

**PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
CHEG 3311- Introduction to Energy Systems
FALL 2021**

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[Include any other evaluation used and omit any method above method (Test, Quizzes, Homework, Laboratory and Project reports) that was not used]

Course Description in ABET Format

CHEMICAL ENGINEERING DEPARTMENT

CHEG 3311 Course Syllabus

1. **Course number and name:** CHEG 3311 INTRODUCTION TO ENERGY SYSTEMS
2. **Credits and contact hours:** 3 credit hours; 6 contact hours
3. **Instructor's or course coordinator's name:** Dr. Kazeem Olanrewaju
4. **Text book: Title:** ENERGY SYSTEMS ENGINEERING, Evaluation and Implementation

Author: Francis M. Vanek; Louis D. Albright; Largus T. Angenent
Publisher, Year & Edition: McGraw-Hill Book Company, New York, 2018, 3th Edition

a. Other Supplemental material

J.W. Tester, E.M. Drake, M.J. Driscoll, M.W. Golay and W.A. Peters, "SUSTAINABLE ENERGY: Choosing Among Options," ISBN-13: 978-0262017473, The MIT Press (September 28, 2012), ISBN-10: 0262017474.

Perry's Chemical Engineers' Handbook, Edition 8, by Don Green, Robert Perry, Robert H. Perry Introduction to Chemical Engineering Thermodynamics. ISBN13: 978-0-07-142294-9.)

David B. Rutledge "Energy Supply and Demand" ISBN 978-1-107-03107-4, Cambridge University Press
5. **Specific course information**
 - a. Brief description of the content of the course (catalog description)

CHEG 3311. Introduction to Energy Systems. (3-0) Credit 3 semester hours. This course introduces fundamental physical and engineering principles associated with various energy systems. Basic energy concepts will be introduced describing the magnitudes and patterns of human energy needs. Historical evolution and present status of the conventional fossil and nuclear-fuelled energy will be investigated along with others such as hydropower, biofuels, and the developing renewable energy systems.
 - b. Prerequisites or Co-requisites

Junior or senior standing in engineering major

- c. *Indicate whether a required, elective, or selected elective (as per definition provided) course in the program Elective

6. a. **Specific goals for the course** This course prepares engineering students with the following outcomes. b. **Explicitly indicate which of the student outcomes listed or other outcomes are addressed by the course.**

Students will be able to :

The specific goals for the course specific outcomes listed on the left column will address the following student learning outcomes:

1. Understand and be able to apply the 1st and 2nd laws of thermodynamics to energy conservation, power cycles, refrigeration cycles and liquefaction systems.

2. Understand and be able to apply the knowledge of multi-component mixture physical equilibrium, and chemical equilibria in reacting and non-reacting systems.

3. Acquire skill in the methodology for solving thermodynamic problems using their knowledge in mathematics, science, and the conservation laws.

4. To apply the above to meaningful situations to understand and formulate solutions to problems

Outcome 1*

An ability to identify, formulate, and solve fundamental engineering problems by applying principles of engineering, science, and mathematics.

7 **Brief list of topics to be covered**

Introduction	(8 hours)
Systems and Policy Tools	(11 hours)
Engineering Economic Tools	(2 hours)
Climate Change and Climate Modeling	(8 hours)
Fossil Fuel Resources	(8 hours)
Stationary Combustion Systems	(7 hours)
Overview of Energy Source and Use	(1 hours)

***Required** courses are required of all students in the program, **elective** courses (often referred to as open or free electives) are optional for students, and **selected elective** courses are those for which students must take one or more courses from a specified group

II ASSESSMENT RESULTS FOR CURRENT AND PAST TWO PERIODS

Program Outcomes Assessed in this course

Outcome D1:

An ability to identify, formulate, and solve fundamental engineering problems (CEP) by applying principles of engineering, science, and mathematics.

Assessment Summary of Class Semester Averages for Outcomes (Should be provided for Fall 2019 through Fall 2021 Assessment Period)

Outcomes	D1
Semester	Semester Class Average (%)
Fall 2019	82.29
Fall 2020	83.31
Fall 2021	74.29
Comments on Trend of Data (Improving or deteriorating)	The outcome for the current semester show that student performance falls slightly below the expected class average and also, the % of students meeting expected average is observed to be lower than the expected average. The last two years show a better performance both on the class average and percentage of students meeting expected average.

*Expected Semester Class Average = 70% (or as defined by the program)

Ideal Semester Class Average = 75% (or as defined by the program)

End of Semester Course Assessment Reports Fall 2021 and Last Two Assessment Periods.

Each summary contains the following Information

1. Performance Statistics

- Total number of students in class
- The class average performance (**stated as %**) in each course outcome assessed in this class and the **two previous times course was assessed**.
- The acceptable class average for the class in each outcome area as set by your Department.
- Percentage of students who scored below the expected average in each outcome.

2. Implementation Summary

- Brief summary of plans implemented during the semester based on last assessment report

3. Perceived Problems

- Instructor's **critical evaluation** of perceived problems that affected students' performance. **Realistic problems should be identified throughout the semester and summarized in this section of the report.**

4. New Plans for Addressing Problems

- Instructor's plans for addressing the perceived problems the next time the class is taught. **These should be specific enough for another instructor to implement. Most of these should be things that, you, the instructor can implement to help students to improve. Be creative.**

5. Overall Trend over last three assessment periods

- Instructors summary of overall performance trend for each outcome measured over the last three periods.

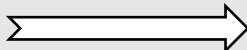
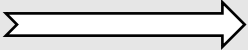
5. Were Expectations Met?

- Answer **YES** if the **class average was above the expected average** and the **stated percentage of students** scored at or above the expected average, else answer NO.

END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
CHEG 3311-P01: INTRODUCTION TO ENERGY SYSTEM
FALL 2021 SEMESTER

Report Prepared by: Dr. Kazeem Olanrewaju

Report Date: December 20, 2021

Semester	Analysis Type	Number of Students	Outcome D1 An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics."			
			Expected Class Average	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
Fall 2019	Direct	21	75	70	82.29	76.19
Fall 2020	Direct	14	75	70	83.31	71.43
Fall 2021	Direct	24	75	70	74.29	66.67
Implementation Summary						
Perceived Problems			Students show little or no interest in coming to class due to the discouraging influence of over a year-long online class necessitated by COVID-19. Technical writing was a challenge to a considerable number of students especially in the area of reference citation and summarizing published article in their own words.			
Plans for Addressing Problems			The following is recommended for implementation: 1. Face-to-face class should be significantly incentivized by attaching one-tenth of the total percentage point to attendance 2. Emphasis on references citation and rephrasing content in a published in their own words should be emphasized in courses designated to handle technical writing. 3. One class section should be earmarked to look into Technical Writing at the beginning of the semester			
Overall Trend over Periods			The outcome for the current semester show that student performance falls slightly below the expected class average and also, the % of students meeting expected average is observed to be lower than the expected average. The last two years show a better performance both on the class average and percentage of students meeting expected average			
Were Expectations Met?	Class Average $\geq 75\%$ and $\geq 70\%$ of Students Performed at or Above Expected Average.		No			

INTRODUCTION TO ENERGY SYSTEMS FALL 2021

Title of Assignment: TEST 1

TOPICS COVERED IN TEST 1

Test 1 covered the following topics:

1. Introduction
2. Relationship between Energy, Population, and Wealth
3. Pressure Facing the World Due to Energy Consumption
4. System and Policy Tools
5. System Dynamics Models: Saturation (logistic and Triangle Function)

**INTRODUCTION TO ENERGY SYSTEMS
FALL 2021**

**SAMPLE TEST QUESTIONS, SOLUTION,
AND GRADING SCHEME FOR TEST 1**

Prairie View A & M University, CHEG 3311: Introduction to Energy Systems, Fall 2021: Test 1,
Monday, September 29, 2021. Instructor: Dr. Kazeem Olanrewaju

Open Book

Name of Student: _____

Problem 1 (80 points)

Electricity generation, transmission and distribution to 300,000 household in a state in the United State of America is from combustion generation system. Starting in the year 1990, households begin to adopt and generate their electricity supply from solar panel in order to reduce carbon dioxide emission and save money from recurring cost of paying for electricity supply from the conventional generation system (Combustion system). In 1990, 5500 households have adopted the use of solar panel while in 1996, 95,000 households are now using solar panel as their source of electricity supply. The ending year for the prediction is 2000. The expected outcome is 100% saturation switch over to the use of solar panel as a means of electricity production and supply for these households. Compute how many households will be adopting solar panel electricity generation in 1998 using

- a. Logistics function
- b. Triangle function

Prairie View A & M University, CHEG 3311: Introduction to Energy Systems, Fall 2021: Test 1, Wednesday, September 29, 2021. Instructor: Dr. Kazeem Olanrewaju

Closed Books

Name of Student: _____

	Terms (A)	Concept (B)
1	Variable	Addressing the excessive interference in the natural systems of the world
2	Model	Responsible for converting usable energy resource to meet the need of the people
3	Kaya Equation	One of the metric of measuring Human Development Index before 2010 is
4	Triangle function	Pursuit of the combination of technologies and their amount of use that achieves some overall target for maximum environmental impact.
5	Deep ecologic	The indispensability of energy resources to bring comforts in our modern times tends to portend and intrinsic danger
6	Purchasing Power Parity	sum of all monetary value of goods and service produce in a country in a given year per her population is
7	Life cycle analysis	A qualitative analytical tools for energy system
8	Fossil	a statistical tool used to measure a country's overall achievement in its social and economic dimensions
9	Efficiency	Changing elements in causal loops are termed
10	GDP Index	a quantitative device that can be calibrated to predict future outcomes with some measure of accuracy, based on quantitative inputs
11	System	GDP adjustment parameter for each nation
12	Analyst	A system tool that evaluates an energy system from cradle to grave is
13	GDP per capita	Factors that contribute to overall CO2 Emissions
14	Mainstream	Parameters a and b are the start and end times of the transition to be modeled in a
15	Human development index	The dominant primary source of energy at present globally is
16	Service Technology	the development that meets the needs of the present without compromising the ability of future generations to meet their own needs
17	Eco-sufficiency	Application of technical changes to resources extraction and by-product disposal
18	Sustainable development	One of the information that life cycle analysis unfold is
19	Conceptual model	A group of interacting components that work together to achieve some common purpose
20	Technology Fragility	The scope of evaluating an energy system is determine by the

(1)

INTRO TO ENERGY SYSTEM TEST 1 PART 2 SOLUTION

Given:

⇒ 300 000 household receive electricity from combustion generation system

⇒ Starting year is 1990
Ending year is 2000

(5)

⇒ Number of household switching to solar panel electricity generation in 1990 = 5500

⇒ Number of ~~household~~ household switching to solar panel electricity generation in 1996 = 95000

⇒ 100% saturation expected.

Formulate

$$f(t) = \frac{F \cdot \exp[C_1 + C_2 t]}{1 + \exp[C_1 + C_2 t]}$$

→ logistic function (5)

Triangle function:

$$f(t) = 2 \left(\frac{t-a}{b-a} \right)^2 \quad \text{if } a \leq t \leq \frac{a+b}{2}$$

$$f(t) = 1 - 2 \left(\frac{b-t}{b-a} \right)^2 \quad \frac{a+b}{2} \leq t \leq b$$

(2)

Solve

(a) To compute how many households will be adopting solar panel electricity ~~in~~ generation in 1998 using Logistic function:

$$\therefore f(t) = \frac{F \cdot \varphi^{[C_1 + C_2 t]}}{1 + \varphi^{[C_1 + C_2 t]}}$$

In 1990, $t = 0$; (5) where F is the maximum fraction and it is equal to 1
 In 1996, $t = 6$;
 $\therefore$ In 1998, $t = 8$;
 C_1 and C_2 are parameters.

$\therefore$ To obtain C_1 and C_2
 at $t = 0$

$$\therefore f(0) = \frac{F \cdot \varphi^{[C_1 + (C_2 \times 0)]}}{1 + \varphi^{[C_1 + (C_2 \times 0)]}} \quad \text{span style="color: red;">(10)}$$

$$f(0) = \frac{1 \cdot \varphi^{C_1}}{1 + \varphi^{C_1}}$$

But $f(0) = \frac{\text{Number of households in 1990 switching to solar}}{\text{Total number of households}}$

(3)

$$f(0) = \frac{5500}{300000} = 0.0183$$

$$\therefore 0.0183 = \frac{\phi^{C_1}}{1 + \phi^{C_1}}$$

$$0.0183(1 + \phi^{C_1}) = \phi^{C_1}$$

$$\phi^{C_1}(1 - 0.0183) = 0.0183$$

$$\phi^{C_1} = \frac{0.0183}{0.9817} = 0.01864$$

$$\log_{\phi} \phi^{C_1} = \log_{\phi} 0.01864 \Rightarrow C_1 \log_{\phi} \phi = \log_{\phi} 0.01864$$

$$C_1 = -3.985 \quad (5)$$

To obtain C_2 :

at $t = 6$

$$f(6) = \frac{F \cdot \phi^{[C_1 + C_2 \cdot 6]}}{1 + \phi^{[C_1 + C_2 \cdot 6]}}$$

$$\therefore f(6) = \frac{1 \cdot \phi^{[-3.985 + C_2 \cdot 6]}}{1 + \phi^{[-3.985 + C_2 \cdot 6]}} \quad (10)$$

but $f(6) = \frac{\text{Number of households switching to solar in 1996}}{\text{Total number of households}}$

$$f(6) = \frac{9500}{300000} = 0.0317$$

(4)

$$\therefore 0.317 = \frac{e^{-3.985 + 6C_2}}{1 + e^{-3.985 + 6C_2}}$$

$$\therefore 0.317 = \frac{e^{-3.985} \times e^{6C_2}}{1 + e^{-3.985} \times e^{6C_2}}$$

$$0.317 = \frac{0.0186 e^{6C_2}}{1 + 0.0186 e^{6C_2}}$$

$$0.317 (1 + 0.0186 e^{6C_2}) = 0.0186 e^{6C_2}$$

$$0.317 + 0.005896 e^{6C_2} = 0.0186 e^{6C_2}$$

$$0.317 = (0.005896 + 0.0186) e^{6C_2}$$

$$0.317 = 0.0127 e^{6C_2}$$

$$e^{6C_2} = \frac{0.317}{0.0127} = 24.96$$

$$\log_e e^{6C_2} = \log_e 24.96$$

$$6C_2 = 3.197$$

$$C_2 = \frac{3.197}{6}$$

$$\therefore C_2 = 0.533$$

(5)

$\therefore$ In 1998 which is at $t=8$

(5)

$$f(8) = \frac{F \cdot e^{[C_1 + C_2 \cdot 8]}}{1 + e^{[C_1 + C_2 \cdot 8]}} \quad (10)$$

$$f(8) = \frac{1 \cdot e^{[-3.985 + (0.533 \times 8)]}}{1 + e^{[-3.985 + (0.533 \times 8)]}}$$

$$f(8) = \frac{1.3218}{1 + 1.3218} = 0.569$$

$$\therefore f(8) = 0.569 = \frac{\text{Number of household in 1998 switching to solar (X)}}{\text{Total number of households}}$$

$$\therefore X = 0.569 \times 300000 \quad (5)$$

$$\therefore X = 170700 \quad \text{Number of household in 1998 switching to solar}$$

(6) To Compute how many household will be adopting solar panel electricity generation in 1998 using ~~linear~~ Triangle function

Where $a = 0$ Starting point $\Rightarrow$ 1990 (5)
 and $b = 10$ Ending point $\Rightarrow$ 2000
 and time $t = 8$ This is 1998, the year of focus

(6)

It appears that

$$\frac{a+b}{2} \leq t \leq b \quad \text{where } t=8$$

$$\therefore f(t) = 1 - 2 \left(\frac{b-t}{b-a} \right)^2$$

$$\therefore f(8) = 1 - 2 \left(\frac{10-8}{10-0} \right)^2 \quad (10)$$

$$f(8) = 1 - 2 \left(\frac{2}{10} \right)^2 = 0.92$$

$$\therefore f(8) = \frac{\text{Number of household in 1998 switching to solar panel (X)}}{\text{Total number of household}}$$

$$\therefore X = f(8) \times \text{Total number of household}$$

$$X = 0.92 \times 300000$$

$$X = 276000$$

(5)
Number of household in 1998 switching to solar

Closed Books

Name of Student: _____

	Terms (A)	Concept (B)	
1	Variable	Addressing the excessive interference in the natural systems of the world	5
2	Model	Responsible for converting usable energy resource to meet the need of the people	16
3	Kaya Equation	One of the metric of measuring Human Development Index before 2010 is	10
4	Triangle function	Pursuit of the combination of technologies and their amount of use that achieves some overall target for maximum environmental impact.	17
5	Deep ecologic	The indispensability of energy resources to bring comforts in our modern times tends to portend and intrinsic danger	20
6	Purchasing Power Parity	sum of all monetary value of goods and service produce in a country in a given year per her population is	13
7	Life cycle analysis	A qualitative analytical tools for energy system	19
8	Fossil	a statistical tool used to measure a country's overall achievement in its social and economic dimensions	15
9	Efficiency	Changing elements in causal loops are termed	1
10	GDP Index	a quantitative device that can be calibrated to predict future outcomes with some measure of accuracy, based on quantitative inputs	2
11	System	GDP adjustment parameter for each nation	6
12	Analyst	A system tool that evaluates an energy system from cradle to grave is	7
13	GDP per capita	Factors that contribute to overall CO2 Emissions	3
14	Mainstream	Parameters a and b are the start and end times of the transition to be modeled in a	4
15	Human development index	The dominant primary source of energy at present globally is	8
16	Service Technology	the development that meets the needs of the present without compromising the ability of future generations to meet their own needs	18
17	Eco-sufficiency	Application of technical changes to resources extraction and by-product disposal	14
18	Sustainable development	One of the information that life cycle analysis unfold is	9
19	Conceptual model	A group of interacting components that work together to achieve some common purpose	11
20	Technology Fragility	The scope of evaluating an energy system is determine by the	12

ABOVE AVERAGE

Above Average Student Original Graded Assignment

Prairie View A & M University, CHEG 3311: Introduction to Energy Systems, Fall 2021: Test 1,
Friday, September 29, 2021. Instructor: Dr. Kazeem Olanrewaju

Open Book

Name of Student: Alessia Williams

77
80

Problem 1 (80 points)

Electricity generation, transmission and distribution to 300,000 household in a state in the United State of America is from combustion generation system. Starting in the year 1990, households begin to adopt and generate their electricity supply from solar panel in order to reduce carbon dioxide emission and save money from recurring cost of paying for electricity supply from the conventional generation system (Combustion system). In 1990, 5500 households have adopted the use of solar panel while in 1996, 95,000 households are now using solar panel as their source of electricity supply. The ending year for the prediction is 2000. The expected outcome is 100% saturation switch over to the use of solar panel as a means of electricity production and supply for these households. Compute how many households will be adopting solar panel electricity generation in 1998 using

- a. Logistics function
- b. Triangle function

$$f(t) = \frac{F \cdot e^{(c_1 + c_2(t))}}{1 + e^{(c_1 + c_2(t))}}$$

$$f(t) = 2 \left(\frac{t-a}{(b-a)} \right)^2$$

$$a \leq t \leq \frac{a+b}{2}$$

$$f(t) = 1 - 2 \left(\frac{b-t}{(b-a)} \right)^2$$

$$\frac{a+b}{2} \leq t \leq b$$

(5)

a) Logistics Function

1990 = year 0 = 5500 households

1996 = year 6 = 95000 households

Total U.S. households = 300,000

$$f(0) = \frac{5500}{300,000} = 0.0183$$

100% saturation $\Rightarrow F=1$

$$f(6) = \frac{95000}{300,000} = 0.3167$$

$$f(0) = 0.0183 = \frac{1 \cdot e^{(c_1 + c_2(0))}}{1 + e^{(c_1 + c_2(0))}} = \frac{e^{c_1}}{1 + e^{c_1}}$$

$$0.0183(1 + e^{c_1}) = e^{c_1}$$

$$0.0183 + 0.0183e^{c_1} = e^{c_1}$$

$$0.0183 = e^{c_1} - 0.0183e^{c_1}$$

$$0.0183 = e^{c_1}(1 - 0.0183)$$

$$\frac{0.0183}{(1 - 0.0183)} = e^{c_1} = 0.0186$$

$$\ln e^{c_1} = \ln 0.0186$$

$$c_1 = -3.98$$

$$f(6) = 0.3167 = \frac{1 \cdot e^{(-3.98 + c_2(6))}}{1 + e^{(-3.98 + c_2(6))}} = \frac{e^{(-3.98 + 6c_2)}}{1 + e^{(-3.98 + 6c_2)}}$$

$$0.3167(1 + e^{(-3.98 + 6c_2)}) = e^{(-3.98 + 6c_2)}$$

$$0.3167 + 0.3167e^{(-3.98 + 6c_2)} = e^{(-3.98 + 6c_2)}$$

$$0.3167 = e^{(-3.98 + 6c_2)} - 0.3167e^{(-3.98 + 6c_2)}$$

$$0.3167 = e^{(-3.98 + 6C_2)} (1 - 0.3167)$$

$$\frac{0.3167}{(1 - 0.3167)} = e^{(-3.98 + 6C_2)} = 0.4635$$

$$\ln e^{(-3.98 + 6C_2)} = \ln 0.4635$$

$$\begin{array}{rcl} -3.98 + 6C_2 & = & -0.7690 \\ +3.98 & & +3.98 \end{array} \quad (10)$$

$$\frac{6C_2}{6} = \frac{3.2110}{6}$$

$$C_2 = 0.54 \quad (5)$$

$$f(8) = \frac{1 \cdot e^{(-3.98 + 0.54(8))}}{1 + e^{(-3.98 + 0.54(8))}} = \frac{e^{0.34}}{1 + e^{0.34}} = 0.58 \quad (10)$$

$$f(8) = 0.58$$

$$0.58 (300,000) = 174,000 \text{ households in } 1998 \quad (4)$$

b. Triangle Function

start time (a) = 1990 = year 0

end time (b) = 2000 = year 10

t = 1998 = year 8

$$a = 0$$

$$b = 10$$

$$t = 8$$

$$\frac{a+b}{2} = \frac{0+10}{2} = 5$$

$$f(t) = 1 - 2 \left(\frac{b-t}{b-a} \right)^2$$

$$5 < t < 10$$

$$f(8) = 1 - 2 \left(\frac{10-8}{8-0} \right)^2 = 1 - 2 \left(\frac{2}{8} \right)^2 = 1 - 2(0.0625) = 1 - 0.125$$

$$f(8) = 0.875$$

$$0.875(300,000) = 262,500 \text{ households in 1998}$$

Closed Books

Name of Student: Alessia Williams

18
20

	Terms (A)	Concept (B)
1	Variable	Addressing the excessive interference in the natural systems of the world 5 ✓
2	Model	Responsible for converting usable energy resource to meet the need of the people 16 ✓
3	Kaya Equation	One of the metric of measuring Human Development Index before 2010 is 10 ✓
4	Triangle function	Pursuit of the combination of technologies and their amount of use that achieves some overall target for maximum environmental impact. 17 ✓
5	Deep ecologic	The indispensability of energy resources to bring comforts in our modern times tends to portend and intrinsic danger 20 ✓
6	Purchasing Power Parity	sum of all monetary value of goods and service produce in a country in a given year per her population is 13 ✓
7	Life cycle analysis	A qualitative analytical tools for energy system 19 ✓
8	Fossil	a statistical tool used to measure a country's overall achievement in its social and economic dimensions 15 ✓
9	Efficiency	Changing elements in causal loops are termed 1 ✓
10	GDP Index	a quantitative device that can be calibrated to predict future outcomes with some measure of accuracy, based on quantitative inputs 2 ✓
11	System	GDP adjustment parameter for each nation 6 ✓
12	Analyst	A system tool that evaluates an energy system from cradle to grave is 7 ✓
13	GDP per capita	Factors that contribute to overall CO2 Emissions 9 X
14	Mainstream	Parameters a and b are the start and end times of the transition to be modeled in a 4 ✓
15	Human development index	The dominant primary source of energy at present globally is 8 ✓
16	Service Technology	the development that meets the needs of the present without compromising the ability of future generations to meet their own needs 18 ✓
17	Eco-sufficiency	Application of technical changes to resources extraction and by-product disposal 14 ✓
18	Sustainable development	One of the information that life cycle analysis unfold is 3 X
19	Conceptual model	A group of interacting components that work together to achieve some common purpose 11 ✓
20	Technology Fragility	The scope of evaluating an energy system is determine by the 12 ✓

AVERAGE

Average Student Original Graded Assignment

Open Book

Name of Student: Cherish Vaughn

53
80

Problem 1 (80 points)

Electricity generation, transmission and distribution to 300,000 household in a state in the United State of America is from combustion generation system. Starting in the year 1990, households begin to adopt and generate their electricity supply from solar panel in order to reduce carbon dioxide emission and save money from recurring cost of paying for electricity supply from the conventional generation system (Combustion system). In 1990, 5500 households have adopted the use of solar panel while in 1996, 95,000 households are now using solar panel as their source of electricity supply. The ending year for the prediction is 2000. The expected outcome is 100% saturation switch over to the use of solar panel as a means of electricity production and supply for these households. Compute how many households will be adopting solar panel electricity generation in 1998 using

- Logistics function
- Triangle function

A) $f = \frac{1 \cdot e^{C_1 + C_2(t)}}{1 + e^{C_1 + C_2(t)}}$ (5)

$f(0) = \frac{5500}{300,000} = 0.0183$ (5)

$f(6) = \frac{95,000}{300,000} = 0.3166$

$f(t) = \frac{1 \cdot e^{C_1 + C_2(t)}}{1 + e^{C_1 + C_2(t)}}$

$0.0183 = \frac{1 \cdot e^{C_1}}{1 + e^{C_1}}$

$0.0183(1 + e^{C_1}) = 1 \cdot e^{C_1}$
 $0.0183 + 0.0183e^{C_1} = e^{C_1}$

$0.0183 + 0.0183e^{C_1} = e^{C_1}$

$0.0183e^{C_1} = e^{C_1} - 0.0183$

$e^{C_1} = \frac{e^{C_1}}{1 - 0.0183}$

$C_1 = 2n(53.644)$

$C_1 = 1.679$ (3)

$$C_2 = \frac{F \cdot e^{(C_1 + C_2 t)}}{1 + e^{(C_1 + C_2 t)}}$$

$$f(b) = \frac{F + e^{(C_1 + C_2(b))}}{1 + e^{(C_1 + C_2(b))}}$$

$$0.3166 = \frac{1 \cdot e^{(\cancel{C_1} + C_2(b))}}{1 + e^{(\cancel{C_1} + C_2(b))}}$$

$$3.98 + C_2$$

$$0.3166 \cdot \frac{1 + e^{(3.98 + C_2(b))}}{1 + e^{(3.98 + C_2(b))}} = 1 \cdot e^{3.98 + C_2(b)}$$

$$0.3166 e^{3.98 + C_2(b)} = 1 \cdot e$$

$$\ln\left(\frac{0.3166}{1 - 0.3166}\right) + 3.98 = 1$$

$$1998 = \frac{1 \cdot e^{(-1.679) + 0.889(8)}}{1 + e^{(-1.679) + 3.182(8)}} = 0.84$$

B) $f(t)$

starting point 1990 = 1
ending point = 2000

$$\begin{aligned} a &= 0 \\ b &= 10 \\ t &= 8 \end{aligned}$$

$$\frac{a+b}{2} = \frac{0+10}{2} = 5$$

$$\frac{2(t-a)^2}{b-a}$$

$$2 \left(\frac{8-0}{10-0} \right)^2 = 1.28$$

$$1.28 = \frac{x}{300000}$$

384000 vehicles

(3)

$$0.84 = \frac{x}{300000}$$

252000 vehicles

(3)

Closed Books

Name of Student: Cherish Vaughn

	Terms (A)	Concept (B)
1	Variable	Addressing the excessive interference in the natural systems of the world 5 ✓
2	Model	Responsible for converting usable energy resource to meet the need of the people 14 X
3	Kaya Equation	One of the metric of measuring Human Development Index before 2010 is 10 ✓
4	Triangle function	Pursuit of the combination of technologies and their amount of use that achieves some overall target for maximum environmental impact. 17 ✓
5	Deep ecologic	The indispensability of energy resources to bring comforts in our modern times tends to portend and intrinsic danger 16 X
6	Purchasing Power Parity	sum of all monetary value of goods and service produce in a country in a given year per her population is 13 ✓
7	Life cycle analysis	A qualitative analytical tools for energy system 2 X
8	Fossil	a statistical tool used to measure a country's overall achievement in its social and economic dimensions 15 ✓
9	Efficiency	Changing elements in causal loops are termed 1 ✓
10	GDP Index	a quantitative device that can be calibrated to predict future outcomes with some measure of accuracy, based on quantitative inputs 19 X
11	System	GDP adjustment parameter for each nation 6 ✓
12	Analyst	A system tool that evaluates an energy system from cradle to grave is 7 X
13	GDP per capita	Factors that contribute to overall CO2 Emissions 3 ✓
14	Mainstream	Parameters a and b are the start and end times of the transition to be modeled in a 4 ✓
15	Human development index	The dominant primary source of energy at present globally is 8 ✓
16	Service Technology	the development that meets the needs of the present without compromising the ability of future generations to meet their own needs 18 ✓
17	Eco-sufficiency	Application of technical changes to resources extraction and by-product disposal 20 X
18	Sustainable development	One of the information that life cycle analysis unfold is 9 ✓
19	Conceptual model	A group of interacting components that work together to achieve some common purpose 11 ✓
20	Technology Fragility	The scope of evaluating an energy system is determine by the 12 ✓

14
20

BELOW AVERAGE

Below Average Student Original Graded Assignment

Prairie View A & M University, CHEG 3311: Introduction to Energy Systems, Fall 2021: Test I,
Friday, September 29, 2021. Instructor: Dr. Kazeem Olanrewaju

Open Book

Name of Student: Dagna Butler

50
80

Problem 1 (80 points)

Electricity generation, transmission and distribution to 300,000 household in a state in the United State of America is from combustion generation system. Starting in the year 1990, households begin to adopt and generate their electricity supply from solar panel in order to reduce carbon dioxide emission and save money from recurring cost of paying for electricity supply from the conventional generation system (Combustion system). In 1990, 5500 households have adopted the use of solar panel while in 1996, 95,000 households are now using solar panel as their source of electricity supply. The ending year for the prediction is 2000. The expected outcome is 100% saturation switch over to the use of solar panel as a means of electricity production and supply for these households. Compute how many households will be adopting solar panel electricity generation in 1998 using

- Logistics function
- Triangle function

300000

a) Start Year 0 $\frac{5500}{300000} = 0.018$
1996 Year 6 $\frac{95000}{300000} = 0.0316$

$f(0) = 0.018$

end Year 9 $\frac{2000}{300000} = 0.0067$ (4) Solve for C_1

$$f(t) = \frac{F \cdot e^{[C_1 + C_2(t)]}}{1 + e^{[C_1 + C_2(t)]}}$$

$$f(0) = \frac{1 \cdot e^{[C_1 + C_2(0)]}}{1 + e^{[C_1 + C_2(0)]}} = \frac{e^{[C_1]}}{1 + e^{[C_1]}} \Rightarrow 0.018 = \frac{e^{[C_1]}}{1 + e^{[C_1]}}$$

0.12

$$a) \quad 0.018 = \frac{e^{C_1}}{1+e^{C_1}} \Rightarrow (1+e^{C_1})0.018 = 0.018(e^{C_1}) = \ln(1+e^{C_1})$$

$$\ln(1+e^{C_1}) = \ln \frac{0.018}{0.817} = \frac{e^{0.018}}{1+e^{0.018}} \Rightarrow e^y = \frac{0.018}{0.817} = C_1 = -1.5$$

Sixth year

$$f(6) = \frac{1 \cdot e^{(-1.5 + C_2(6))}}{1 + e^{(-1.5 + C_2(6))}} = 0.317 \Rightarrow \frac{e^{-1.5} \cdot e^{C_2(6)}}{1 + e^{-1.5} \cdot e^{C_2(6)}} = \frac{0.22 \cdot e^{C_2(6)}}{1.22 \cdot e^{C_2(6)}}$$

$$(1.22 \cdot e^{C_2(6)}) \cdot 0.317 = 0.22 \cdot e^{C_2(6)}$$

$$0.22e^{C_2(6)} - 0.07e^{C_2(6)} = 0.317$$

$$\frac{e^{C_2(6)} \cdot 0.15}{0.15} = \frac{0.317}{0.15} \Rightarrow \ln e^{C_2(6)}$$

$$\ln \frac{0.317}{0.15} = \frac{C_2 \cdot 6}{6} = \frac{0.748}{6}$$

$$C_2 = 0.125$$

Plug in to Year 8

$$f(8) = \frac{1 \cdot e^{[-1.5 + 0.125(8)]}}{1 + e^{[-1.5 + 0.125(8)]}} = \frac{e^{-0.5}}{1 + e^{-0.5}} = 0.3775$$

b)

$$t=8$$

$$a=0$$

$$b=10$$

$$f(t) = 1 - 2 \left(\frac{b-t}{b-a} \right) \quad (2)$$

$$1 - 2 \left(\frac{10-8}{10-0} \right) = 1 - 2 \left(\frac{2}{10} \right) \quad (7) \Rightarrow -1 \left(\frac{1}{5} \right) = -0.2$$

Closed Books

Name of Student: Dayna Butler

14
20

	Terms (A)	Concept (B)
1	Variable	Addressing the excessive interference in the natural systems of the world 5 ✓
2	Model	Responsible for converting usable energy resource to meet the need of the people 16 ✓
3	Kaya Equation	One of the metric of measuring Human Development Index before 2010 is 3 X
4	Triangle function	Pursuit of the combination of technologies and their amount of use that achieves some overall target for maximum environmental impact. 20 X
5	Deep ecologic	The indispensability of energy resources to bring comforts in our modern times tends to portend and intrinsic danger 6 ✓
6	Purchasing Power Parity	sum of all monetary value of goods and service produce in a country in a given year per her population is 13 ✓
7	Life cycle analysis	A qualitative analytical tools for energy system 19 ✓
8	Fossil	a statistical tool used to measure a country's overall achievement in its social and economic dimensions 15 ✓
9	Efficiency	Changing elements in causal loops are termed 1 ✓
10	GDP Index	a quantitative device that can be calibrated to predict future outcomes with some measure of accuracy, based on quantitative inputs 2 ✓
11	System	GDP adjustment parameter for each nation 10 ✓
12	Analyst	A system tool that evaluates an energy system from cradle to grave is 7 X
13	GDP per capita	Factors that contribute to overall CO2 Emissions 14 X
14	Mainstream	Parameters a and b are the start and end times of the transition to be modeled in a 4 ✓
15	Human development index	The dominant primary source of energy at present globally is 8 ✓
16	Service Technology	the development that meets the needs of the present without compromising the ability of future generations to meet their own needs 18 ✓
17	Eco-sufficiency	Application of technical changes to resources extraction and by-product disposal 17 X
18	Sustainable development	One of the information that life cycle analysis unfold is 9 ✓
19	Conceptual model	A group of interacting components that work together to achieve some common purpose 11 ✓
20	Technology Fragility	The scope of evaluating an energy system is determine by the 12 ✓

INTRODUCTION TO ENERGY SYSTEMS

FALL 2021

HOMEWORK 1

TOPICS COVERED IN HOMEWORK 1

1. Correlation between Energy Use and Wealth
2. Human Development Index: An alternative Means of Evaluating Prosperity
3. Energy Consumption : Industrial versus Emerging Countries

**INTRODUCTION TO ENERGY SYSTEMS
FALL 2021**

**SAMPLE HOMEWORK QUESTIONS, SOLUTION,
AND GRADING SCHEME FOR HOMEWORK**

CHEG 3311: Introduction to Energy System

HOMEWORK 1 (Due Date: 9/15/2021)

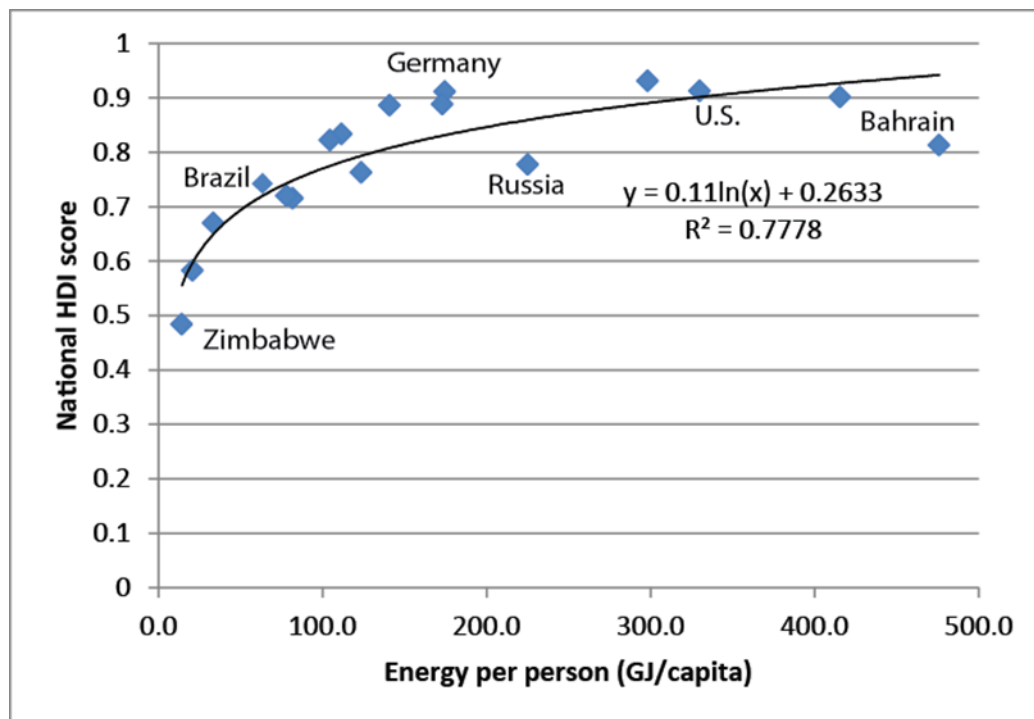
Name: _____

Problem 1

The table below show the data gathered by the United Nation Development Program to evaluate the Human Development Index of the following four countries.

	LE	MYS	EYS	GNlpc/\$
Spain	82.4	11.4	16.1	45,711
Nigeria	69.5	4.8	12.5	3,250
Germany	85.6	11.7	16.8	48,573
Haiti	63.1	5.2	9.1	1,657

- Calculate the HDI for the four countries
- Use the chart or figure to estimate the Energy per capita of people residing in the four countries



Problem 2

Convert the energy consumption values for the countries of Canada, Australia, Russia, Bahrain and India in 2008 from Table 1-1 (Check power point slides) into units of million toe and quads.

(1)

INTRO TO ENERGY SYSTEMS HOMEWORK 1 FALL 2021 SOLUTIONS

Problem 1

Given:

	LE	MYS	EYS	GNIpc/\$
Spain	82.4	11.4	16.1	45711
Nigeria	69.5	4.8	12.5	3250
Germany	85.6	11.7	16.8	48373
Haiti	63.1	5.2	9.1	1657

Formulate

$$HDI = (LEI \times II \times EI)^{1/3}$$

$$LEI (\text{Life Expectancy Index}) = \frac{LE - 20}{85 - 20}$$

$$\text{Education Index (EI)} = \frac{MYSI + EYSI}{2}$$

$$MYSI = MYS/15 ; EYSI = EYS/18$$

$$\text{Income Index (II)} = \frac{[\ln(GNIpc) - \ln(100)]}{[\ln(75000) - \ln(100)]}$$

Solve:

(a) To calculate the HDI for the four countries

Spain:

(2)

$$LEI = \frac{82.4 - 20}{85 - 20} = 0.96$$

(5)

$$EI = \frac{MYSI + ETSI}{2}$$

$$MYSI = \frac{11.4}{15} = 0.760$$

$$ETSI = \frac{16.1}{18} = 0.894$$

$$\therefore EI = \frac{0.760 + 0.894}{2} = 0.827$$

$$PI = \frac{\ln(45711) - \ln(100)}{\ln(35000) - \ln(100)} = 0.925$$

$$\therefore HAI = (0.96 \times 0.827 \times 0.925)^{1/3} = 0.902$$

$$\therefore HAI \text{ for system} = 0.902$$

Nigeria:

$$LEI = \frac{69.5 - 20}{85 - 20} = 0.762$$

(5)

$$EI = \frac{MYSI + ETSI}{2}$$

(3)

$$M^*SI = \frac{4.8}{15} = 0.320$$

$$E^*SI = \frac{12.5}{18} = 0.694$$

$$EI = \frac{M^*SI + E^*SI}{2} = \frac{0.320 + 0.694}{2} = 0.507$$

$$II = \frac{\ln(3250) - \ln(100)}{\ln(7500) - \ln(100)} = 0.526$$

$$\therefore H\Delta I = (0.762 \times 0.507 \times 0.526)^{1/3} = 0.588$$

$$\therefore \boxed{H\Delta I \text{ for Nigeria} = 0.588}$$

Germany

$$LEI = \frac{85.6 - 20}{85 - 20} = 1.009$$

(5)

$$M^*SI = \frac{11.7}{15} = 0.78$$

$$E^*SI = \frac{16.8}{18} = 0.933$$

$$EI = \frac{0.78 + 0.933}{2} = 0.857$$

$$II = \frac{\ln(48573) - \ln(100)}{\ln(7500) - \ln(100)} = 0.934$$

(4)

$$\therefore HAI = (1.009 \times 0.857 \times 0.934)^{1/3} = 0.931$$

$$\therefore \boxed{HAI \text{ for Germany} = 0.931}$$

Haiti

$$LEI = \frac{63.1 - 20}{85 - 20} = 0.663$$

(5)

$$MYSI = \frac{5.2}{15} = 0.347$$

$$EYSI = \frac{9.1}{18} = 0.506$$

$$EI = \frac{0.347 + 0.506}{2} = 0.427$$

$$\therefore II = \frac{\ln(1657) - \ln(100)}{\ln(7500) - \ln(100)} = 0.424$$

$$\therefore HAI = (0.663 \times 0.427 \times 0.424)^{1/3} = 0.493$$

$$\therefore \boxed{HAI \text{ for Haiti} = 0.493}$$

(6) To use the chart or figures to estimate the Energy per capita for the four countries

Spain

Equation of the trend line can be used to estimate Energy per capita for Spain

(5)

$$\therefore Y = 0.11 \ln(X) + 0.2633$$

(5)

Where $Y = HAI$

$X = \text{Energy per capita}$

$HAI \text{ for Spain} = 0.902$

$$\therefore 0.902 = 0.11 \ln(X) + 0.2633$$

$$\therefore \ln(X) = \frac{0.902 - 0.2633}{0.11} = 5.806$$

$$\therefore X = e^{5.806} = 332 \text{ GJ per capita}$$

Energy per capita for Spain = 332 GJ

Nigeria

Equation of the trendline can be used to estimate Energy per capita for Nigeria

$$\therefore Y = 0.11 \ln(X) + 0.2633$$

(5)

Where $Y = HAI$

$X = \text{Energy per capita}$

$HAI \text{ for Nigeria} = 0.588$

$$0.588 = 0.11 \ln(X) + 0.2633$$

$$\ln(X) = \frac{0.588 - 0.2633}{0.11} = 2.952$$

$$\therefore X = e^{2.952} = 19.14 \text{ GJ per capita}$$

Energy per capita for Nigeria = 19.14 GJ

(6)

Germany

Equation of the trendline can be used to estimate Energy per capita for Germany

$$\therefore \hat{y} = 0.11 \ln(x) + 0.2633$$

Also $\hat{y} = H\Delta I$

$X = \text{Energy per capita}$

$H\Delta I \text{ for Germany} = 0.931$

$$0.931 = 0.11 \ln(x) + 0.2633$$

$$\ln x = \frac{0.931 - 0.2633}{0.11} = 6.07$$

$$\therefore X = e^{6.07} = 432.68 \text{ GJ per capita}$$

Energy per Capita for ~~At~~ Germany = 432.68 GJ

Haiti

Equation of the trendline can be used to estimate Energy per capita for Nigeria

$$\therefore \hat{y} = 0.11 \ln(x) + 0.2633$$

Also $\hat{y} = H\Delta I$

$X = \text{Energy per capita}$

$$\therefore 0.893 = 0.11 \ln(x) + 0.2633$$

$$\ln(x) = \frac{0.893 - 0.2633}{0.11} = 2.09$$

$$\therefore X = e^{2.09} = 8.08 \text{ GJ per capita}$$

$\therefore \text{Energy per capita for Haiti} = 8.08 \text{ GJ}$

Problem 2

To convert the energy consumption values for the countries of Canada, Australia, Russia, Bahrain and India

Canada

Energy Consumption in Canada in 2008 = $14.79 \times 10^{13} \text{ J}$

$$\frac{14.79 \times 10^{13} \text{ J}}{4.1840 \times 10^{10} \text{ J}} = \frac{14.79 \times 10^3 \text{ TOE}}{4.1840} \quad (10)$$

~~$\therefore 14290$ million~~

$$\therefore = \frac{1429 \text{ Millions TOE}}{4.1840} = \boxed{341.54 \text{ Millions TOE}}$$

$$\frac{14.79 \times 10^{13} \text{ J}}{1.055 \times 10^{13} \text{ J}} = 13.55 \text{ quad.}$$

$$\therefore = \boxed{13.55 \text{ quad}}$$

Australia

Energy Consumption in Australia in 2008 = $6.07 \times 10^{13} \text{ J}$

$$\frac{6.07 \times 10^{13} \text{ J}}{4.1840 \times 10^{10} \text{ J}} = \frac{6.07 \times 10^3 \text{ TOE}}{4.1840} \quad (10)$$

$$\therefore = \frac{607 \text{ Millions TOE}}{4.1840} = \boxed{145.08 \text{ Millions TOE}}$$

(8)

$$\frac{6.07 \times 10^{18} \text{ J}}{1.055 \times 10^{18} \text{ J}} \left\{ \frac{1 \text{ quad}}{1.055 \times 10^{18} \text{ J}} \right. = 5.75 \text{ quad}$$

$$\therefore = \boxed{5.75 \text{ quad}}$$

RussiaEnergy Consumption in Russia in 2008 = $32.10 \times 10^{18} \text{ J}$

$$\therefore \frac{32.10 \times 10^{18} \text{ J}}{4.1840 \times 10^{10} \text{ J}} \left\{ \frac{1 \text{ TOE}}{4.1840 \times 10^{10} \text{ J}} \right. = 7.67 \times 10^8 \text{ TOE} \quad (10)$$

$$\therefore = \boxed{767 \text{ Millions TOE}}$$

$$\frac{32.10 \times 10^{18} \text{ J}}{1.055 \times 10^{18} \text{ J}} \left\{ \frac{1 \text{ quad}}{1.055 \times 10^{18} \text{ J}} \right. = 30.43 \text{ quad}$$

$$= \boxed{30.43 \text{ quad}}$$

BahrainEnergy Consumption in Bahrain in 2008 = $0.58 \times 10^{18} \text{ J}$

$$\therefore \frac{0.58 \times 10^{18} \text{ J}}{4.1840 \times 10^{10} \text{ J}} \left\{ \frac{1 \text{ TOE}}{4.1840 \times 10^{10} \text{ J}} \right. = 0.139 \times 10^8 \text{ TOE} \quad (10)$$

$$= \boxed{13.9 \text{ Millions TOE}}$$

(9)

$$\frac{0.58 \times 10^{12} \text{ J}}{1.055 \times 10^{12} \text{ J}} \left\{ \begin{array}{l} 1 \text{ quad} \end{array} \right. = 0.550 \text{ quad}$$

$$= \boxed{0.550 \text{ quad}}$$

India

Energy Consumption in India in 2008 = $21.05 \times 10^{12} \text{ J}$

$$\therefore \frac{21.05 \times 10^{12} \text{ J}}{4.1840 \times 10^{10} \text{ J}} \left\{ \begin{array}{l} 1 \text{ TOE} \end{array} \right. = 5.03 \times 10^2 \text{ TOE} \quad (10)$$

$$= \boxed{503 \text{ Millions TOE}}$$

$$\frac{21.05 \times 10^{12} \text{ J}}{1.055 \times 10^{12} \text{ J}} \left\{ \begin{array}{l} 1 \text{ quad} \end{array} \right. = 19.95 \text{ quad}$$

$$\therefore = \boxed{19.95 \text{ quad}}$$

ABOVE AVERAGE

Above Average Student Original Graded Assignment

CHEG 3113: Introduction to Energy System

HOMEWORK 1 (Due Date: 9/15/2021)

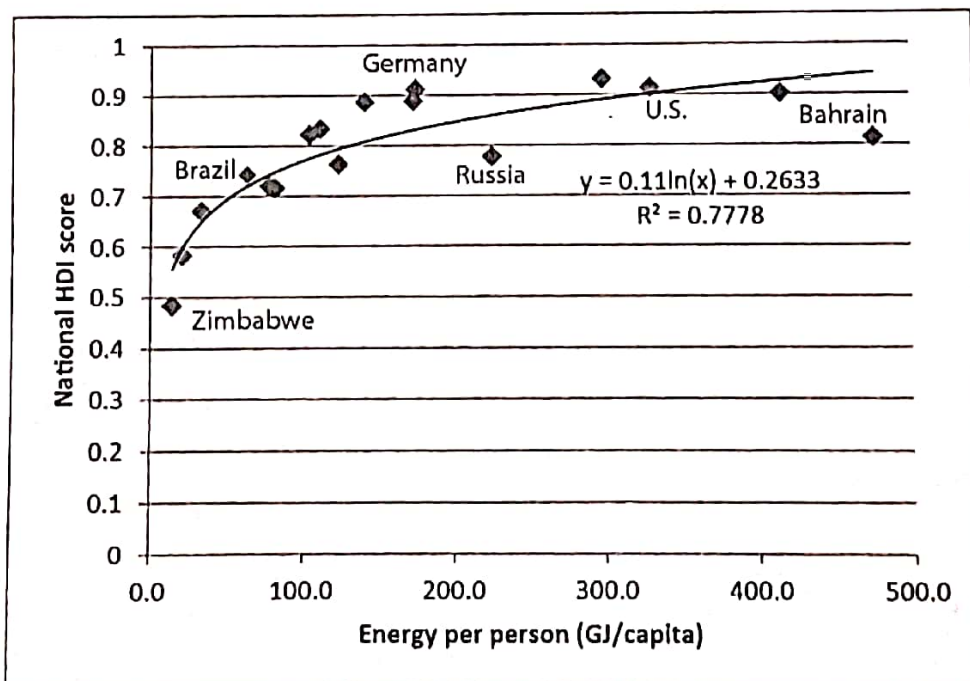
Name: Meredith Meyer

Problem 1

The table below show the data gathered by the United Nation Development Program to evaluate the Human Development Index of the following four countries.

	LE	MYS	EYS	GNIPC/\$
Spain	82.4	11.4	16.1	45,711
Nigeria	69.5	4.8	12.5	3,250
Germany	85.6	11.7	16.8	48,573
Haiti	63.1	5.2	9.1	1,657

- Calculate the HDI for the four countries
- Use the chart or figure to estimate the Energy per capita of people residing in the four countries



Problem 1 (a)

Spain

$$LEI = (82.4 - 20) / (85 - 20) = 0.96$$

$$MYSI = (11.9) / 15 = 0.76$$

$$EYSI = 16.1 / 18 = 0.894$$

$$EI = (0.76 + 0.894) / 2 = 0.827$$

$$II = [\ln(45,71) - \ln(100)] / [\ln(75,000) - \ln(100)] = 0.93$$

$$HDI = (0.96 \cdot 0.827 \cdot 0.93)^{1/3} = \boxed{0.90}$$

Nigeria

$$LEI = (69.5 - 20) / (85 - 20) = 0.76$$

$$MYSI = (4.8) / 15 = 0.32$$

$$EYSI = 12.5 / 18 = 0.69$$

$$EI = (0.32 + 0.69) / 2 = 0.505$$

$$II = [\ln(3250) - \ln(100)] / [\ln(75,000) - \ln(100)] = 0.53$$

$$HDI = (0.76 \cdot 0.505 \cdot 0.53)^{1/3} = \boxed{0.588}$$

Germany

$$LEI = (85.6 - 20) / (85 - 20) = 1.01$$

$$MYSI = (11.7) / 15 = 0.78$$

$$EYSI = 16.8 / 18 = 0.93$$

$$EI = (0.78 + 0.93) / 2 = 0.855$$

$$II = [\ln(48,573) - \ln(100)] / [\ln(75,000) - \ln(100)] = 0.93$$

$$HDI = (1.01 \cdot 0.855 \cdot 0.93)^{1/3} = \boxed{0.93}$$

Haiti

$$LEI = (63.1 - 20) / (85 - 20) = 0.66$$

$$MYSI = 5.2 / 15 = 0.35$$

$$EYSI = 9.1 / 18 = 0.506$$

$$EI = (0.35 + 0.506) / 2 = 0.428$$

$$II = [\ln(1657) - \ln(100)] / [\ln(75,000) - \ln(100)] = 0.424$$

$$HDI = (0.66 \cdot 0.428 \cdot 0.424)^{1/3} = \boxed{0.49}$$

Problem 1B

Energy per capita

$$y = 0.11 \ln(x) + 0.2633$$
$$y - 0.2633 = 0.11 \ln(x)$$
$$\frac{y - 0.2633}{0.11} = \ln(x)$$
$$x = e^{\frac{y - 0.2633}{0.11}}$$

$$\text{Spain} = e^{\frac{0.90 - 0.2633}{0.11}} = 326.42 \text{ GJ/capita}$$

$$\text{Nigeria} = e^{\frac{-0.588 - 0.2633}{0.11}} = 19.49 \text{ GJ/capita}$$

$$\text{Germany} = e^{\frac{0.93 - 0.2633}{0.11}} = 428.77 \text{ GJ/capita}$$

$$\text{Haiti} = e^{\frac{-0.49 - 0.2633}{0.11}} = 7.85 \text{ GJ/capita}$$

Problem 2

Convert the energy consumption values for the countries of Canada, Australia, Russia, Bahrain and India in 2008 from Table 1-1 (Check power point slides) into units of million toe and quads.

$$1 \text{ million toe} = 4.1868 \times 10^{16} \text{ joules} \quad (5) \quad 1 \text{ quad} = 1.055 \times 10^{18} \text{ joules}$$

Canada

$$\frac{14.79 \times 10^{18} \text{ joules}}{4.1868 \times 10^{16} \text{ joules}} \times 1 \text{ million toe} = 353.25 \text{ million toe}$$

$$\frac{14.79 \times 10^{18} \text{ joules}}{1.055 \times 10^{18} \text{ joules}} \times 1 \text{ quad} = 14.02 \text{ quads} \quad (10)$$

Australia

$$\frac{6.07 \times 10^{18} \text{ joules}}{4.1868 \times 10^{16} \text{ joules}} \times 1 \text{ million toe} = 144.98 \text{ million toe}$$

$$\frac{6.07 \times 10^{18} \text{ joules}}{1.055 \times 10^{18} \text{ joules}} \times 1 \text{ quad} = 5.75 \text{ quads} \quad (10)$$

Russia

$$\frac{32.10 \times 10^{18} \text{ joules}}{4.1868 \times 10^{16} \text{ joules}} \times 1 \text{ million toe} = 776.7 \text{ million toe}$$

$$\frac{32.10 \times 10^{18} \text{ joules}}{1.055 \times 10^{18} \text{ joules}} \times 1 \text{ quad} = 30.43 \text{ quads} \quad (10)$$

Problem 2

1 million toe = 4.1868×10^{16} joules

1 quad = 1.055×10^{18} joules

Bahrain

$$\frac{10.58 \times 10^{18} \text{ joule} / 1 \text{ million toe}}{4.1868 \times 10^{16} \text{ joule}} = 13.85 \text{ million toe}$$

$$\frac{10.58 \times 10^{18} \text{ joule} / 1 \text{ quad}}{1.055 \times 10^{18} \text{ joule}} = 0.549 \text{ quads}$$

India

$$\frac{21.05 \times 10^{18} \text{ joule} / 1 \text{ million toe}}{4.1868 \times 10^{16} \text{ joule}} = 502.777 \text{ million toe}$$

$$\frac{21.05 \times 10^{18} \text{ joule} / 1 \text{ quad}}{1.055 \times 10^{18} \text{ joules}} = 19.95 \text{ quads}$$

AVERAGE

Average Student Original Graded Assignment

CHEG 3113: Introduction to Energy System

HOMEWORK 1 (Due Date: 9/15/2021)

87
100

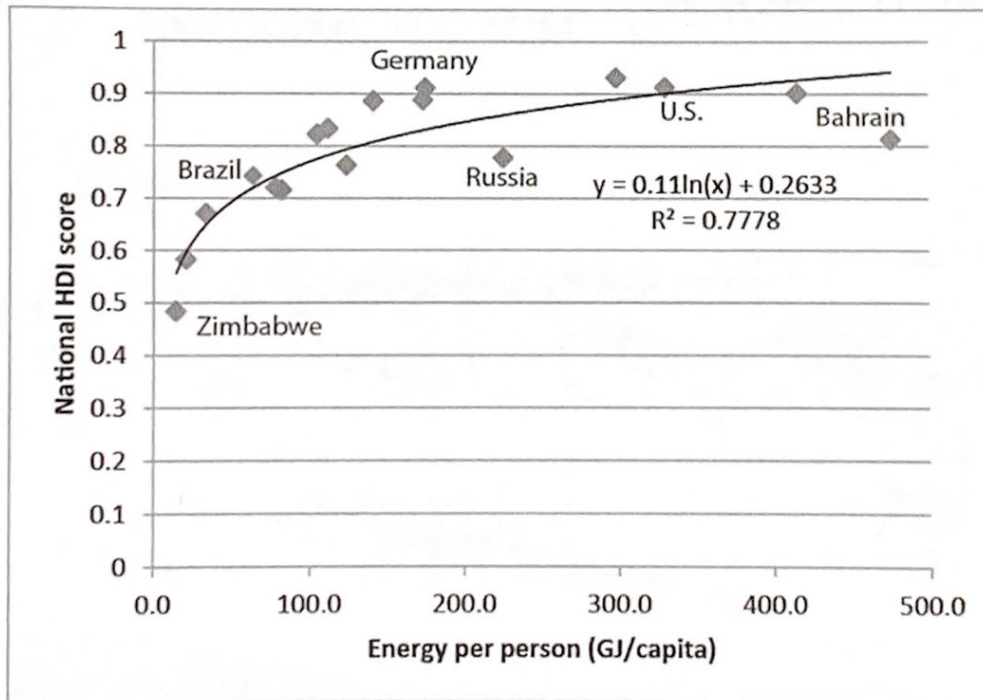
Name: Canidanan Coulibaly

Problem 1

The table below show the data gathered by the United Nation Development Program to evaluate the Human Development Index of the following four countries.

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Haiti	63.1	5.2	9.1	1,657

- Calculate the HDI for the four countries
- Use the chart or figure to estimate the Energy per capita of people residing in the four countries



Problem 1 (solution)

a) Calculate HDI for the four countries

* Spain

$$HDI = \sqrt[3]{(LEI)(EI)(II)} = \sqrt[3]{(0.96)(0.83)(0.93)} = \boxed{0.90}$$

$$\begin{aligned} - LEI &= (LE - 20) / (85 - 20) \\ &= (82.4 - 20) / (85 - 20) \end{aligned}$$

$$LEI = \boxed{0.96}$$

$$\begin{aligned} - EI &= (MYSI + EYSI) / 2 = \left[\frac{11.4}{15} + \frac{16.1}{18} \right] / 2 \\ &= \left[\frac{11.4}{15} + \frac{16.1}{18} \right] / 2 = \boxed{0.83} \end{aligned}$$

$$- II = \frac{[\ln(GNIPC) - \ln(100)]}{[\ln(75000) - \ln(100)]} = \frac{[\ln(45711) - \ln(100)]}{[\ln(75000) - \ln(100)]} = \boxed{0.93}$$

* Nigeria

$$- LEI = (LE - 20) / (85 - 20) = (69.5 - 20) / 65 = 0.76$$

$$- EI = \frac{[MYI/15 + EYI/18]}{2} = \frac{[4.8/15 + 12.5/18]}{2} = 0.51$$

$$- II = \frac{[\ln(GNIPC) - \ln(100)]}{\ln(75000) - \ln(100)} = \frac{[\ln(3250) - \ln(100)]}{\ln(75000) - \ln(100)} = 0.53$$

$$HDI = \sqrt[3]{(LEI)(EI)(II)} = \sqrt[3]{(0.76)(0.51)(0.53)}$$

$$\boxed{HDI = 0.59}$$

* Germany

$$- LEI = (LE - 20) / 65 = (85.6 - 20) / 65 = 1$$

$$- EI = \frac{[MY/15 + EY/18]}{2} = \frac{[11.5/15 + 16.8/18]}{2} = 0.86$$

$$- II = \frac{\ln(GNIPC) - \ln 100}{\ln(75,000) - \ln 100} = \frac{\ln(48573) - \ln 100}{\ln(75,000) - \ln 100} = 0.93$$

$$HDI = \sqrt[3]{(1)(0.86)(0.93)} = 0.93$$

* Haiti

$$- LEI = (LE - 20) / 65 = (63.1 - 20) / 65 = 0.66$$

$$- EI = \frac{[MY/15 + EY/18]}{2} = \frac{[5.2/15 + 9.1/18]}{2} = 0.43$$

$$- II = \frac{\ln(1657) - \ln 100}{\ln(75,000) - \ln 100} = 0.42$$

$$HDI = \sqrt[3]{(0.66)(0.43)(0.42)} = 0.49$$

b) Estimate energy per capita of 04 countries:

* Spain Energy per capita = 310 GJ/capita

* Nigeria Energy per capita = 10 GJ/capita

* Germany Energy per capita = 460 GJ/capita

* Haiti Energy per capita = 0.3 GJ/capita

Problem 2

Convert the energy consumption values for the countries of Canada, Australia, Russia, Bahrain and India in 2008 from Table 1-1 (Check power point slides) into units of million toe and quads.

Solution.
• million toe

* Australia :

$$E_A = (6.07 \times 10^{18} \text{ J}) \left(\frac{2.38846 \times 10^{-17} \text{ Mtoe}}{1 \text{ J}} \right) = \boxed{145 \text{ Mtoe}} \quad (5)$$

* Bahrain

$$E_B = (0.58 \times 10^{18} \text{ J}) \left(\frac{2.38846 \times 10^{-17} \text{ Mtoe}}{1 \text{ J}} \right) = \boxed{13.85 \text{ Mtoe}} \quad (5)$$

* Canada

$$E_C = (14.79 \times 10^{18} \text{ J}) \left(\frac{2.38846 \times 10^{-17} \text{ Mtoe}}{1 \text{ J}} \right) = \boxed{353.25 \text{ Mtoe}} \quad (5)$$

* India

$$E_I = (21.05 \times 10^{18} \text{ J}) \left(\frac{2.38846 \times 10^{-17} \text{ Mtoe}}{1 \text{ J}} \right) = \boxed{502.77 \text{ Mtoe}} \quad (5)$$

* Russia

$$E_R = (32.10 \times 10^{18} \text{ J}) \left(\frac{2.38846 \times 10^{-17} \text{ Mtoe}}{1 \text{ J}} \right) = \boxed{766.70 \text{ Mtoe}} \quad (5)$$

• Quads

$$E_A = (6.07 \times 10^{18} \text{ J}) \left(\frac{9.4782 \times 10^{-19} \text{ Quads}}{1 \text{ J}} \right) = \boxed{5.75 \text{ Quads}} \quad (5)$$

$$* E_D = (0.58 \times 10^{18})(9.4782 \times 10^{-19}) = \boxed{0.55 \text{ quads}} \quad (5)$$

$$* E_C = (14.79 \times 10^{18})(9.4782 \times 10^{-19}) = \boxed{14.02 \text{ quads}} \quad (5)$$

$$* E_I = (21.05 \times 10^{18})(9.4782 \times 10^{-19}) = \boxed{19.95 \text{ quads}} \quad (5)$$

$$* E_R = (32.10 \times 10^{18})(9.4782 \times 10^{-19}) = \boxed{30.42 \text{ quads}} \quad (5)$$

x

BELOW AVERAGE

Below Average Student Original Graded Assignment

Problem 1:

a) Spain

$$LEI = \frac{(82.4 - 20)}{(85 - 20)} = \frac{62.4}{65} \quad LEI = 0.96$$

$$EI = \frac{(76 + 0.89)}{2} = 0.89$$

$$HDI = (0.96 \times 0.89 \times .93)^{1/3}$$

$$II = .93$$

$$= .93$$

$$II = \frac{[\ln(45711) - \ln(100)]}{[\ln(75000) - \ln(100)]} = \frac{6.12}{6.62} = .93$$

Nigeria

$$LEI = \frac{(69.4 - 20)}{(85 - 20)} = .76 \quad LEI = .76 \quad EI = .505 \quad II = .53$$

$$EI = \frac{(.32 + .69)}{2} = .505$$

$$HDI = (.76 \times .505 \times .53)^{1/3} = .59$$

$$II = \frac{[\ln(3250) - \ln(100)]}{[\ln(75000) - \ln(100)]} = .53$$

Germany

$$LEI = 1.01 \quad EI = .86 \quad II = .93$$

$$LEI = \frac{(85.6 - 20)}{(85 - 20)} = 1.01$$

$$EI = \frac{(.78 + .93)}{2} = .86$$

$$HDI = (1.01 \times .86 \times .93)^{1/3} = .93$$

$$II = \frac{[\ln(48573) - \ln(100)]}{[\ln(75000) - \ln(100)]} = .93$$

Haiti

$$LEI = .66 \quad EI = .43 \quad II = .42$$

$$LEI = \frac{(63.1 - 20)}{(85 - 20)} = .66$$

$$EI = \frac{(.35 + .51)}{2} = .43$$

$$HDI = (.66 \times .43 \times .42)^{1/3} = .49$$

$$II = \frac{[\ln(1657) - \ln(100)]}{[\ln(75000) - \ln(100)]} = .42$$

Problem 1:

b. Spain = 410 EJ/capita (3) Nigeria = 10 EJ/capita (3) Germany = 175 EJ/capita (3)
 Haiti = 8 EJ/capita (3)

Problem 2:

Canada

$$\frac{14.79 \times 10^{18} \text{ J}}{10^9 \text{ J}} \times \frac{1 \text{ EJ}}{10^6 \text{ J}} \times \frac{1 \text{ quad}}{1.055 \text{ EJ}} = 14.028 \text{ quad}$$

$$\frac{14.79 \times 10^{18} \text{ J}}{10^9 \text{ J}} \times \frac{1 \text{ Mtoe}}{41.868 \text{ EJ}} = 35.32 \times 10^7 \text{ Mtoe}$$

Australia

$$\frac{6.07 \times 10^{18} \text{ J}}{10^9 \text{ J}} \times \frac{1 \text{ EJ}}{10^6 \text{ J}} \times \frac{1 \text{ quad}}{1.055 \text{ EJ}} = 5.758 \text{ quad}$$

$$\frac{6.07 \times 10^{18} \text{ J}}{10^9 \text{ J}} \times \frac{1 \text{ Mtoe}}{41.868 \text{ EJ}} = 14.49 \times 10^7 \text{ Mtoe}$$

Russia

$$\frac{32.10 \times 10^{18} \text{ J}}{10^9 \text{ J}} \times \frac{1 \text{ EJ}}{10^6 \text{ J}} \times \frac{1 \text{ quad}}{1.055 \text{ EJ}} = 30.438 \text{ quad}$$

$$\frac{32.10 \times 10^{18} \text{ J}}{10^9 \text{ J}} \times \frac{1 \text{ Mtoe}}{41.868 \text{ EJ}} = 76.67 \times 10^7 \text{ Mtoe}$$

Bahrain

$$\frac{0.58 \times 10^{18} \text{ J}}{10^9 \text{ J}} \times \frac{1 \text{ EJ}}{10^6 \text{ J}} \times \frac{1 \text{ quad}}{1.055 \text{ EJ}} = 0.558 \text{ quad}$$

$$\frac{0.58 \times 10^{18} \text{ J}}{10^9 \text{ J}} \times \frac{1 \text{ Mtoe}}{41.868 \text{ EJ}} = 1.39 \times 10^7 \text{ Mtoe}$$

India

$$\frac{21.05 \times 10^{18} \text{ J}}{10^9 \text{ J}} \times \frac{1 \text{ EJ}}{10^6 \text{ J}} \times \frac{1 \text{ quad}}{1.055 \text{ EJ}} = 19.958 \text{ quad}$$

$$\frac{21.05 \times 10^{18} \text{ J}}{10^9 \text{ J}} \times \frac{1 \text{ Mtoe}}{41.868 \text{ EJ}} = 50.27 \times 10^7 \text{ Mtoe}$$

**INTRODUCTION TO ENERGY SYSTEMS
FALL 2021**

MIDTERM EXAM

TOPICS COVERED IN MIDTERM EXAM

1. Introduction
2. Relationship between Energy, Population, and Wealth
3. Pressure Facing the World Due to Energy Consumption
4. System and Policy Tools
5. System Dynamics Models
6. Engineering Economic Tools
7. Climate Change and Climate Modeling

**INTRODUCTION TO ENERGY SYSTEMS
FALL 2021**

**SAMPLE MIDTERM EXAM QUESTIONS, SOLUTION,
AND GRADING SCHEME FOR MIDTERM EXAM**

Prairie View A & M University, CHEG 3311: Introduction to Energy System; Fall 2021: Mid-Term Exam, Monday, October 20, 2021. Instructor: Dr. Kazeem Olanrewaju

You should not reference to or have access to your class notes, laptop, tablet, cell phone, smart phone, and any other electronic gadgets.

Open Book

Name of Student: _____

Problem 1 (40 points)

Multi-criteria decision making: An Energy System Company in California is evaluating three processing routes for gasoline production in order to choose the one that is mostly sustainable. As shown in the figure below, three different ways of producing gasoline are considered: the bioliq process with the feedstock wheat straw (bioliq straw) or forest residues (bioliq wood), and a classical refinery process as fossil reference (fossil). Main process steps of the classical refinery process are distillation and reforming. Main process steps of the production of gasoline from straw or wood are pyrolysis, gasification and fuel synthesis. Environmental, economical, and social sustainability are the three criteria used as metrics to assess which of the production route is mostly sustainable. The environmental criterion is evaluated based on the ecological impact of producing one liter of the gasoline, while the other three are evaluated based on the amount of dollar, number of employees involve and amount energy used in the production of 1 liter of the gasoline. The scoring for each criterion is calculated by assigning the inferior production route a score of 100, and then assigning the superior production process a score that is the ratio of the superior to inferior raw score multiplied by 100. Using the data given below, choose the production route that is mostly sustainable. The lower the overall weighted score the lesser the impact on the aggregate outlook of the three dimensions. (Note that numbers are provided only to illustrate the technique and do not indicate the true relative worth of the production route).

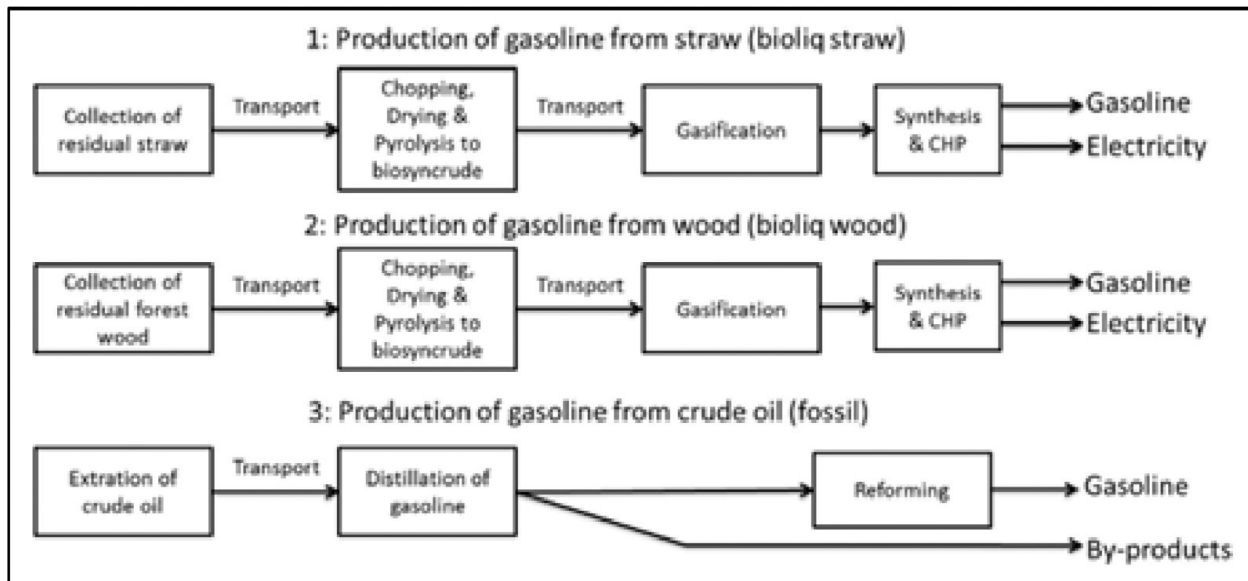
Dimension	Units	Bioliq straw	Bioliq wood	Fossil	Weight
Environmental	impact/liter	1.1	0.18	1.05	0.40
Economy	\$/liter	1.47	1.58	0.38	0.28
Social	Employees/liter	6.51	7.21	1.05	0.12
Energy used	KW/liter	10	10	15	0.20

Problem 2 (40 points)

Use the various plots given to you to calculate the following:

- Total emission of CO₂ (in kiloton) in country with the highest and lowest CO₂ emission per capita

- b) Total amount of energy utilized in the country with the highest and lowest energy use per capita
- c) Calculate the exact amount of Fossil fuel energy consumption in the country with highest and lowest energy use per capita in (b)
- d) Determine the human development index for the country with the highest CO₂ emission per capita, highest energy use capita and lowest fossil fuel consumption (lowest use per capita) based on HDI metric after 2010.



Closed Books

Name of Student: _____

	Terms (A)	Concept (B)	Answer
1	Photosynthesis	This is an example of conversion technologies in a conceptual model system tool analysis	
2	Net Present Worth	One of the components of gross energy consumption in a country is	
3	Free availability	To obtain HDI for any country in 1990	
4	Scenarios	Understanding Contributing Factors to Time Series Energy Trends Using	
5	Absorption wavelength	One of the reasons why industrialized nations consumed less energy than emerging countries in 2008	
6	Rate of return	One of the driver behind the study of energy system and its improvement is	
7	Transportation	This analytical tool help create a story due to implication of one or more variables on another in analyzing an energy system	
8	Energy efficient device	Establishing connection between warming and fossil fuels	
9	Exponential function	This variable is one of the determinant of greenhouse effect	
10	Antiquity age	This is based on how much material and energy is consumed at the different point in the energy system from resource extraction to final energy deliverables	
11	Callendar	One of the metric of measuring Human Development Index after 2010 is	
12	Carbon dioxide emission	One of the economic analysis tools easily understood by most people for assessing an Energy System is	
13	Income index	An economic analysis tool use to evaluate the viability of an Energy project is	
14	GDP per capita	Power output by energy system in our modern times is in the order of six as compare to the	
15	Life cycle analysis	The concentration of carbon dioxide release into the atmosphere due to expiration from human system is neutralize by	
16	Resource scarcity	One of the component of Kaya Equation is	
17	Divisia analysis	One of the advantages of renewable energy sources is	
18	GDP index	is a projection about the relationship between inputs and outcomes that incorporates quantitative data, without proving that the values used are the best fit for the current or future situation	
19	Biorefinery	A numerical device that can be used to predict variation of energy consumption/production with numbers years in the future	
20	Causal loop	Negative effect of Energy use is not directly link to gross consumption of energy but	

INTRO TO ENERGY SYSTEM MIDTERM EXAM FALL 2024

SOLUTION

Problem 1

Given:

(5)

Dimension	Units	Biolig. straw	Biolig. wood	Fossil	Weight
Environmental	Impact/Liter	1.1	0.18	1.05	0.40
Economy	\$/Liter	1.47	1.58	0.38	0.28
Social	Employers/Liter	6.51	7.21	1.05	0.12
Energy used	KW/Liter	10	10	15	0.20

Assigning the inferior production route a score of 100, and then assigning the superior production process - - - -

formulate

$$Score_i = \sum W_c X_{ic} \forall i$$

(5)

where:

$Score_i$ = Total Score for the Alternative
in Dimensionless unit

W_c = The weight of criterion c relative to other criteria

X_{ic} = the score for alternative i in terms of criterion c

$\forall i$ = for all alternative

Solution:

The scoring for each criterion is calculated by assigning the inferior production route a score of

(2)

100, and then assigning the Superior production process a score that is the ratio of the Superior to inferior raw score multiplied by 100.

Scoring each alternative per criterion

Environmental

Interior route under this criterion is Brolog Straw with a score of 100 $\Rightarrow 1-1$

$$\therefore \text{Brolog Straw score} = \frac{1-1}{1-1} \times 100 = 100$$

$$\text{Brolog wood score} = \frac{0.18}{1-1} \times 100 = \cancel{95.45} 16.36$$

$$\text{Forest score} = \frac{1.05}{1-1} \times 100 = 95.45$$

Economy

Interior route under this criterion is Brolog Wood with a score of 100 $\Rightarrow 1.58$

$$\therefore \text{Brolog Straw score} = \frac{1.47}{1.58} \times 100 = 93.04$$

$$\text{Brolog wood score} = \frac{1.58}{1.58} \times 100 = 100$$

(3)

$$\text{Fossil Semp} = \frac{0.38}{1.58} \times 100 = 24.05$$

Social

In known route under this criterion is Brothg. wood
with a Semp of 100 $\Rightarrow$ 7.21

$$\therefore \text{Brothg. Straw Semp} = \frac{6.51}{7.21} \times 100 = 90.29$$

$$\text{Brothg. wood Semp} = \frac{7.21}{7.21} \times 100 = 100$$

$$\text{Fossil Semp} = \frac{1.05}{7.21} \times 100 = 14.56$$

Energy used

In known route under this criterion is fossil
with a Semp of 100 $\Rightarrow$ 15

$$\therefore \text{Brothg. Straw Semp} = \frac{10}{15} \times 100 = 66.67$$

$$\text{Brothg. wood Semp} = \frac{10}{15} \times 100 = 66.67$$

$$\text{Fossil Semp} = \frac{15}{15} \times 100 = 100$$

(4)

To obtain the overall score for each alternative let

Biblig score $\equiv BS$; Brody wind $\equiv BW$; Forest $\equiv F$ (5)

$$\therefore \text{Score}_s = (0.40 \times 100) + (93.04 \times 0.20) + (0.12 \times 90.29) + (0.20 \times 66.67)$$

$$\text{Score}_s = 90.22$$

$$\text{Score}_{BW} = (0.40 \times 16.36) + (0.28 \times 100) + (0.12 \times 100) + (0.20 \times 66.67) + (0.20 \times 66.67)$$

$$\text{Score}_{BW} = 59.89$$

$$\therefore \text{Score}_F = (0.40 \times 95.45) + (0.28 \times 24.05) + (0.12 \times 14.56) + (0.20 \times 100)$$

$$\text{Score}_F = 66.66$$

The route that is mostly sustainable is Brody wind production route and the reason is because it has the lowest impact. (5)

Prairie View A & M University, CHEG 3311: Introduction to Energy Systems, Fall 2021: Midterm Exam,
 Wednesday, October 20, 2021. Instructor: Dr. Kazeem Olanrewaju

Closed Books

Name of Student: _____

	Terms (A)	Concept (B)	Answer
1	Photosynthesis	This is an example of conversion technologies in a conceptual model system tool analysis	19
2	Net Present Worth	One of the components of gross energy consumption in a country is	7
3	Free availability	To obtain HDI for any country in 1990	18
4	Scenarios	Understanding Contributing Factors to Time Series Energy Trends Using	17
5	Absorption wavelength	One of the reasons why industrialized nations consumed less energy than emerging countries in 2008	8
6	Rate of return	One of the driver behind the study of energy system and its improvement is	16
7	Transportation	This analytical tool help create a story due to implication of one or more variables on another in analyzing an energy system	20
8	Energy efficient device	Establishing connection between warming and fossil fuels	11
9	Exponential function	This variable is one of the determinant of greenhouse effect	5
10	Antiquity age	This is based on how much material and energy is consumed at the different point in the energy system from resource extraction to final energy deliverables	15
11	Callendar	One of the metric of measuring Human Development Index after 2010 is	13
12	Carbon dioxide emission	One of the economic analysis tools easily understood by most people for assessing an Energy System is	6
13	Income index	An economic analysis tool use to evaluate the viability of an Energy project is	2
14	GDP per capita	Power output by energy system in our modern times is in the order of six as compare to the	10
15	Life cycle analysis	The concentration of carbon dioxide release into the atmosphere due to expiration from human system is neutralize by	1
16	Resource scarcity	One of the component of Kaya Equation is	14
17	Divisia analysis	One of the advantages of renewable energy sources is	3
18	GDP index	is a projection about the relationship between inputs and outcomes that incorporates quantitative data, without proving that the values used are the best fit for the current or future situation	4
19	Biorefinery	A numerical device that can be used to predict variation of energy consumption/production with numbers years in the future	9
20	Causal loop	Negative effect of Energy use is not directly link to gross consumption of energy but	12

ABOVE AVERAGE

Above Average Student Original Graded Assignment

Prairie View A & M University, CHEG 3311: Introduction to Energy System; Fall 2021: Mid-Term Exam, Monday, October 20, 2021. Instructor: Dr. Kazeem Olanrewaju

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Open Book

Name of Student: Franck Nangomoko

70+4
70

Problem 1 (40 points)

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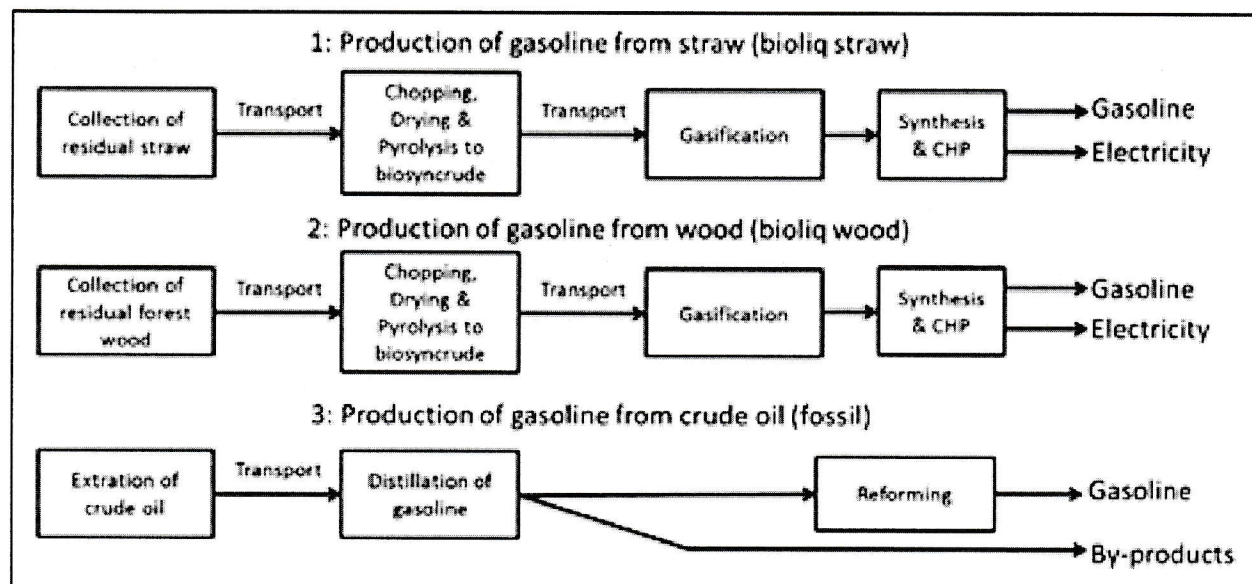
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Energy used	KW/liter	10	10	15	0.20

Problem 2 (40 points)

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Public Data

12 Countries, Sub-Saharan Africa ?

World Development Indicators

Economic Policy and Debt

Education

Environment

Access to clean fuels and technol...

Access to electricity (% of populat...

Agricultural land (sq. km)

Agricultural machinery, tractors pe...

Agricultural production index

Alternative and nuclear energy (%...

Annual freshwater withdrawals, tot...

Aquaculture production (metric tons)

Arable land (hectares per person)

Average precipitation in depth (m...

Chart

Compare by Country

Region Sub-Saharan Africa

Lending Type All

Income Level All

Niger

Nigeria

Rwanda

São Tomé and Príncipe

Senegal

Seychelles

Sierra Leone

South Africa

South Sudan

Sudan

Tanzania

Togo

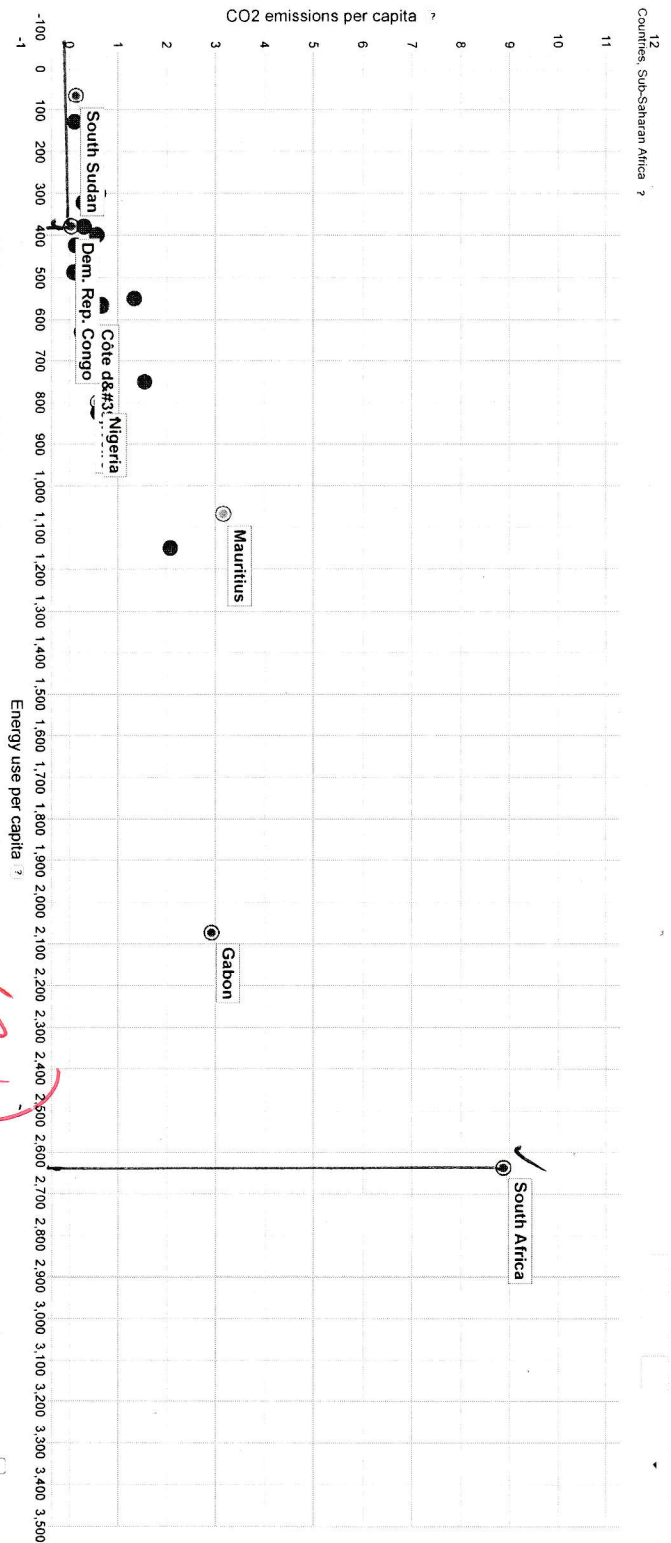
The Gambia

Uganda

Zambia

Zimbabwe

Clear selections



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Public Data

World Development Indicators

- Economic Policy and Debt
- 2005 PPP conversion factor, GDP...
- 2005 PPP conversion factor, priva...
- Adjusted net national income (ann...
- Adjusted net national income (con...
- Adjusted net national income (cur...
- Adjusted net national income per...
- Adjusted net national income per...
- Adjusted saving (% of GNI)
- Adjusted saving (current US\$)
- Agriculture value added per work...
- Aid flows at constant US\$
- Aid flows at current US\$
- Average crude barrel on new exte...

Clear

Compare by Country

Region Sub-Saharan Africa

Lending Type All

Income Level All

Nigeria

Rwanda

Sao Tome and Principe

Senegal

Seychelles

Sierra Leone

Somalia

South Africa

South Sudan

Sudan

Tanzania

Togo

The Gambia

Uganda

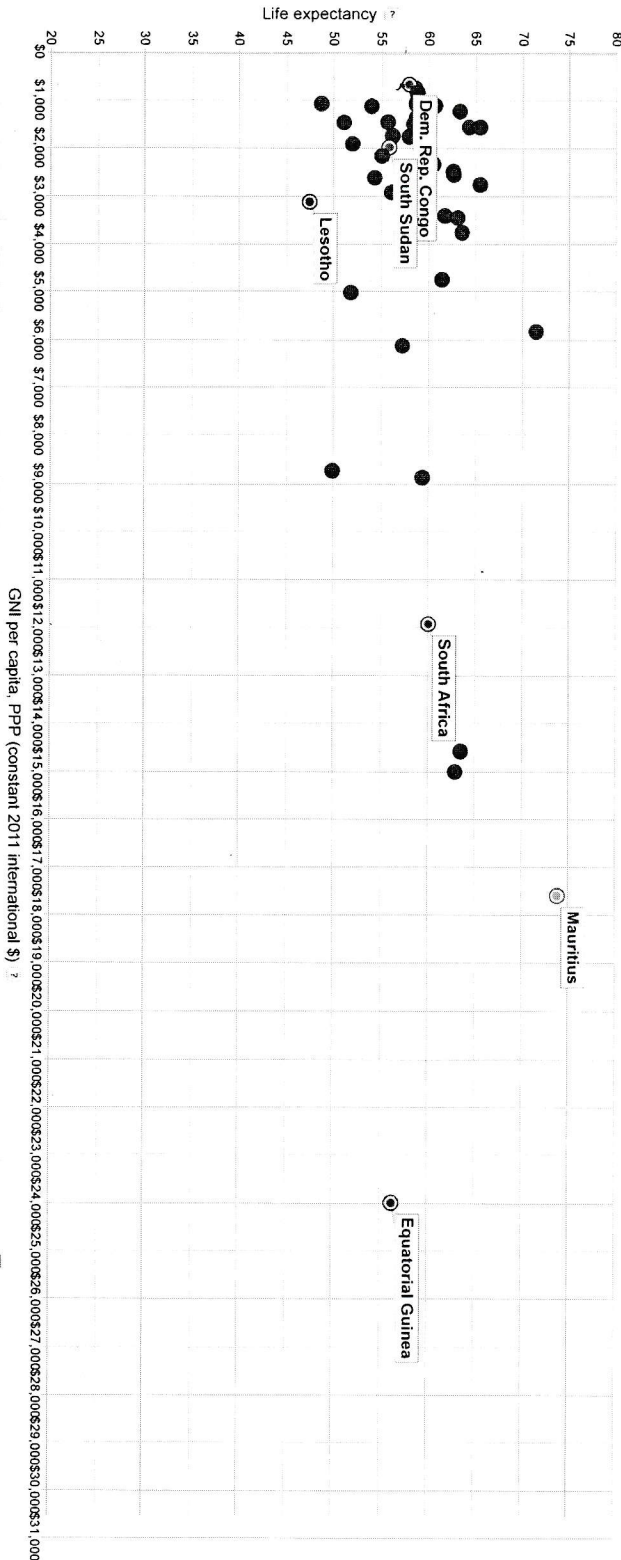
Zambia

Zimbabwe

Clear selections

Gender

Countries, Sub-Saharan Africa



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2012

Search public data or change visualization

Public Data

World Development Indicators

Economic Policy and Debt

Education

Environment

Access to clean fuels and technol...

Access to electricity (% of populat...

Agricultural land (sq. km)

Agricultural machinery, tractors

Agricultural production index

Alternative and nuclear energy (%...

Annual freshwater withdrawals (%...

Aquaculture production (metric tons)

Arable land (hectares per person)

Clear

Compare by Country

Region Sub-Saharan Africa

Lending Type All

Income Level All

Worldwide

Niger

Nigeria

Rwanda

Sao Tome and Principe

Senegal

Seychelles

Sierra Leone

Somalia

South Africa

South Sudan

Sudan

Tanzania

The Gambia

Togo

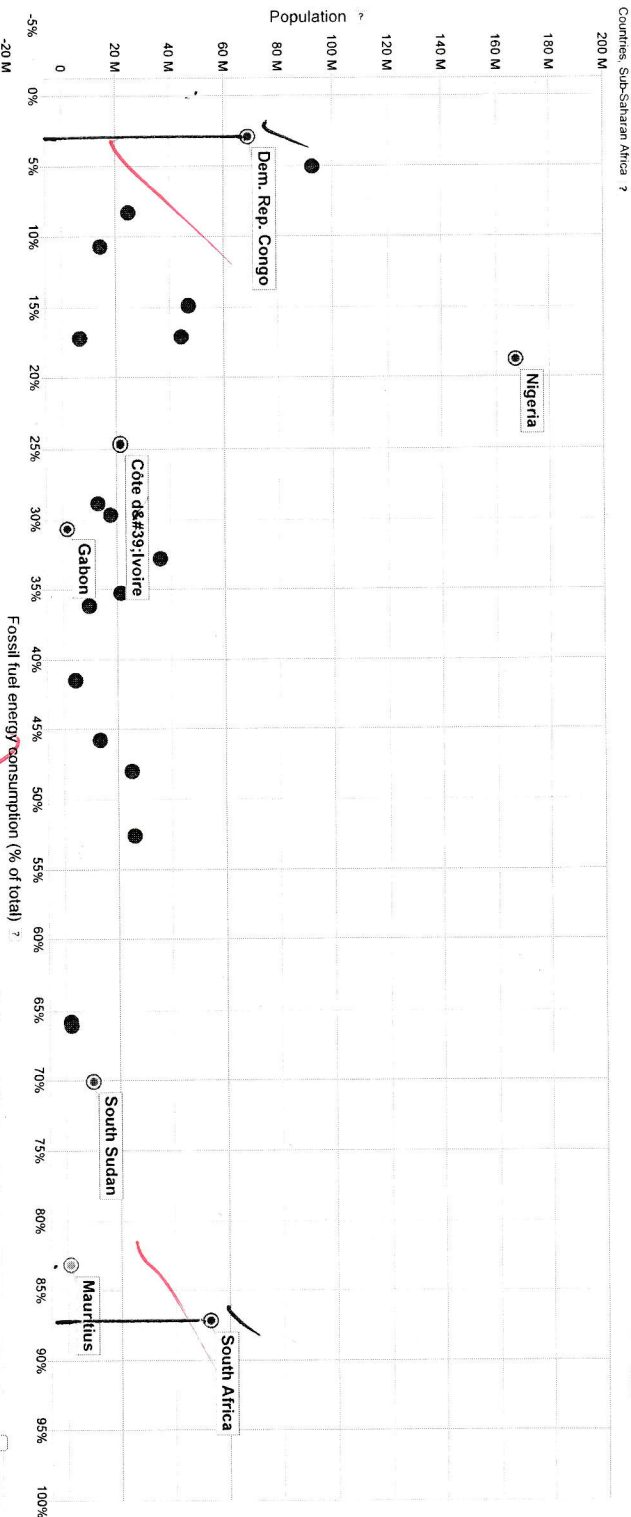
Clear selections

Age

Gender

Urban/Rurals

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① Dimension	Biolog Biolog straw	Biolog wood	Fossil	weight
- Environmental	100	16.36	95.45	0.40
- Economy	$\frac{1.47}{1.58} \times 100 = 93.04$	100	$\frac{0.38}{1.58} \times 100 = 24.05$	0.28
- Social	$\frac{6.51}{7.21} \times 100 = 90.29$	100	$\frac{1.05}{7.21} \times 100 = 14.56$	0.12
- Energy used	$\frac{10}{15} \times 100 = 66.66$	$\frac{10}{15} \times 100 = 66.66$	100	0.20

Environmental 100

$$\frac{0.18}{1.1} \times 100 = 16.36$$

$$\frac{1.05}{1.1} \times 100 = 95.45$$

~~Biolog straw = (100 \times 0.40) + (93.04 \times 0.28) + (90.29 \times 0.12) + (66.66 \times 0.20) = 90.218~~

$$\text{Biolog straw} = (100 \times 0.40) + (93.04 \times 0.28) + (90.29 \times 0.12) + (66.66 \times 0.20) = 90.218$$

$$\text{Biolog wood} = (16.36 \times 0.4) + (100 \times 0.28) + (100 \times 0.12) + (66.66 \times 0.20) = \boxed{59.876}$$

$$\text{Fossil} = (95.45 \times 0.4) + (24.05 \times 0.28) + (14.56 \times 0.12) + (100 \times 0.20) = 66.66$$

∴ Biolog blood

(+5)

#2

(9) highest CO₂ Emission Country (South Africa)

$$\text{CO}_2 \text{ emission} = \frac{8.9}{2640} \times 55 \times 10^6 = \frac{185}{2640} \text{ KT CO}_2$$

What do
these numbers
represent

(6) + 1

lowest CO₂ Emission country Dem Rep Congo

$$\text{CO}_2 \text{ emission} = \frac{0.2}{380} \times 70 \times 10^6 = 36 \text{ KT CO}_2 \text{ emission}$$

(b) highest energy per capita = South Africa

lowest energy per capita = Dem Rep Congo

Know the
figures?
Numbers

(c) Fossil fuel consumption for (b)

$$\text{South Africa} = \frac{85.4}{100} \times 55 \times 10^6 = 46.9 \times 10^6$$

$$\text{Dem Rep Congo} = \frac{4}{100} \times 70 \times 10^6 = 2.8 \times 10^6$$

What do
these numbers
represent

~~South Africa~~ Dem. Rep. Congo

$$\textcircled{1} LEI = \frac{LE-20}{85-20} = \frac{58-20}{85-20} = 0.585$$

South Africa

$$- LEI = \frac{60-20}{85-20} = 0.615$$

$$- EI = \frac{MYSI + EYSI}{2} = \frac{0.73 + 0.38}{2} = 0.783$$

$$MYSI = \frac{11}{15} = 0.73$$

$$EYSI = \frac{15}{18} = 0.38$$

$$- II = \frac{\ln(GNI/p_c) - \ln(100)}{\ln(75000)}$$

$$II = \frac{\ln(12000) - \ln(100)}{\ln(75000)} = 0.426$$

$$HDI = (LEI \times EI \times II)^{\frac{1}{3}} = \sqrt[3]{0.615 \times 0.783 \times 0.426}$$

$$HDI = 0.589$$

DEM. REP Congo

$$LEI = \frac{58-20}{85-20} = 0.585$$

$$EI = \frac{0.73 + 0.38}{2} = 0.783$$

$$MYSI = \frac{11}{15} = 0.73$$

$$EYSI = \frac{15}{18} = 0.38$$

$$II = \frac{\ln(600) - \ln(100)}{\ln(75000)} = 0.159$$

$$HDI = \sqrt[3]{LEI \times EI \times II}$$

$$= \sqrt[3]{0.585 \times 0.783 \times 0.159}$$

$$HDI = 0.417$$

- highest CO₂ emission = South Africa
per capita
- highest energy use = South Africa
capita
- lowest fossil fuel = Dem Rep Congo
consumption

Closed Books

Name of Student: Franck Nangonoko

15
20

	Terms (A)	Concept (B)	Answer
1	Photosynthesis	This is an example of conversion technologies in a conceptual model system tool analysis	19
2	Net Present Worth	One of the components of gross energy consumption in a country is	18
3	Free availability	To obtain HDI for any country in 1990	16
4	Scenarios	Understanding Contributing Factors to Time Series Energy Trends Using	17
5	Absorption wavelength	One of the reasons why industrialized nations consumed less energy than emerging countries in 2008 8	8
6	Rate of return	One of the driver behind the study of energy system and its improvement is	7
7	Transportation	This analytical tool help create a story due to implication of one or more variables on another in analyzing an energy system	4
8	Energy efficient device	Establishing connection between warming and fossil fuels	11
9	Exponential function	This variable is one of the determinant of greenhouse effect	5
10	Antiquity age	This is based on how much material and energy is consumed at the different point in the energy system from resource extraction to final energy deliverables	15
11	Callendar	One of the metric of measuring Human Development Index after 2010 is	13
12	Carbon dioxide emission	One of the economic analysis tools easily understood by most people for assessing an Energy System is	6
13	Income index	An economic analysis tool use to evaluate the viability of an Energy project is	2
14	GDP per capita	Power output by energy system in our modern times is in the order of six as compare to the	10
15	Life cycle analysis	The concentration of carbon dioxide release into the atmosphere due to expiration from human system is neutralize by	1
16	Resource scarcity	One of the component of Kaya Equation is ,	14
17	Divisia analysis	One of the advantages of renewable energy sources is	3
18	GDP index	is a projection about the relationship between inputs and outcomes that incorporates quantitative data, without proving that the values used are the best fit for the current or future situation	20
19	Biorefinery	A numerical device that can be used to predict variation of energy consumption/production with numbers years in the future	9
20	Causal loop	Negative effect of Energy use is not directly link to gross consumption of energy but	12

AVERAGE

Average Student Original Graded Assignment

Prairie View A & M University, CHEG 3311: Introduction to Energy System; Fall 2021: Mid-Term Exam, Monday, October 20, 2021. Instructor: Dr. Kazeem Olanrewaju

57
80

You should not reference to or have access to your class notes, laptop, tablet, cell phone, smart phone, and any other electronic gadgets.

Open Book

Name of Student: Shumpert Kirksey

Problem 1 (40 points)

Multi-criteria decision making: An Energy System Company in California is evaluating three processing routes for gasoline production in order to choose the one that is mostly sustainable. As shown in the figure below, three different ways of producing gasoline are considered: the bioliq process with the feedstock wheat straw (bioliq straw) or forest residues (bioliq wood), and a classical refinery process as fossil reference (fossil). Main process steps of the classical refinery process are distillation and reforming. Main process steps of the production of gasoline from straw or wood are pyrolysis, gasification and fuel synthesis. Environmental, economical, and social sustainability are the three criteria used as metrics to assess which of the production route is mostly sustainable. The environmental criterion is evaluated based on the ecological impact of producing one liter of the gasoline, while the other three are evaluated based on the amount of dollar, number of employees involve and amount energy used in the production of 1 liter of the gasoline. The scoring for each criterion is calculated by assigning the inferior production route a score of 100, and then assigning the superior production process a score that is the ratio of the superior to inferior raw score multiplied by 100. Using the data given below, choose the production route that is mostly sustainable. The lower the overall weighted score the lesser the impact on the aggregate outlook of the three dimensions. (Note that numbers are provided only to illustrate the technique and do not indicate the true relative worth of the production route).

Dimension	Units	Bioliq straw	Bioliq wood	Fossil	Weight
Environmental	impact/liter	1.1 100	0.18 16	1.05 95	0.40
Economy	\$/liter	1.47 93	1.58 100	0.38 24	0.28
Social	Employees/liter	6.51 90	7.21 100	1.05 15	0.12
Energy used	KW/liter	10 67	10 67	15 100	0.20

(4)
(4)
(4)
(4)

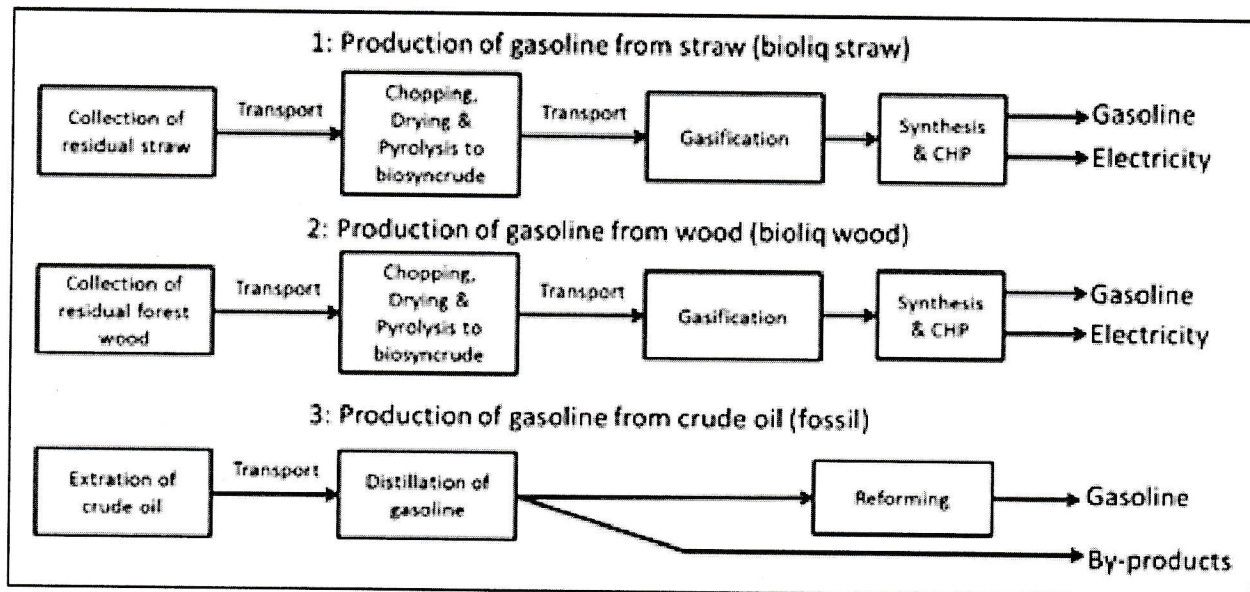
Problem 2 (40 points)

You cannot show the table out separately and show the calculation!

Use the various plots given to you to calculate the following:

- Total emission of CO₂ (in kiloton) in country with the highest and lowest CO₂ emission per capita

- b) Total amount of energy utilized in the country with the highest and lowest energy use per capita
- c) Calculate the exact amount of Fossil fuel energy consumption in the country with highest and lowest energy use per capita in (b)
- d) Determine the human development index for the country with the highest CO₂ emission per capita, highest energy use per capita and lowest fossil fuel consumption (lowest use per capita) based on HDI metric after 2010.



$$LEI = (LE - 20) / (85 - 20)$$

$$EI = (MYSI + EYSI) / 2$$

Problem 2)

a) Highest: South Africa @ 8.9 Lowest: Dem. Rep. Congo @ .07

b) Highest: South Africa @ 2,640 Lowest: South Sudan @ 70

c) Highest: South Africa

$$.873 \times 5.7 \times 10^6 = 4,976,100$$

Lowest: South Sudan

$$.701 \times 1.1 \times 10^6 = 771,101$$

d) * South Africa: Highest CO₂ & Energy Use

$$LEI = (60 - 20) / (85 - 20) = .62$$

$$EI = \frac{\left(\frac{11}{15}\right) + \left(\frac{15}{18}\right)}{2} = .78$$

$$II = \frac{\ln(11,920) - \ln(100)}{\ln(75,000) - \ln(100)} = .72$$

$$HDI = (.62 \times .78 \times .72)^{1/3} = .70 \text{ of South Africa}$$

* Dem. Rep. Congo: Lowest fossil fuel consumption

$$LEI = (57.6 - 20) / (85 - 20) = .57$$

$$EI = .78$$

$$II = \frac{\ln(870) - \ln(100)}{\ln(75,000) - \ln(100)} = .32$$

$$HDI = (.57 \times .78 \times .32)^{1/3} = .52 \text{ of Dem. Rep. Congo}$$

Sharp
is the
Calculation?
and how
these numbers
need to
arrive at
these solutions

Search public data or change visualization

Public Data

World Development Indicators
 Economic Policy and Debt
 2005 PPP conversion factor, gnp...
 2005 PPP conversion factor, gnp...
 Adjusted net national income (ann...
 Adjusted net national income (ann...
 Adjusted net national income (ann...
 Adjusted net national income per...
 Adjusted net national income per...
 Adjusted net national income per...
 Adjusted saving (% of GNI)
 Adjusted saving (current US\$)
 Agriculture value added per worke...
 Aid flows at constant US\$
 Aid flows at current US\$
 Average cruce deficit on new exte...

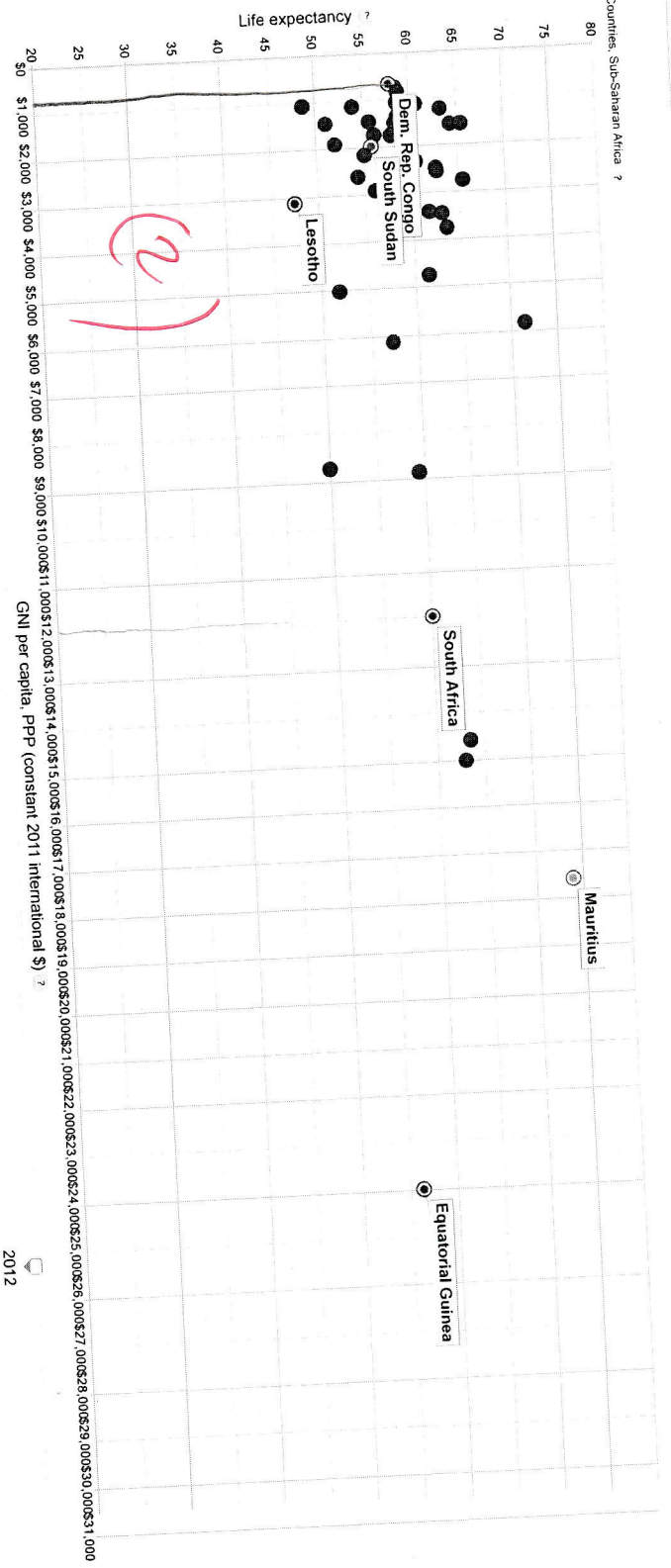
Chart

Compare by Country
 Region Sub-Saharan Africa
 Lending Type All
 Income Level All

Nigeria
 Rwanda
 Sao Tome and Principe
 Senegal
 Seychelles
 Sierra Leone
 Somalia
 South Africa
 South Sudan
 Sudan
 Tanzania
 The Gambia
 Togo
 Uganda
 Zambia

Clear selections

Gender



Search public data or change visualization

Sign in

Public Data

4 12 Countries, Sub-Saharan Africa ?

World Development Indicators

Economic Policy and Debt

Education

Environment

Access to clean fuels and technol...

Access to electricity (% of populati...

Agricultural land (sq. km)

Agricultural machinery, tractors

Agricultural machinery, tractors pe...

Agricultural production index

Alternative and nuclear energy (%)

Annual freshwater withdrawals (%)

Annual freshwater withdrawals, tot...

Aquaculture production (metric tons)

Arable land (hectares per person)

Arable land (hectares)

Average precipitation in depth (m...

Clear

Compare by Country

Region Sub-Saharan Africa

Lending Type All

Income Level All

Niger

Nigeria

Rwanda

San Tomé and Príncipe

Senegal

Seychelles

Sierra Leone

Somalia

South Africa

South Sudan

Sudan

Tanzania

The Gambia

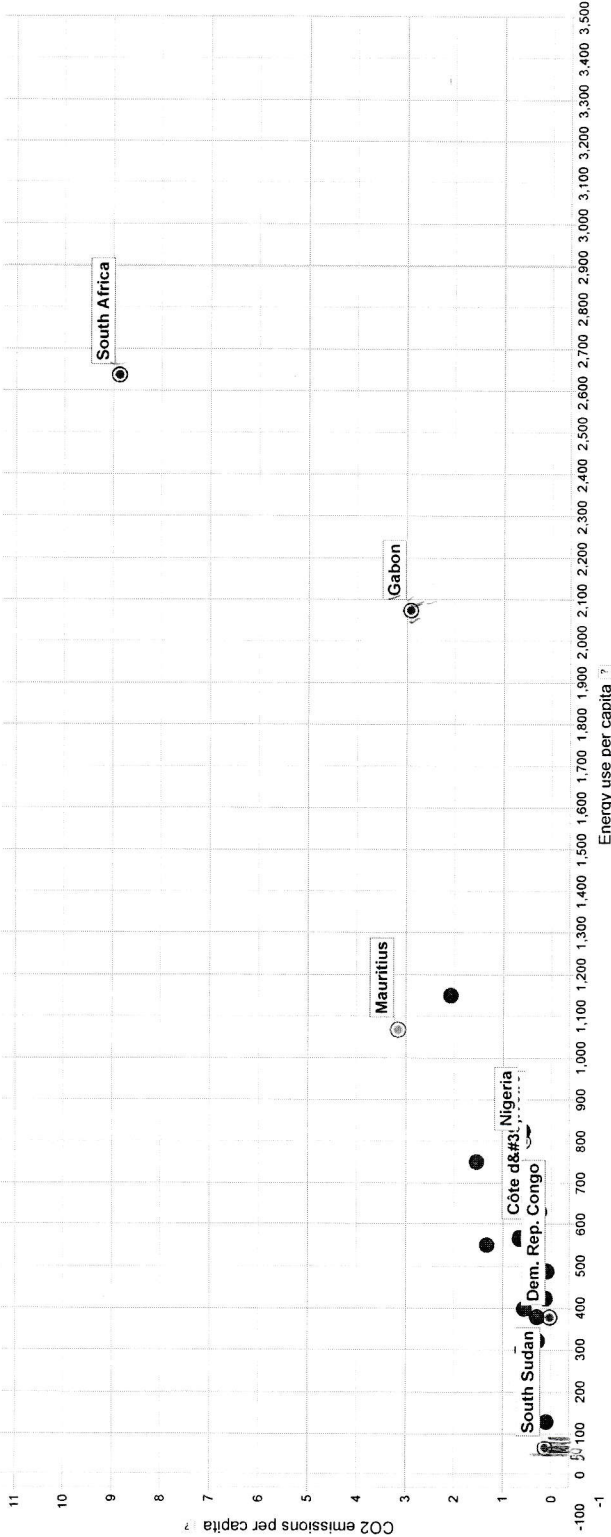
Togo

Uganda

Zambia

Zimbabwe

Clear selections



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2012

Sign in

Search public data or change visualization

Public Data

World Development Indicators

- Economic Policy and Debt
- 2005 PPP conversion factor, GDP...
- 2005 PPP conversion factor, priva...
- Adjusted net national income (ann...
- Adjusted net national income (con...
- Adjusted net national income (curr...
- Adjusted net national income per...
- Adjusted net national income per...
- Adjusted net national income per...
- Adjusted saving (% of GNI)
- Adjusted saving (current US\$)
- Agriculture value added per work...
- Aid flows at constant US\$
- Aid flows at current US\$
- Average grace period on new exte...

Clear

Compare by Country

Region Sub-Saharan Africa

Lending Type All

Income Level All

Country

Nigeria

Rwanda

São Tomé and Príncipe

Senegal

Seychelles

Sierra Leone

Somalia

South Africa

South Sudan

Sudan

Tanzania

The Gambia

Togo

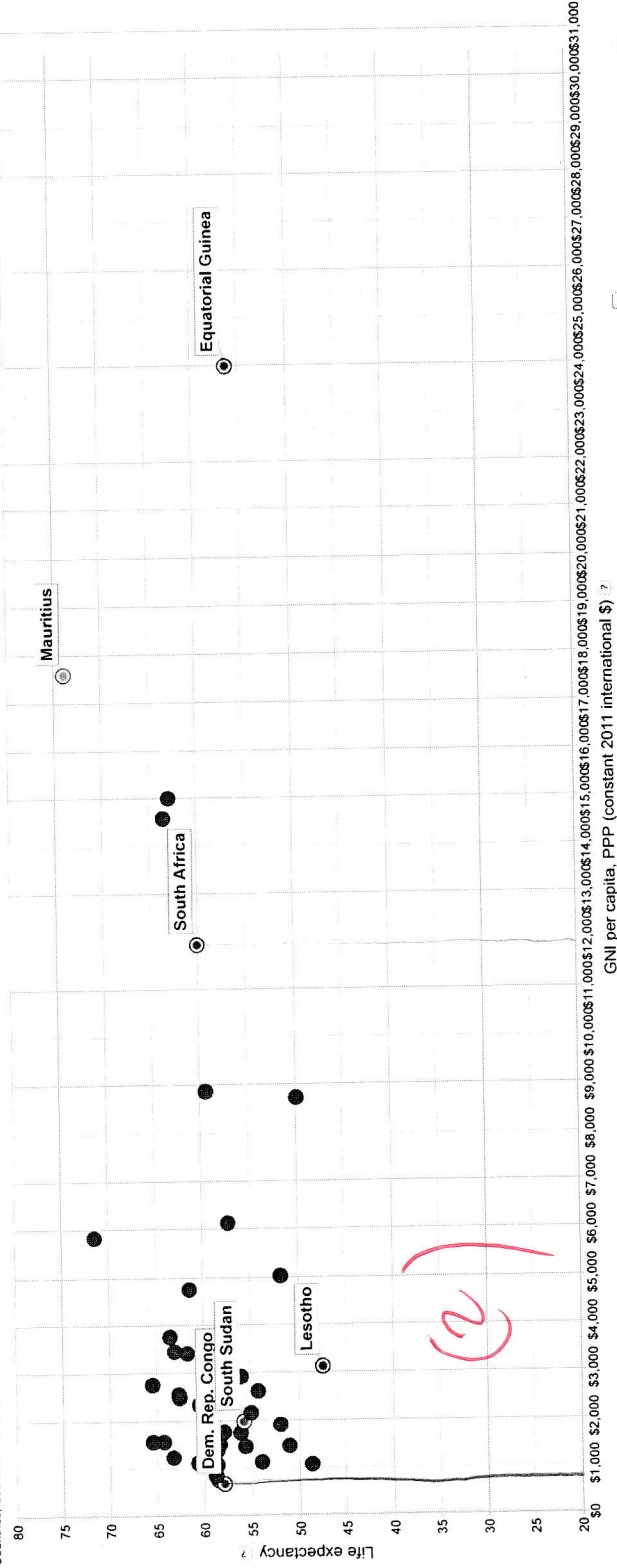
Uganda

Zambia

Clear selections

Gender

Countries, Sub-Saharan Africa ?



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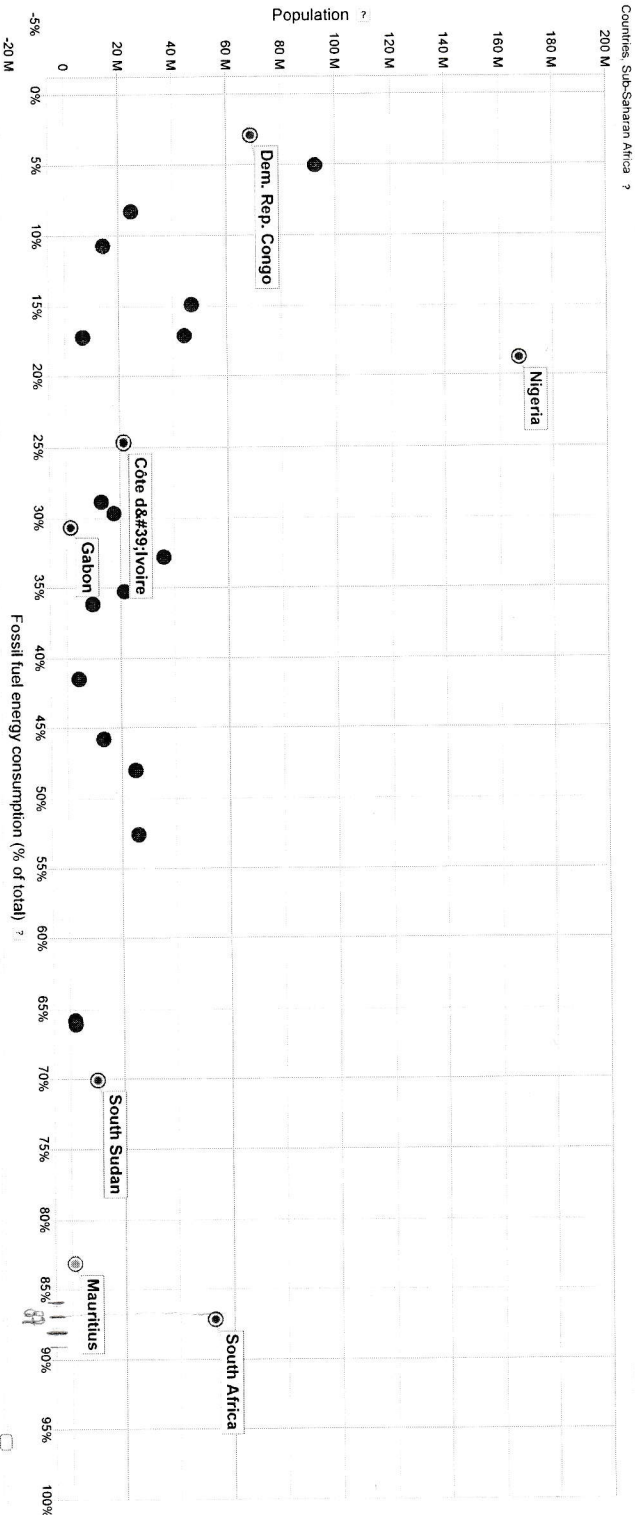
Search public data or change visualization

Public Data

- World Development Indicators
- Economic Policy and Debt
- Education
- Environment
- Access to clean fuel and technol...
- Access to electricity (% of populat...
- Agricultural land (sq. km)
- Agricultural machinery tractors
- Agricultural machinery tractors pe...
- Agricultural production index
- Alternative and nuclear energy (%)
- Annual freshwater withdrawals (%)
- Annual freshwater withdrawals (tot...
- Aquaculture production (metric tons)
- Arable land (thousands of hectare)

Chart

Compare by Country
Region Sub-Saharan Africa
Lending type All
Income Level All



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Age
Gender
Urban/Rurals

Closed Books

Name of Student: Shumpert Kirksey

18
20

	Terms (A)	Concept (B)	Answer
1	Photosynthesis	This is an example of conversion technologies in a conceptual model system tool analysis	19
2	Net Present Worth	One of the components of gross energy consumption in a country is	7
3	Free availability	To obtain HDI for any country in 1990	18
4	Scenarios	Understanding Contributing Factors to Time Series Energy Trends Using	17
5	Absorption wavelength	One of the reasons why industrialized nations consumed less energy than emerging countries in 2008	8
6	Rate of return	One of the driver behind the study of energy system and its improvement is	4 X
7	Transportation	This analytical tool help create a story due to implication of one or more variables on another in analyzing an energy system	20
8	Energy efficient device	Establishing connection between warming and fossil fuels	11
9	Exponential function	This variable is one of the determinant of greenhouse effect	5
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17	Divisia analysis	One of the advantages of renewable energy sources is	3
18	GDP index	is a projection about the relationship between inputs and outcomes that incorporates quantitative data, without proving that the values used are the best fit for the current or future situation	16 X
19	Biorefinery	A numerical device that can be used to predict variation of energy consumption/production with numbers years in the future	9
20	Causal loop	Negative effect of Energy use is not directly link to gross consumption of energy but	12

BELOW AVERAGE

Below Average Student Original Graded Assignment

Prairie View A & M University, CHEG 3311: Introduction to Energy System; Fall 2021: Mid-Term Exam, Monday, October 20, 2021. Instructor: Dr. Kazeem Olanrewaju

You should not reference to or have access to your class notes, laptop, tablet, cell phone, smart phone, and any other electronic gadgets.

Open Book

Name of Student: Bryson Marshall

47
80

Problem 1 (40 points)

Multi-criteria decision making: An Energy System Company in California is evaluating three processing routes for gasoline production in order to choose the one that is mostly sustainable. As shown in the figure below, three different ways of producing gasoline are considered: the bioliq process with the feedstock wheat straw (bioliq straw) or forest residues (bioliq wood), and a classical refinery process as fossil reference (fossil). Main process steps of the classical refinery process are distillation and reforming. Main process steps of the production of gasoline from straw or wood are pyrolysis, gasification and fuel synthesis. Environmental, economical, and social sustainability are the three criteria used as metrics to assess which of the production route is mostly sustainable. The environmental criterion is evaluated based on the ecological impact of producing one liter of the gasoline, while the other three are evaluated based on the amount of dollar, number of employees involve and amount energy used in the production of 1 liter of the gasoline. The scoring for each criterion is calculated by assigning the inferior production route a score of 100, and then assigning the superior production process a score that is the ratio of the superior to inferior raw score multiplied by 100. Using the data given below, choose the production route that is mostly sustainable. The lower the overall weighted score the lesser the impact on the aggregate outlook of the three dimensions. (Note that numbers are provided only to illustrate the technique and do not indicate the true relative worth of the production route).

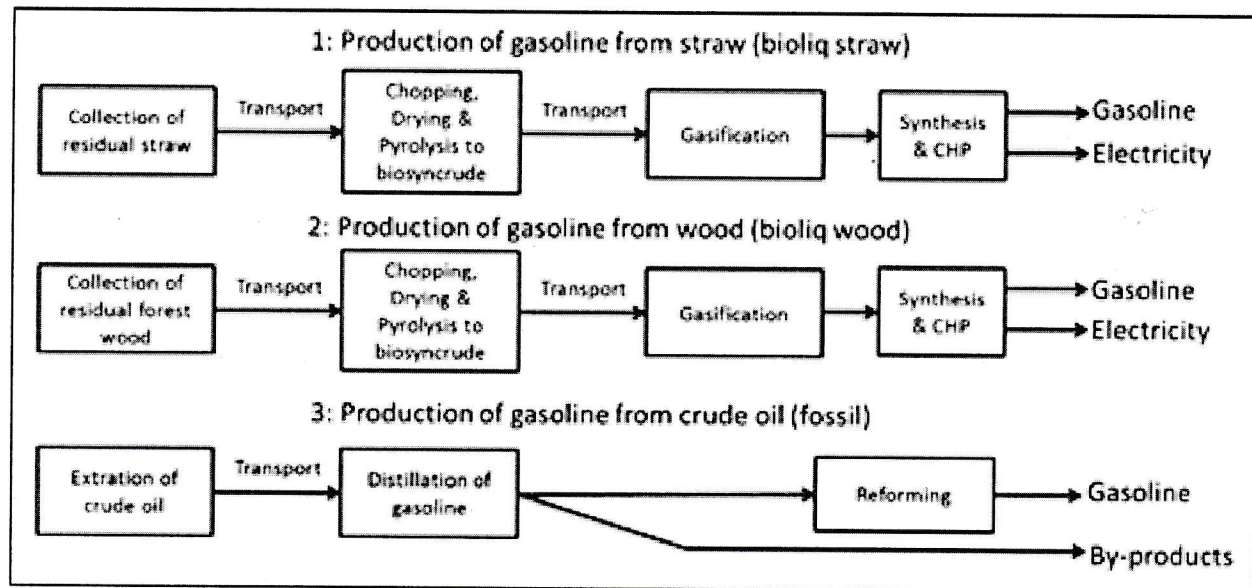
Dimension	Units	Bioliq straw	Bioliq wood	Fossil	Weight
Environmental	impact/liter	1.1	0.18	1.05	0.40
Economy	\$/liter	1.47	1.58	0.38	0.28
Social	Employees/liter	6.51	7.21	1.05	0.12
Energy used	KW/liter	10	10	15	0.20

Problem 2 (40 points)

Use the various plots given to you to calculate the following:

- Total emission of CO₂ (in kiloton) in country with the highest and lowest CO₂ emission per capita

- b) Total amount of energy utilized in the country with the highest and lowest energy use per capita
- c) Calculate the exact amount of Fossil fuel energy consumption in the country with highest and lowest energy use per capita in (b)
- d) Determine the human development index for the country with the highest CO₂ emission per capita, highest energy use capita and lowest fossil fuel consumption (lowest use per capita) based on HDI metric after 2010.



Problem 1

Biolig. Straw:

$$1.1 \div 0.40 = 2.75$$

$$1.47 \div 0.29 = 5.07$$

$$6.51 \div 0.12 = 54.25$$

$$10 \div 0.20 = 50$$

Biolig Straw is the most sustainable

Biolig. Wood:

$$0.18 \div 0.40 = 0.45$$

$$1.58 \div 0.28 = 5.64$$

$$7.21 \div 0.12 = 60.08$$

$$10 \div 0.20 = 50$$

Fossil:

$$1.05 \div 0.40 = 2.63$$

$$0.38 \div 0.28 = 1.36$$

$$1.05 \div 0.12 = 8.75$$

$$15 \div 0.20 = 75$$

You need to take the ratio of the ~~sp~~ superior to the inferior and multiply with 100 to normalise the score per 100. You did not do that!

(+5)

Problem 2

a)

Curacao = 39 CO₂ emissions Per Capita, 152,088

Haiti = 1 CO₂ emissions Per Capita, 10,000,000

Curacao = 5,931,432 kiloton of total CO₂ emission

Haiti = 10,000,000 kiloton of total CO₂ emission

(5) +1

b)

Trinidad and Tobago = 14,100 energy use Per Capita, 1,000,000

Haiti = 300 energy use Per Capita, 10,000,000

Trinidad and Tobago = 1.41×10^{10} KW of energy used

Haiti = 3×10^9 KW of energy used

(5) +1

c)

Trinidad and Tobago = 100% Fossil fuel

Haiti = 27% Fossil fuel

Trinidad and Tobago = 1.41×10^{10} Fossil fuel Consumption

Haiti = 8.1×10^8 Fossil fuel Consumption

(7)

d)

Curacao : 77.5, 27,788

Trinidad and Tobago, 72.2, 27,546

Haiti

$$LEI = (LE - 20) / (85 - 20)$$

$$EI = (MYSI + EYSI) / 2$$

$$MYSI = MYS / 15$$

$$EYSI = EYS / 18$$

(5)

$$II = [\ln(641Pc) - \ln(100)] / [\ln(75,000) - \ln(100)]$$

$$MYSI = 11 / 15 = 0.733$$

$$EYSI = 15 / 18 = 0.833$$

Haiti :

$$LEI = (61 - 20) / (85 - 20) = 0.631$$

$$EI = 0.783$$

(3)

$$II = [\ln(1500) - \ln(100)] / [\ln(75,000) - \ln(100)]$$

$$II = 0.409$$

$$HDI = 0.587 \text{ for Haiti}$$

Trinidad and Tobago:

$$(72.7 - 20) / (85 - 20) = LEI = 0.81$$

$$EI = 0.783$$

(3)

$$II = [\ln(27,545) - \ln(100)] / [\ln(75,000) - \ln(100)] = 0.849$$

$$HDI = 0.814 \text{ for Trinidad}$$

Curacao:

$$EI = 0.783$$

$$LEI = (77.5 - 20) / (85 - 20)$$
$$= 0.885$$

3

$$II = [\ln(27,785) - \ln(100)] / [\ln(75,000) - \ln(100)]$$
$$= 0.85$$

$$HDI = 0.838 \text{ for Curacao}$$

Search public data or change visualization

549m

Public Data

- GNi per capita, Atlas method (curr...
- GNi per capita, PPP (constant 2...
- GNi, Atlas method (current US\$)
- GNi, PPP (constant 2011 internat...
- Grants, excluding technical coope...
- Gross Domestic Product
- Gross National Income in PPP dol...
- Gross domestic income (constant...
- Gross domestic savings (current L...
- Gross national expenditure deflat...
- Gross savings (% of GDP)
- Gross savings (current LCU)
- Gross savings (current US\$)
- Gross value added at basic prices...
- Gross value added at basic prices...

Clear

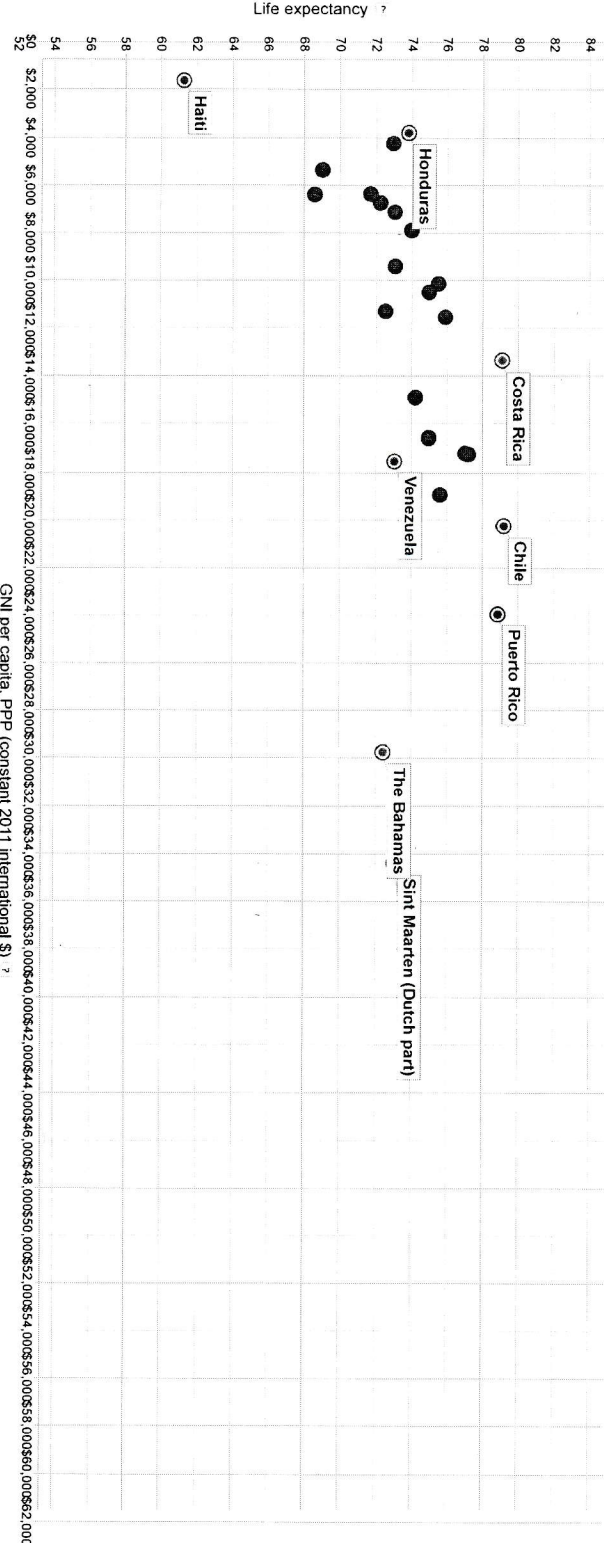
- Compare by Country
- Region Latin America & amp; Caribbean
- Lending Type All
- Income Level All

- Paraguay
- Peru
- Puerto Rico
- Sint Maarten (Dutch part)
- St. Kitts and Nevis
- St. Lucia
- St. Martin (French part)
- St. Vincent and the Grenadines
- Suriname
- The Bahamas
- Trinidad and Tobago
- Turks and Caicos Islands
- Uruguay
- Venezuela

Clear selections

Gender

Country: Latin America & amp; Caribbean



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2012

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Sign in

Public Data

- World Development Indicators
- Economic Policy and Debt
- Education
- Environment
 - Access to clean fuels and technol...
 - Access to electricity (% of populati...
 - Agricultural land (sq. km)
 - Agricultural machinery, tractors
 - Agricultural machinery, tractors pe...
 - Agricultural production index
 - Alternative and nuclear energy %...
 - Annual freshwater withdrawals (cu...
 - Annual freshwater withdrawals (%...
 - Aquaculture production (metric tons)
 - Arable land (hectares per person)
 - Arable land (hectares)
 - Average precipitation in depth (m...

Clear

Compare by Country

Region Latin America & the Caribbean

Lending Type All

Income Level All

Antigua and Barbuda

Argentina

Aruba

Barbados

Belize

Bolivia

Brazil

British Virgin Islands

Cayman Islands

Chile

Colombia

Costa Rica

Cuba

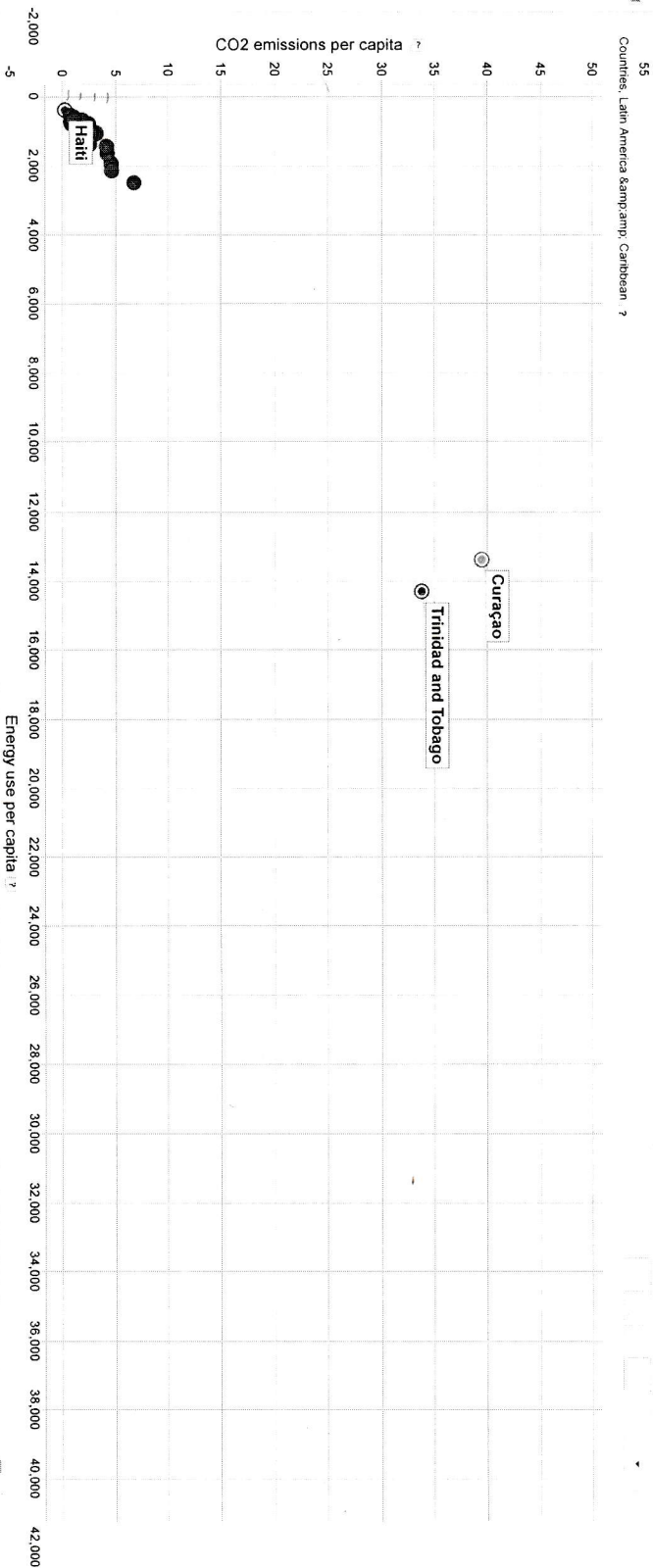
Curacao

Dominica

Dominican Republic

Ecuador

Clear selections



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2012

Search public data or change visualization

Public Data

- World Development Indicators
- Economic Policy and Debt
- Education
- Environment
- Access to clean fuels and technol...
- Access to electricity (% of populati...
- Agricultural land (sq. km)
- Agricultural machinery, tractors
- Agricultural machinery, tractors pe...
- Agricultural production index
- Alternative and nuclear energy (%)
- Annual freshwater withdrawals, tot...
- Annual freshwater withdrawals, tot...
- Aquaculture production (metric tons)
- Arable land (ha/forest net variann)

Clear

Compare by Country

Region Latin America &...

Lending Type All

Income Level All

- Costa Rica
- Cuba
- Curacao
- Dominica
- Dominican Republic
- Ecuador
- El Salvador
- Grenada
- Guatemala
- Guyana
- Haiti
- Honduras
- Jamaica
- Mexico

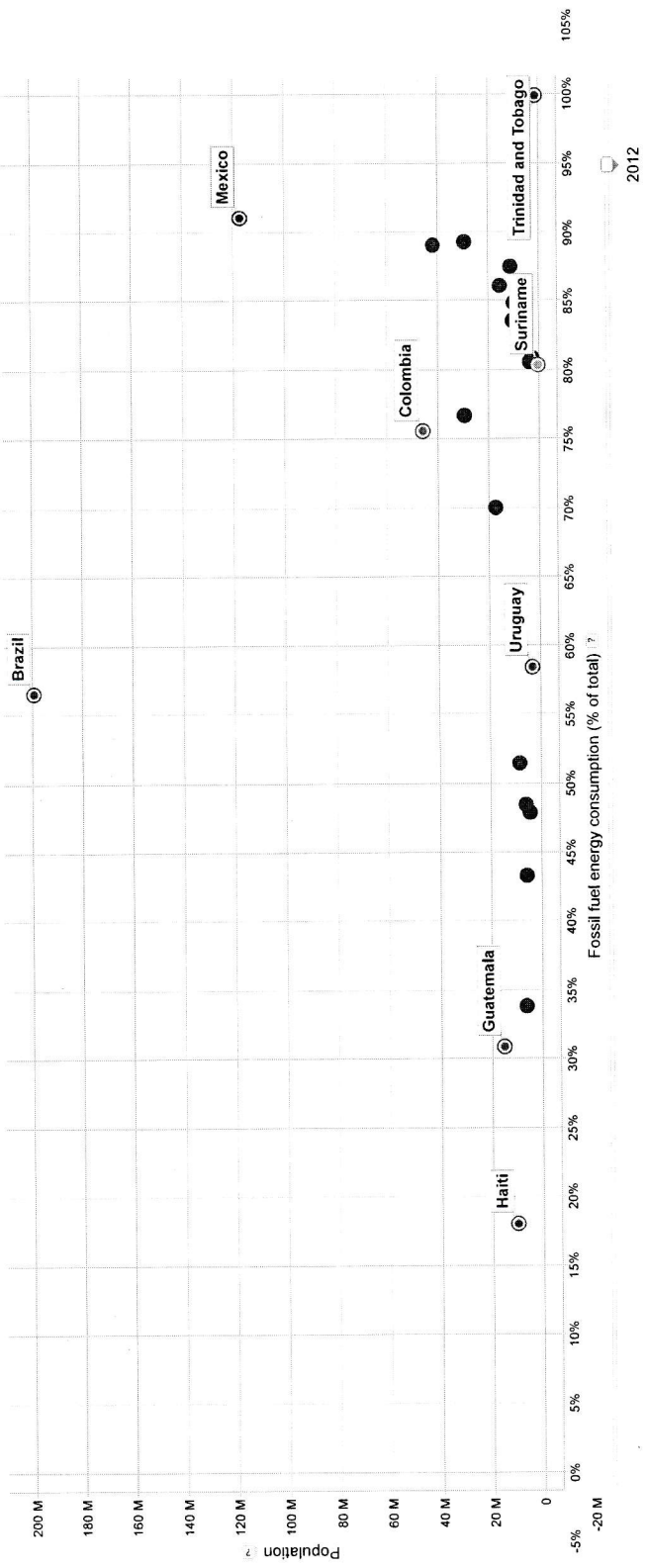
Clear selections

Age

Gender

Urban/Rural

Country Latin America & Caribbean



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Closed Books

Name of Student: Bryson Marshall

6
W

	Terms (A)	Concept (B)	Answer
1	Photosynthesis ✓	This is an example of conversion technologies in a conceptual model system tool analysis	20X
2	Net Present Worth ✓	One of the components of gross energy consumption in a country is	18X
3	Free availability ✓	To obtain HDI for any country in 1990	13X
4	Scenarios ✓	Understanding Contributing Factors to Time Series Energy Trends Using	11X
5	Absorption wavelength ✓	One of the reasons why industrialized nations consumed less energy than emerging countries in 2008	14X
6	Rate of return ✓	One of the driver behind the study of energy system and its improvement is	7X
7	Transportation ✓	This analytical tool help create a story due to implication of one or more variables on another in analyzing an energy system	4X
8	Energy efficient device ✓	Establishing connection between warming and fossil fuels	10X
9	Exponential function ✓	This variable is one of the determinant of greenhouse effect	5 ✓
10	Antiquity age ✓	This is based on how much material and energy is consumed at the different point in the energy system from resource extraction to final energy deliverables	15 ✓
11	Callendar ✓	One of the metric of measuring Human Development Index after 2010 is	13 ✓
12	Carbon dioxide emission ✓	One of the economic analysis tools easily understood by most people for assessing an Energy System is	2X
13	Income index	An economic analysis tool use to evaluate the viability of an Energy project is	6X
14	GDP per capita	Power output by energy system in our modern times is in the order of six as compare to the	19X
15	Life cycle analysis ✓	The concentration of carbon dioxide release into the atmosphere due to expiration from human system is neutralize by	1 ✓
16	Resource scarcity	One of the component of Kaya Equation is	17X
17	Divisia analysis ✓	One of the advantages of renewable energy sources is	3 ✓
18	GDP index ✓	is a projection about the relationship between inputs and outcomes that incorporates quantitative data, without proving that the values used are the best fit for the current or future situation	9X
19	Biorefinery ✓	A numerical device that can be used to predict variation of energy consumption/production with numbers years in the future	8X
20	Causal loop ✓	Negative effect of Energy use is not directly link to gross consumption of energy but	12 ✓

**INTRODUCTION TO ENERGY SYSTEMS
SEMESTER PROJECT
FALL 2021**

PROJECT TITLE: FINAL EXAM PROJECT

TOPICS COVERED IN PROJRCT

Project covered the following topics:

1. Pressure Facing the World Due to Energy Consumption
2. System and Policy Tools
3. System Dynamics Models
4. Engineering Economic Tools
5. Climate Change and Climate Modeling
6. Fossil Fuel Resources
7. Stationary Combustion Systems

**INTRODUCTION TO ENERGY SYSTEMS
SEMESTER PROJECT
FALL 2021**

**DETAILED PROJECT PROBLEM STATEMENT
AND REQUIREMENTS**

CHEG 3311 ENERGY SYSTEM FINAL PROJECTS SELECTION

The final Projects tested broad education necessary to understand the impact of engineering solutions in a global and societal context.

Group #	Final Project Selection	Project Title
Group 1	12	Advances in Nuclear Power
Group 2	13	Battery Technology of the Future
Group 3	14	Biomass Energy Resource from Algae
Group 4	4	The Current Status and Future Prospects of Wind Energy
Group 5	8	Environmental Impacts of Nuclear Energy Power.
Group 6	4	Solar Energy: Current and Future contributions to Renewable Energy

The General Deliverables of the Project (Questions that the Project must answer):

1. Motivations/Drivers behind your energy system project
2. Techniques tools adopted for your energy systems
3. Is your energy system stationary or Transportation applications
4. Is there any interaction and influence in your energy system if it is stationary application on transportation application and vice versa
5. How is your energy system driven? Is it fossil-driven, nuclear powered driven or renewable-resource driven

6. What is the relevant of your energy system to any Transportation energy technologies if not explain why it is not relevant
7. Is the energy resource adopted in the energy system you are working with renewable, sustainable and reliable
8. Is there any way you can improve on the energy system you are working with and make it more sustainable or more sustainable (sustainable: environmental, Economic, and Societal friendly)
- 9. You will prepare a 9-page report (2 pages for Appendix and References List)**
- 10. Report presentation: class presentation or a video presentation of the project via YouTube (Each member of the group will be involved in the presentation).**
- 11. Report due on or before 12/03/2021**

Format of the report:

- I. Font : 12 Times New Roman
- II. Paragraph : 1.5 spacing

INTRODUCTION TO ENERGY SYSTEMS

FALL 2021

DETAILED PROJECT GRADING SCHEME

Structure of the report:

1. **Introduction/Background: 15 points** (Answer to question 1 and background information on the topic of your project)
2. **Methods: 25 points** (How the project was approach. It was approach on a Modular basis and explain succinctly the tasks for each module. You can also include answer to question 2)
3. **Results and Discussion: 30 points** (Answers to questions 3, 4, 5, and 6. Discuss also the application of the system tools used in analyzing your project and findings from the research done on the topic of your project)
4. **Conclusion: 20 points** (Answers to question 7 and 8, and other any other but brief and necessary information summarizing the key findings as it relates to your topic)
5. **References : 10 points**

**ABOVE AVERAGE
PROJECT REPORT**

**Above Average Student/Group Original Graded Assignment
Including Rubric Showing Grading**

Battery Technology of the Future

Group 2

By: Kennedy Henderson, Taylor Linton, and Jevaun Christie



Introduction/ Background

We were assigned to discuss the background, motivations, methods and more about battery technology of the future. Battery technology is the storing of electricity in a chemical form, inside a closed-energy system. Millions of people around the world use battery technology on a daily basis. Some may not realize but you are using battery technology when charging your phone and/or laptop. We were motivated to discuss battery technology of the future due to its sustainable development, effects on climate change, and its changing resource availability. We will also discuss the systems, economic and hard engineering tools. Lastly, we will discuss how this energy system applies to the public, the influence it has had, and its future.

“Sustainable development can be described as any development or growth that meets the needs of the present without depleting resources for future generations”(11). Achieving sustainable development is a goal of any society.

We will be discussing three battery technologies that have the potential to provide energy sustainability. The first one being, lithium- ion batteries. Lithium-ion batteries provide energy storage due to the movement of ions from the positive to the negative electrode. Lithium- ion battery technology allows for high performance, such as fast charge, long lifetime, low self-discharge, and thousands of charging cycles. A new generation of Lithium- ion batteries are expected to be developed, and be used for transportation and energy storage systems. The next technology that may provide sustainability is the Lithium- Sulfur battery. Lithium- Sulfur batteries do not have a host structure unlike lithium-ion. During use the sulfur anode is consumed and the lithium is turned into various chemical compounds. Some advantages of this battery type include its light weight and high energy density. Solid- state battery is the third new battery technology of the future. In a solid- state battery, the liquid electrolyte is replaced by the solid compound. This allows the lithium ions to migrate within the compound. Solid electrolytes are also safer and are non- flammable when heated. They allow the use of high- voltage high-capacity materials, leading to denser, light weight batteries with a better shelf- life. With the rapid development of these battery technologies, the goal of achieving energy sustainability is attainable.

$$I = 14$$

$$M = 21$$

$$R \Delta = 26$$

$$C = 18$$

$$R = 7$$

In today's society, a numerous number of factors contribute to climate change. However, in the near future, lithium-ion batteries will be able to decrease those factors. One of the most important contributions is transportation because batteries reduce transportation emissions. As the world searches for lower-carbon transport solutions and customers desire fewer emissions, battery technology has become the answer to both (BP, 2018). Tesla, the popular electric vehicle company, is one of a few to start the world's transition to sustainable energy. Their cars are composed of over 6,000 individual lithium-ion cells which allows the vehicle to function the same as a gas vehicle. Along with vehicles, companies are also working towards all-electric airplanes and public transportation. As transportation emissions decrease, climate change will gradually become better.

Another contribution to climate change is greenhouse gas emissions. In order to combat this, solar panels have been implemented in certain places to produce electricity that prevents us from burning greenhouse gas-producing fossil fuels. Lithium-ion batteries have been paired with solar panels because it improves the panels storage capacity and better choice for renewable energy. Overall, going solar reduces the demand for fossil fuels, limits greenhouse gas emissions, and shrinks the world's carbon footprint.

As society becomes more dependable on batteries, we encounter the issue of keeping up with the availability of lithium to produce our batteries. Lithium-ion batteries have been our default source of portable energy because of its high energy density. Now that we are encountering a shortage of the element Lithium, we must look to alternatives that would be more environmentally friendly, abundant, and have high energy density capabilities.

One alternative we have come across in previous summer research is the use of MXenes. MXenes are a 2 dimensional nano-material which comprises transitional metals such as carbides, carbonitrides, and nitrides. These materials are a relatively new material, however, it has shown major promises for the future. With its high energy storage capabilities, it has shown to become a competitor against the lithium ion batteries. The MXene is developed by first starting in the "MAX" phase. The M stands for early transitional metal (such as: Ti, Nb, Cr, V, etc.), A stands for a group A element (such as: Al, Sn, In, etc.), and the X stands carbon, carbonitride, or nitrogen. There are multiple etching processes that the MAX must go through in order to be synthesized into a MXene. These etching processes are environmentally friendly due to the fact that it hasn't been produced on a mass scale as of today.

With these new alternatives, there is the capability of having a safe impact on the environment. With these new MXenes and hydrogen fuel cells, we would be able to combat the scarcity of resources by using other abundant resources. Since the world is slowly shifting to net zero emissions, this would be a perfect time to transition to a cleaner source of energy. The primary motivation for the future of battery technology is to ensure that we are able to give back to the environment, as much as we are taking from it. This right here would be a great step in the right direction.

Methods

When conducting research, we found it best to separate the various tools used within battery technology into three different sections. We will discuss system tools, develop cash flow estimates, and describe the application of engineering courses to better understand the importance of battery technology.

Batteries are an essential part of everyday life. They can be used to power cars, appliances, telecommunication and can be used in medical procedures (Battery Technologies). Due to the rapid growth of population and economy, the demand for clean energy is continuously increasing. The traditional Li-ion batteries are not capable of satisfying the demand due to their limited capacity and energy density. Therefore, the development of new battery technology is on the horizon. Specifically, we could soon see the rise of solid state batteries. We will be investigating the systems approach as it applies to battery technology.

There are four steps associated with the application of systems approach. Those include determining stakeholders, goals, scope and boundaries and finally launching the project (Vanek, 2016). The stakeholders would be customers as well as battery and transportation companies. The goal is to implement a battery that is more sustainable, safe, charges quickly, more energy dense, and has greater range. The scope is the development of an all-around better type of battery. This project has yet to be launched; however, research is currently being carried out to quickly implement the newfound technology.

This new technology is expected to experience exponential growth after it hits the market. Exponential growth is an example of a system dynamic model (Vanek, 2016).

Exponential growth can occur during the introduction of a new product or due to an increase in population. It can be assumed that once people learn about the advantages of the solid-state battery, in comparison to the lithium-ion battery, the demand will increase drastically. We could potentially see exponential growth for the demand of solid-state batteries. IDTechEx forecasts that the solid-state battery market will grow to \$8 billion by 2031 (IDTechEx, 2021). The next systems approach will focus on causal loops. A causal loop provides representation of key variables and how they are connected (Marketlinks Team, 2019). The variables involved with battery technology of the world include constant demand, new innovations, production and consumption. There is currently a high demand for a more efficient battery. Eventually the new battery technology will be available to customers but once flaws are discovered, there will be a need for a better version. This cycle will continue to occur.

In the appendix, Figure 1 shows the Cash Flow Diagram of a Lead- Acid Battery System in Los Angeles, 90 kWh lead-acid system, 50 kW PV. This is the cash flow diagram of only one out of three battery storages used in the economical analysis case study in Los Angeles. First year displays a cash influx due to tax savings and cash incentives. Shortly, the following years resulted in negative cash flow due to accumulating debt payments. Three additional battery banks were set in place to counteract the depreciation that started in year seven. With these additional battery banks in place, it was essential for them to offset the financial benefits of installing such storage tanks in order to reduce demand charges.

We were able to find the Net Present Worth (NPV) and Internal Rate of Return (IRR) using the equations below. For the results of each year refer to Table 1 in the appendix.

Net Present Value: NPV: **-\$8,247.02**

$$NPV = \frac{\text{Cash flow}}{(1 + 0.0814)^t}$$

- 8.14%= The nominal discount rate of the project
- t= time of cash flow

Internal Rate of Return: IRR: **1.424%**

$$0 = NPV = \sum_{t=1}^T \frac{C_t}{(1 + IRR)^t} - C_0$$

- C_t = Net cash inflow during period t
- C_0 = Total initial investment cost

As we conducted more research on battery technology of the future, we noticed we can use previous courses taught within the Prairie View's chemical engineering curriculum to further understand our project. For example, Intro to Electrical Engineering would help to explain how a battery operates. A battery is composed of an anode, cathode, separator, electrolyte, and two current collectors. The lithium within the battery is stored in the anode and cathode. The electrolyte transports positively charged lithium ions to the cathode from the anode. According to the Office of Energy Efficiency & Renewable Energy, this movement creates free electrons which then creates a charge at the positive current collector. As the current flows from the current collector through a powered device to the negative collector, the separator blocks the flow of electrons inside the battery (Office of Energy Efficiency & Renewable Energy, 2017). This is only the beginning of how a battery functions. As time has progressed, batteries have now been installed in laptops, phones, cameras, and portable games. In the future, the number of lithium batteries will gradually increase as they are being used within transportation.

Another course that helps to understand battery technology is thermodynamics. This would be the relationship between heat transfer and chemical energy within the battery. Heat is applied to a battery, which in this case contains lithium, and allows for it to charge different items. For example, a thermodynamic process with a battery may consist of an external heat source providing heat to the battery. As this happens, the cell temperature rises within the battery.

Lastly, material science is able to explain how materials can be manipulated to better store and transfer energy. Referring back to how batteries operate, it is necessary to have an anode and cathode material. According to a presentation from Karlsruhe Institute of Technology, Graphite, Carbons, and Tin have a much lower capacity for anode materials. This is why Lithium is a more used material within batteries because they are capable of holding over 3,000 Ah/kg of Lithium metal in batteries (Seifert et al., 2012). Lithium also works best for the cathode materials because its potential is higher than Manganese Dioxide or Vanadium Pentoxide. The research has already been conducted for Lithium batteries and more must be done before the batteries are used for bigger things in the future.

You did not talk about the molecular approach to the project.

Results and Discussion

Battery technology is used to power many items that we use on a daily basis. Batteries are reusable and rechargeable as a power source in many appliances and machinery. Some examples of battery applications may include, digital cameras, mobile phones, video game devices, remote control cars, and electric cars. Batteries are used to store chemical energy to eventually be converted into electricity. The raw materials that make up a battery are considered a nonrenewable source of energy. However, batteries that are rechargeable can be considered renewable due to their ability to replenish the energy for continued use. In our society we are constantly searching for the next best thing; that goes for battery technology as well. We will be discussing the relevance of new battery technology on handheld technology and transportation.

As time progresses, smartphones have become more and more advanced. The operating systems that power them have become increasingly more efficient. Still, researchers work to find ways to improve battery life and decrease charging time. Lithium-ion is the backbone of smartphones as well as many other appliances. However, with this high dependence, lithium is close to reaching its threshold. Meaning that scientists are working diligently to find the next battery breakthrough (Bhushan, 2020). The next breakthrough in battery technology could be graphene because it is capable of storing more energy, charging quicker and holding a charge longer than lithium batteries. Currently the fastest phone battery takes just 39 minutes to fully charge. Allegedly Samsung is working on a graphene battery powered cell phone that can be fully charged in less than thirty minutes.

Along with cell phones, new battery technology for electric cars is also in high demand. Over the past century, electric vehicles have made great progress. This is due to the growing demand for car purchases, and more people making the switch from gas run cars to electric. Currently, car companies make use of the lithium-ion batteries. However, electric vehicle companies are hoping to see a new advancement in battery technology. Lithium-ion has limitations due to their limited capacity and energy density. But, a battery science company has revealed a new advanced technology that can power electric vehicle batteries. This new breakthrough technology fuses silicon nanowires onto commercial graphite powders. This new development is said to increase battery range while decreasing charging time. The name of this

new discovery is Sinanode (Billington, 2021). It can be integrated into almost any existing manufacturing process, thus tripling the current energy density and greatly decreasing the cost. The future of battery technology is advancing rapidly. It will only be a matter of time before we see these new advancements available for all to use.

As mentioned, a relevant application of battery technology of the future is electric vehicles. Electric vehicles have influenced society by demonstrating that while making minimal changes, we can still care for our environment and obtain the long-term benefits. Electric vehicles are environmentally friendly and durable because they do not emit fumes, direct greenhouse gas emissions, or air pollution (Ghosn, 2021). This new form of transportation is also cost effective due to the lack of gasoline needed for electric vehicles. The use of lithium-ion batteries has also influenced others by demonstrating a “grid-scale of renewable energy” (Hoster, 2020).

Society’s interactions with electric vehicles has not been positive for everyone. As to be assumed, a survey conducted by Pew Research Center showed over fifty-percent of Gen Z and Millennial adults “favor phasing out production of new gas-powered vehicles by 2035” (Spencer & Funk, 2021). This was to be expected because Gen Z and Millennials are more open to change and understand the evolution happening within technology. However, older generations have not been accepting of the new and upcoming electric vehicles. Only thirty-eight percent of Baby Boomers and older Americans would like to increase the production of electric vehicles (Kagan, 2021).

Conclusion

As technology advances, we must be able to adapt to the change in systems that help us throughout our daily lives. Battery technology has a bright future in the world because of its sustainable use of lithium batteries. By using batteries, it decreases our emissions rate and provides a lower-carbon transport solution for the environment. Battery technology has become more economically sustainable due to decrease in gasoline purchases . Lastly, it is societal friendly because as time continues, more people are becoming interested in electric vehicles. Overall, battery technology has created a new way of operations that will make the world a better place.

Appendix

Figure 1: Cash Flow Diagram of a Lead- Acid Battery System in Los Angeles

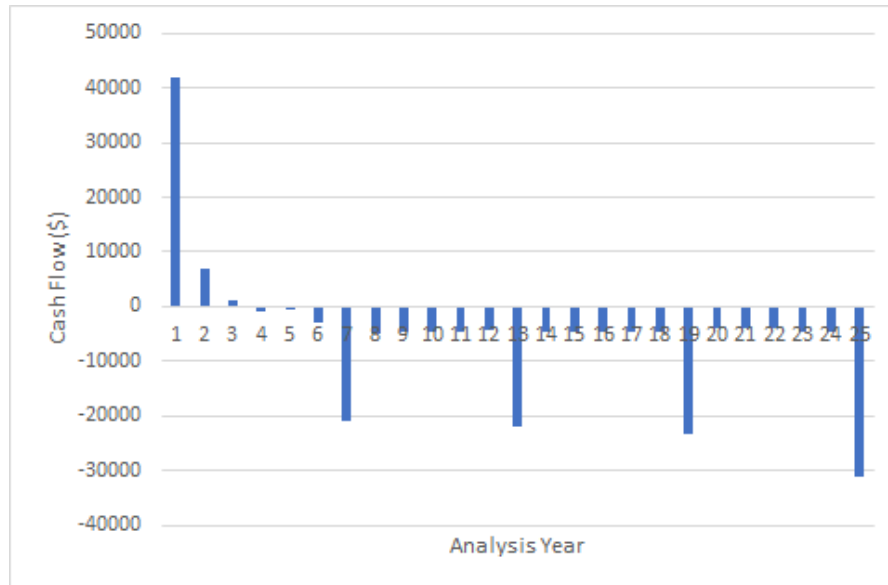


Table 1

Year	Cash Flow (\$)	NPV
1	42000	38838.54
2	7000	5985.843
3	1000	790.7531
4	-750	-548.423
5	-500	-338.095
6	-3000	-1875.87
7	-21000	-12142.7
8	-5000	-2673.49
9	-4800	-2373.36
10	-4700	-2148.99
11	-4500	-1902.67
12	-4250	-1661.7
13	-22000	-7954.26
14	-4800	-1604.84
15	-4700	-1453.12
16	-4650	-1329.45
17	-4650	-1229.38
18	-4600	-1124.61
19	-23500	-5312.84
20	-4000	-836.243
21	-4000	-773.297
22	-4000	-715.089
23	-4800	-793.514
24	-4500	-687.923
25	-31000	-4382.3

Note: NPV and IRR calculated by using excel function

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Battery Technology of the Future

Jevaun Christie, Kennedy Henderson & Taylor Linton

Agenda

- ❖ Background/ Motivation
- ❖ Introduction
- ❖ Methods
- ❖ Results
- ❖ Conclusion

Background/ Motivation

- Battery technology
 - Storing of electricity in a chemical form, inside a closed-energy system
- Millions of people use battery technology daily
 - Charging your cell phone/ laptop
 - Electric cars
 - Remote/ Garage opener
- Motivation
 - Bring awareness to the impact that this technology have on our lives
 - Routes to take when advancing this technology
 - Mass production



Introduction

(Sustainable development, Climate change, Availability)

Sustainable Development

- Lithium Ion
 - Fast charge, long lifetime, low self-discharge
- Lithium Sulfur
 - Light weight, high energy density
- Solid-state
 - Non-flammable, light weight, reduced self-discharge/better shelf- life



Climate Change

- Transportation
 - reduce transportation emissions

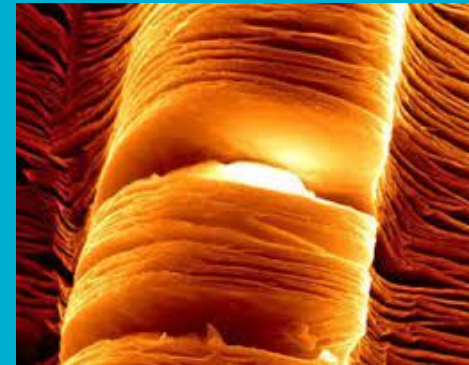
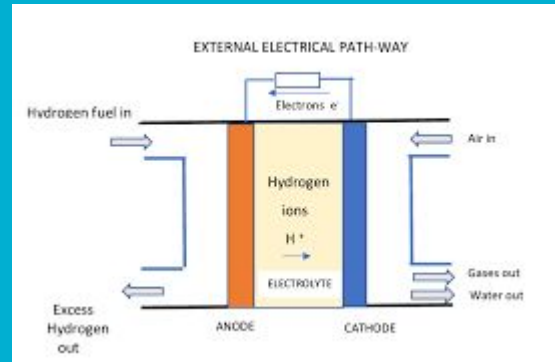


- Solar Panels
 - improves storage capacity



Availability

- Lithium-ion battery is the default source of portable energy because...
 - High energy density
 - Longer battery life
 - Better rate capability
- Lithium resources are very limited
- Must find alternatives that are:
 - Environmentally friendly
 - Abundant
 - High energy density capabilities
- Alternatives:
 - MXenes
 - Hydrogen Fuel Cell

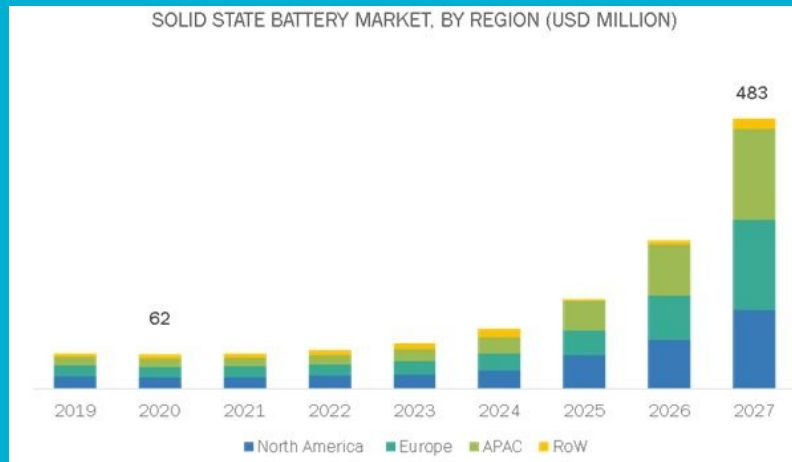


Methods

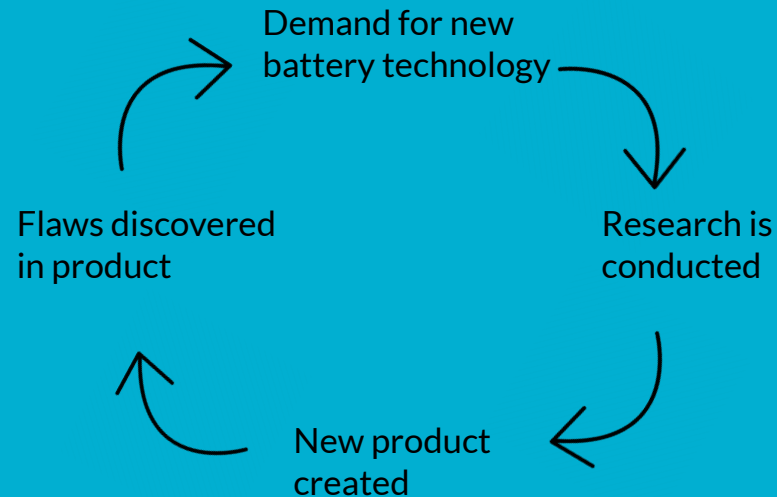
(System tools, Economic tools & hard engineering tools)

System Tools

- Exponential Growth



- Causal loop

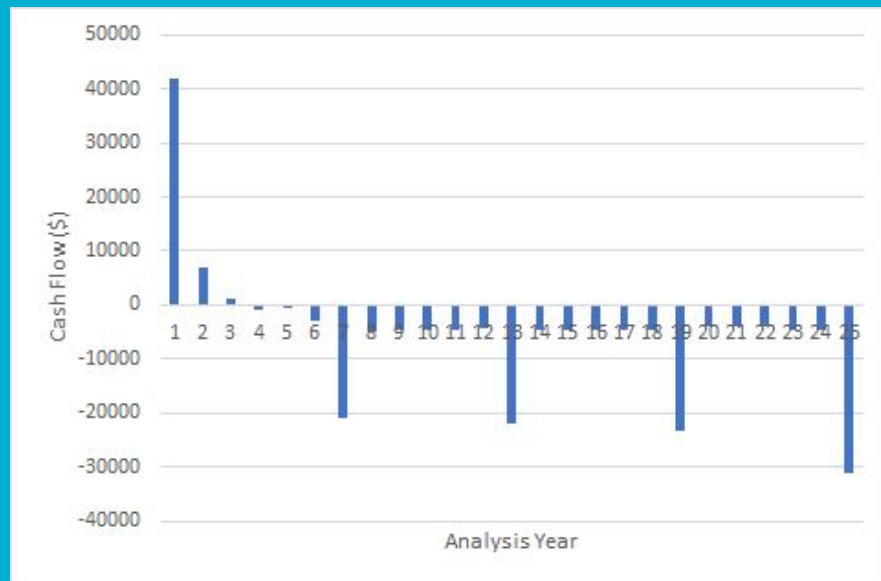


Economic Tools

- Cash Flow Diagrams
- Net Present Value
- Internal Rate of Return

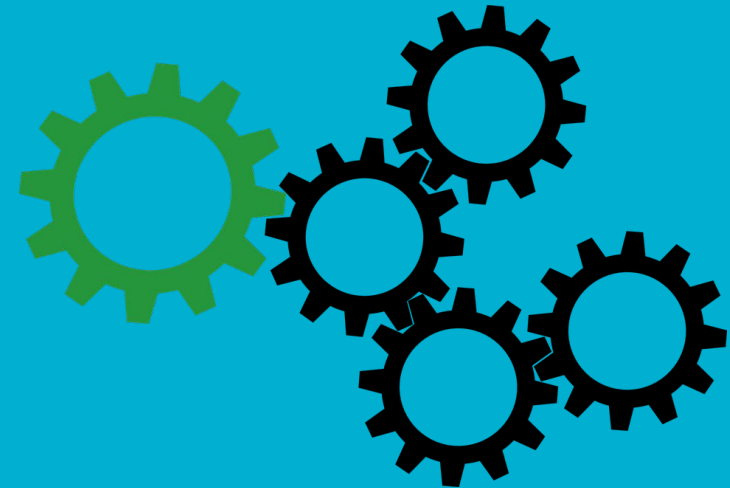
According to the NREL...

- Year 1 - Large cash influx occurs as cash incentives and tax savings are accrued.
- Year 5 - MACRS depreciation contributes to net positive cash flows over the first three years.
- Year 7 - 1st battery replacement occurs resulting in a large negative cash flow.
- Three additional battery bank replacements occur over the rest of the analysis period, offsetting the financial benefit of installing storage to reduce demand charges.



Hard Engineering Tools

- Intro to Electrical Engineering
- Thermodynamics
- Material Science



Discussion

(Stationary/transportation application and Influence)

Stationary/ Transportation application

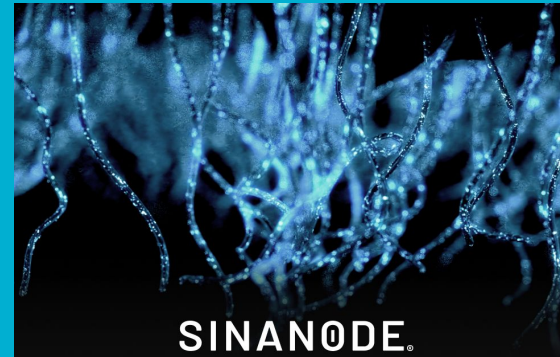
Smartphone

- Future Battery: Graphene
 - More energy storage
 - Shorter charging time
 - Holding a longer charge



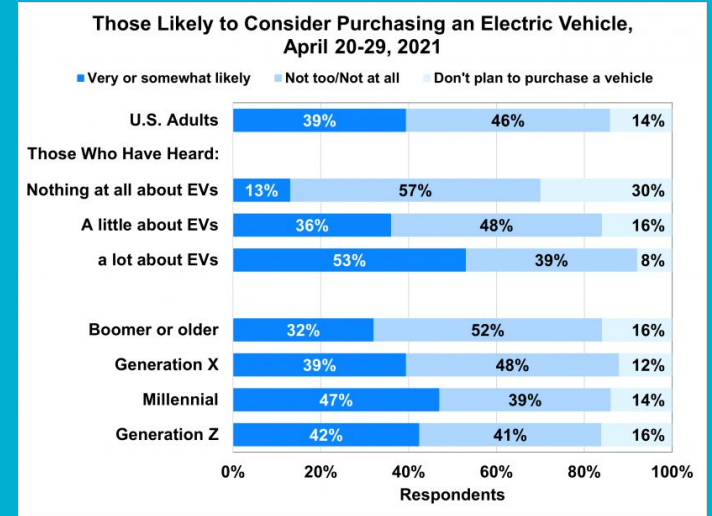
Electric Cars

- New Technology: Sinnanode
 - Increases battery range
 - Decreases charging time
 - Can be integrated into existing manufacturing processes



Influence

- More companies are shifting to electric
- Societal interaction



Conclusion

- Sustainable
 - Environmental
 - Economical
 - Societal friendly



**AVERAGE
PROJECT REPORT**

**Average Student/Group Original Graded Assignment
Including Rubric Showing Grading**

CHEG 3311 Introduction to Energy Systems: Final report
Solar Energy: Current and Future Contributions to Renewable Energy

(86/100)



Presented by: Team 6

Jasmine Davenport, Danielle Hillary, Jeffrey Sanders, and Alessia Williams

Dr. Kazeem

Due date: December 6, 2021

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Introduction

Renewable energy is an everlasting source of energy of which there are many types. To name a few there is nuclear energy, which can be caused by nuclear fission, wind energy, which uses wind to turn wind turbines, and solar energy, which harnesses the sun's light and heat. These unique sources of energy each have their own impacts on the environment, its efficiency, as well as its sustainability. The purpose of this report is to explore the contributions of solar energy from the past to the future in regards to its discovery, sustainable development, effects on climate change, resource availability, and resource scarcity.

Solar energy was first recognized in 1839 by a French physicist named Edmond Becquerel (Smithsonian 2020). His observation and discovery of the photovoltaic effect, which is a process that when exposed to light produces an electric current, was among the first steps of solar energy. Several decades later in 1883 Charles Fritts, an American inventor, developed the first solar cell. This solar cell, which is selenium coated with a nearly transparent layer of gold, was highly inefficient, yielding one percent conversion, and expensive to produce. Later in 1941 an American engineer, Russell Ohl, developed a solar cell using silicon which was more efficient, yielding over five percent conversion, slightly more cost efficient than its selenium counterpart, and is a technology that is still used in modern times (Dhar 2017).

Even before the modernized solar cell and panel was invented, an English inventor, Edward Weston patented an idea of the solar energy process. He proposed, "light energy is focused via a lens onto the solar cell and a thermopile," and with this process light is converted into heat which then creates electricity (Smithsonian 2020). To break this down further, light is transferred onto a solar cell which then causes an excitation of electrons. Afterwards, this energy is moved to conductive metal plates which transfers them to wires where the electricity, or energy currency, can be used on a given service (Dhar 2017). Furthermore, this patent continues to be used today as well as influence its continued innovations. Next, the sustainable development of solar energy will be discussed.

$I = 15$

$M = 20$

$P = 28$

$C = 15$

$R = 8$

Sustainable Development

The discovery of solar energy goes in hand with sustainable development. This renewable source of energy requires the most naturally abundant source of energy, which is the sun. Knowing that, it's safe to say that solar energy is not destructive to the environment. For example, passive

Your sectionalizing the report from this point causing to the structure of the report stipulated makes it difficult to grade!

sunlight is the energy used for the majority of space heating (Foroudastan). With this the future generations will be able to thrive comfortably with the peace of mind that the energy source will not run out.

Climate Change

Climate change has been a heightened topic as of the last couple of decades or so, a lot of pressure has been put on our government for the prevention/regulation of greenhouse gases and the effects that increased CO₂ emissions have had on our environment. Globally climate change has been responsible for over 150,000 deaths per year, this is because in addition to extreme weather events, climate change also contributes to the spread of diseases, reduced food production and many other problems. Clean renewable energy has become a necessary step towards sustainable energy development and the main replacement of fossil fuels and the traditional resources for energy. Solar energy is one source that has been proven to have minimal impact on the environment and counters the effects of global warming by reversing these harmful gas emissions from reaching our ozone. Many alternatives have been made to capture the sunlight and use it as an energy source, one of those being the usage of solar panels. Solar panels have been in production as an option for reducing future greenhouse gas emissions, offsetting 50% of all future growth in thermal electricity generation by photovoltaics (PVs) would reduce annual global carbon emission from projected increased levels by 10% in 20 years and 32% in 50 years (Drennen 1999). Solar energy activates the panel and the cells within the panel convert the sunlight into electrical energy, in the same way as burning a fossil fuel like coal would do, in exchange there are no harmful gas emissions that will affect the earth. Solar energy systems help mitigate the production of air pollution from greenhouse gases and has a positive indirect effect on the environment through these processes.

Changing Resource Availability And Resource Scarcity

Another driver behind our research into solar energy and its current and future contributions to renewable energy is resource availability. Notably important is the resource availability of its primary competitor, fossil fuel. Despite fossil fuel being “nonrenewable”, the scarcity of supply is a capitalist constructed idea to generate increased power and profit of oil-based countries. In other words, there is no and has never been an actual shortage of oil. Rather there is an

where is the source of this information?

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abundance of oil, especially as companies use the falsehood of supply shortage to gain approval and funding to exploit “non-conventional sources” (Winter 2016). As no profit or power comes from abundance, companies and the government both work to “perpetuate a capitalism of inefficiency” to push political and economic power (Winter 2016). Not only is the government interested in controlling oil for global power, the government relies on oil control for its own agency. Without oil profits, the government would have to rely on the money earned through citizen taxes and therefore be more constrained to the will’s and wishes of its citizens, i.e. be forced to function as a democracy vs autocracy (Winter 2016). Defining the political economic control in place on fossil fuel is important for exemplifying the precise impact fossil fuel has on solar energy development. As the U.S. government is directly involved with preserving oil-based power and profit, it is naturally opposed to supporting the replacement of this fossil energy with renewable alternatives. The healthy supply of oil will only prolong the fight for nationwide solar energy implementation.

When looking at solar energy itself, solar energy and the resources required for proper infrastructure are scarce. Despite the potential to power the globe, the sun is not consistently available. Opportunities to harvest power are limited by obstructive weather conditions and the rotation of the Earth. The variability and “natural scarcity” of solar energy raises the cost and lowers the appeal of this alternative. In addition, the technology required to capitalize off of the immense power the sun provides and distribute it for widespread use is lacking. The primary method for storage is battery technology, however, the current supply of necessary minerals doesn't even meet $\frac{1}{3}$ of the prospective demand for 2030 (Dave 2021). Not to mention, a grid that supports battery storage, one designed for liquids, is currently unavailable and would require the complete renovation of the one in place. This fate is similar for most, if not all, proposed solutions for storage and distribution methods for solar energy. Therefore, the scarcity of supply and facilitating technology limits the development of solar energy to onsite capture and use and limits the propensity for expansion.

Methods

System tools 1

Demand side management (DSM) controls consumer demand through the implementation of certain technologies or programs. Currently, solar panels do not efficiently convert solar power to electrical energy. Current efficiency ratings range from 11 to 15% (Login). Therefore, the energy

The instruction given to you on how the project was approached on a modular basis was not

source is both limited in terms of duration of sunlight but also in terms of total energy produced. The energy consumption of the average household (9000 kWh) far exceeds the energy output of individual solar panels (250 - 400 kW) (Sunrun). Demand side management technologies are implemented to mitigate the stress of having low efficiency panels that do not meet consumer demand. Maximizing a building's usage of available solar energy requires demand side management where technologies are implemented that reduce electricity waste. These technologies/programs include time-based rates, demand response, distributed generation and/or storage, energy efficiency, and electric vehicles (Energy.gov).

Time-based rates control the demand of solar power by encouraging consumer use during times of day when solar energy is abundant. The quantity of available solar energy is highest during the middle of the day at which point solar electricity rates are the lowest. On the other hand, in the evening-time available solar energy is low and energy consumption is at its peak. Rates in the evening are much higher than rates in the middle of the day (Qureshi). The time-based solar electricity rates function to deter consumer use during the evening and encourage more use during the day when there is more available and therefore supply is able to meet periodic demand.

Distributed storage, i.e. battery technology, is critical for controlling the demand of solar energy by allowing consumers energy freedom. The energy available during midday exceeds the demand at that time, therefore, to maximize consumer use battery technology is necessary for the energy to be stored and used in the evening when sunlight source is limited. This storage technology lowers demand in the evening, because the energy required would have already been largely met from midday capture and storage. Aside from demand control, battery technology is attractive for taking advantage of lower midday rates. Rather than using directly converted energy at high evening rates, consumers are able to utilize energy stored in batteries obtained during low midday rates. Intelligent battery storage automatically switches between storing and using stored energy to optimize low energy costs for consumers.

Distributed energy generation is a form of demand side management as it allows for optimal efficiency of solar power generation for a consumer. The angle and location of the panel should work with the architecture and geographic location of the building it is installed on (Login). Commercial buildings can further improve possible energy capture by utilizing solar tracking equipment to ensure prime use and storage during the day.

Electric vehicles are another tool for demand-side management as their social implementation drives up demand for solar power and therefore boosts overall industry growth for solar energy. The attractive energy source is clean, has lower prices of materials, and lower installation costs making more affordable vehicles with a lower environmental impact (Qureshi). Battery technology will also improve the growth of the electric vehicles industry and positively drive demand for solar power.

System tools 2

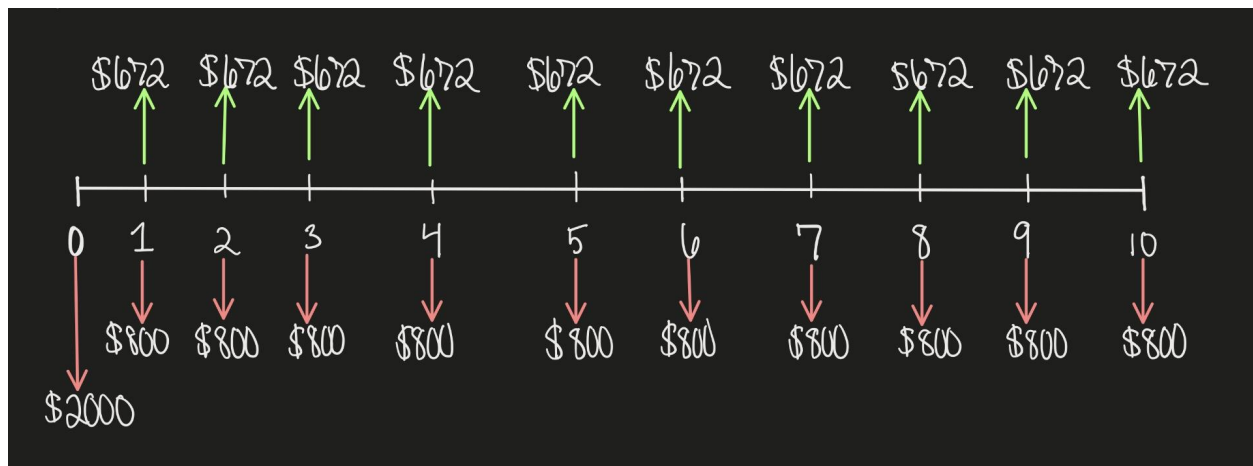
System dynamic modeling is the second component of system tools to be discussed, it analyzes the following components: exponential growth, saturation and causal loops. Issues involving the constant increase in the price of oil and environmental awareness have attracted the extensive research of renewable energy resources. In our case Solar energy is that particular energy source in which we believe will have a future presence in our economy. The exponential growth of the concept of solar energy has stemmed from the research conducted that the greenhouse gas effect on our planet globally has had dire consequence to our environment. In 2010, solar energy combined made up about 2% of the global electricity. By last year, it had climbed to 9% far higher than what had previously been predicted by mainstream energy models. The International Energy Agency expected that global solar energy generation would reach 550 terawatt-hours in 2030, but that number was exceeded by 2018 (Jaegar). These models often assume that the growth of solar energy will be linear, but in reality the growth has been exponential (Jaegar). Growth of solar energy has increased dramatically as outlets concerning our planet's health have become broader and statements regarding climate change and global warming have become more profound. Falling costs in manufacturing these solar energy products have also contributed to the exponential growth. Since 2010 the costs of solar photovoltaic electricity has fallen 85%, and are now cost competitive with fossil fuel electric energy sources. Saturation of solar technology has become evident through the growth of popularity of the products and the need of a renewable energy resource becoming more pivotal in mitigating the effects of fossil fuel burning. The more relevant source comes in the form of panel implementations that use solar energy to produce a reliable source of energy through means of capturing sunlight which in return is used to create electricity. The market has seen higher rates of this renewable resource becoming sought after as

the primary source of energy and replacing fossil fuels in the grand scheme of things, with it being more cost effective as technology improves, allowing more designs to be implemented.

Economic tools

The average cost of solar panels in Texas is a little over \$13,000 for a 5 kW system, although pricing ranges from \$11,500 to \$15,500 (Energysage, 2021). With the addition of the federal solar tax credit, which decreases the overall cost by 26 percent, the new total cost is slightly above \$10,000 (Marsh, 2021). Since most solar energy homeowners pay off their solar panels within 10 years, there is an initial down payment followed by a monthly payment, or annual in this case, which will be made throughout the 10 years. Also, with the average household in Texas spending about \$156 on energy without solar panels and about \$100 with solar panels, annually about \$670 is saved according to Figure 1.

Figure 1: Cash flow diagram of installation cost and annual savings for solar powered homes in Texas



Next, the net present worth, given that the federal solar tax credit of 26 percent over a period of 10 years with a cash flow of \$672 this totals to over \$13,000. However, subtracting the down payment, we are left with about \$11,000. According to this value within this time, a homeowner will have an additional \$1000 in profits from the purchase of solar panels.

Lastly for rate of return, using our values of \$11,000 subtracted by the spending cost we are left with \$1000. After finding this value, it is then divided by the spending cost which gives a grand return rate of 0.1 percent.

Materials design

Designing the electronic properties of carbon-based materials by understanding and controlling the path from single molecular structures via nano-morphology to film growth. A prime example is bulk heterojunctions in organic solid state solar cells which need a nanometer control of morphology in the key active layer.

Areas where scientific and materials breakthroughs may be possible and of potential importance:

- Multiple-band gap tandem solar cells incorporating scalable materials;
- Light concentration through far field optics for multiple-band gap materials;
- Nanophotonics in dielectrics and semiconductors for light-matter coupling, light trapping/ light management;
- Plasmonics for light-matter coupling, to direct energy to the semiconductor structure in photovoltaic devices;
- Combination with solar fuel generation, e.g., hydrogen generation by photovoltaic layers with catalyst electrodes.

Developments of silicon photovoltaic markets and technology

The goal of 0.4 €/Wp for photovoltaic (PV) modules is close to appearing in the silicon photovoltaic market, where the wholesale price is now 0.5 €/Wp, and where the financial difficulties of most companies indicates that variable costs in their production are c. 0.4 €/Wp. The dramatic reductions of silicon PV sales prices (to 20 % during the last 5 years) are mainly due to market pressure resulting from oversupply, increased production volumes leading to cost reduction by scale, and to some degree also due to technological advancement.

Identification of research needs of the coming decades

Nanophotonic strategies for light trapping in thin structures

The well established Yablonovitch limit for light trapping in the limit of geometrical optics is not relevant when arriving at thin film structures that must be analyzed with the wave optics

approach. This goes for thin film devices with extremely thin absorbers, and new strategies for optical compression of solar light into such thin absorbers have been proposed. Considerable experimental developments are necessary to exploit such strategies, shaping, and integrating thin film absorbers in a benign optical environment.

Results and Discussion

Mode of application (stationary or transportation application)

Solar energy could either be used in the stationary form such as used in homes for electricity or can have a transportational application such as technology advancement looking into using solar power for cars, but for this project we are going to be focusing on the stationary use of solar energy. The first application is the solar heating of buildings; Solar energy is often used to directly heat a house or the building. Heating a building requires much more energy and larger panels than heating a building's water system. Generally (in China), a building that is directly heated by solar energy will have its solar water heated system. Solar heating of buildings includes all kinds of passive and active solar energy utilization technologies, which is commonly integrated with buildings themselves. These technologies involve trombe wall, solar roof and solar greenhouse energy utilization system (ChenBin et al., 2006). Solar energy is the best heating building mode. Solar heating requires almost no energy transformation, so it has a very high efficiency. Heat energy can be stored in the liquid and air, or in a packed bed. A packed bed is a container filled with small objects (such as stones) that can hold heat among the air space. Heat energy is also often stored in phase-changer or heat-of-fusion units with the wall materials. Another mode of application of solar energy is refrigeration and air-conditioning. Utilization of solar air-conditioning is the most ideal harmonious state between human and nature, which can create both favorable indoor and outdoor environment temperatures. Therefore, the effect of "warm-island" in the big cities will be cut down. The absorption chiller driven by solar energy demands no Freon refrigerants, so it does not damage the ozone layer, and is hence named "green air-conditioning". Other uses for solar energy include utility scale solar PV farms that can generate enough electricity to power entire cities. An even more efficient solar technology is concentrated solar power (CSP). A CSP solar farm uses mirrors to reflect and concentrate the sun's energy towards a tower or other receiver, generating heat that can power a turbine to create electricity. That thermal energy may be stored before powering a generator, which makes it a more flexible source of electricity than solar PV. The world's largest CSP solar farm is the 390

megawatt (MW) Ivanpah project in California's Mojave Desert, although an even larger 580 MW CSP plant under construction in Morocco may soon claim that title.

Another application of solar energy, especially in the southern and southwestern U.S., is heating swimming pools. Water is circulated to a collector where it is heated by sunlight and then pumped back into the pool. With costs between \$3,000 and \$4,000 and a payback of 1.5 to 7 years, the U.S. DOE says that "solar pool heating is the most cost-effective use of solar energy in many climates."

Solar lights have become ubiquitous and can be found everywhere from home landscaping and security lights to road signs and street lights. These solar lighting technologies for your home are inexpensive and readily available from basic to high-end designs everywhere from your local hardware store to online shopping websites such as Amazon.com.

Influence and interaction of application

While stationary modes of application for solar energy are widely used, transportation application is lacking. Solar powered vehicles (the primary mode of transportation) has not been confirmed as a viable mode of transportation (William, 2021). Solar powered boats, on the other hand, make up the majority of the transportation mode of application for solar energy as they are widely used commercially (William, 2021). A major issue that prevents solar powered vehicles from being implemented as a reliable mode of transportation is the high initial cost due to expensive necessary components for solar converting systems. Furthermore, current solar cells require too much surface area for installment on vehicles. Another critical area that poses an issue for solar powered vehicles is battery technology. Batteries are incredibly important for user freedom of solar vehicles, as solar power is weather dependent and non-existent at night. Not only will the specialty batteries developed specifically for vehicle application be expensive, but current battery technology does not have the ability to store energy efficiently enough for vehicle use (William, 2021).

The relationship between stationary modes of application and transportation modes of application is the progress of technology improvement in solar cells for stationary application uses would encourage and allow for the development of practical solar powered vehicles. Despite stationary being the primary mode of application, solar technology for stationary

application is new and therefore has lots of room for technology improvement. Solving the same issues that prevent vehicle application of solar energy, would make solar cells more attractive and improve overall use of solar cells for stationary applications. Lowering material cost, concentrating the conversion of solar energy to reduce required surface area for the device, and improving battery technology and energy storage as a whole for more user freedom of the renewable source would drive research and implementation of transportation applications.

Conclusion

Renewability

Renewable energy is any source of energy that replenishes naturally without human intervention on a human timescale. Solar energy is a growing commodity energy resource that in many ways will help improve the environment in the future providing clean energy that will counter the effect of the rising CO₂ levels and its effects on our society. Solar energy is one of the cleanest most abundant renewable resources, meaning it won't ever run out or be in short supply. In just one hour, enough sunlight shines on the earth's atmosphere to hypothetically provide electricity for every person on earth for a year (Marsh,2019) proving the longevity of the energy source and the amount of energy that is available for use. Simply building the correct number of solar panels could help capture this amount of available energy and convert it to electricity. Solar energy reaches us via the sun's rays, while fossil fuels are ancient carbon-rich remains found on earth that are limited in supply. Solar energy has an unlimited supply as long as the sun is shining solar energy will be around, (NASA scientists say that the sun is around halfway through its lifecycle, which means we have around 4.5 billion years left to take advantage of the sun's solar energy) (Marsh,2019). Solar energy is a remarkably dependable and safe source of energy in which we will have at our disposal for many lifetimes, which means we should take advantage of it and its positive effects to ensure the health of our environment. The continued high availability of solar energy remains the most vital role in why we should be using it taking advantage of a clean renewable source of energy whilst able to power cities and such in a safe manner to correct the greenhouse gas effect and what it has done to our ozone layer.

Technology applicable

Solar energy is harnessed in a few different ways: photovoltaics, concentrating solar power, and solar heating and cooling. Photovoltaics involves using the sun's light to convert into electricity

Your conclusion never address the Sustainability components !

via semiconductors. Devices that use this technology include solar panels that supply power water pumps, solar panels that charge batteries for phone booths, and solar panels that supply energy to homes (Ryan, 2009). Concentrated solar power is derived from using a series of mirrors to concentrate the sun's energy in order to power steam turbines that create electricity (SEIA, 2019). The mirrors that make up the vast array include curved mirrors, referred to as a parabolic trough system, and flat mirrors, referred to as compact linear fresnel reflector. An application for this mode of energy includes industrial heating in processes such as food processing, enhanced oil recovery, and mineral processing (Energy, 2016). Lastly, solar heating and cooling uses the sun's thermal energy to substitute electricity and natural gas. Utilizations of this method include providing hot water, space heating and cooling, as well as pool heating (SEIA, 2019).

In addition to the previous modes of use mentioned, solar energy can be stored. The storage process begins with the generation of electricity via solar panels during the day, also known as peak hours. Next, the surplus electricity is stored in a solar battery essentially charging the battery. Finally, during the night, the energy stored within the battery can be used even though the sun is no longer expelling energy (EnergySage, 2016). This storage and use of energy is used to supply power to household appliances such as washing machines, dryers, dishwashers, and many additional appliances. Furthermore, solar batteries provide power off the grid meaning if there is a power outage a given home's electricity will not be at risk. Another application includes the storage of solar energy on highways in order to illuminate street signs at night.

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Solar Energy

Current and future contributions to renewable energy

Presented by Team 6

Jasmine Davenport, Danielle Hillary, Jeffrey Sanders, and Alessia Williams



Overview

Introduction

Sustainable development

Climate change

Resource availability

Systems tools

Economic tools

Material design

Mode of application

Influence

Renewability

Technology applicable

Introduction

How solar energy works:

<https://www.nrel.gov/research/re-solar.html>



Sustainable development

- Requires the most naturally abundant source of energy, The sun
- Not environmentally destructive
- Uses passive sunlight energy



Climate change

What does it mean?

- Climate change is the change in global or regional climate patterns, the change has become apparent in the mid to late 20th century.
- Globally climate change has been responsible for over 150,000 deaths per year, this is because in addition to extreme weather events, climate change also contributes to the spread of diseases, reduced food production and many other problems.

Clean and renewable energy has become a necessary step in combating climate change, this is where solar energy takes its place in reversing the effects of CO₂ emissions and what it has done to our planet.

Many alternatives have been made to capture the sunlight and use it as an energy source, one of those being the usage of solar panels

- Photovoltaics (PVs)
- Concentrated Solar Energy
- Thermal Solar Energy

Solar energy systems help mitigate the production of air pollution from greenhouse gases and has a positive indirect effect on the environment through these processes.

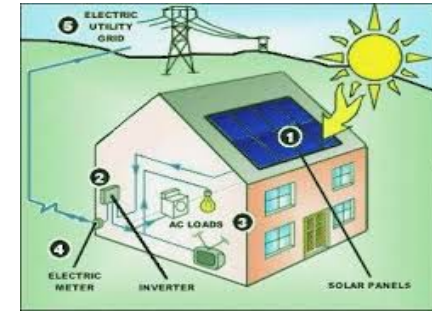


Resource availability

- Infinite source
- Limited availability
 - solar cycle
 - obstructive weather conditions
- Increase cost and lowers appeal



Systems tools



- Currently, solar panels do not efficiently convert solar power to electrical energy. Current efficiency ratings range from 11 to 15%
- The energy consumption of the average household (9000 kWh) far exceeds the energy output of individual solar panels (250 - 400 kW)
- Time-based rates control the demand of solar power by encouraging consumer use during times of day when solar energy is abundant
- Distributed storage, i.e. battery technology, is critical for controlling the demand of solar energy by allowing consumers energy freedom
- Distributed energy generation is a form of demand side management as it allows for optimal efficiency of solar power generation for a consumer.
- Issues involving the constant increase in the price of oil and environmental awareness have attracted the extensive research of renewable energy resources
- In 2010, solar energy combined made up about 2% of the global electricity. By last year, it had climbed to 9% far higher than what had previously been predicted by mainstream energy models
- The International Energy Agency expected that global solar energy generation would reach 550 terawatt-hours in 2030, but that number was exceeded by 2018.
- Falling costs in manufacturing these solar energy products have also contributed to the exponential growth. Since 2010 the costs of solar photovoltaic electricity has fallen 85%, and are now cost competitive with fossil fuel electric energy sources.

Economic tools

Total cost of installation: \$10,000

\$\$ saved on energy per year: \$672

Total time: 25 years

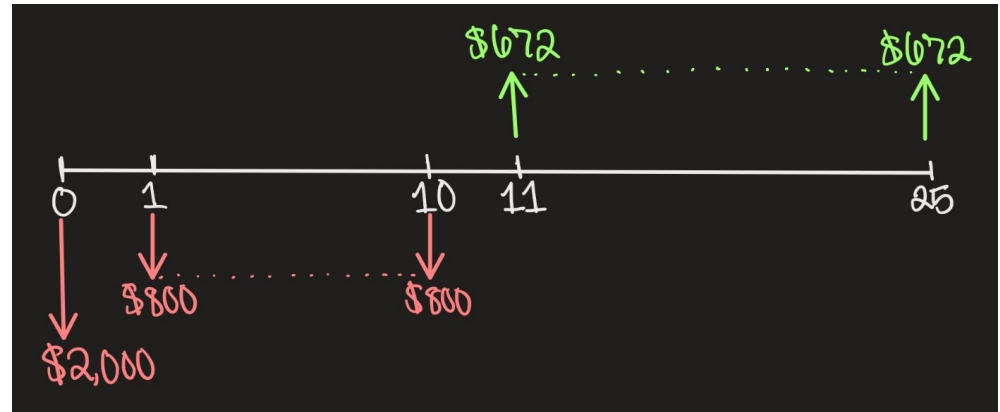


Figure 1: Example cash flow diagram of solar installation cost and return of a homeowner with a 5 kW solar panel system

Material design



- Multiple-band gap and scalable materials
- Light concentration
- Light-matter coupling, light trapping/ light management
- Combination with solar fuel generation,
 - e.g., hydrogen generation by photovoltaic layers with catalyst electrodes.

Mode of application

- Solar Electricity
- Solar water heating
- Solar ventilation
- Solar lightning
- Solar transportation
- Portable solar



Influence of Applications

Issues of Transportation Mode

- Cost of expensive necessary components
- No compact design
- Unfavorable battery technology

Influence of Stationary Mode - Technology Development

- Compact designs
- Improved battery efficiency



Renewability

Renewable energy is any source of energy that replenishes naturally without human intervention on a human timescale. Solar energy is a growing commodity energy resource that in many ways will help improve the environment in the future providing clean energy that will counter the effect of the rising CO2 levels and its effects on our society.

- Solar energy is one of the cleanest most abundant renewable resources.
- In just one hour, enough sunlight shines on the earth's atmosphere to hypothetically provide electricity for every person on earth for a year.
- Solar energy has an unlimited supply as long as the sun is shining solar energy will be around.
- NASA scientists say that the sun is around halfway through its lifecycle, which means we have around 4.5 billion years left to take advantage of the sun's solar energy.



Technology applicable

Solar panels

Solar panel farms

Solar space heating and cooling

Storage of solar energy (solar battery)

Solar lights



**BELOW AVERAGE
PROJECT REPORT**

**Below Average Student/Group Original Graded Assignment
Including Rubric Showing Grading**

Environmental Impacts of Nuclear Energy:

Introduction:

The environmental impacts of nuclear energy have been a serious discussion now-a-days as the world decided to move towards sustainable energy development program (Lester and Rosner 2009). It results from the nuclear cycle, its mechanism, operating conditions and effects of nuclear accidents happened. The greenhouse gases emissions are way lower for nuclear energy as compared to the other energy sources like fossil fuels while having less health hazards as well. There are still some concerns related to the potential risks if containment fails that can be caused as a result of melting of fuels by overheating and release of the products formed after fission reaction takes place (International Atomic Energy Agency 2004). This risk could eliminate all the benefits associated with the usage of nuclear energy and precautionary measures are required to be taken by disposing off nuclear or radioactive wastes far from the population (5-Power 2004). The spent nuclear fuel has the capability to be reused while yielding more energy after fission reaction (Al-Forkan et al. 2021). Due to recycling of spent fuel, the quantity of radioactive wastes produced can be reduced and risks will be mitigated. There has been a lot of opposition faced by the public regarding the use of nuclear energy because of high risks associated with this technology (International Atomic Energy Agency (IAEA) 2016). The global demand for the energy consumption keeps rising and the focus is being shifted towards renewable resources. Nuclear energy has been used for almost 20 years to meet the energy demands and that is why the energy generation capacity of world in 1976 was 80 GW in 19 countries of world (Hore-Lacy 2007).

Background and Motivation:

Nuclear energy is often termed as atomic energy which is obtained as a result of nuclear fission reactions carried out in nuclear reactors. The energy release is tremendous and a controlled release of energy is required for the conversion of this energy into electricity (DOE 2020). There is also another process to acquire nuclear energy i.e., nuclear fusion but this reaction has tough operating conditions and require very high temperatures (Miller et al. 2009). Most of the reactions that takes place in nuclear reactors are nuclear fission reactions in which uranium or plutonium breaks down into lighter nuclei by releasing a tremendous amount of energy (IAEA

76
150

$I = 15$

$M = 15$

$R_{\Delta} = 27$

$C = 12$

$R = 7$

2006). The energy is released in form of electromagnetic radiations which are gamma rays and later these gamma rays are used to produce electricity (NNR 2015). But if the reaction goes uncontrolled then it can cause destruction.

The motivation behind the use of nuclear energy is that it produces a lot of energy upon fission reaction without having any harmful effects on the environment. Fossil fuels are one of the biggest sources of GHG emissions and renewable resources could lead to the prevention of climatic changes by fulfilling the demands of consumers.

Drivers behind energy system:

The drivers behind nuclear energy system are increasing energy and water demands, economics, insurance of energy price exposure and security of energy supply. All these factors are the major drivers that led to the development of nuclear energy system for the generation of electricity. The CO₂ concentration level is required to be kept between 450-550 ppm and it requires a pilot scale decarbonization of the global energy supply lines by improving or replacing the technologies with renewable energy resource (Global 2020)s. The current levels of carbon footprints in the environment are not sustainable due to increased focus on fossil fuels for the generation of electricity but the benefits and energy security obtained from nuclear energy will become a huge factor to be act as driver for nuclear energy system for electricity generation (International Atomic Energy Agency (IAEA) 2016).

Due to rapid industrialization, the world is in self-destructive mode and there is a need of moving towards sustainable development to keep our habitat habitable. These advancements create a lot of waste that comes from the industrial sector [1]. There is a need for treatment techniques to mitigate the harmful effects on the environment, but it has major drawbacks i.e., it is costly sometimes. A safer passage to meet our energy requirements would be the switch to nuclear source as it doesn't emit harmful gases and that is why it is termed green energy [2]. Although it has its pros and cons, which will be discussed later, it is a stake to a more sustainable future. Here we will discuss some stationary applications of nuclear energy which will shape the energy

sector of the future.

Generation of nuclear reactor: To get nuclear energy, a nuclear plant should be designed, and the core of any nuclear plant is the reactor. When a nuclear reactor is designed, safety, economics, sustainability, reliability, proliferation, and physical protection must be kept in mind. Economics is of more concern to the engineers as the plant itself has a very high capital cost and this factor deters nuclear energy and hence competition [3]. Sustainability has more concern with the disposal of nuclear waste. It is achieved by reusing nuclear waste and extracting maximum energy from the source, hence minimizing waste. At last, safety is as important as before mentioned factors. Working in a radioactive environment can cause serious harm to workers and the environment, hence it is of paramount importance [4].

Electricity production

Clean energy can be produced by nuclear power plants hence replacing the older methods like fossil fuels which generate harmful emissions. This clean energy can be used in electric vehicles and then we really would be able to reduce emissions from various sources or we can be delusional enough to call ourselves environmental enthusiasts by introducing electric vehicles and powering them with fossil-produced electricity.

Plant mutation breeding

Nuclear energy also finds its way into the agriculture sector. The process involves exposing a seed or a plant to radiation I.e., gamma rays which cause mutation in them. The mutation is tested for the desired properties and then allowed to grow [7]. Radiation method catalysis the natural process of mutation.

Fertilizers

Fertilizers are fancy yet important products and should be used effectively I.e., maximum

absorption by the plant than in the environment. The use of radioactive isotope I.e. nitrogen-15 can help to identify how much fertilizer is absorbed in the soil by a method called.

Industrial tracers

Maintenance and flow measurement can be done by short-lived radioactive isotopes. They are introduced in the flow stream and hence flow measurement and leaks can be detected via nuclear technology [6].

Desalination

In this era, where many developing nations face a clean water crisis, nuclear technology can be employed to circumvent this problem. Where pure water from streams and wells is not possible to get, the use of desalination can be of great help, even for areas along the coast [8]. Fossil fuel desalination has the same problem of harmful emissions. Desalination by nuclear technology will be the future of water production from impure sources [1].

Nuclear power and environment

Although nuclear power plants do not produce CO₂ or NO_x emissions as other fossil fuel-based power plants, the main concern is nuclear waste and the energy required to manufacture the plant.

We know that nuclear plants require huge capital to get designed and a lot of energy to construct the structure that would house the equipment. If that energy is obtained by burning fossil fuel, these emissions would be contributed to the energy produced by a nuclear plant.

Radioactive waste is another concern. It is comprised of spent nuclear fuel, uranium mill tailings, and other radioactive waste. This kind of waste cannot be taken for granted, and strict regulatory boards constitute rules and regulations to prevent the environment and the employees working at plant sites as this waste can stay radioactive for thousands of years.

Nuclear energy used in desalination is proving to be a helping hand to eradicate the water-stressed notion in different areas of the world. The problem arises from the waste that nuclear plant produces to provide energy and that energy then drives the desalination plants. We are providing humanity with clean water, but on the other, we are exposing them to radioactive waste. This seems to be a dilemma and, it should be dealt with prudence.

If we talk about nuclear technology in the agriculture sector, the main concern is the safety of the personnel working there in the testing labs. Plant mutation would bring evolution in this field, but the gamma rays can damage the surroundings if not contained or used safely. They would cause mutations in the seed and provide fast growth and innovative products. However, this may damage DNA and cause issues for the plant site.

When used in industries as industrial traces, care should be exercised even when dealing with short-lived radioactive isotopes. Proper standard operating procedures should be followed when discharging waste streams to the environment. If a small active quantity is discharged into the water or soil, it can decimate the marine life or affect the soil and underground water wells. Hence proper treatment would be necessary and strict regulations should be employed.

Contrary to the stationary applications of nuclear energy, nuclear energy has played a major role in influencing other forms of clean energy. A small percentage of nuclear energy is used for non-electric purposes such as desalination, which also help protect the environment by reducing carbon emission. Nuclear energy has the potential to influence the environmental impact of transportation through another form of sustainable energy. Nuclear energy is currently being studied as a method to supply power (electricity and heat) to hydrogen production plants. Since nuclear energy can produce power with little to no CO₂ emissions, it can replace fossil fuels used to power these plants [9]. Regarding transportation, hydrogen is currently being tested

to power vehicles [10]. In turn, this will reduce the carbon emission created by gas- and diesel-powered vehicles.

Also, the energy produced by nuclear power plants can allow for the rise of electric vehicles. By providing electricity to countries with rapidly increasing populations, nuclear energy can power public transportation such as trains and trolleys. It can also make way for the rise of electric vehicles by providing power to homes with vehicle charging stations. Doing so will propel the achievement of the world sustainable development.

Is the energy resource adopted in the energy system you are working with renewable, sustainable and reliable?

Is there any way you can improve on the energy system you are working with and make it more sustainable or more sustainable (sustainable: environmental, Economic, and Societal friendly)



Is nuclear energy renewable?

Renewable energy indicates that the energy people extract from nature will, in most cases, be replenished. Energy sources are deemed non-renewable if they require a very long time to develop, such as fossil fuels, or if their formation occurred a long time ago and is unlikely to occur again, such as uranium. Although it is true that the energy produced by nuclear power plants are renewable, the fuel required for it, is not.

Is the nuclear energy sustainable?

According to the United Nations definition, Sustainability is described as filling the demands of the present without jeopardizing future generations's ability to fulfill their own needs at their turn.

It would mean that everyone, everywhere is able to fulfill their fundamental requirements in

energy indefinitely. In the case of nuclear energy, it has been associated with sustainable development, meaning increase nuclear energy sustainability. This was introduced when the United Nations believed that nuclear energy could play a major role in their seventeen Sustainable Development Goals (SDGs) adopted at the UN Summit on Sustainable Development in 2015.

Is the nuclear energy reliable?

Nuclear energy is reliable and steady. In contrast to other energy sources considered in place of fossils such as wind and solar, nuclear power is accessible 24 hours a day, seven days a week. When unanticipated catastrophes disrupt the energy supply chain. Nuclear power plants are designed to resist natural disasters like tornadoes, hurricanes, floods, heat waves, and droughts, as well as record-breaking winter snow and ice. Demand for electricity skyrocketed during the 2014 polar vortex. When other plants failed, nuclear reactors worked wonderfully.

- Environmental

The mining of uranium is the most devastating environmental effect related with nuclear energy production. However, if fast reactors can become commercially viable, as it is projected in the coming years, the necessity for uranium extraction would be greatly reduced. In second, developing innovative technologies for recycling old fuel effectively would dramatically minimize the radioactive waste quantities. Some of them have already been tested and are in the final stages of development for commercial use. As an illustration, consider that the amount of radiation contamination in a site holding this sort of waste would be equivalent to that of natural uranium found all over the world after around 300 years. Reducing from a time scale of hundreds of thousands of years to a few hundred years. Another negative impact is the current commercial nuclear power reactors, cooling water needs. Named Light-Water Reactor, they use more cooling

water than the fossil fuel facilities. However, to fix this issue, future generation nuclear reactors will have running temperatures like those of fossil power facilities, demanding approximately the same amount of cooling water. They are called liquid-metal-cooled fast reactors.

- Economical

The economic competitiveness of future nuclear power plants concerns due to their high capital costs

can be fixed using the method used by the French. In France national energy program, nuclear fission

supplies almost 75% of the market, and the unit price of power is among the lowest in the world. Over

the course of two decades, France transitioned most of its electrical energy production from fossil-fuel

to uranium-based. They kept the cost of nuclear power plants low by producing them in a series of

identical units and limiting the necessary adjustments, which were done in a coordinated manner in all

facilities in a particular series. Furthermore, building delays, which can be highly costly, were avoided by

meticulous planning by both the government and the utility, including total disclosure to the public and

a quick licensing procedure that duly focused on the critical safety problems [2].

- Societal

Societal impact to sustainable development is ambiguous. While nuclear

energy contributes to energy security, local employment, and scientific advancement, it may also

be politically controversial many nations. Some of these feelings can be linked to military applications of nuclear energy, the popularization of its use to make nuclear weapons, as well as general worries about technological development and danger. The nuclear energy discussion must include public perception issues. Nuclear energy will need to gain a greater degree of social acceptance than it now has in many nations to satisfy sustainable development goals. The governments should inform the public regarding the process of using nuclear plants and also keep full disclosure of any use of nuclear. Furthermore, accords may be signed between nations to agree to a low usage of the nuclear energy to produce weapons if not completely restrain from doing it at all.

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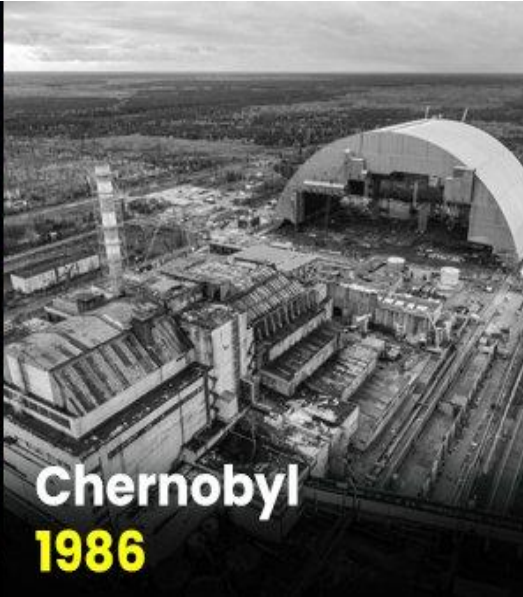
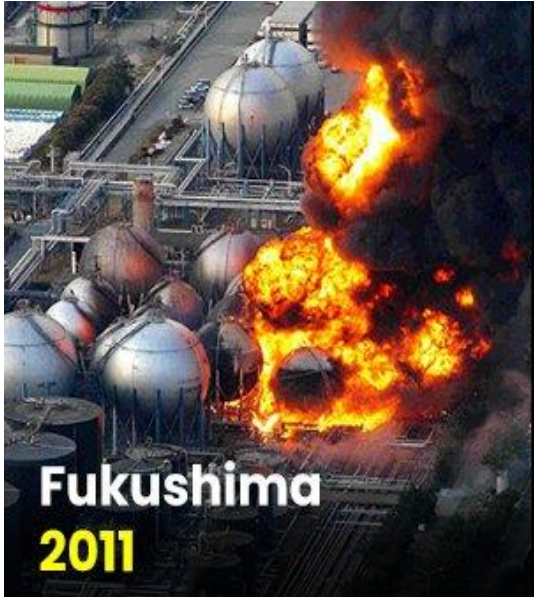
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Environmental Impact Nuclear Energy

Franck Nangomoko, Zenab Coulibaly-Diakite,
Cherish Vaughn, Shumpert Kirksey



Introduction



Introduction

- ❑ What is Nuclear Energy Power?
- ❑ How does Nuclear Energy affect us?
- ❑ Why Nuclear Energy Power?
- ❑ Is Nuclear Energy Power safe?
- ❑ Motivations/Drivers





Background

What is Nuclear Energy?

- ▶ Nuclear energy is a form energy released from the nucleus, the core of atoms are made up of protons and neutrons.
- ▶ The energy can be produced through fission.

Fuel Source Used?

- ▶ Uranium



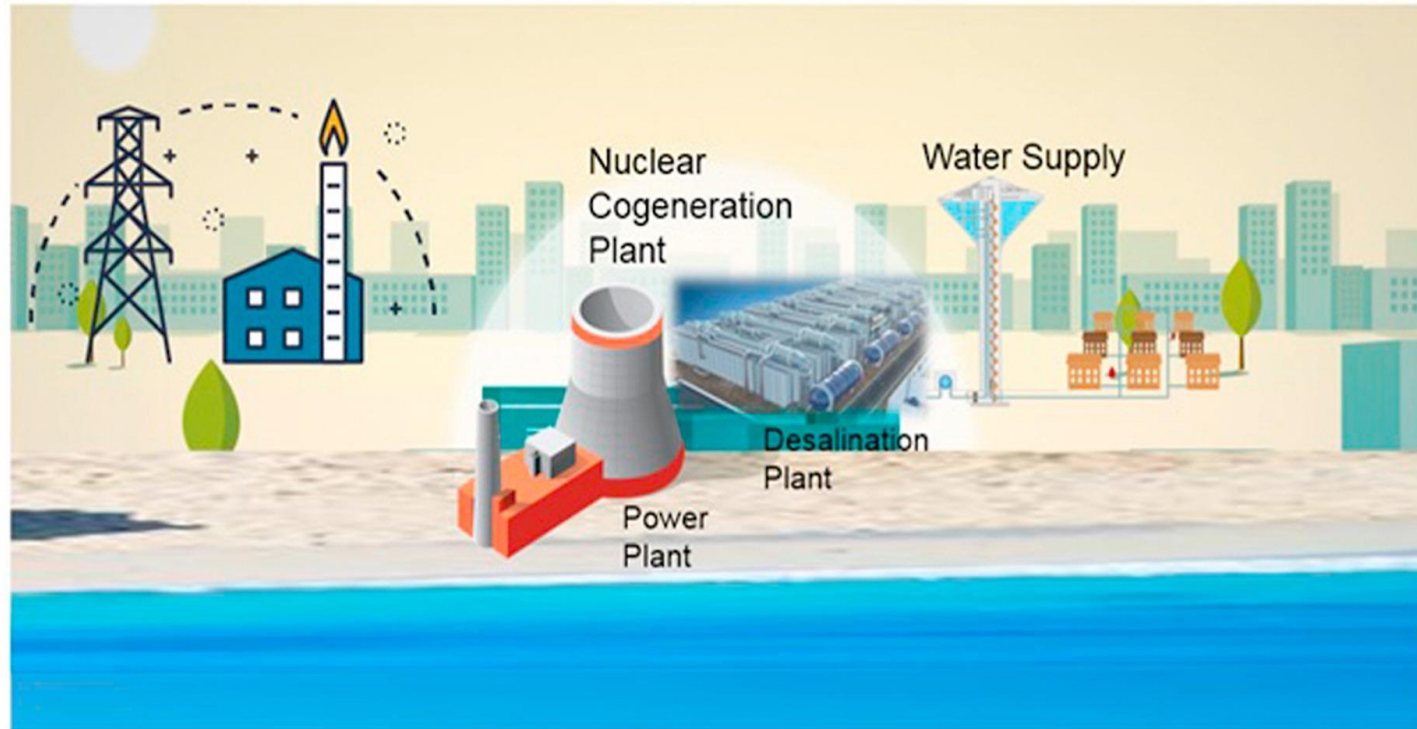
Techniques/ Tools

- ▶ Systems Tools
 - ▶ Demand Side Management
 - ▶ Combining Energy Production for Electricity and Transportation
- ▶ Economic Tools
- ▶ Hard engineering Tools
 - ▶ Thermodynamics I & 2
 - ▶ Separations

Applications

Stationary

- Electricity
- Desalination



Applications

Influence on Non-Stationary

- ▶ Hydrogen Production
 - ▶ Electricity and Heat
 - ▶ Palo Verde Nuclear Generating Plant
- ▶ Hydrogen Fuel Cell Vehicles (FCVs)
 - ▶ California
- ▶ Other modes of transportation
 - ▶ Trains/Trolleys



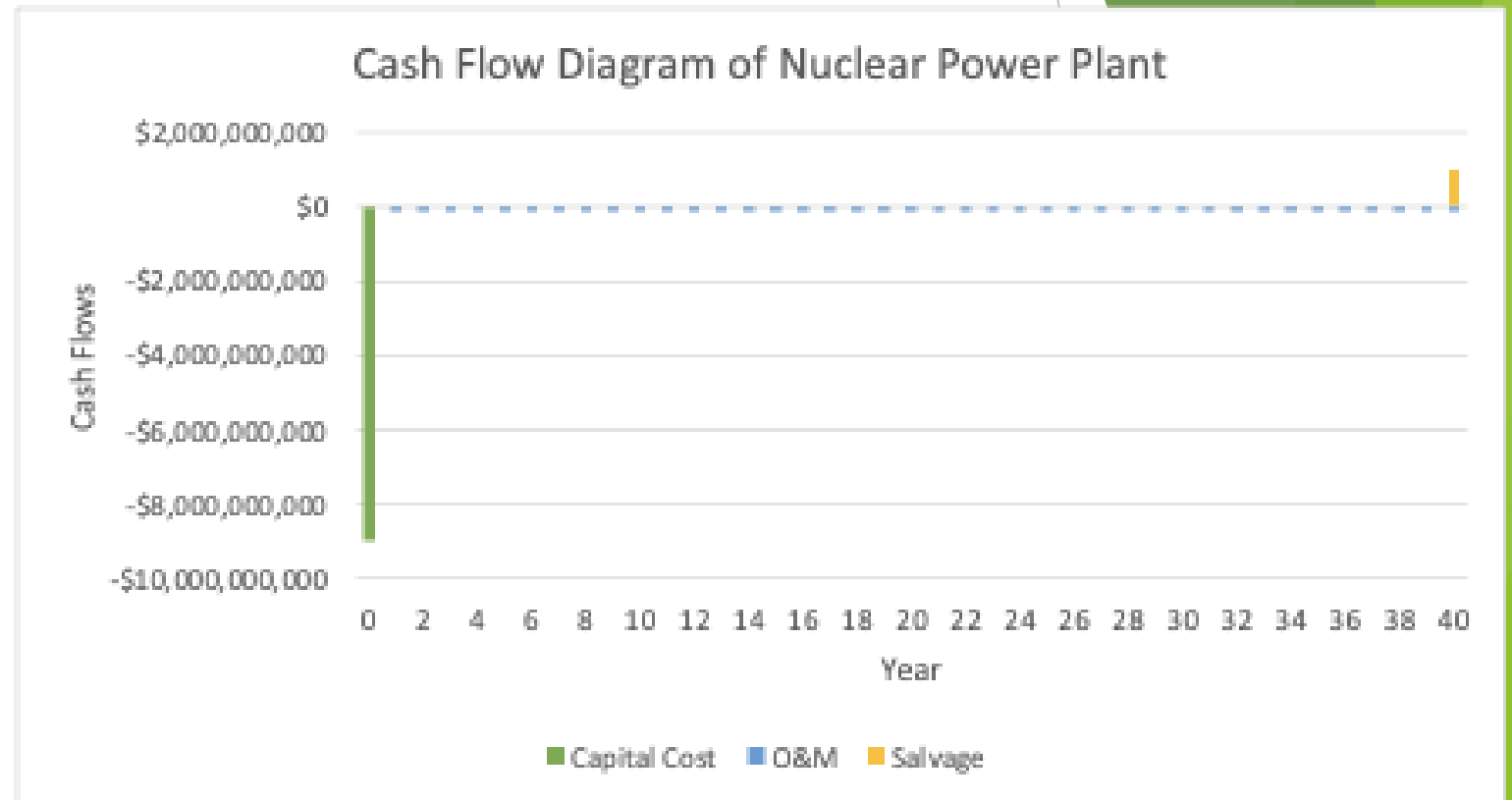
Cash Flow

- ▶ Plant Life: 40 years
- ▶ Discount Rate: 10%
- ▶ Capital Cost: \$9 billion
- ▶ Annual Benefit: \$542 million
- ▶ Annual Cost: \$682 million
- ▶ Salvage: \$1 billion



Cash Flow

- ▶ $PW = -9,000,000,000 + 542,000,000 (P/A, 10\%, 40) - 682,000,000 (P/A, 10\%, 40) + 1,000,000,000 (P/F, 10\%, 40)$
- ▶ $(P/A, 10\%, 40) = 9.779$
- ▶ $(P/F, 10\%, 40) = .0221$
- ▶ $PW = -10,346,960,000 = -10.3$ billion



Improvements

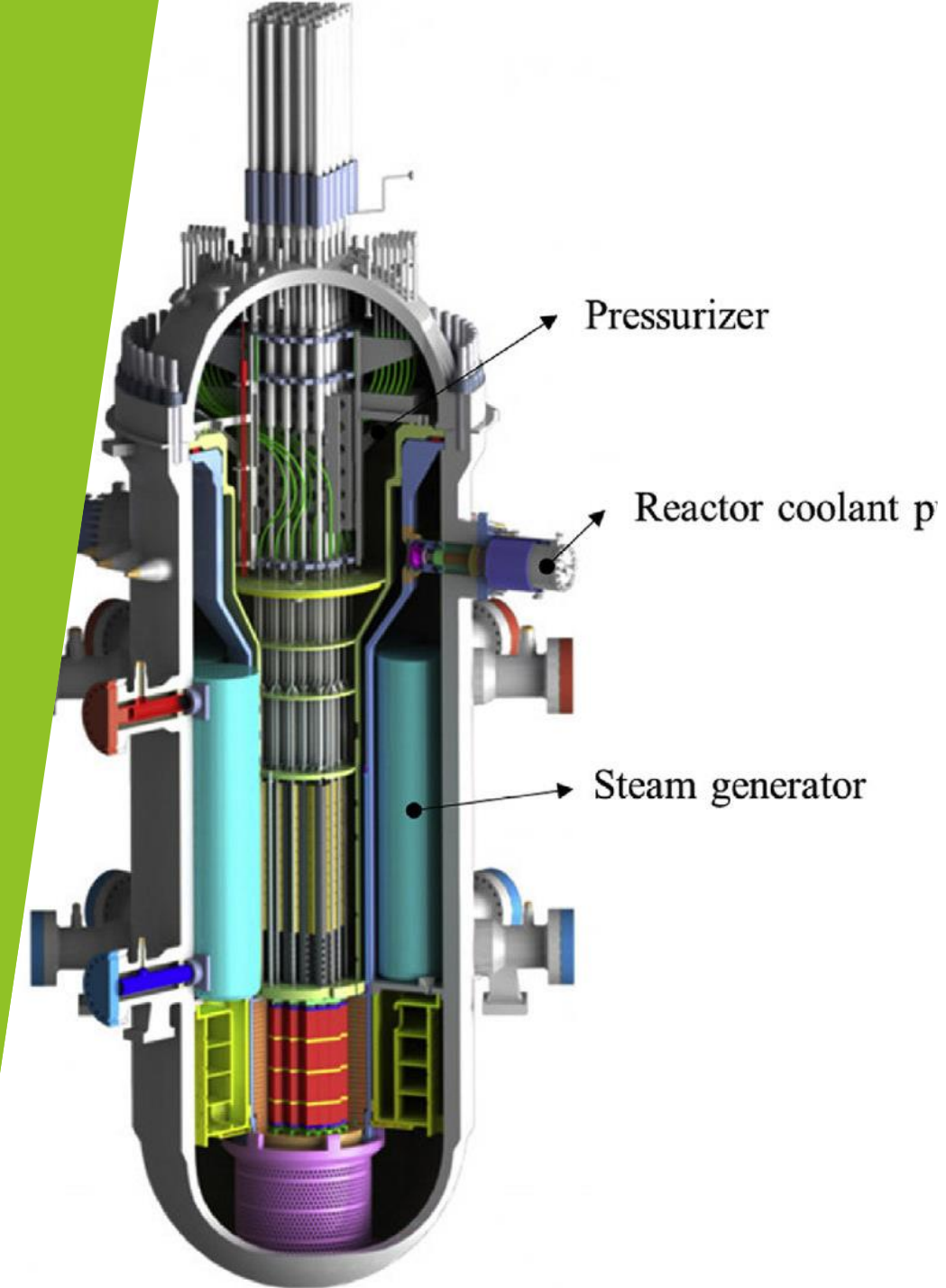
- ▶ Terra Power (Bill Gates)
- ▶ Natrium Reactor
- ▶ Less nuclear waste
- ▶ Liquid sodium
- ▶ Natrium technology
- ▶ Energy storage
- ▶ Molten salt-battery





Challenges

- ▶ Impact on Human life
- ▶ Public Awareness
 - I. Dangerous/unstable
 - II. Global nuclear accidents
 - III. Miss use of nuclear energy
- ▶ Constructing New power plants
- ▶ High operating costs
- ▶ Fuel Availability/Raw material
- ▶ Nonrenewable



Recommendations

- Small Modular Reactors (SMR)
 1. Modularity (scalability)
 2. Eco friendly
 3. Greater efficiency
 4. Construction time and financing



Conclusion

- ▶ Is the nuclear energy renewable?
- ▶ Is the nuclear energy sustainable?
- ▶ Is the nuclear energy reliable?
- ▶ Sustainable Development:
 - ▶ Environmental
 - ▶ Economical
 - ▶ Societal

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Questions