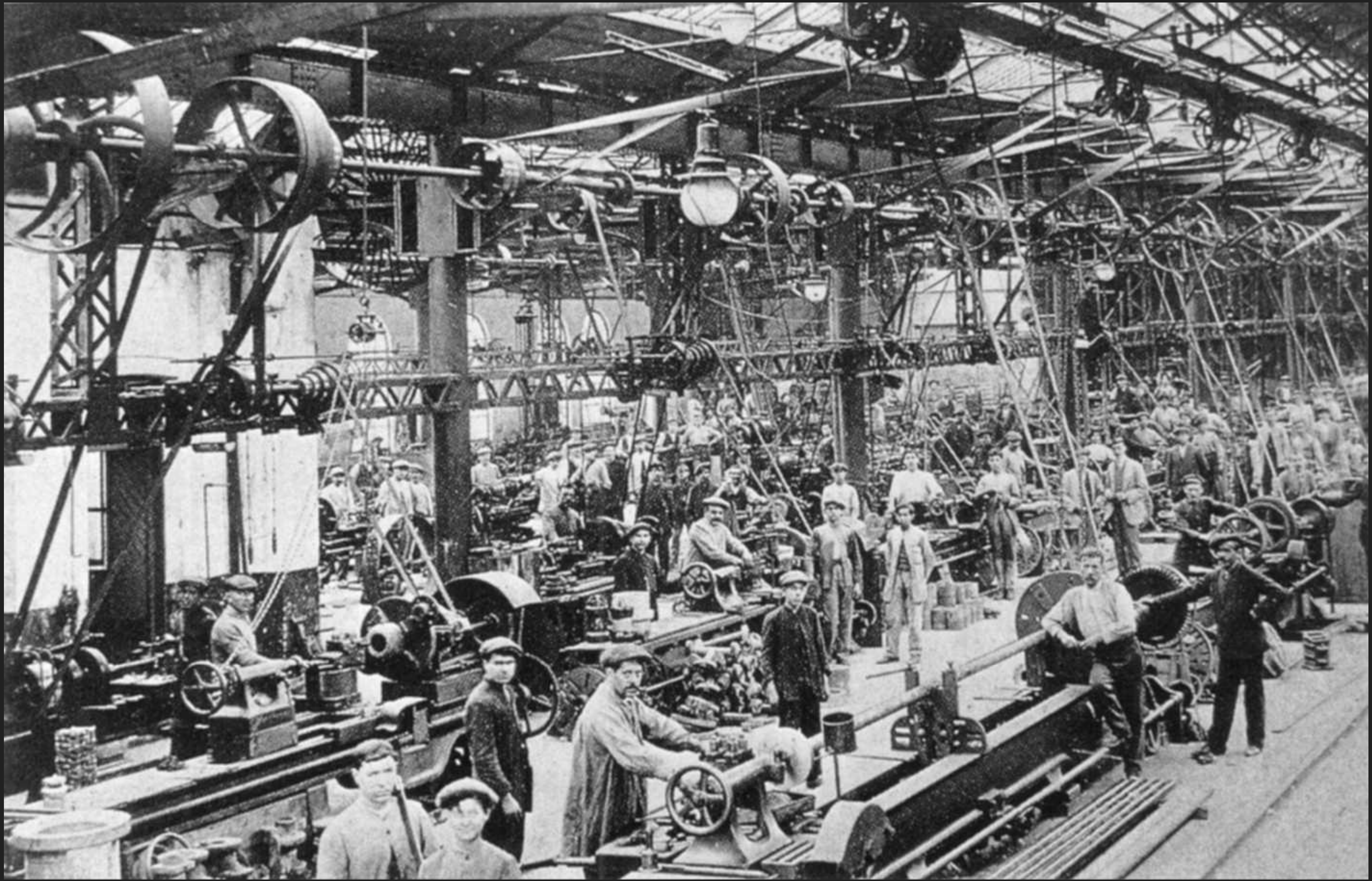
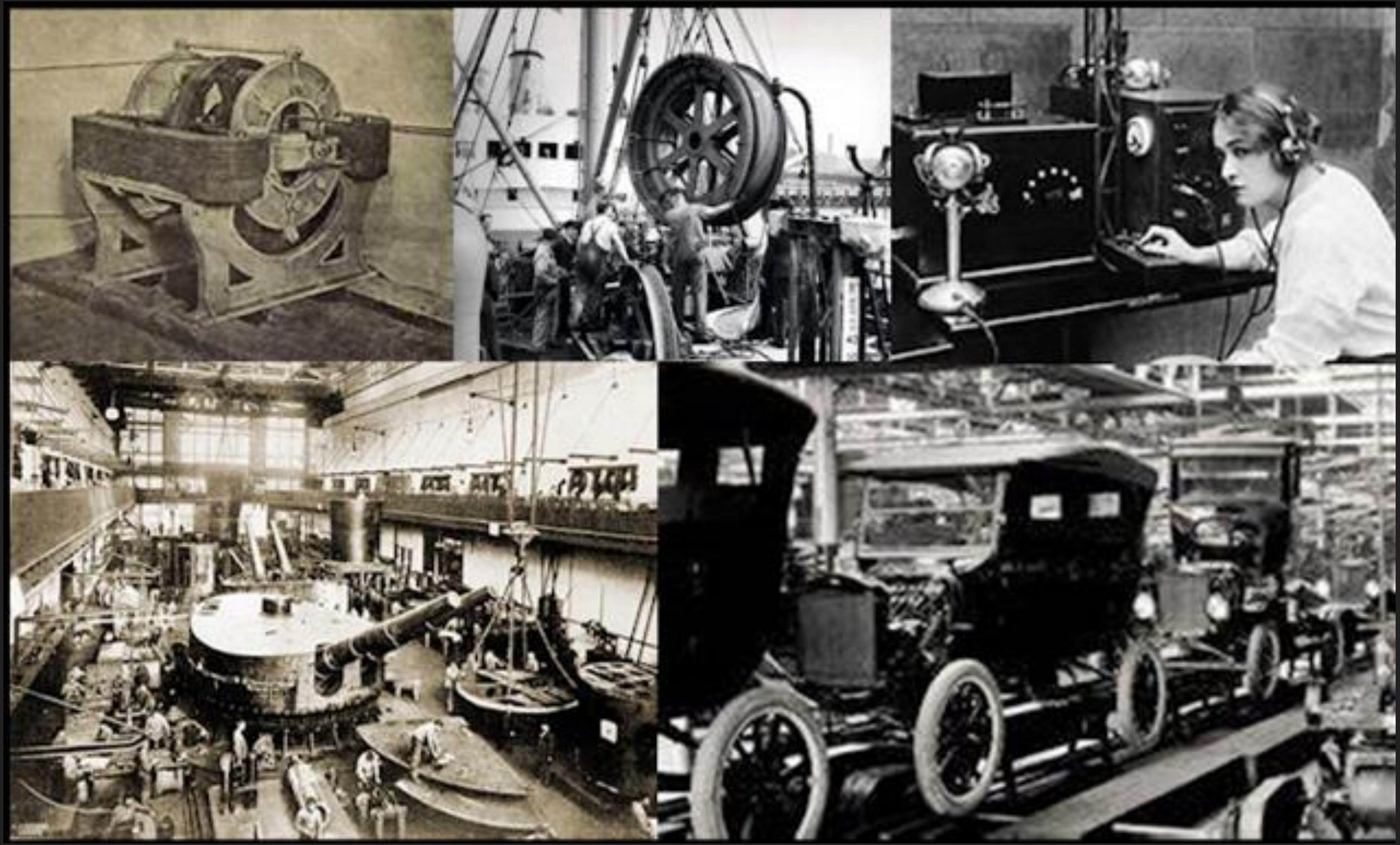




1780 – 1840
First Industrial Revolution

1770 – 1850
Engineering Education 1.0

1st Industrial Revolution	**1st Engineering Education**
• Development of steam machine • Textile technology • Iron mass-production process • Mechanized factories	• Education Focused on training public employees • Concentration on industrialization and mass-production • Classic Engineering Fields: civil, mechanics, mining and agricultural • Focus on mathematics, Science, civil eng., structures and war technology.



1860 – 1914
Second Industrial Revolution

1880–1940
Engineering Education 2.0

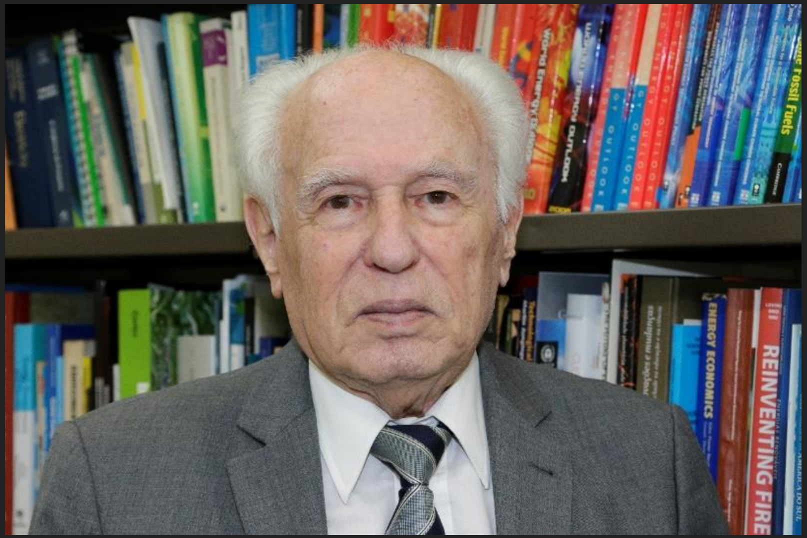
2st Industrial Revolution	**2st Engineering Education**
● Electricity, electrification and electrical industries. ● Development of Chemical and petroleum industries. ● New transport methods: automobile and airplane	● Arts, crafts, and technology seen as a new Unity. ● Search for balance between theoretical and practical disciplines. ● Inclusion of more math and Science, in parallel to the birth of modern physics.

1950 – 1990
Third Industrial Revolution

1960–1990

Engineering Education 3.0

3rd Industrial Revolution	*3rd Engineering Education*
• Transition from analogue to digital electronics. • Digital information and communication technologies. • Internet and digital cellular phones. • Micro and nanotechnology and micro and nanofabrication. • Shifting to renewable energies	• Incorporation of quality control and KPIs. • Accreditation bodies for standard curricula. • ICT Applied to quality promotion and effectiveness. • New areas: informatic, biomedical, space, telecom. • Energy programs • Biofuels in Brazil • Creation of the first Production Engineering in Brazil



REPORT

Energy Balance for Ethyl Alcohol Production from Crops

JOSÉ GOMES DA SILVA, GIL EDUARDO SERRA, JOSÉ ROBERTO MOREIRA, JOSÉ CARLOS CONÇALVES, AND JOSÉ GOLDEMBERG Authors Info & Affiliations

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Energy Balance for Ethyl Alcohol Production from Crops

Abstract. *Energy requirements to produce ethyl alcohol from three different crops in Brazil (sugarcane, cassava, and sweet sorghum) were calculated. Figures are presented for the agricultural and industrial phases. The industrial phase is always more energy-intensive, consuming from 60 to 75 percent of the total energy. Sugarcane is the more efficient crop for ethyl alcohol production, followed by sweet sorghum and cassava from a net energy viewpoint. The utilization of sweet sorghum stems might increase the total energy gain from this crop to almost the same level as sugarcane. Cassava has a lower energy gain at the present state of agriculture in Brazil.*

The difference between the energy available from crops and the energy expended in producing them was analyzed previously by Heichel (*1*, *2*) and Pimentel *et al.* (*3*). The energy expended in crop production includes all the forms of energy used in agricultural and industrial processing, except the solar energy that the plants use for growth. Moreira and Goldemberg (*4*) in Brazil did a similar analysis, taking into account the native technology, to estimate the possibility of using ethyl alcohol produced from crops to replace oil.

In this report we present the cultural energy balance of three different crops and analyze the possibilities of using these crops in Brazil to produce ethyl alcohol: sugarcane, cassava, and sweet sorghum.

The National Alcohol Program (PNA) was started in Brazil in November 1975 for the purpose of increasing ethyl alcohol production so that it might be used to replace automotive gasoline, diesel oil, and several other synthetic products (*5*, *6*). The choice of the best raw material for alcohol production is an important part of the program. Sugarcane, cassava and, more recently, sweet sorghum (*7*, *8*) are now being considered as suitable crops. This is the reason for centering the present study on them.

Data on crops and yields must be selected carefully since they must represent the real average production in the country. There are large differences in the types and levels of technology used for different crops in different regions of the country. Since the PNA is a large-scale agricultural project supported by government funds, for any of the crops selected it will be possible to use the most advanced technology available. Taking this fact into consideration we assume the same technological level for all three different crops.

For sugarcane and cassava we used crop data and yields of Nascimento de Toledo (*9*). Because such information is not yet available for sweet sorghum in Brazil, we used data on corn crops, taken from the same source, because very similar agricultural practices are used for sorghum and corn (*9*, *10*).

Total manpower, oil-consuming machinery, fertilizers, insecticides, and herbicides were translated into an energy equivalent by using the data of Heichel (*2*) and Pimentel *et al.* (*3*). Human labor was translated into energy by assuming an energy consumption of 544 kcal per work-hour for a farm laborer [see (*3*, *11*)].

The total weight of the farm equipment (tractors, trucks, and miscellanea) required for the production of 1 ha of plant cane, on a farm where high technology is used, was estimated to be 0.5 metric ton. This figure is very similar to the one obtained by Pimentel *et al.* (*3*) for corn crops in the United States. Since data on energy consumption for equipment fabrication and maintenance are not available in Brazil, we used the figure reported in (*3*), that is, 1,050,000 kcal/ha. This energy component was calculated for ratoon cane, cassava, and sweet sorghum, the energy equivalent being scaled down according to the weight of equipment used per hectare.

The only cultural energy computed in the industrial stage was the energy necessary for raw material processing and absolute alcohol distillation, which is accomplished by steam generation. The energy embodied in the equipment for alcohol production also should have been taken into account, as explained in (*12*). This was not done, however, because raw data for input-output or process energy analysis is not yet available in Brazil. Since capital costs of the processing plants are very similar for the three raw materials under consideration we still can make a proper evaluation of the differences between net energy performance indices. These differences may have more meaning than the absolute values of the indices (*12*).

Distillery effluent, in spite of its recognized value as a fertilizer, was not considered in our calculations, since there is a lack of information on the total amount and composition of this residue for cassava and sorghum processing.

The following data supply more details on the cultural techniques and assumptions used in our calculations.

Sugarcane. The calculations were based on a sugarcane plantation and the two ratoon crops with yields of 103, 62, and 50 tons, respectively, per hectare (*9*), averaging 72 ton/ha. This is equivalent to 54 tons per hectare per year, since plant cane is harvested 18 months after plantation and uses the soil for 2 years

Table 1. Energy expended in the agricultural production of sugarcane.

Inputs		Plant cane		First ratoon		Second ratoon		Total		Average	
Item	Amount (per hectare)	Mcal/ha	%	Mcal/ha	%	Mcal/ha	%	Mcal/ha	%	Mcal/ha	%
Manual labor*		234	2.94	120	2.79	120	2.79	474	2.86	158	2.86
Machines*		1,050	13.21	750	17.43	750	17.43	2,550	15.41	850	15.41
Combustibles*		4,065	51.16	1,920	44.62	1,920	44.62	7,905	47.76	2,635	47.76
Nitrogen	65 kg of N	1,204	15.15	1,204	27.98	1,204	27.98	3,612	21.82	1,204	21.82
Phosphorus†		146	1.84	44	1.02	44	1.02	234	1.41	78	1.41
Potassium	100 kg of K_2O	192	2.42	192	4.46	192	4.46	576	3.50	192	3.50
Lime	100 kg of K_2O	150	1.89					150	.91	50	.91
Seed		820	10.32					820	4.95	273	4.95
Insecticide	0.5 kg	12	.15					12	.07	4	.07
Herbicide	3.0 kg	73	.92	73	1.70	73	73	219	1.32	73	1.32
Total		7,946	100.0	4,303	100.0	4,303	100.0	16,552	100.0	5,517	100.0

*Includes transportation to industry. †Amount: 100 kg of P_2O_5 for plant cane; 30 kg of P_2O_5 for the first and second ratoon crops.

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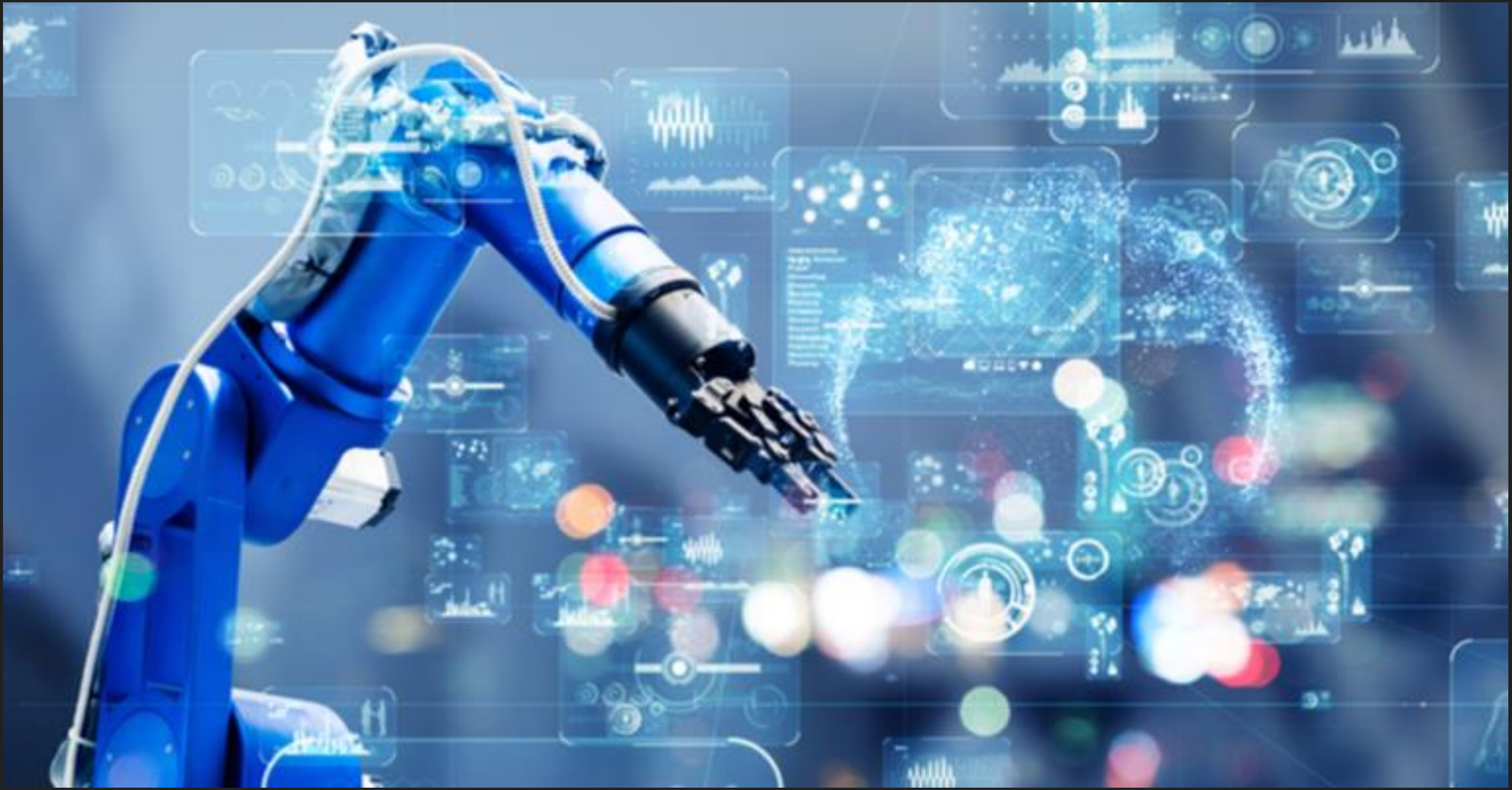
Fourth Industrial Revolution



2000 – 2020
Fourth Industrial Revolution

2000 – present
Engineering Education 4.0

4th Industrial Revolution	***4th Engineering Education***
• Cyberphysical systems + IoT • AI, ML and Deep Learning • Big Data and Data Science • Flexible and solid free form fabrication • Simulation, augmented and virtual reality • 5G wireless communication	• Student-centered (Bologna Method) • Supported by PBL activities • Professional and transverse outcomes • Research supported: nano, bio, info, and others.

Engineering practices: critical thinking and emotional intelligence

Boeing List of "Desired Attributes of an Engineer"

- A good understanding of engineering science fundamentals
  - Mathematics (including statistics)
  - Physical and life sciences
  - Information technology (far more than "computer literacy")
- A good understanding of design and manufacturing processes (i.e. understands engineering)
- A multi-disciplinary, systems perspective
- A basic understanding of the context in which engineering is practiced
  - Economics (including business practice)
  - History
  - The environment
  - Customer and societal needs
- Good communication skills
  - Written
  - Oral
  - Graphic
  - Listening
- High ethical standards
- An ability to think both critically and creatively - independently and cooperatively
- Flexibility. The ability and self-confidence to adapt to rapid or major change
- Curiosity and a desire to learn for life
- A profound understanding of the importance of teamwork.

Diversity – wanted and needed !

http://www.boeing.com/companyoffices/pwu/attributes/attributes.html


Society 5.0
for
SUSTAINABLE
DEVELOPMENT
GOALS
17 PARTNERSHIPS FOR THE GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
Fin Tech
InsurTech InsTech
RETech
Tour Tech
Auto Tech
Trans Tech
DP Tech
Urban Tech
Infra Tech
Con Tech
Ed Tech
Sports Tech
Home Tech
Fashion Tech
Ene Tech
Retail Tech
Ad Tech
Media Tech
Entertainment Tech
Health Tech
Care Tech
Agri Tech
Envi Tech
Bio Tech
Food Tech
Frontier Tech
Legal Tech
Job Tech
Civic Tech
Gov Tech
BigData
IoT
AI
Robot
Drone
Sensor
3DPrint
Blockchain
PKI
Sharing
OnDemand
Mobile
Edge
Cloud
5G
VR
AR
MR
Citizen
Large enterprise
SME
Startup
Organization
Investor
Academic institution
Educational institution
Medical institution
Community
Government

2030 – Towards singularity?
Society 5.0

2020 – future
Engineering Education 5.0

Beyond 2030

- Biohybrid artificial systems.
- Intelligent machines and process.
- Quantum supremacy.
- Biofabrication of vascularized organs.
- Materials made to order, smart materials + structures.
- Nanobiotechnology and biological computing.
- Extended life, synthetic biology and artificial life.
- Space colonization

5th Engineering Education

- Holistic, flexible and dynamic approach.
- Student-centered and Sustainability focused.
- PBL hybridized with servisse-learning.
- Focus on personal and professional development.
- Research-oriented and technology-aided.
- Collaborative, enjoyable, humanistic, international.
- Ethical compromise of students and institutions.
- Engineers as solvers of global challenges.

Engineering practices: critical thinking, emotional intelligence, and more.

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Engineering Education 5.0: Continuously Evolving Engineering Education*

ANDRÉS DÍAZ LANTADA
Escuela Técnica Superior de Ingenieros Industriales, Universidad Politécnica de Madrid (UPM), c/ José Gutiérrez Abascal 2, 28006 Madrid, Spain. E-mail: andres.diaz@upm.es

This study presents the concept of "Engineering Education 5.0", a future educational paradigm linked to a vision of engineering education characterized by a need for continuous evolution, as a consequence of a challenging quest for a more sustainable and caring future. In a way, this forthcoming evolution emanates from very relevant advances in engineering education achieved in the last decades and from a view inspired by the Sustainable Development Goals, but beyond the Agenda 2030 in terms of temporal framework. Besides, it outruns current emergent approaches and innovation trends, linked to supporting the expansion and application of Industry 4.0 technologies and principles. Engineering Education 5.0 transcends the development and application of technology and enters the realm of ethics and humanism, as key aspects of for a new generation of engineers. Ideally, engineers educated in this novel educational paradigm should be capable of leading and mentoring the approach to technological singularity, which has been defined as a future point in time at which technological growth becomes uncontrollable and irreversible leading to unpredictable impact on human civilization, while ensuring human rights and focusing on the construction of a more sustainable and equitable global society.

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Influencing Engineering Education: One (Aerospace) Industry Perspective*

JOHN H. MCMASTERS
Ed Wells Initiative, The Boeing Company, Seattle WA 98124-2207, USA.
E-mail: john.h.mcmasters@boeing.com

The purpose of this paper is to discuss some of the steps that we within the broader technical community (industry, government and academe) can and should take to assure an adequate future supply of well-prepared engineering graduates for the full range of employers who have need for such talent. While presented from an aerospace industry perspective, and thus from that of a 'mature industry' (at least in some major traditional product areas), it is believed that the issues to be addressed have far wider relevance, because the evolution of engineering (and specifically design) practice in the 'airplane business' provides a lens for discerning future trends and requirements for both university and post-employment engineering education programs. Although much has been accomplished in the past decade to enhance engineering education, we, as both educators and practitioners, have much to do to cooperatively create a strong and vivid vision of our future and assure the proper development of a future generation of engineers with the skills and motivation to meet society's needs in our always evolving and ever-volatile enterprise.

INTRODUCTION: A PERSPECTIVE FROM THE PAST

THE PRESENT PAPER is based in part on a series [1–4] begun in 2000 under the general rubric, 'The Demise of Aerospace—We Doubt It.' The series was initiated to counter some of the excesses

graduates than it does those with explicit *aerospace* engineering degrees. In this sense, the subsequent text relates to our company (and industry) interests in engineering education enhancement and reform in a broad sense.

As pointed out earlier [1–4], the development of aeronautics was a symbiotic co-evolution with the