Nigerian Chemical & Engineering Industry MAGAZINE

A Four-Monthly Publication of Nigerian Society of Chemical Engineers
(A Division Of Nigerian Society Of Engineers)

November 2022 - February 2023 | Vol. 5 No. 2 Edition

Profile of NSChE President

Engr. Anthony Ogbuigwe, *FAEng, FNSE, FNSChE*
NSChE President, 2023

Decarbonizing the World's Energy Mix

Engr. Elozino Olaniyan, *FNSE, FNSChE*
(GM, Safety & Environ., Shell Nigeria)

Skills in Modern Chemical Engineering Practice

Prof. Idris Bugaje, *FNSChE*
Executive Secertary, NBTE

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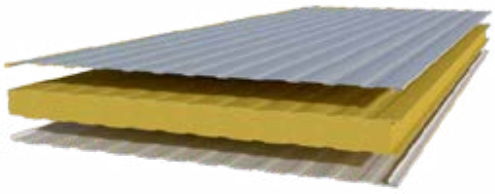

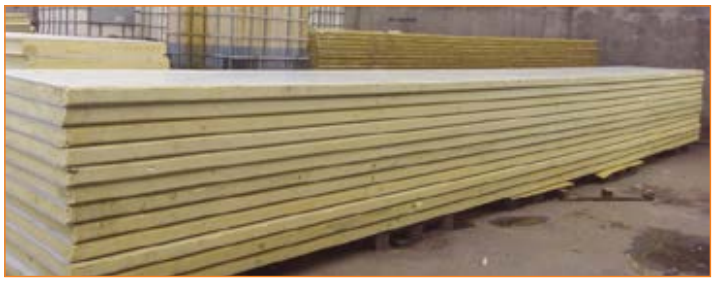

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NSChE VISION

"To be the Center of excellence for the Chemical Engineering Profession in Africa and the Prime Mover of Industrialization in Nigeria".

NSChE MISSION

"To organize the Nigerian Society of Chemical Engineers into a virile professional body capable of promoting the relevance and versatility of the profession, achieving better training and updating of Chemical Engineers through its activities. Fostering of relationships with the academia, research institutes, industries, other professional bodies and government will be the basis for stimulating accelerated industrialization of the country and improving the quality of life of the Nigerian people".

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The views and opinions expressed in this Magazine do not necessarily reflect those of NSChE.
"Nigerian Chemical and Engineering Industry" Magazine is produced
three times a year by SENDINA LIMITED for
Nigerian Society of Chemical Engineers.

Producer's Office: Sendina Limited: Plot 22b, Kola Olosan Street, Ofada (Via Mowe), Ogun State, Nigeria. Tel: +234(0)7060545011, 09065913181, 09055181454 Email: sendina7x@gmail.com

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Prof. Bugaje

FROM THE *Editorial* SUITE

Engr. Donatus Uweh, *MNSChE*
(Editor-in-Chief)

It is always a thing of delight for us to come up with each edition of our well read magazine. In line with our tradition and commitment, this edition offers very educative presentations to our teeming readers.

You will be excited to read the profile of Engr. Anthony Ogbuigwe, FAEng, FNSE, FNSChE who is now on the saddle as the 23rd National President of Nigerian Society of Chemical Engineers (NSChE). The Society's Fellows and Members welcome him with his track record of excellence which is expected to be manifested in this new leadership position. We wish him a successful two-year tenure.

Clean energy is at the front burner as a global concern. The NSChE Executive Secretary, Engr. Anthony Ogheneovo, FNSChE, presents his thoughts on the subject with an outlook peeping into 2030.

NSChE conducted its Annual Conference/AGM in Ilorin in November 2022. This edition of our magazine serves our readers with the communiqué issued at the end of the event as well as the memorable pictures.

Shell is often referred to as 'Energy Giant'. In this edition, Engr. Elozino Olaniyan, FNSE, FNSChE, General Manager, Safety & Environment, Shell Companies in Nigeria, presents a thought-provoking material entitled **"De-carbonizing the World's Energy Mix."** There is no doubt her wealth of experience in the 'Energy Giant' is brought to bear in her presentation. Another presentation is the one on **"Skills in Modern Chemical Engineering Practice"** by Prof. Idris Bugaje, FNSChE, Executive Secretary, National Board for Technical Education. There is no gainsaying that skills acquisition is now gaining prominence in national discourse in various levels of education. The presentation by Prof. Bugaje is instructive in this regard. Indeed the some of the contents apply not only to Chemical Engineers but also other engineers as well as non-engineers. Another spectacular placement in this edition is **"Special Spotlight on Matrix Petro-Chem Limited."** This company is headed by Engr. Dr. John Erinne, FAEng, FNSE, FNSChE.

His entrepreneurial prowess is brought to bear in the successful commissioning and operation of a lubricating plant in Port Harcourt, Rivers State. The success story is an eye opener to Chemical Engineers in particular and would-be entrepreneurs (or technopreneurs) in general. We wish the company greater successes in the years ahead as it consolidates on the marketing of its quality brands of lubricants and other products in its portfolio.
Finally, we thank all the contributors who made the publication of this edition successful.

"In line with our tradition and commitment, this edition offers very educative presentations to our teeming readers."

Please relax and read to your delight.

Engr. Donatus Uweh, *MNSChE*
(Editor-in-Chief)

BRIEF PROFILE OF ENGR. ANTHONY OGBUIGWE, *FAEng, FNSE, FNSChE*

Engr. Anthony Ogbuigwe is the current National President of Nigerian Society of Chemical Engineers. He has had over 40years experience in the Oil and Gas Industry including senior positions in the Nigerian National Petroleum Corporation (NNPC) Group and in Nigeria Liquefied Natural Gas (NLNG) Company. He is currently the National President of the Nigerian Society of Chemical Engineers.

He was the Executive Project Manager Nigeria LNG Ltd from 2002 to 2010, responsible for managing the construction of LNG Trains 4, 5, and 6 which together produce about 12.6million tons per annum of liquefied natural gas (LNG). Thereafter, he became the Managing Director, Port Harcourt Refining Company (PHRC) from February 2010 till June 2012. He was then appointed Group Executive Director, Refining and Petrochemicals of the Nigerian National Petroleum Corporation (NNPC) until December 2013 before retiring statutorily and meritoriously.

In recognition of his wide ranging experience and expertise, he was elected President of the African Refiners and Distributors Association (ARDA) in March 2013, a position he held until 2014. Since then, he has continued to function as an Advisor to the Association for the ECOWAS Region. This Association is the voice for the entire Petroleum Refineries and Downstream petroleum marketing and distribution sector in Africa. They have championed investment in infrastructure, improvement of the efficiency of the sector and the quality of petroleum products produced and sold in the continent.

Engr. Anthony Ogbuigwe

He is a Fellow of the Nigerian Academy of Engineering, the Nigerian Society of Engineers, the Nigerian Society of Chemical Engineers and the British Institution of Chemical Engineers. In a special role as Senior Ambassador, he served to foster cooperation between the NSChE and the IChemE. He is also the Chairman of the Board of the Centre for Gas, Refining and Petrochemicals Studies of the University of Port Harcourt, through which he continues to foster cooperation between Academia and Industry to produce graduates that meet the needs of Industry.

He is happily married to Dr. Mrs. Akpezi Ogbuigwe and they have children and grandchildren.

"In recognition of his wide ranging experience and expertise, he was elected President of the African Refiners and Distributors Association (ARDA)..."

CLEAN ENERGY PLANS FOR NIGERIA BY 2030

***Engr. Anthony Ogheneovo**, FNSChE*
(Executive Secretary, NSChE)

Clean energy is energy that comes from renewable, zero-emission sources that do not pollute the atmosphere when used and the good news is that Nigeria is blessed with renewable energy resources like wind, solar, biomass and hydropower. Nigeria's primary energy carrier is biomass (81.25%), followed by natural gas (8.2%), petroleum products (5.3%), crude oil (4.8%), hydropower (0.4%), and others (< 1%). Nigeria committed to net-zero emissions by 2060 and the availability of clean energy sources makes the commitment not so daunting. A recent article published in Climate Policy shows that standalone solar and hybrid mini-grids could provide modern energy access to over 88 million Nigerians by 2030.

However the question of access remains as Nigeria has continued to struggle to meet the energy demands of its citizens. Despite privatisation of the power sector in 2013, things have not improved and some reports say the sector has deteriorated even more. If Nigeria can't meet demands with its current capacity, how will it tackle the challenge of generating and distribution of clean energy?
An estimated 85 million people lack access to electricity, and 176 million people lack clean cooking fuels or technologies.

The country's power system is characterised by a massive gap between supply and demand. The current power demand is estimated at 17,520MW, including latent and suppressed demand, against 5,300MW peak generation capability. Despite the 13,000MW installed capacity almost a decade after the sector was privatised, power generation still hovers just around 5,000 MW.
To bridge this gap, Nigeria plans to generate 30,000MW by 2030, and 3,000MW (10%) of the promised increment will be from renewable energy sources to serve its over 200 million people.
Renewable energy is touted as one of the ways to bridge the energy supply gap in Nigeria as well as drive sustainable development especially for disadvantaged groups.
The book, Financing Climate Futures: Rethinking Infrastructure posited that a clean energy revolution is needed urgently in sub-Saharan Africa to win the fight against energy poverty, promote robust development, and make it more sustainable. "Clean energy can unlock sustainable economic growth, improve human health and well-being and enable women and children to lead more productive lives. "It will also raise human security and build resilience in nation-states and communities."

During the COP26 summit in Glasgow, President Buhari pledged that Nigeria would cut its carbon emissions and reach net-zero by 2060. He also underlined the crucial role of gas in the country's energy transition roadmap. The federal government committed to delivering and maintaining 5 million new solar connections under a 'solar power strategy' as Nigeria's plan.
This strategy is expected to support 250,000 new jobs and impact up to 25 million beneficiaries. The plan will also support the upstream value chain by promoting the large-scale assembly of solar components in Nigeria. The Federal Government has also said it would distribute 10,000,000 cylinders of the Petroleum Liquefied Gas into circulation nationwide to increase access to the commodity.

Some of these initiatives are tied to the Sustainable Energy for All Agenda which Nigeria, alongside 44 other African countries signed on to to advance sustainable energy and increase access for all Africans.

Data on Sustainable Development Goal 7 (SDG7) – shows that progress in Africa is not yet on track to meet global targets. An estimated 565 million people still lack access to electricity, while 900 million lack clean cooking solutions. The covid 19 pandemic only expanded the deep divide in Africa on energy access progress.

For Nigeria, Covid-19 led to, among other things, supply disruptions and falling investments in the Nigerian off-grid renewable energy sector, with adverse implications for energy access goals. The pandemic induced lockdowns highlighted more than ever the energy poverty challenges across the country.

Nigeria is said to be one of the fastest growing markets for solar, and is the 5th largest market in terms of volume of solar products sold although the Nigeria Solar Report puts the contribution of solar to energy generation in Nigeria at a mere 1.1%.

Individuals have increasingly turned to solar energy to reduce the burden of powering fuel and diesel generators on which Nigerians spend about $25bn annually.
Unfortunately, 95% of solar energy equipment (Solar Panels, Inverters, Charge Controllers, Batteries etc.) is still largely imported. About $150m worth of solar equipment were imported into the country in 2019 and China is the biggest supplier of solar equipment to the country. So, when the pandemic hit and countries were shut in, the supply of solar energy equipment dried up.

Governments worldwide launched large-scale fiscal stimulus packages and expansionary monetary policies to counteract the pandemic-induced economic downturn. These packages and policies captured "green" investments, including renewable energy, to offset the drawback on net-zero emissions goals.

Reference: Int'l Renewable Energy Agency (IRENA)

COMMUNIQUE OF THE 52ND ANNUAL CONFERENCE/ ANNUAL GENERAL MEETING OF THE NIGERIAN SOCIETY OF CHEMICAL ENGINEERS

(A DIVISION OF THE NIGERIAN SOCIETY OF ENGINEERS)

THEME:

"REJUVENATION OF THE NIGERIA INDUSTRIAL SECTOR: THE CHEMICAL ENGINEERING PERSPECTIVE"

HELD 10 - 12 NOVEMBER, 2022 AT DE-PEACE HOTELS & SUITES, ILORIN IN KWARA STATE

The 52nd Annual Conference/Annual General Meeting (AGM) of the Nigerian Society of Chemical Engineers (NSChE) was hosted by the Oyo/Osun/Kwara Chapter. The theme was: "Rejuvenation of the Nigerian Industrial Sector: The Chemical Engineering Perspectives". The hybrid Conference featured keynote addresses, plenary speeches, technical sessions and social events like sports, spouse programmes and the Fellows investiture, dinner and awards night. The keynote speaker at the opening Ceremony was the Executive Governor of Kwara State, represented by the Alahaji Okanlawon Olanrewaju Musa, Permanent Secretary, Ministry of Solid Mineral. Prof. Mamma Shaaba Jibril, the Secretary to the State Government represented the Governor of Kwara State during the visit of some Past Presidents of the Society, Board members and some members of the Local organizing committee. Other notable dignitaries at the conference include:

- Dr. Johnson Adewumi, the Proprietor of Johnson Adewumi University was the Chairman of the opening ceremony.
- Mr. Taiye Willams, the Managing Director of LUBCON, Ilorin
- Prof. S. S Adefila, who chaired the opening ceremony
- Present and Past Presidents of the Society
- Representative of the President of COREN
- Fellows of the Society and other dignitaries.

In addition to the three (3) keynote presentations on the main theme, seventy two (72) papers delivered under various sub-themes framed the deliberations of the Conference. The hub of these deliberations is the pursuit of re-inventing Nigeria's ailing industrial sector through capacity building, process development, and economic networking for sustainable competitiveness in the emerging world.

In both developed and developing economies, Chemical Engineers have been identified as catalysts of economic survival. They have reputation for developing and troubleshooting process systems which is why almost all process facilities heavily rely on their expertise to increase productivity and improve product quality safely and economically. In reference to the above, the participants within the conference period x-rayed the past, present and future of the Nigerian industrial sector within the context of the current challenging global economy. This is to put forward technical and feasible decisions that are capable of birthing a new frontier of the sustainable, competitive and profitable industrial sector in Nigeria.

Therefore, the participants in the Conference:

a. congratulate the NSChE for successfully organising the 52nd International Conference and Annual General Meeting dedicated to addressing the challenges of Industrialisation in Nigeria;

b. applaud the recent development in the oil and gas industry of Nigeria and globally ranging from the Petroleum Industry Act (PIA) and the emerging energy transition discourse. Energy transition discourse should however revolve around the implementation of a fair, equitable and sustainable energy mix that entrenches the principles of inclusiveness and guarantees energy security

c. identified the following seven solutions to ensure effective governance for industrial progress:

   i. reduce the scope of the state: quality of public services and its independence from politics,

   ii. invest more deliberately in infrastructure for industrial manufacturing,

   iii. redouble efforts on industrialization and building technological innovation capacity,

   iv. economic diversification in deeds not words,

   v. prioritize the security of agricultural and industrial assets,

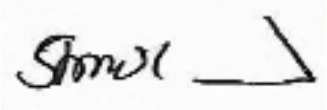
   vi. the credibility of the government's commitment to visions and industrial policies; and

   vii. bridge the trust deficit between the government and citizens.

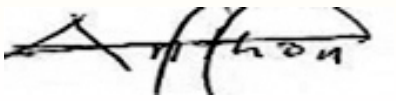
d. acknowledge the prospect of Nanotechnology in the fourth Industrial Revolution and the need for commercialisation of the research outputs from the various Educational Institutions under the Society to enhance global outlook and more economic reward; and

e. resolve to work together to surmount the real challenges hindering the growth and relevance of the Nigerian Industrial sector for continental relevance within a globally competitive environment.

For: Nigerian Society of Chemical Engineers



Engr. Saidu Aliyu Mohammed, *FNSE, FNSChE*
National President, NSChE (2022)



Engr. Ogheneovo Anthony, *FNSChE*
Executive Secretary, NSChE

PHOTOS OF NSChE'S 52ND ANNUAL CONFERENCE/AGM

2022 NSChE Fellowship Investiture by the National President, Engr. Saidu Aliyu Mohammed

2022 NSChE Fellowship Investiture by the National President, Engr. Saidu Aliyu Mohammed

Election of new board members for the year 2022/2023 by past presidents of NSChE

Award of plaque to Lagos/Ogun chapter for winning 2022 NSChE Dynamics For Chapters.

A cross section of attendees of a parallel section at the 2022 NSChE Annual Conference

Lunch break at the 52nd Annual Conference of NSChE

Registartion for the 2022 Annual General Meeting of NSChE at Depeace Hotel, Ilorin.

Cross section of members of NSChE attending the Annual General Meeting.

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DECARBONIZING THE WORLD'S ENERGY MIX: THE CHEMICAL ENGINEERS' ROLE

Engr. Elozino Olaniyan, *FNSE, FNSChE*
(GM, Safety & Environment, Shell Nigeria)

DECARBONIZING THE WORLD'S ENERGY MIX; THE CHEMICAL ENGINEER'S ROLE

Engr. Mrs. Elozino Olaniyan, FNSE, FNSChE
GM Safety & Environment, Shell Companies in Nigeria

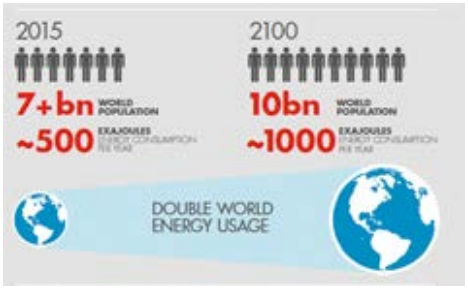
The Nigerian Society of Chemical Engineers
Lagos/Ogun Chapter

OUTLINE

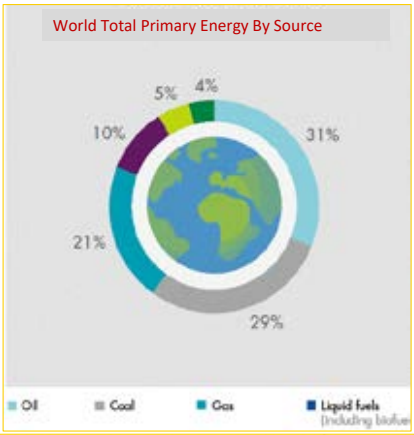
- The Global Energy Challenge
- The Energy Transition
- Emission Reduction Strategy
- The Nigerian Challenge (opportunity)
- The Chemical Engineer's Role
- Key Takeaways

2

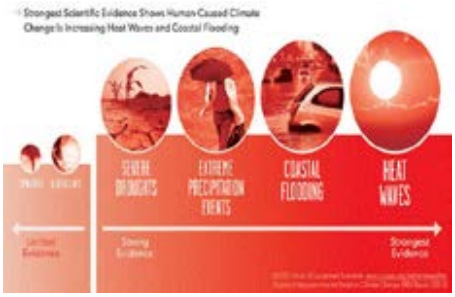
The Global Energy Dilemma



Source: IEA, Key world statistics 2015 and World energy outlook 2015



Source: International Energy Agency, Key world energy statistics 2015 and World energy outlook 2015



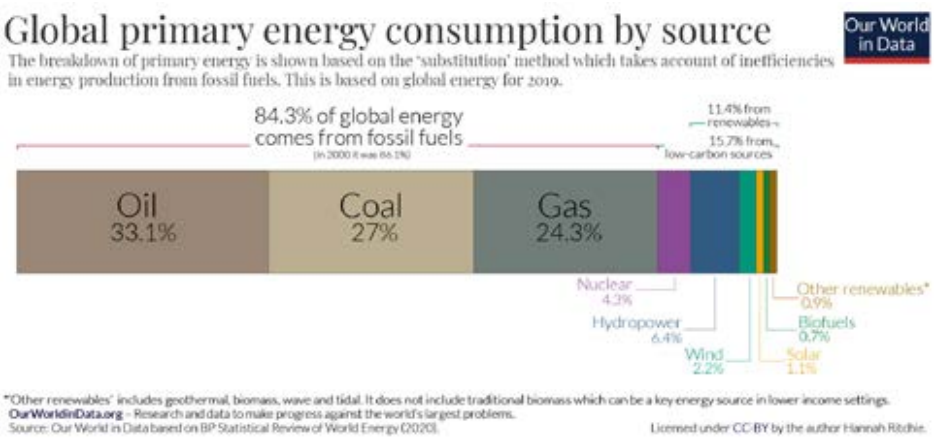
Source: CNN

How can we meet the increasing world energy demand without increasing emissions in the atmosphere that can result in irreversible climate conditions?

What happens if we remove fossil fuel today?

Almost everything in the modern world is either made from oil derivatives or uses oil-based energy to produce and transport it!

Energy Transition : Creates an opportunity for technological intervention



What it is...

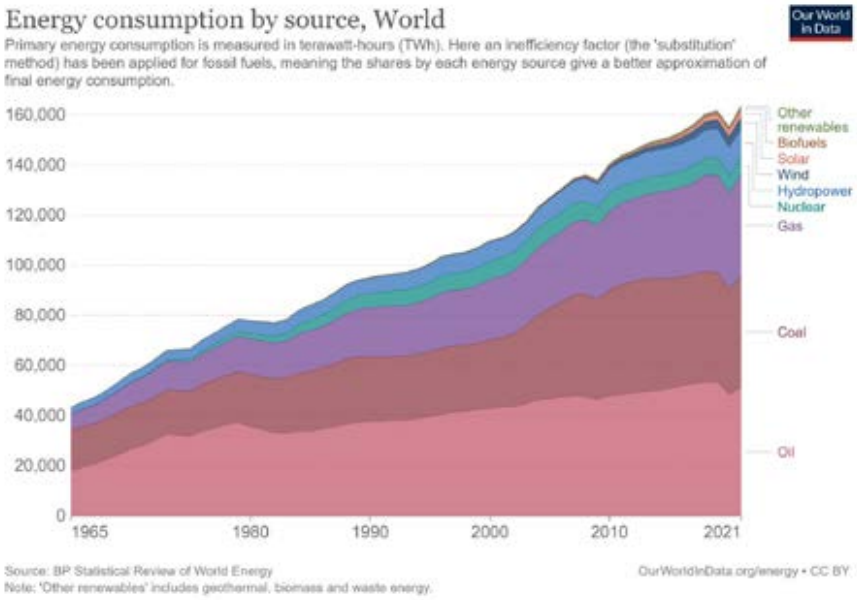
- A complex, multi-dimensional change
- Achieving net zero emissions
- Good for people and the planet
- A gradual replacement of fossil fuels with renewable energy (GREEN) source that will be time and research intensive

What it is not...

- Going to be easy to achieve.
- A total elimination of oil and gas.
- Going to be achieved by words alone.
- Achievable instantaneously

5

The World's Energy Mix

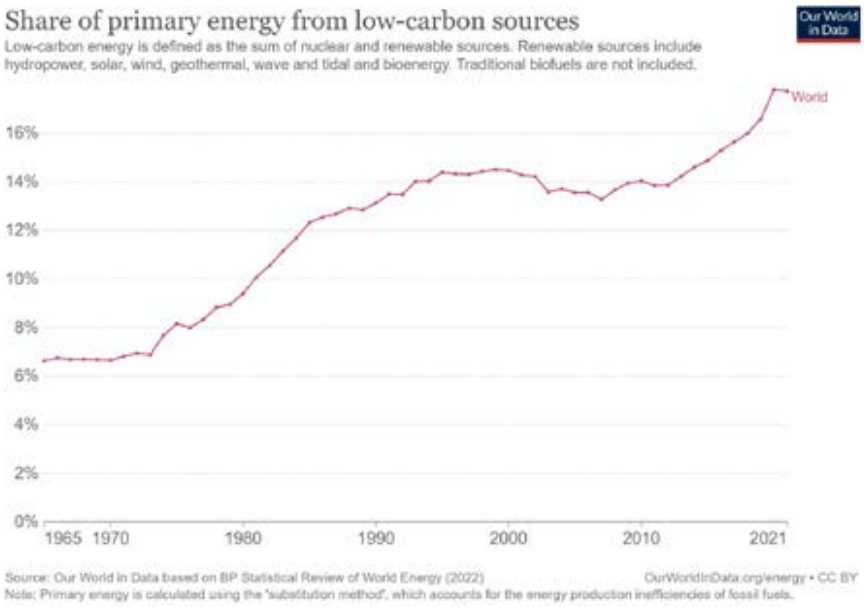


The global energy mix is still dominated by fossil fuels – accounting for more than 80% of energy consumption.
However, we've certainly made progress since half a century ago: while the global consumption of energy increased 3.8-fold, the share of low carbon sources has more than doubled.

Alternative sources/Renewable technology need to be more competitive and efficient than Fossil fuels to overtake them – cost, applicability, accessibility.

6

The World's Energy Mix



- A small portion of our energy currently comes from low-carbon sources, currently ca 20%
- We have seen a step change in recent years, but is that sufficient?
- How can we contribute to the steady rise of low carbon energy sources and thereby solve the energy transition dilemma

7

New Technologies must embrace Emission Reduction Strategies

AVOID

First, **avoid** creating carbon emissions wherever possible.

- New Energy Systems
- Solar, Wind, Hydro
- Hydrogen
- Tidal, Nuclear, Geothermal

REDUCE

Then **reduce** emissions that cannot be avoided.

- Operational Efficiency
- Natural Gas Shift
- Low Carbon Fuels – biofuels, Sustainable Aviation Fuels (SAFs)
- Energy Efficiency

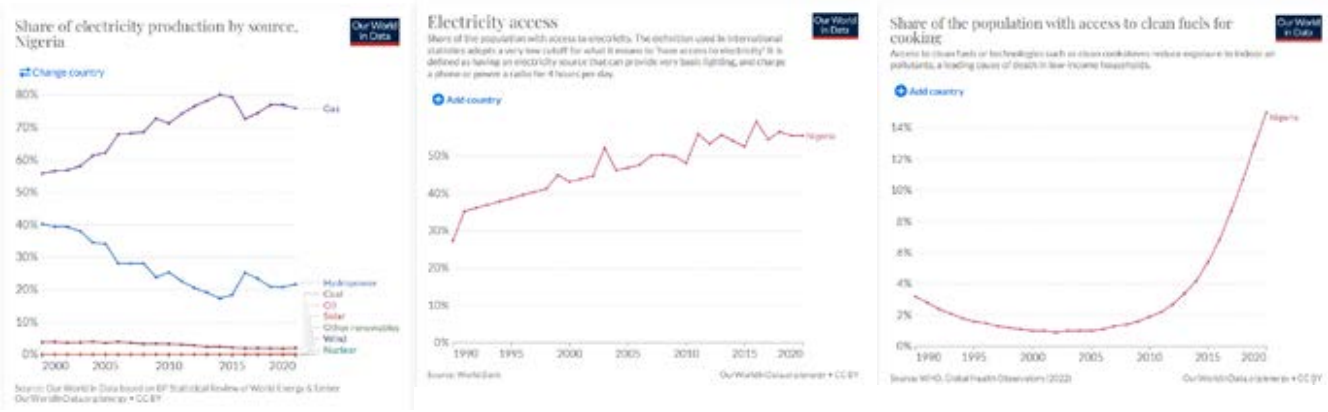
COMPENSATE

Then **compensate** the emissions you can't avoid or reduce to zero.

- Carbon Capture, Utilization and Storage
- Nature Based Solutions
- Carbon Trading

8

The Nigerian Challenge (or Opportunity)



- Nigeria has its peculiar challenges, which can be translated into opportunities
  - Only 50% of our population have access to basic Electricity
  - Only 14% have access to clean cooking fuels

The Chemical Engineer's Role

Research and Development

- No/Low Carbon Energy Systems – biofuels, SAF, etc.
- Recyclable Technology
- Carbon Capture, Utilization and Storage
- Waste Management

Creative Technological Solutions

- Recyclable Technology
- Energy Efficient Products – fuel conservation,
- Energy Storage and Transport
- Nuclear Power

Emission Reduction Integration

- Adopt Renewables for Chemical Production/Operation/Processes
- Operational Efficiency
- Reduced Industrial Emissions
- Nature Based Solutions

KEY TAKEAWAYS

- We have a global challenge to meet the increasing energy demand without increasing carbon emission in the atmosphere.
- This is driving a transition to a Low-Carbon Energy System.
- Energy Transition is a journey to Net Zero Emissions
- The Emission Reduction Strategy is to Avoid, Reduce and Compensate
- The Energy Transition will require realism, vision and collaboration
- Nigeria presents an opportunity for Chemical Engineers
  - Research & Development, Technological (and economical) Solutions that align with the Emission Reduction Strategies and contribute to national development
  - Creating sustainable businesses that meet the needs of an energy starved population

11

- **How do we contribute to decarbonizing the World's Energy Mix?**
- **How do we contribute to decarbonizing Nigeria's Energy Mix?**

12

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SKILLS IN MODERN CHEMICAL ENGINEERING PRACTICE

PAPER OF A DISCUSSION ORGANISED BY NSCHE, KADUNA STATE CHAPTER AT ABU, ZARIA, 14/01/23

BY PROF. IDRIS MUHAMMAD BUGAJE, *FNSChE*
EXECUTIVE SECRETARY, NATIONAL BOARD for TECHNICAL EDUCATION (NBTE)

Prof. Idris M. Bugaje

1.0 INTRODUCTION

Chemical engineering is a dynamic and rapidly evolving field that plays a crucial role in many industries, including energy, pharmaceuticals and consumer goods. The practice of chemical engineering has undergone significant changes in recent years, with new technologies and techniques emerging rapidly.

2.0 WHO IS A CHEMICAL ENGINEER?

The design and operation of process plants where raw materials are converted into finished and semi-finished products, involving physical and chemical processes, as well as improvement of these production processes, is what chemical engineering is all about. Until the end of the 20th century, it was the youngest and most practicing branch of the engineering profession, but now overtaken by others. Many universities no longer offer it as a course, but rather its components, such as Biotech Eng. (UIA), Polymer Eng. (U-Zagreb), Energy Eng. (UTM), Bioprocess Eng. (KECK Grad Inst. CA), and others.

3.0 DIVISION OF LABOUR IN CHEMICAL ENGINEERING

In Chemical Engineering, the division of labour refers to the different levels of education and training required for different roles within the field. The different roles include:

- **Engineers** - Holders of BEng Hons (Chemical) are considered engineers. They have typically completed a five-year Bachelor's degree in Chemical Engineering and have a strong foundation in the field's theoretical and practical aspects. They are responsible for designing, developing, and managing complex chemical processes and systems.

- **Technologists** - HND graduates (Chemical) are considered technologists. They have completed a two-year Higher National Diploma in Chemical Engineering and have a good understanding of the practical applications of chemical engineering. They typically work in technical roles and are involved in implementing and maintaining chemical processes and systems.

- **Technicians** - ND graduates (Chemical) are considered technicians. They have completed a two-year National Diploma in Chemical Engineering and have a basic understanding of the field. They typically work in support roles, assisting engineers and technologists with implementing and maintaining chemical processes and systems.

- **Craftsmen/Master-Craftsmen** - NTC/ANTC holders are now NSQ levels 1-9. They have completed a trade or apprenticeship program in Chemical Engineering and have practical skills and knowledge of specific aspects of the field.

"The practice of chemical engineering has undergone significant changes in recent years, with new technologies and techniques emerging rapidly."

They are responsible for hands-on tasks, such as fabrication, installation, and maintenance of chemical equipment and systems.

Each of these roles requires different levels of education and training, but all are essential to Chemical Engineering. Together, they form a comprehensive system of knowledge and skills that are required for the successful operation of chemical processes and systems. Crossover and cross-fertilisation are necessary among these four categories.

4.0 MAJOR RECENT CHEMICAL ENGINEERING PROJECTS IN NIGERIA AND THE ROLE PLAYED BY CHEMICAL ENGINEERS

Chemical engineers by training have the knowledge and capacity to be involved in designing, developing and implementing chemical engineering projects such as the Dangote Refinery, BUA Refinery, Dangote Fertilizer Plant, Ajaokuta – Kaduna – Kano (AKK) Gas Pipeline Projects, the upcoming Trans-Saharan Gas Pipeline and Kolmani Oil and Gas fields in Nigeria. See Fig. 1 and Fig. 2.

"...comprehensive system of knowledge and skills that are required for the successful operation of chemical processes and systems. Crossover and cross-fertilisation..."

Fig. 1: Dangote Refiney in Lekki, Lagos.

Fig.2: Ajaokuta – Kaduna – Kano Gas Pipeline.

Overall, chemical engineers play critical roles in designs, developments and operations of chemical engineering projects in Nigeria, working to ensure that these projects meet all the required standards and are optimised for efficient and safe operation.

5.0 SKILLS IN CHEMICAL ENGINEERING PRACTICE

5.1 SOFT SKILLS

i. **Mentoring Co-Workers:** Chemical engineers use mentoring co-workers as an effective tool in modern Chemical engineering practice. This is because mentoring enables professionals to share their knowledge, experience and skills. This can be an invaluable source of learning and development for both the mentor and the mentee. Mentoring can also allow chemical engineers to share ideas and solutions to common problems, collaborate on research projects. Mentoring co-workers is a vital tool for modern Chemical engineering practice that can help improve the quality of work, promote innovation and foster strong team dynamics.

ii. **Creativity:** Chemical engineers have a unique skill set that allows them to use creativity to solve complex problems in modern Chemical engineering practice. One way in which chemical engineers use creativity is by developing new technologies. Chemical engineers use their knowledge of the properties of different substances and their chemical interactions to develop new methods of production and ways to produce products. Chemical engineers use creativity to develop new processes and designs.

Chemical engineers use their creativity to solve complex problems in modern Chemical engineering practice.

iii. **Communication:** Communication is an essential tool for chemical engineers in today's practice. It enables them to effectively collaborate with other professionals and present their ideas, opinions and solutions to problems. By communicating their plans and proposals, chemical engineers can ensure that their projects are understood.

Finally, communication is essential to the safety process, as it can help prevent accidents and ensure that the proper safety protocols are observed. Chemical engineers must be able to accurately explain their Chemical engineers use problem-solving to identify, assess and develop the most suitable solutions to the problems that arise. They must design, develop and apply the most appropriate strategies to address the problem.

iv. **Problem Solving:** Chemical engineers use problem-solving in the development of

new products and systems. By analysing the industry's requirements, they can develop solutions that meet the needs of their clients. This may involve creating materials that are more resistant to corrosion, more efficient in energy consumption or better suited to a particular application.

"In order to design, operate and maintain chemical plants optimally, chemical engineers must be proficient in a wide range of ICT skills, including programming, Computer Aided Design and simulation, Pressure vessel design..."

Problem-solving is also used in the analysis of data and the development of models. Using mathematical models and simulations, chemical engineers can gain insights into the behaviour of a system or process. By understanding and analysing the underlying principles and processes, they can develop and apply solutions that meet the needs of the industry.

v. **Analytical Thinking:** Analytical thinking is a key tool utilised by modern chemical engineers to successfully design, develop and optimise various chemical processes and systems. Chemical engineers use analytical thinking to analyse and understand processes' complexity, identify and solve problems, design safe and efficient systems, and develop optimal solutions. Analytical thinking helps in ensuring that the processes comply with the relevant regulations and standards.

   Chemical engineers must be able to assess data and develop models that accurately represent the behaviour of the process. Additionally, they must be able to interpret the results of the simulation and take appropriate action.

vi. **Team Leadership:** Team leadership is a precious tool for chemical engineers, allowing them to manage and delegate tasks to achieve desired results effectively. This can be especially important in modern practice, where engineers often need to collaborate with multiple teams and different types of professionals.

vii. **Contract Negotiation:** Contract negotiation is an important tool for chemical engineers in today's world. It is used to ensure that the project will be completed in a timely and effective manner. Chemical engineers must be able to negotiate to ensure that the project meets the needs of all parties involved. This includes being able to negotiate terms and conditions, cost and safety protocols. By understanding the legal implications of the contract, chemical engineers can ensure that the project meets all legal requirements. The contract negotiation process can be used to negotiate the scope of the project, the duration of the project, the cost, and the timeline. It also helps to identify any potential problems and to prevent complications from occurring.

5.2 SOFTWARE SKILLS

The field of chemical engineering is constantly evolving and advancing, with new technologies and techniques being developed all the time. One area in which chemical engineers are increasingly finding themselves in need of new skills is in the realm of Information and Communication Technology (ICT).

In order to design, operate and maintain chemical plants optimally, chemical engineers must be proficient in a wide range of ICT skills, including programming, Computer Aided Design and simulation, Pressure vessel design material selection, data analysis and visualisation, process control and automation, Process flowsheeting, Computer Aided Manufacturing, Computational Fluid Dynamics, material selection, Internet of Things (IoT) and Industry 4.0 technologies, cybersecurity, and Hybrid modelling, which combines first principles models and Artificial Intelligence (AI).

i. **Computer Programming:** With the increasing use of computer simulations and modelling in chemical engineering, engineers must be able to write code in order to create and run simulations, analyse data, and control processes. Chemical engineering software is often developed using general purpose programming languages such as C++, Java, or Python. Additionally, many software developers specialising in chemical engineering programs use Visual Basic or LabVIEW for their programming.

ii. **Computer-Aided Design (CAD):** Computer-aided design (CAD) and process simulation software are essential tools for chemical engineers. These programs allow engineers to create detailed models of chemical plants and processes and to run simulations to test different design options and operating conditions.

Simulation software such as Aspen Plus, Aspen HYSYS, Pro/II, Chemcad and others provide an invaluable resource for engineers who are tasked with designing process plants. These simulators provide the ability to evaluate the alternative design and operational strategies, such as alternative plant configurations and process control strategies, and to visualise and analyse the performance of the plant over a range of operating conditions.

iii. **Data Analysis and Visualisation Skill:** Data analysis and visualisation are essential skills for chemical engineers to solve chemical plant problems. Data analysis involves collecting, organising and analysing data to gain important insights and make informed decisions. On the other hand, visualisation provides a visual representation of data that can help identify patterns, trends and correlations in the data. Data analysis and visualisation allow chemical engineers to understand their chemical plants and operations better. By analysing the data, they can identify areas of improvement, detect inefficiencies and optimize processes.

Chemical companies use a variety of software programs to analyse and visualise data in their plants. JMP and Microsoft Excel and its Add-in are popular data analysis software used to speed up development timelines and find robust solutions to problems quickly. Cority, CDD Vault, VelocityEHS, Labguru, Momentum QMS, LabCollector, LIMS SBN Inspect, ePSM, Salute Safety, BatchMaster, and Assent Supply Chain Sustainability Platform are also used for data visualisation, environmental sustainability, occupational health and safety, quality management, drug discovery informatics and process safety management. For chemical process optimisation, dataPARC is a powerful tool with dynamic trend controls and product/batch filtering.

iv. **Process Control and Automation:** Process control and automation is another key area for chemical engineers to gain ICT skill. With the increasing use of automation in chemical plants, engineers must be able to design and implement control systems to ensure that processes run smoothly and efficiently. Engineers should be familiar with software that incorporate control systems such as PID and LQR, and with automation technologies such as SCADA and PLCs, such as Aspen Watch.

The other SCADA software are AVEVA Intouch, FactoryTalk view, Cimplicity SCADA, SIMATIC WinCC V7, Ignition SCADA, Open Automation Software, VTSCADA and others. Aspen Watch Online Monitoring for Advanced Process Control can be used to improve

"Chemical companies use a variety of software programs to analyse and visualise data in their plants. JMP and Microsoft Excel and its Add-in are popular data analysis software used to speed..."

process control within industrial process systems. It allows for real-time monitoring of process performance. The system enables the collection of process data from various sources. This data can then be analysed to identify areas which could benefit from improved process control. Aspen Watch can then be used to automatically adjust process parameters to optimise performance. Additionally, the system can be used to detect process anomalies and provide alerts to OPERATORS, allowing them to respond quickly and efficiently.

v. **The Internet of Things (IoT):** The Internet of Things (IoT) and Industry 4.0 technologies have become increasingly important in the chemical engineering field.

These technologies allow engineers to collect and analyse real-time data from chemical plants and to use this data to optimise processes and improve efficiency. Engineers should be familiar with IoT technologies, such as sensors and IoT platforms and Industry 4.0 technologies, such as cloud computing and edge computing.

vi. **Cybersecurity:** Cybersecurity is crucial for chemical engineers to be aware of, as chemical plants and processes are increasingly vulnerable to cyberattacks.
Engineers should be familiar with cybersecurity concepts such as threat modelling, penetration testing, and incident response including the use of security tools such as firewalls and intrusion detection systems.

vii. **Artificial Intelligence and Machine learning:** First principles models and Artificial Intelligence (AI) are becoming increasingly important in the chemical engineering field. Engineers should be familiar with basic concepts of AI, such as machine learning, deep learning and neural networks, as well as with the use of AI in process optimisation and control.

viii. **Material Selection:** In equipment manufacturing, material selection is crucial in ensuring a product's quality, safety, and performance. It is essential that the selected material is suitable for its intended use, considering factors such as mechanical strength, thermal expansion, corrosion resistance, and wear resistance.

The Cambridge Engineering Selector (CES) software is a powerful tool used to select the best materials for fabricating process equipment. It is a comprehensive database of materials, including metals, plastics, composites and ceramics, that can be used for various industrial applications.

ix. **Process flowsheeting:** This is the process of creating diagrams that visually represent the flow of material, energy, and information in a process plant. These diagrams are used to design, troubleshoot, modify, and optimise process systems while ensuring safety and compliance with regulations. They provide a comprehensive view of the entire process, from raw materials to finished products and are used to ensure efficient and cost-effective production.

"These technologies allow engineers to collect and analyse real-time data from chemical plants and to use this data to optimise processes and improve efficiency. Engineers should be familiar with IoT technologies, such as sensors and IoT platforms and Industry 4.0 technologies, such as cloud computing and edge computing."

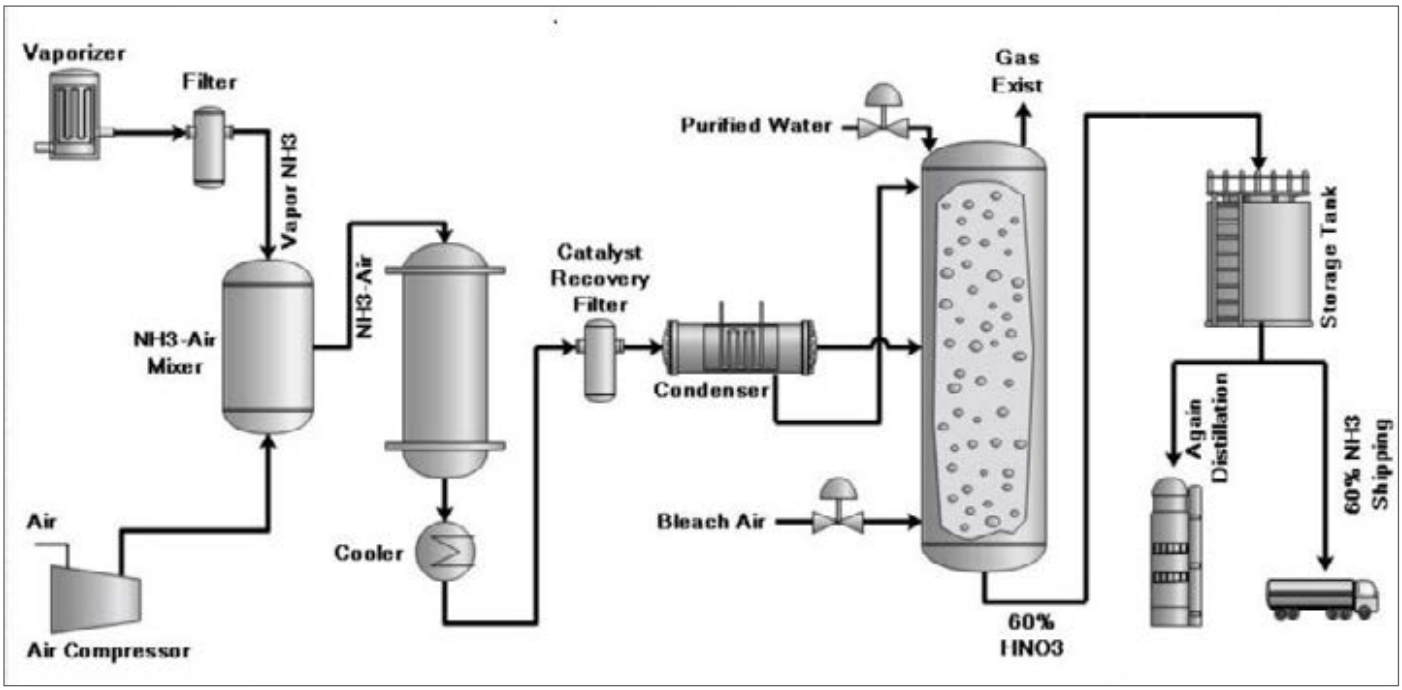
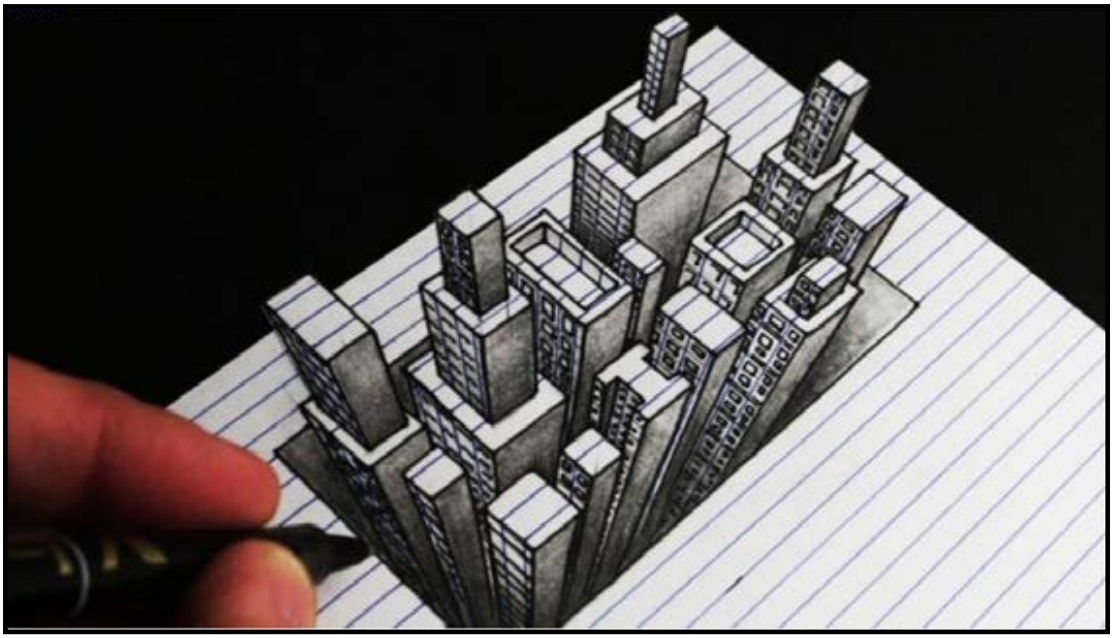


Fig. 3: Process flow diagram

x. **Process Flow Diagram:** AutoCAD is a software program that rapidly produces process flow diagrams (PFDs) of process plants. The software allows users to quickly and accurately create and edit process flow diagrams representing the full range of processes within a process plant. PFDs are essential for designing, operating, and maintaining process plants see Fig. 3. They provide a comprehensive overview of a process plant's physical, operational and control systems.

xi. **Piping and Instrumentation Diagrams (P&ID):** AutoCAD P&ID (Piping and Instrumentation Diagrams) is a software program that rapidly produces process plant piping and instrumentation diagrams (P&IDs). The software allows users to quickly and accurately create and edit P&IDs of process plants. P&IDs are essential for the process plants' design, operation and maintenance.

xii. **Plant 3D Diagrams:** Plant 3D diagrams are essential for Computer-Aided Design (CAD). They provide a comprehensive overview of the physical, operational and control systems of a design project see Fig 4. Plant 3D diagrams enable users to quickly and accurately create and edit complex designs without requiring complex manual procedures. The industry standard plant 3D software is Plant Design Management



"Plant 3D diagrams enable users to quickly... create and edit complex designs..."

Fig. 4: 3D Diagram

Fig. 5: A computer-aided manufacturing, CAM, vehicle assemply plant.

System (PDMS). The other Plant 3D software are SP3D- SmartPlant 3D, E3D, CADWorks., Autoplant 3D, AutoCAD Plant 3D, PDS, S3D – Smart 3D and others. PDMS is an essential tool for chemical industries because it provides comprehensive plant design management capabilities. It offers many features, including an integrated database, 3D visualisation, design automation, and intelligent engineering.

xiii. **Computer Aided Manufacturing (CAM):** CAM plays a crucial role in the process equipment fabrication industry by automating and streamlining various aspects of the manufacturing process see Fig. 5. Some of the key roles and benefits of CAM in process equipment fabrication include:

- **Design and modelling:** CAM software is used to create 3D models of process equipment, simulate various manufacturing processes, among other uses.
- **CNC programming:** CAM software can be used to generate accurate and efficient code for Computer Numerical Control (CNC) machines, which are used to fabricate process equipment components.

Process simulation and optimisation: CAM software can be used to simulate and optimise various manufacturing processes, such as machining, welding and casting.

- **Quality control:** CAM software can be integrated with metrology equipment, such as laser scanners and coordinate measuring

"CAM plays a crucial role in the process equipment fabrication industry by automating and streamlining various aspects of the manufacturing process."

"CFD is a critical tool in modernchemical engineering practice, enabling chemical engineers to optimize the design, operation, and maintenance..."

machines, to perform in-process inspections and ensure that components are manufactured to the correct specifications.

- **Automation:** CAM software can be integrated with robotic and automation systems, allowing for the automation of various manufacturing processes.
  The industry standard CAM software is Solidworks and its Add-in Solidworks CAM.

  The list of other CAM software to gain skills from are Fusion 360, Solid Edge, NX CAM, GibbsCAM, CAMWorks and HSM. Manufacturing (CAM) software. SolidWorks is a versatile software that can be used throughout the entire product development process, from design and simulation to manufacturing and documentation.

xiv. Computational Fluid Dynamics (CFD): CFD is a critical tool in modernchemical engineering practice, enabling chemical engineers to optimize the design, operation, and maintenance of chemical plants. By using CFD, chemical engineers can improve efficiency, reduce costs and enhance the safety of their operations, making them more competitivein the market see Fig. 6.

xv. Pressure Vessel Design: Chemical engineers use software for pressure vessel design to improve accuracy and efficiency in the design process. The software allows for the calculation of various parameters such as stress, pressure, temperature and material strength, which are critical to ensuring the safe operation of the vessel. Examples are PV Elite, COMPRESS, DesignCalc, CerebroMix, AutoPIPE used in performing

"Chemical engineers use software for pressure vessel design to improve accuracy and efficiency in the design process."

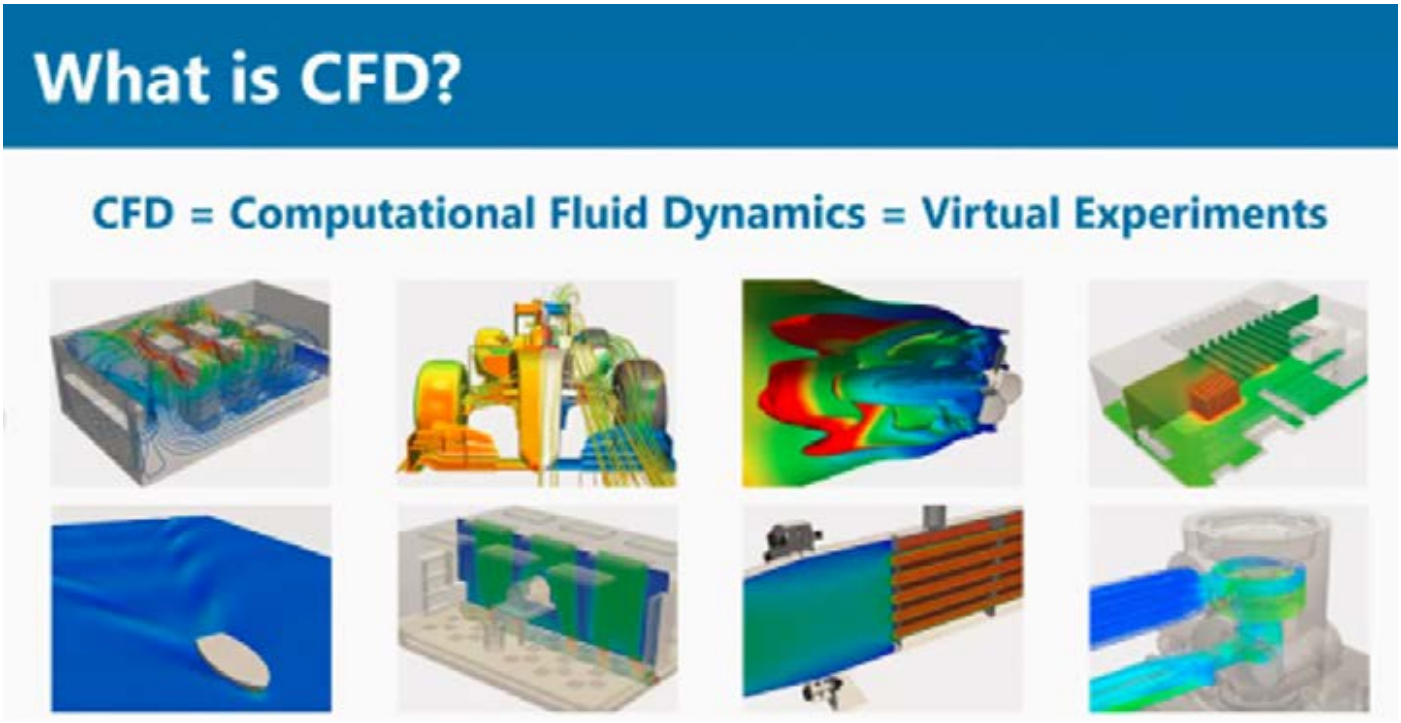


Fig. 6: Diagram showing what computational fluid dynamics (CFD) means.

various calculations and simulations needed for the design of pressure vessel equipment.

By using Pressure Vessel Design and Analysis Software, chemical engineers can design and analyse pressure vessel equipment such as reactors, heat exchangers, distillation columns, absorbers, adsorption columns and other pressure vessel equipment with accuracy and efficiency, ensuring that they meet the necessary safety and performance standards.

5.3 HARD SKILLS

The National Skills Qualification (NSQ) certification is a government-recognised qualification awarded to individuals who have demonstrated a high level of proficiency in a specific skill or trade. The NSQ certification verifies that the holder has the knowledge, skills and competences required to perform a specific job or task in their field of expertise. The purpose of NSQ certification is to provide a standard for recognising and assessing skills and to encourage the development of a highly skilled workforce see Fig. 7.

NSQ certification programs vary by country but typically include a combination of education, training, and examination.

To get the National Skills Qualification (NSQ) certification, you will need to complete any necessary training or education required for the NSQ certification program.

"You have to pass the NSQ certification exam, which may include written and practical components. It is advisable to contact the relevant authority or organisation offering the NSQ certification..."

You have to pass the NSQ certification exam, which may include written and practical components. It is advisable to contact the relevant authority or organisation offering the NSQ certification program for detailed information on the process and requirements. Chemical Engineers may get an NSQ certification from one of the skills shown in Table 1 to enhance progress.

There is need for Chemical Engineers to be dynamic, up-skill, reskill and re-invent skills. Skills have become the global currency of labour as the job market has shifted towards a focus on specific, highly in-demand skills. Employers are looking for workers with the practical, hands-on abilities to perform

Kiln Operator Welding Integrity Testing Process Plant	Installation and Commissioning	Boiler Operator Pipeline Scaffolding
Welding and	Fabrication	industrial electronics Food Process/Safety
Protocols	Pumps and	Compressors
Project Management,	etc	Other Eng Skills
(AC&R, etc.)		

Table 1: Hard Skills in Chemical Engineering Practice

Fig. 7: N-Power as part of National Skills Qualification (NSQ) certification programme.

"...chemical engineering is a dynamic and challenging field requiring diverse skills and knowledge to succeed. From an understanding of chemical processes and systems to an ability to use advanced software and simulation tools, chemical engineers must be equipped with the skills and knowledge..."

specific tasks rather than just theoretical knowledge acquired through a degree.

This is why certifications and other forms of recognition for specific skills are becoming more important for workers.

Microsoft, Google, Oracle, Apple, Amazon, and other major employers of labour are looking for workers with practical, hands-on skills. They are interested in workers who have demonstrated their abilities and can immediately contribute to their operations. In many cases, these employers prefer to hire workers with skills certifications because they provide a tangible way to measure a worker's expertise.

6.0 CONCLUSION

In conclusion, chemical engineering is a dynamic and challenging field requiring diverse skills and knowledge to succeed. From an understanding of chemical processes and systems to an ability to use advanced software and simulation tools, chemical engineers must be equipped with the skills and knowledge necessary to tackle the complex challenges that arise in the field.

EDITOR'S NOTE: *This is an abridged version of the paper presented by Prof. Idris Bugaje in a seminar organized by NSChE Kaduna Chapter held in Ahmadu Bello University, Zaria, Nigeria on January 16, 2023.*

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- Etc

Engr. Dr. John Erinne, *FAEng, FNSE, FNSChE*
(CEO, Matrix Petro-Chem Limited)

COMPANY VISION STATEMENT

To build a virile and highly respected indigenous **Nigerian** petroleum services concern operating actively in the upstream, midstream and downstream sectors of the oil & gas industry.

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To be one of the leading and **most** respected indigenous concerns in the oil & gas industry in nigeria.

To be a **provider** of **quality** services and solutions of global standards to our valued clients.

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