

Physics for Sustainable Development in Africa

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PRESENTATION OUTLINE

1. **BACKGROUND**
2. **POLITICAL COMMITMENT FOR DEVELOPPEMENT THROUGH SCIENCE AND TECHNOLOGY**
3. **WHAT PHYSICS IS? WHY IS IT IMPORTANT**
4. **POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063**
5. **POTENTIAL BARRIERS TO MEETING THE CHALLENGES - WAYS TO STRENGTHEN PHYSICS IN AFRICA**

BACKGROUND

Some Characteristics of Africa's Economy

- ▶ World Bank projections about Africa : home to **90 percent of the world's extreme poor by 2030**

(Accelerating Poverty Reduction in Africa, Washington, DC: World Bank, 2019)

- ▶ Countries in sub-Saharan Africa : **only 2 percent of global economic activity for 14 percent of the world population**

- ▶ While Africa mineral wealth places it among the world's richest continents

Very large share of the world's mineral resources

Coal, petroleum, [natural gas](#), [uranium](#), radium, low-cost thorium, iron ores, [chromium](#), [cobalt](#), [copper](#), lead, zinc, tin, [bauxite](#), titanium, antimony, [gold](#), [platinum](#), tantalum, germanium, lithium, phosphates, and diamonds.

BACKGROUND

Some Characteristics of Africa's Economy

- ▶ From the economic report Africa's Development Dynamics 2021: Digital Transformation for Quality Jobs jointly prepared by the African Union Commission (AUC) and the OECD Development Centre :
 - The COVID-19 pandemic reveals again that, the African continent is highly exposed to external shock
 - Africa will experience its first recession in 25 years
 - The report identifies four priorities :
 1. Ensuring universal access to the digital solutions;
 2. Making digital technology a lever for productivity, especially for small and medium-sized enterprises (SMEs);
 3. Developing skills tailored to the fourth industrial revolution so that the expertise of the African workforce is aligned with 21st century markets;
 4. Co-ordinating the multiplicity of digital strategies at the continental, regional, national and local levels to better prioritize, implement, monitor and evaluate progress.

POLITICAL COMMITMENT FOR DEVELOPPEMENT THROUGH SCIENCE AND TECHNOLOGY

▶ Several action plans to achieve this goal have been adopted:

- the Monrovia Strategy (1979)
- the LPA for the economic development of Africa [1980-2000] and the Lagos Final Act in April 1980
- the Abuja Treaty (1994) to achieve mutually beneficial economic integration through establishing an African Economic Community (AEC)
- ...

LPA resolution : by 1990, every African country should be spending at least 1% of its GDP on science and technology.

▶ The creation of AU (2001) was associated with the adoption of the New Partnership for Africa's Development (NEPAD).

▶ The AU Commission (AUC) includes the Department of HR, Science and Technology, with the mandate to advance education, science and technology, and human capital development in the continent

POLITICAL COMMITMENT FOR DEVELOPPEMENT THROUGH SCIENCE AND TECHNOLOGY

- ▶ The AU Commission (AUC) established the **Conference of Ministers in charge of Science and Technology (AMCOST)**, to enable the Union to periodically deliberate and have a collective voice on science and technology issues
- ▶ In 2005, **the Consolidated Plan of Action (CPA)** was presented as an instrument for the implementation of the decisions of the African Union Assembly of Heads of State and Government on **STI**

POLITICAL COMMITMENT FOR DEVELOPPEMENT THROUGH SCIENCE AND TECHNOLOGY

The CPA was to address 5 flagship research and development programs:

- ▶ **Cluster 1:** Biodiversity, Biotechnology and Indigenous Knowledge
- ▶ **Cluster 2:** Energy, Water and Desertification
- **Cluster 3:** Material Sciences, Manufacturing, Laser and Post-Harvest Technologies
- **Cluster 4:** Information and Communication Technologies
- **Cluster 5:** Mathematical Sciences: including the Next Einstein Initiative. The African Institute for Mathematical Sciences (AIMS) established in 2003.

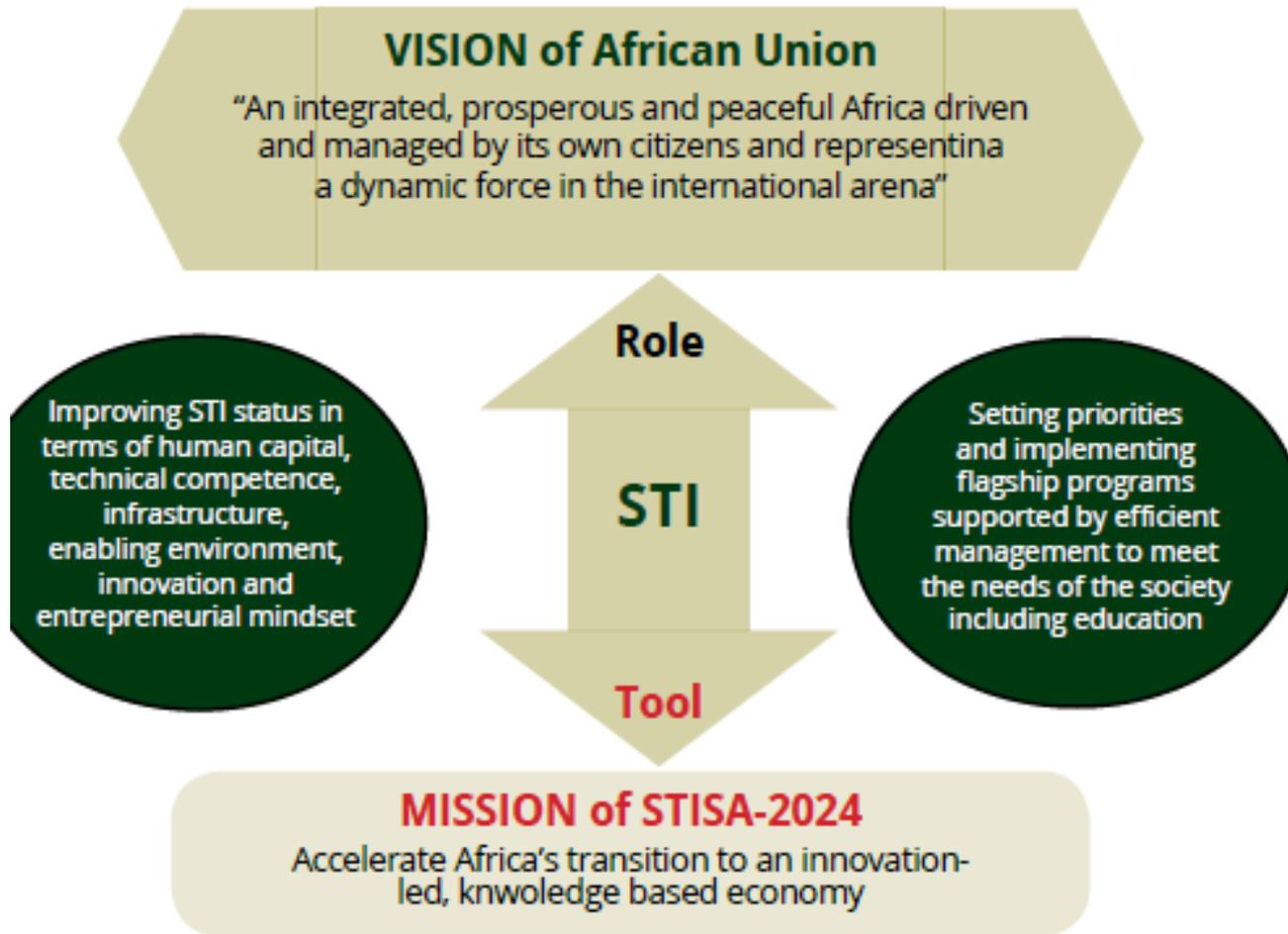
Mission : empower the continent's youth to shape the continent's future through science, technology, engineering, and mathematics (STEM) education by training the next generation of African leaders.

POLITICAL COMMITMENT FOR DEVELOPPEMENT THROUGH SCIENCE AND TECHNOLOGY

New Strategies for development through science and technology

- ▶ The Pan African University (PAU) was established by The African Heads of State and Government in 2010 AU is expected to prioritise its research activities including Water, Energy, Climate change, Science Technology & Innovation, Health, Agriculture, Earth sciences, Space Science.
- ▶ The 10-year Science, Technology and Innovation Strategy for Africa (STISA-2024), adopted in June 2014 (**STISA-2024** places STI at the epicentre of Africa's social and economic development within the long-term AU Agenda 2063).
- ▶ Through its implementation, STI are expected to impact critical sectors including agriculture, energy, environment, health, infrastructure, mining, security, and water, among others. This strategy is designed to respond to the need of transforming Africa into a **Knowledge-based and Innovation-led Society**
- ▶ The African Space Policy and the African Space Strategy were approved by the AU Assembly Heads of State in January 2016.

POLITICAL COMMITMENT FOR DEVELOPPEMENT THROUGH SCIENCE AND TECHNOLOGY



The role of STI in achieving the vision of the African Union

POLITICAL COMMITMENT FOR DEVELOPPEMENT THROUGH SCIENCE AND TECHNOLOGY

More than 60 years after independence, almost all African countries are still trying to achieve economic development

- ▶ The African Union is committed to achieve its Pan African Vision of *An integrated, prosperous and peaceful Africa, driven by its own citizens, representing a dynamic force in the international arena*

Agenda 2063 is the concrete manifestation of how the continent intends to achieve this vision within a 50-year period from 2013 to 2063.

- ▶ Agenda 2063 seeks to deliver on a set of **Seven Aspirations**

The focus for this presentation is on the **Aspiration 1: A prosperous Africa based on inclusive growth and sustainable development**

A question : How could physics contribute to Africa sustainable development?

WHAT IS PHYSICS? WHY IS IT IMPORTANT?

- ▶ Physics can be defined as the study of how objects behave (from the very tiny to the very big, and from the beginning of the Universe to its ultimate fate), the study of matter energy and their interactions
- ▶ Physics is one of the most important parts of the science as its principles are matter, force, energy, and motion.

Whatever we do, there is physics involved : for everyday living, all the technologies exploit the rules of physics: mechanical devices, transportation, communications, telematics, food technology,....

- ▶ **Physics is also a cross-cutting discipline that has applications in many sectors of economic development, including health (e.g. cancer treatment), agriculture, environment (tackling climate change) water, energy, information technology...**

WHAT IS PHYSICS ? WHY IS IT IMPORTANT ?

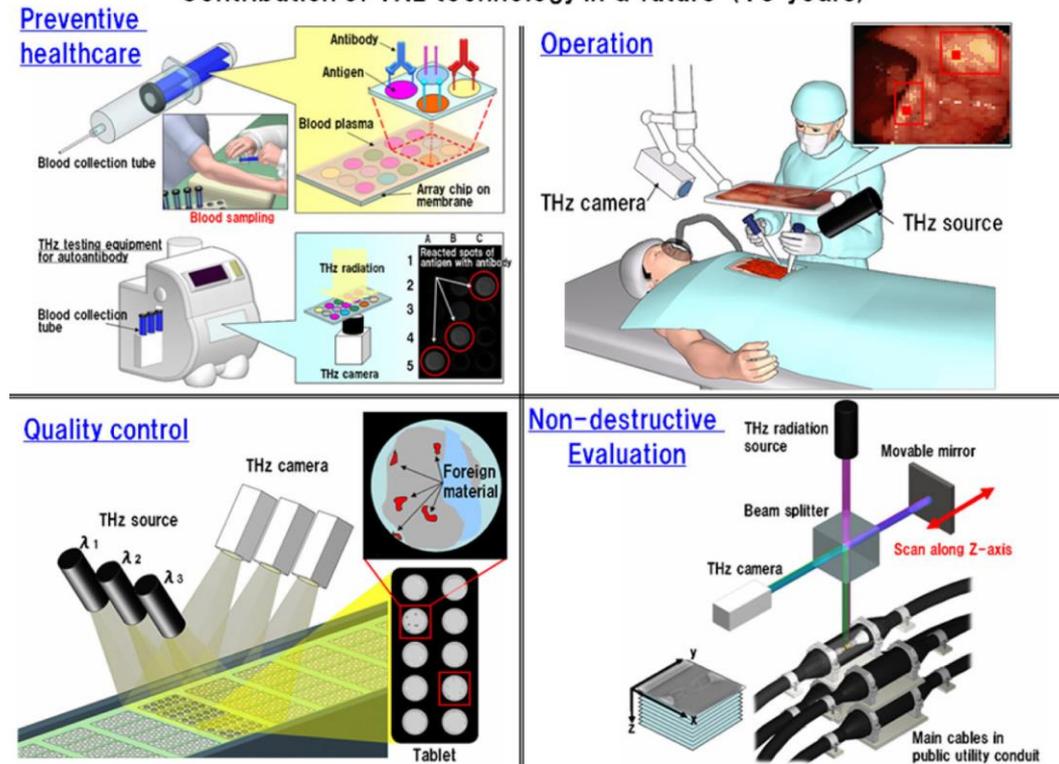
▶ *Examples of the importance of Physics to Society from a statement adopted by IUPAP, March 1999 :*

1. Physics generates **fundamental knowledge** needed for the future **technological advances** that will continue to drive the economic engines of the world.
2. Physics is an important element in **the education of chemists, engineers and computer scientists**, as well as practitioners of the other physical and biomedical sciences.
3. Physics extends and enhances our understanding of other disciplines, such as **the earth, agricultural, chemical, biological, and environmental sciences**, plus **astrophysics and cosmology** - subjects of substantial importance to all peoples of the world.
4. Physics improves our quality of life by providing the basic understanding necessary for developing new instrumentation and techniques for medical applications, such as **computer tomography, magnetic resonance imaging, positron emission tomography, ultrasonic imaging, and laser surgery**.

WHAT IS PHYSICS ? WHY IS IT IMPORTANT ?

- ▶ Physics is the source of many scientific and technological developments. Today, physicists continue to generate new knowledge about our world and lead innovation in cutting-edge areas such as:
 - terahertz medical imaging ([Joo-Hiuk Son](#) and al. “Potential clinical applications of terahertz radiation”, Journal of Applied Physics 125, 190901 (2019);
 - research on sustainable energy production and other global challenges.

Contribution of THz technology in a future (10 years)



POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

The flagship projects of **Agenda 2063** refers to key programmes and initiatives which have been identified as key to accelerating Africa's economic growth and development as well as promoting our common identity

▶ 1. INTEGRATED HIGH SPEED TRAIN NETWORK

The project aims to connect all African capitals and commercial centres through an African High Speed Train Network thereby facilitating the movement of goods, factor services and people. The increased connectivity by rail also aims to reduce transport costs and relieve congestion of current and future systems.

Challenge: Sustainable solutions for the movement of people, goods, and services

What can physics do to build a well interconnected and integrated networks of transport infrastructure ?

- Statistical physicists of complex networks (Albert et al. Statistical mechanics of complex networks. Rev. Mod. Phys. 74, 47 (2002); Seaton et al, Stations, trains and small-world networks. Physica A 339, 635–644 (2004).
- Physics of transportation (Gómez, S. et al. Diffusion dynamics on multiplex networks. Phys. Rev. Lett. 110, 1154–1154 (2013)

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

- Information and Communication Technologies: Intelligent transport systems (ITS) ([Hiroshi Makino et al Solutions for urban traffic issues by ITS technologies IATSS Research Volume 42, Issue 2, July 2018, Pages 49-60](#)); The Internet of Things (IoT) ; Big data analytics
- Modelling interconnected infrastructure systems(Complex Network Theory)
- Alternative energies

Technology Enhances Rail Safety & Efficiency

ADVANCED FUEL MANAGEMENT SYSTEMS

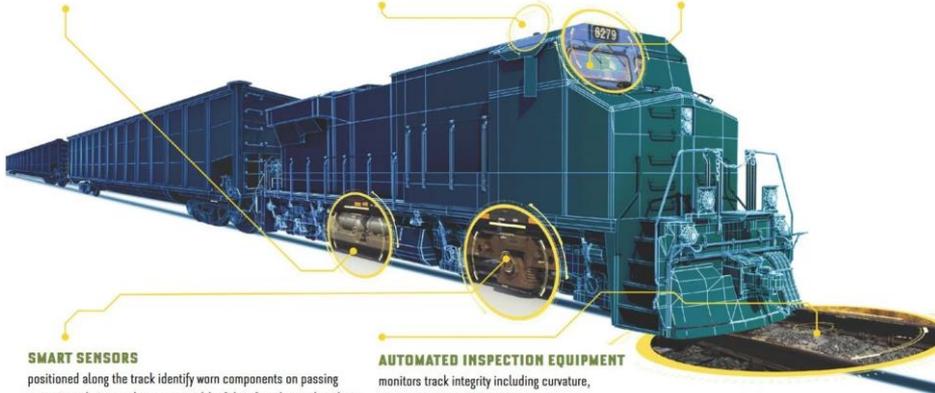
assess track grade, train weight, wind speed and more, allowing our Locomotives to move one ton of freight 400+ miles on a single gallon of fuel – 3-4x more efficient than trucks.

POSITIVE TRAIN CONTROL

continuously analyzes the hundreds of variables required to safely stop a train at any given time, counteracting human error.

MODERN TIER 4 LOCOMOTIVES

are outfitted with hundreds of sensors that generate thousands of performance readings per minute to maximize efficiency.

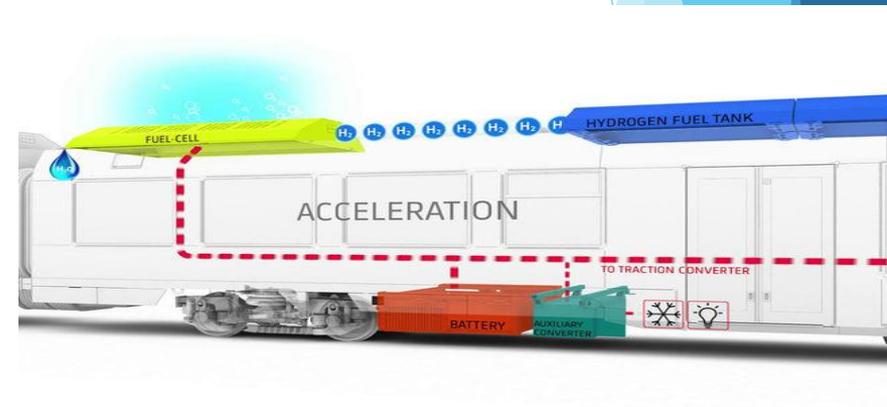


SMART SENSORS

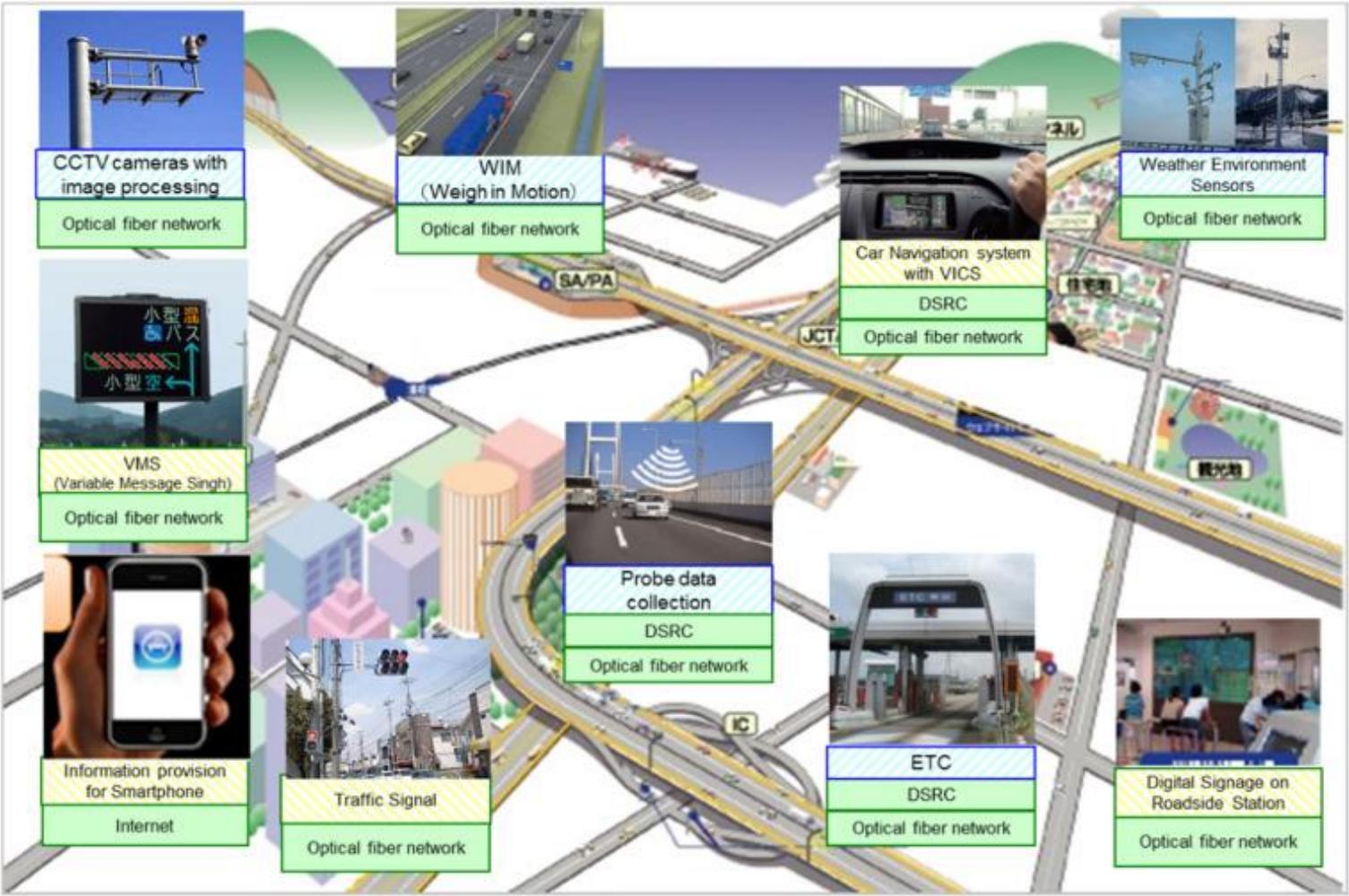
positioned along the track identify worn components on passing trains in real-time and amass a wealth of data for advanced analysis.

AUTOMATED INSPECTION EQUIPMENT

monitors track integrity including curvature, alignment, grade, ballast and more.



POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063



Conceptual illustration of ITS deployment.

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

▶ 2.FORMULATION OF AN AFRICAN COMMODITIES STRATEGY

- ❖ to transform Africa from simply being a raw materials supplier for the rest of the world to a continent that actively uses its own resources to ensure the economic development of Africans,
- ❖ Digital Transformation Strategy 2020-2030 was developed to provide a pathway for the creation of a continental digital single market by 2030
- ❖ The African Continental Free Trade Area (AfCFTA) founded in 2018 is an agreement among the AU Member States to create a single market of 1.2 billion people.
- ❖ **The AfCFTA aims to be the Africa's response to the fourth Industrial Revolution.** African countries lag behind in the use of the more advanced IR 4.0 digital technologies, such as cloud-computing applications, artificial intelligence and smart machines (e.g. robots and 3D printers)
- ❖ The AfCFTA gives Africa's people the opportunity for seamless trade, value addition and diversification of both goods and services.

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

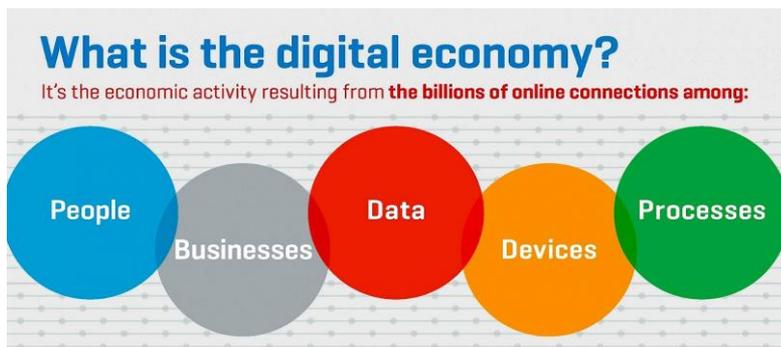
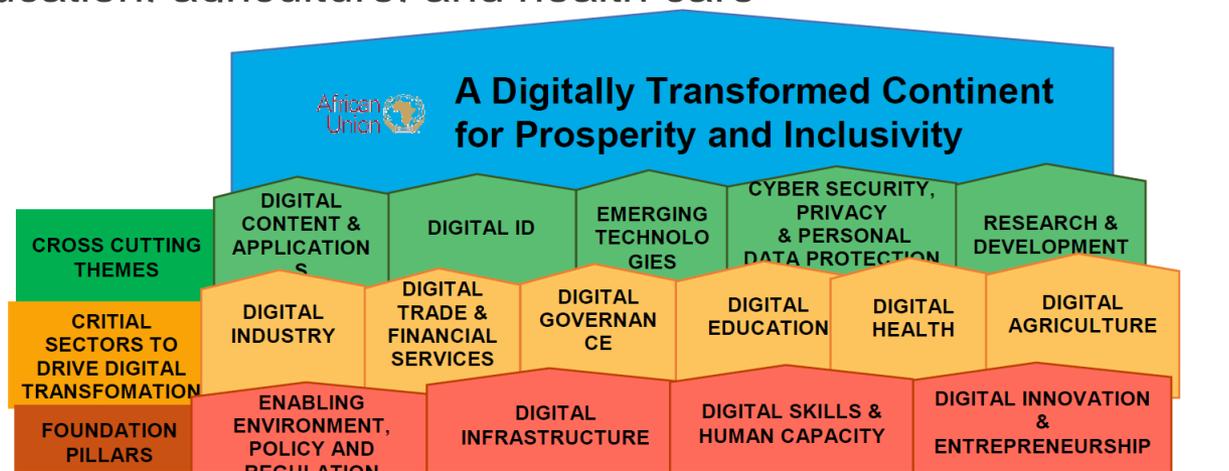
▶ 2.FORMULATION OF AN AFRICAN COMMODITIES STRATEGY

Challenges:

- Increased levels of industrialization in African countries;
- Enhance efforts to digitalize trade in Africa at a larger scale;
- create more jobs for the growing youth population (by 2030 it estimated that Africa's youth shall reach 1.6 billion people. Indeed, job creation is a top priority for each and every leader)
- Generate wealth across the continent

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

It is projected that the digital economy will contribute USD 180 billion to the economy of Africa by 2025. Digital platforms have increased access to education, agriculture, and health care



► The digital economy is significantly and irreversibly transforming value chains, skills development, production and trade. The use of tools such as automated cargo tracking and digital reporting of non-tariff barriers is growing in African cross-border trade

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

What can physics do to contribute to digital transformation of Africa ?

- ▶ **Contribute to create Digital Infrastructure that facilitates the development, provisioning, use and sharing of digital systems: these include Telecommunications fixed and wireless networks; terrestrial optic fibre networks, submarine cables, satellite communication, mobile communication, IXPs; Digital and smart devices, etc.**
- **Contribute to the development and growth of the ICT industry (production of computer software and hardware in Africa, Establish ICT assembling and manufacturing plants**
- **Contribute to digital health and digital agriculture**

Potential contribution of physics to the achievement of the objectives of the flagship projects of Agenda 2063

What can physics do to contribute to digital transformation of Africa ?

Contribute to digital agriculture

Agriculture today accounts for 32% of GDP in Africa and is the sector that offers greatest potential for poverty reduction and job creation.

To fulfil the demand of food, maintain the control and supply while world population is increasing day by day, maintaining the manual process does not seem to be practical. Likewise, IoT is playing an important role in agriculture and termed it into “**Smart Agriculture**”.



IoT based smart farming automates the irrigation system and monitors the fields with the help of sensors. It keeps factors like light, humidity, temperature, soil, etc under check and enables a closer observation from anywhere.

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

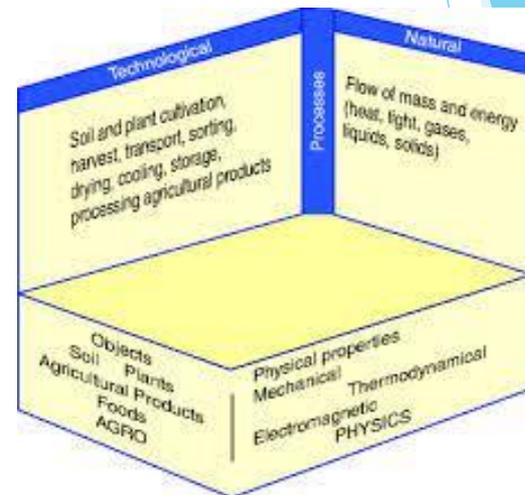
What can physics do to contribute to digital transformation of Africa ?

Contribute to digital agriculture

Agrophysics is one of the branches of natural sciences dealing with the application of physics in agriculture and environment. It plays an important role in the limitation of hazards to agricultural objects (soils, plants, agricultural products and foods) and to the environment.

Agrophysical knowledge can be helpful in evaluating and improving the quality of soils and agricultural products as well as the technological processes.

Agricultural researchers use every possible tool from electron microscopes to satellites to do their work.



POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

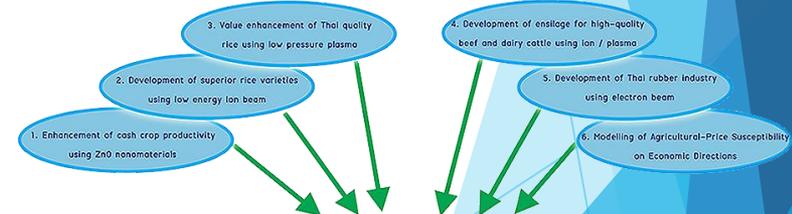
What can physics do to contribute to digital transformation of Africa ?

Examples of the contribution of physics to agriculture in another region

Thailand Center of Excellence launched in 2016 the research program of **“Innovative Physics for Enhancing Value of Agricultural Products”**.

❖ **Research Project on Innovative Physics Using ZnO-Nanomaterials for Enhancing Value-Added Agricultural Products:** Spraying ZnO-nanomaterials mixed with water every two weeks can lengthen the rice stalks and promote the booting stage compared to other rice plants with no use of ZnO-nanomaterials.

❖ **Research Project on Innovative Physics Using Low Energy Ion Beam for Quality Rice Breeding :** research project aimed to improve both rice varieties through the use of ion beam generated from a compact low-energy ion accelerator/implanter for inducing rice mutants.



POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

Exemples of physics contribution to agriculture in Africa

► Features of Agriculture in Africa

- Agriculture accounts for Africa's 15% GDP, 15% exports and 60 to 80% of the workforce
- Africa possesses 60% of the world's arable land, 70% of global water resources,
- Africa has the greatest % of people with food insecurity
 - ❖ Some of the most innovative ways of improving agricultural practices involve nuclear technology, using isotopes or radiation techniques to control pests and diseases, increase crop production, protect land and water resources and ensure food safety. FAO and the IAEA , create a Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture to build knowledge and enhance capacity in this area.

- **Improved soil and water management** : the University of Abomey-Calavi and the National Agricultural Research Institute of Benin, introduced a nuclear isotope nitrogen-15 stable isotope fertiliser to the soil as well to trace fertilizer uptake and soil health.

Food security and nutrition: in Sierra Leone, nuclear technology is used to develop cassava and rice crops that yield greater quantity, are rich in nutrients and are less vulnerable to disease outbreaks.

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

- **Plant Breeding and Genetics:**In Sudan, a drought-resistant groundnut variety was developed. This groundnut can grow with only 250 millimetres of rain a year compared with traditional varieties that require 350 millimetres. Its yield is 27 percent higher than traditional varieties, paving the way for Sudan's return to being a leading groundnut producer, improving food security in the country and helping the economy
- **Seeds can be irradiated with gamma rays, X rays, ion or electron beams to initiate genetic changes.** This increased diversity allows for a wider selection of genetics for breeding techniques

Insect pest management

The nuclear-derived, sterile insect technique (SIT) is a method of managing insect pests: tse-tse fly eradication in Senegal

The World Bank, under the West Africa Agricultural Transformation Project is also utilizing nuclear technology to combat disease-causing pests as part of its Pest Management Plan (PMP) to increase food security throughout the nation.

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

► Energy Development Strategies and Initiatives in Africa

Main objective: to increase energy access to the African people, improve livelihoods and to ensure environmental sustainability:

Implementation strategies:

- Facilitation and implementation of the energy projects of PIDA - PAP (Programme for Infrastructure Development in Africa - Priority Action Plan);
- Operationalization and Implementation of the [Africa Renewable Energy Initiative \(AREI\)](#) adopted at the COP21 in Paris, December 2015;
- Facilitation of [Sustainable Energy for All \(SE4ALL\)](#) Initiative Implementation adopted by the Conference of Energy Ministers of Africa (CEMA), in November 2012;
- Implementation of the [Hydropower 2020 Initiative](#) to promote the development of Africa's hydropower potential; and
- Facilitation and advocacy for the development of [Grand Inga Hydropower project](#) as one of AU Agenda 2063 flagship projects.

Potential contribution of physics to the achievement of the objectives of the flagship projects of Agenda 2063

The Africa Renewable Energy Initiative (AREI) aims to accelerate and scale up the harnessing of the continent's huge renewable energy potential

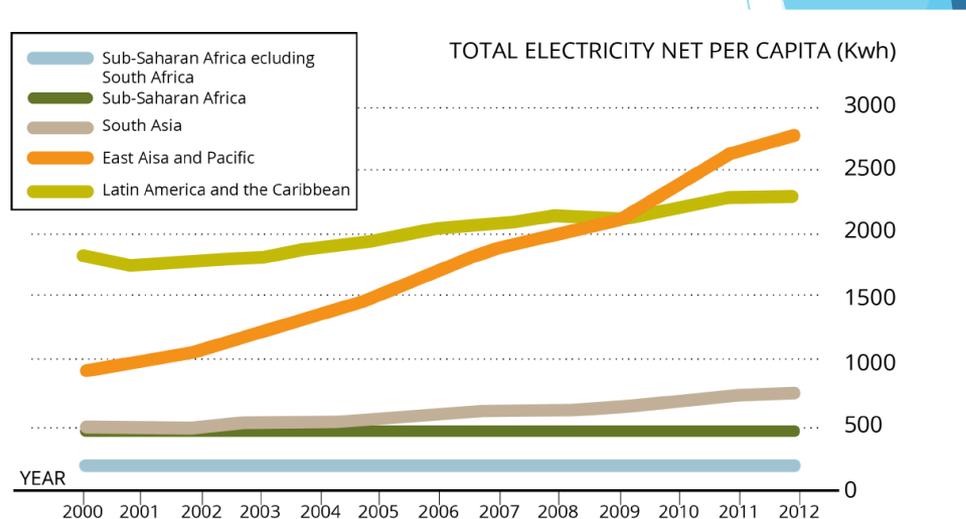
Access to energy services is a prerequisite for human development and well-being as well as prosperous economic development and job creation. Africa has urgent needs to address “access to energy” through a rapid and wide scale expansion of both electricity generating capacity – on-grid and off-grid – and the supply of other forms of energy

- ▶ The Initiative is set to achieve at least 10 GW of new and additional renewable energy generation capacity by 2020, and at least 300 GW by 2030.
- ▶ A major objective of the Africa Renewable Energy Initiative is, therefore, to help reconcile the twin challenges of expanding energy access and curbing climate change

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

► Challenges:

- Energy for community services is essential for health ‘(diagnosis with medical imagery, telemedicine, sterilization equipment, etc.) and education.
- use information and communication technologies (ICTs)
- etc.



Potential contribution of physics to the achievement of the objectives of the flagship projects of Agenda 2063

▶ Flagship 6. IMPLEMENTATION OF THE GRAND INGA DAM PROJECT

- The Inga Dam is expected to generate 43,200 MW of power, to support current regional power pools and their combined service to transform Africa from traditional to modern sources of energy and ensure access of all Africans to clean and affordable electricity.
- Upon completion, the entire project is expected to produce up to 42,000 MW of electricity, over twice the power generation capacity of the Three Gorges in China, which at present is the biggest hydropower project in the world, and more than a third of the total electricity currently produced in the whole of Africa.
- In June 2021, the Government of DRC appointed Fortescue Metals Group, a West Australian company to develop the Grand Inga hydroelectric power project

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

What can physics do to contribute to Energy Development Strategies and Initiatives in Africa ?

- ▶ **From energy generation, conversion and storage, to sustainability and resources, physicists play a key role.**
- ▶ **Different fields of Physics** : quantum and solid-state physics, materials science, biophysics, polymer science, aerodynamics, thermodynamics, superconductivity and optics

To contribute in:

- Photovoltaic and solar fuel sciences, Wind/wave/tidal/oceanic/hydro-based power sources
- Energy harvesting and storage technologies, Hydrogen production and fuel cells
- Geothermal power and heat pumps, Nuclear-sciences-based power cycle;
- Desalination and water treatment; Carbon-capture sciences
- Recyclable, biodegradable, low-toxicity and sustainable materials
- Renewable sources for carbon-based materials

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

What can physics do to contribute to Energy Development Strategies and Initiatives in Africa ?

- ▶ The next century: What research for the next generation of renewable energy products and systems? **Hydrogen generation and storage; fuel cells; thermophotovoltaics**—using heat instead of sunlight to generate electricity and advanced wind turbines. (Top research results and reviews on topics related to the physics of renewable energy can be found in the *Journal of Physics D: Applied Physics*)

Examples of innovative research

- ▶ Ion-based quantum computers could boost battery performance, how fuel cells are decarbonizing energy (*Physics World Weekly* podcast February 10, 2022)
- ▶ Combining Artificial Intelligence with Physics-Based Methods for Probabilistic Renewable Energy Forecasting, *Energies* 2020, 13(8), 1979; <https://doi.org/10.3390/en13081979> (In Kuwait A modern renewable energy forecasting system blends physical models with artificial intelligence to aid in system operation and grid integration)

Potential contribution of physics to the achievement of the objectives of the flagship projects of Agenda 2063

What can physics do to contribute to Energy Development Strategies and Initiatives in Africa ?

- ▶ The use of fuel cells: their development requires research in a range of physics-based fields, such as **solid-state physics, materials science, thermodynamics and mechanics**
- ▶ The use of Magnetic Materials are perceived as key in driving the 21st century industrial revolution

Some examples of research studies in Africa:

- **“The Impact of Magnetic Materials in Renewable Energy-Related Technologies in the 21st Century Industrial Revolution: The Case of South Africa** ([Advances in Materials Science and Engineering / 2018 /Volume 2018 |Article ID 3149412 | https://doi.org/10.1155/2018/3149412](https://doi.org/10.1155/2018/3149412), Wallace Matizamhuka)

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

What can physics do to contribute to Energy Development Strategies and Initiatives in Africa

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- ▶ **Is Africa Ready for Nuclear Power?** The Executive Secretary of the African Commission on Nuclear Energy(IAEA's 65th GC in 2021, said that “more than 12 African countries are considering the inclusion of nuclear power to their energy mix strategy.
- ▶ **How nuclear energy can help sustainable development in Africa?**
 - The year 2019 marks Africa's sixty-year involvement with nuclear technology (dating from the Democratic Republic of the Congo's TRICO I research reactor at the University of Kinshasa).
 - 12 research reactors have thus far been built in eight countries throughout the continent, supported by the IAEA.
 - Africa's research reactors are a vital component of the societal role played by nuclear science and technology, they provide:
 - neutrons to probe materials for structural integrity, to manufacture semiconductors through transmutation doping,

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

What physics can do to contribute to Energy Development Strategies and Initiatives in Africa

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- to create radioisotopes for medical and industrial diagnostics and life-saving cancer treatments,
- to address pollution issues, and to assist farmers in crop selection and land use.
- Research reactors also support nuclear data and improve our knowledge of the subatomic world.
- They are typically regarded as being a starting point for national nuclear power programmes and as being essential to power reactors, since they can be used to train scientists and engineers and to provide experimental capabilities for studies of material damage, radiation shielding and waste containment.

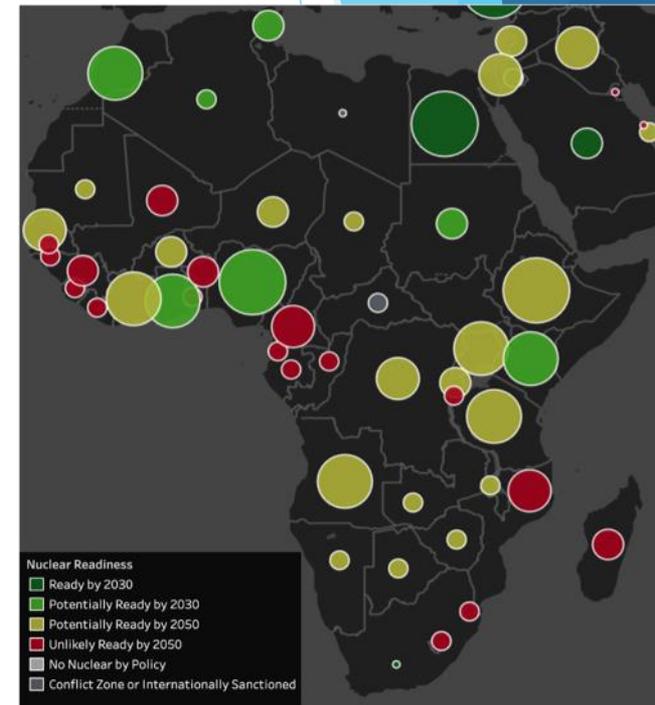
POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

What physics can do to contribute to Energy Development Strategies and Initiatives in Africa ?

► Is Africa Ready for Nuclear Power?

Nuclear power is a potential source of power to drive industrialization and growing incomes, especially **with new smaller, safer and more flexible designs** expected to come to the market over the next decade (How Advanced Nuclear Technologies Could Accelerate Deployment Across Africa, February 20, 2020, Energy for growth Hub, by Jessica Lovering)

- ✓ Only Egypt and South Africa are ready today (dark green)
- ✓ Seven more could be ready for nuclear by 2030: Algeria, Ghana, Kenya, Morocco, Nigeria, Sudan, Tunisia (light green)
- ✓ An additional seventeen countries have taken steps toward becoming ready and could be potential markets by 2050 (yellow)



POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

What can physics do to contribute to Energy Development Strategies and Initiatives in Africa

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- ▶ **Is Africa Ready for Nuclear Power?** One of the biggest problems with conventional nuclear technology for African countries is their tremendous size
- ✓ New models using advanced technologies soon coming to market may overcome some of the size, price, safety, and complexity barriers to deploying nuclear power in African markets:

A new generation of far smaller and cheaper nuclear technologies may offer more appropriate options for African countries to accelerate deployment of reliable, low-carbon electricity: **Small Modular Reactors (SMRs) and microreactors**

Advantages of SMRs or Microreactors : SMRs are less than one-third the size of today's typical plants (<300 MWe) and will be manufactured at a central facility, rather than constructed on-site, potentially bringing capital costs down dramatically and speeding up construction.

Microreactors, a subcategory of SMRs, are even smaller (<10 MWe) and could be an attractive option for off-grid industries in remote locations, such as mining, that want access to reliable electricity

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

What can physics do to contribute to Energy Development Strategies and Initiatives in Africa

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► Examples of SMRs or microreactors than can be beneficial in Africa: High-Temperature Gas-Cooled Reactors (HTGRs)

HTGRs use gas as the primary coolant instead of water, as in conventional nuclear plants. They have advantages in terms of improved safety and efficiencies

HTGRs could make nuclear power more feasible in inland regions where there are no major rivers to provide a constant cooling source, like Mali, or easier in different parts of the country, such as inland Nigeria, Kenya, or South Africa. Additionally, HTGRs can produce high-quality heat for industrial applications like fertilizer production or paper mills.

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

What can physics do to contribute to Energy Development Strategies and Initiatives in Africa

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► Is Africa Ready for Nuclear Power ?

- The debate about the role nuclear power should play in the future energy mix: many myths and misconceptions, sceptics who consider the technology to be too risky for the whole world and particularly inappropriate for the African continent.
- Indeed, after the construction of a nuclear reactor or a nuclear power plant, it is important to keep in mind the necessary safety, security, safeguards, legislative and regulatory processes that must be put in place beforehand and strictly followed.
- Besides power production, nuclear technologies are increasingly used in the various industrial and medical applications, raising concerns regarding the supply of the experts with very specific knowledge, skills and competence.

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

What can physics do to contribute to Energy Development Strategies and Initiatives in Africa

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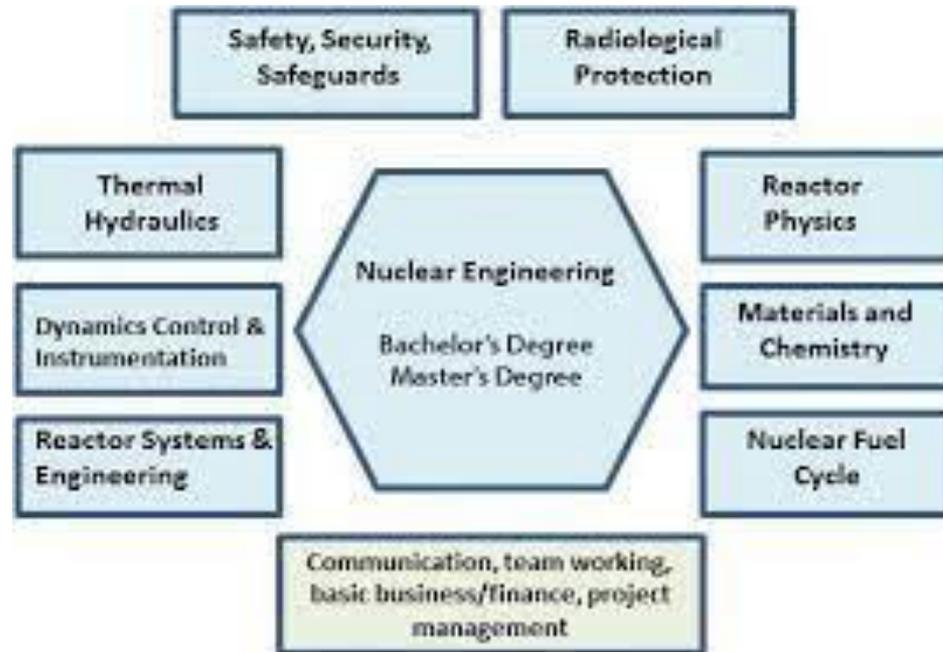
- ▶ **Is Africa Ready for Nuclear Power ?**
- **Important Knowledge Areas for Nuclear Power Reactor Operators**
- **Physics**—Knowledge and prediction of physical principles, laws, their interrelationships, applications to understanding fluid, material, and atmospheric dynamics, and mechanical, electrical, atomic and sub-atomic structures and processes.
- **Mechanical Engineering Technicians:**
- Civil Engineering Designer
Electro-Mechanical Technician (E/M Technician)
Electronics Technician
- **Nuclear technician, nuclear engineer, and medical physicist** are just three of the possible careers for those trained in nuclear science.

POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

What can physics can do to contribute to Energy Development Strategies and Initiatives in Africa

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- ▶ Is Africa Ready for Nuclear Power ?
- Nuclear engineering academic programmes



POTENTIAL CONTRIBUTION OF PHYSICS TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE FLAGSHIP PROJECTS OF AGENDA 2063

What can physics do to contribute to Energy Development Strategies and Initiatives in Africa

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► Is Africa Ready for Nuclear Power ?

Knowledge Requirements (physics-related) for a graduate with a Bachelor's Degree in Nuclear Engineering

—Basics of mechanics, oscillations and waves, thermodynamics, electrical and magnetic phenomena, statistical physics, physics of the atomic nucleus, and optics. — Neutron transport theory, thermal hydraulics, applications of computer code systems for mathematical simulation of thermophysical and neutronics analysis.— Basic laws of heat and mass exchange in power equipment units of nuclear power plants, requirements for heat transfer and heat removal systems, thermophysical processes in heat exchangers. — Thermodynamic principles, types and operation of steam turbines, calculation of efficiency, reliability, operation and maintenance. — Basic principles of radiation protection. Methods for detecting ionizing radiation. Hazards of radioactive materials. Concepts and definitions of radiation and dose units

POTENTIAL BARRIERS TO MEETING THE CHALLENGES- WAYS TO STRENGTHEN PHYSICS IN AFRICA

- ▶ Why do we not see greater impact of physicists in African development?

Some challenges of physics in Africa

- ❖ Limited research infrastructures
- ❖ Lack of industry that would require people with a PhD or master's degree in physics-job opportunities for physicists
- ❖ There are few physicists compared to other scientists
- ❖ Lack of funding and funding policies. African governments must have a policy and vision for science and technology in which physics should have a central role
- ❖ Lack or limited use of research outcomes and results to advise policy-makers
- ❖ Cultural barriers to girls and women entering physics

POTENTIAL BARRIERS TO MEETING THE CHALLENGES- WAYS TO STRENGTHEN PHYSICS IN AFRICA

Focus on Medical physics in Africa:

MP faces peculiar challenges:

- Lack of recognition of the profession and appreciation of MPs' roles in most African countries.
- Africa has 1,040 MPs, unevenly distributed among a population of 1.3 billion in the region. It has the smallest number of MPs per million inhabitants globally.
- The highest concentrations of radio-diagnostic and radiation therapy facilities are in South Africa and northern sectors of the region.
- Half of African countries have no radiotherapy facilities, creating limited access to radiotherapy cancer care.
- Inadequate numbers of academic and clinical training centres, and lack of job posts.

POTENTIAL BARRIERS TO MEETING THE CHALLENGES- WAYS TO STRENGTHEN PHYSICS IN AFRICA

► **Ways to strengthen physics in Africa**

- ❖ Recognition of research in physics as a priority and its promotion to underline its role in developing technologies that may lead to economic
- ❖ Strengthening the research capacity besides developing the research environment.
- ❖ Advocacy for physics-based evidence to inform decision-making processes
- ❖ Align research in physics to support national agendas towards human, environmental and socio-economic development in order to remain relevant and benefit from continual local funding
- ❖ Physics curricula should emphasize project work and problem solving with a complement of activities in entrepreneurship
- ❖ Physicists in Universities should be involved in interdisciplinary research groups and take advantages of collaborative research projects with the private sector or non-governmental organizations to secure funding and ensure the use of research findings.

POTENTIAL BARRIERS TO MEETING THE CHALLENGES- WAYS TO STRENGTHEN PHYSICS IN AFRICA

- ▶ **Ways to strengthen physics in Africa**
- ❖ Strengthen and support areas of discipline application such as medical physics, materials science, renewable energy, nuclear energy.
- ❖ Human capacity development in medical physics will better support the efforts by African governments that annually dedicate large resources of their national budgets to attend to the health needs of their citizens against communicable and non-communicable diseases.
- ❖ Modern technologies used in agriculture are well founded in the principles of physics and could be customized through innovation to reach food security.

CONCLUSION

- ▶ Physics is vital for Africa in the building of structures: roads, hospitals, aqueducts, electricity grids, mechanized agriculture plants, food conservation, water prospecting and mapping of aquifers, application of light (photonics) and nano- and micro-devices in health and medicine, etc.
- ▶ Physics-based science and technology should be promoted and use to solve problems in Africa.
- ▶ However, Africa offers incredible opportunities and the biggest of these is the world's youngest population.
- ▶ Some other opportunities
- ❖ African School of Fundamental Physics and Applications (ASP), which has held its annual meeting in a different location every year since 2010;
- ❖ AIMS (African Institute for Mathematical Sciences) network, which act as powerful incubators of young talents.
- ❖ The African Light Source Foundation (AfLS) is working to establish an advanced light source on the African continent
- ❖ The African Strategy for Fundamental and Applied Physics (ASFAP) Initiative whose vision is that Africa should occupy an equal place as a co-leader in the global scientific process, with all the socio-economic benefits that entails.

CONCLUSION

- ▶ Young Physicists, you are the future of Africa!
- ▶ But YOU NEED to be enlightened by leaders and scientists who are visionaries
- ▶ A speech that is still relevant today

President Kwame Nkrumah,
First speech at the foundation summit of the
Organization of African Unity,
Addis Ababa, 24 May 1963

We shall accumulate machinery and establish steel works, iron foundries and factories; we shall link the various states of our continent with communications; we shall astound the world with our hydroelectric power; we shall drain marshes and swamps, clear infested areas, feed the undernourished, and rid our people of parasites and disease. It is within the possibility of science and technology to make even the Sahara bloom into a vast field with verdant vegetation for agricultural and industrial developments”.