



KFUPM
RESEARCH
STRATEGY
2024-2030



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Embarking on the transformative journey of KFUPM's Research Strategy 2024-2030, we present our strategic plan as a testament to our unwavering commitment to becoming a global beacon of innovation and research excellence. Our vision goes beyond academic feats; it aspires to make a tangible impact, shaping a brighter future through solutions to society's grand challenges and propelling economic diversification. This commitment fuels our dedication to interdisciplinary research. We foster an environment that attracts the finest minds and offers world-class infrastructure, igniting breakthrough discoveries through diverse perspectives. Strong partnerships with industry and government ensure our knowledge translates into the real world. We prioritize research addressing critical challenges and producing tangible economic and societal impact, ultimately improving lives. A diverse, equitable, and inclusive research environment is at the heart of our pursuit of excellence. We empower every voice and provide robust resources to nurture a vibrant research community. Attracting and retaining top-tier researchers is our goal, fostering an atmosphere where creativity and excellence flourish.

This booklet presents a summarized KFUPM innovation-based research strategy, aligning with the Kingdom's national priorities. The booklet only presents the articulated KFUPM's Grand challenges in the four national focus areas: Energy and Industrial Leadership, Sustainable Environment and Essential Needs, Economies of the Future, and Health and Wellness. The booklet also dwells on how to achieve the set grand challenges through the well-defined innovation goals that were developed by taking into consideration all stakeholders' feedback, KFUPM's current and future capabilities, and the national and international trends in research for the sake of helping our economy and for the betterment of humanity. As Vice President of Research and Innovation, I am excited about the immense potential on the horizon. This strategy is our roadmap. Together, we will shape the future and leave an indelible mark on the world.

KFUPM INNOVATION-BASED RESEARCH STRATEGY

National Focus Areas

KSA's national research priorities that were addressed by KFUPM in the Research Strategy 2024-2030

Energy and Industrial Leadership

- Clean, Economic Hydrogen
- Renewable Energy
- Crude Oil-to-Chemical Conversion
- Geoenery Leadership
- Electric Vehicles (EVs) and EV Batteries
- Nuclear Energy

Sustainable Environment and Essential Needs

- Innovative Water Research
- Net Zero Emissions
- Reuse of Materials and Products in Industry
- Biodiversity

Economies of the Future

- Cognitive Cities
- Automation of Logistics
- Industrial Robots
- Net Zero Aviation
- New Space Leadership
- FinTech
- Gaming and ESports

Health and Wellness

- Health and Bioengineering Innovation



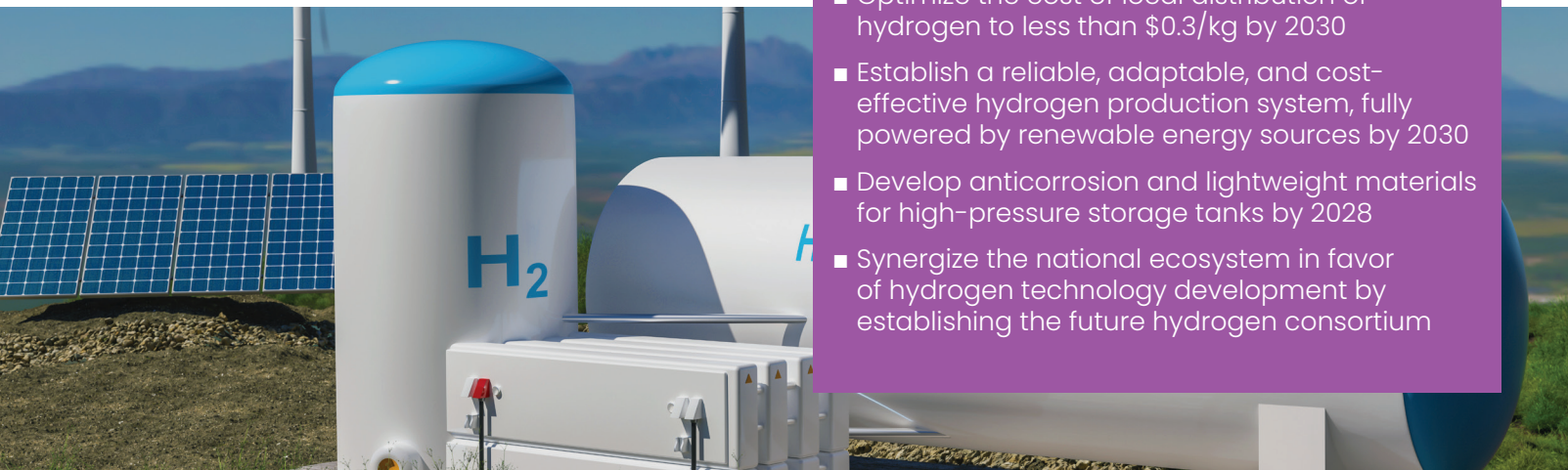
CLEAN, ECONOMIC HYDROGEN

KFUPM will invent technologies and develop innovations that enable the following by 2030:

1. Produce hydrogen at less than \$0.5/kg.
2. Store hydrogen at less than \$0.2/kg.
3. Distribute hydrogen at less than \$0.3/kg.

Innovation Goals

- Develop the in-well hydrogen production process to TRL5 by 2026
- Reduce the cost of electrolyzer stacks (membrane, electrode...etc) by 50% to produce green hydrogen by 2030
- Improve the cost of hydrogen production from hydrocarbons to less than \$0.5/kg by 2030
- Survey 50% of KSA's geological formations for natural hydrogen sources by 2026
- Develop efficient and sustainable hydrogen storage solutions with a cost of less than \$0.2/kg of H₂ by 2030
- Identify the geological formations suitable for large-scale hydrogen storage by 2026
- Optimize the cost of local distribution of hydrogen to less than \$0.3/kg by 2030
- Establish a reliable, adaptable, and cost-effective hydrogen production system, fully powered by renewable energy sources by 2030
- Develop anticorrosion and lightweight materials for high-pressure storage tanks by 2028
- Synergize the national ecosystem in favor of hydrogen technology development by establishing the future hydrogen consortium





RENEWABLE ENERGY

KFUPM will develop methods and applications that enable the following by 2030:

1. Improve photovoltaic (PV) power output by 40% under challenging KSA conditions.
2. Increase life span of solar and wind technologies by 20%.
3. Develop long-duration (>10 hours) energy storage technology at \$100/kWh.
4. Reduce loss of load probability to less than 2% at 50% renewable penetration to achieve a resilient KSA electricity grid.

Innovation Goals

- Develop structures for renewable energy devices that reduce power degradation by 40% and prolong product lifespan by 20% by 2030
- Develop artificial intelligence-based monitoring, cooling, and cleaning technologies to achieve 20% life cycle cost reduction and 55% efficiency retention of solar PV systems by 2030
- Demonstrate operation of 10 kW redox flow batteries with a cost-effective electrolyte, enabling \$100/kWh by 2030
- Develop control and adaptive protection strategies to ensure reliable and stable power transmission and distribution systems with 30% renewable energy penetration by 2030

CRUDE OIL - TO - CHEMICAL CONVERSION

KFUPM will develop a multifunctional catalyst that directly converts crude oil to chemicals at 90% selectivity and 85% conversion and simplifies refining into a one-step process by 2030.

Innovation Goal

- Develop efficient multifunctional catalysts and technology capable of removing 90% of impurities produced in cracking crude oil, resulting in a higher yield of light olefins and BTX aromatics at a conversion rate higher than 80% by 2030

KFUPM will develop methods and applications that enable KSA to achieve the following by 2030:

1. Increase the recovery factors from subsurface reservoirs (hydrocarbons, geothermal fluids) by 30%.
2. Become the leader in achieving the global sustainability targets of hydrocarbon production, H_2 storage, CO_2 sequestration, and wastewater recycling in petroleum reservoirs.

Innovation Goals

- Consolidate geophysical methods (oil and gas, geothermal, CO_2/H_2 groundwater, etc.) in the characterization and monitoring phase by 2030
- Develop and produce oilfield chemicals in a sustainable manner locally (field trial-proven) with the goal of increasing the production potential by 20% and lowering the overall carbon footprint by 50%
- Develop H_2 and CO_2 storage capabilities for safely and economically sequestering the gases underground and handling the indirect global warming potential of gaseous H_2

GEOENERGY LEADERSHIP

EVs AND EV BATTERIES

KFUPM will invent technologies and develop systems to achieve the following by 2030:

1. Reduce the cost of EV level 2 charging systems from \$1,000 to \$900.
2. Increase the efficiency of EV motors from 90% to 95%.
3. Mitigate heat risks of batteries while developing high energy density (>400 Wh/kg), durable ($>1,000$ cycles) rechargeable batteries.

Innovation Goals

- Develop a bidirectional charging controller to reduce the charging system cost from \$1,000 to \$900 by 2029
- Increase the efficiency of electric motor drives from 90% to 95% by 2029
- Invent heat-resistant, durable batteries for EVs, achieving energy density exceeding 400 Wh/Kg and $>1,000$ cycles by 2029



NUCLEAR ENERGY

KFUPM will develop the following by 2030:

Internationally competitive modeling and simulation infrastructure to enable KSA to adopt the design and safe operation technologies of Generation IV (Gen IV) nuclear fission power plants.

Innovation Goals

- Adopt and develop an advanced modeling and simulation platform to support the design and safety aspects of Gen IV reactors by 2030
- Develop a simulation platform for radiation/particle-matter interactions to facilitate the use of materials for Gen IV reactor designs by 2030



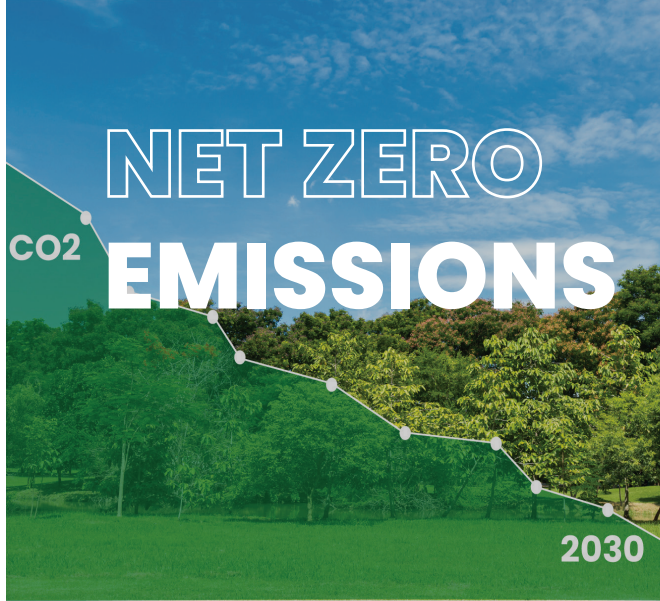
INNOVATIVE WATER RESEARCH

KFUPM will invent technologies and develop systems to enable the following by 2030:

1. Develop a chemical system that reduces the energy consumption of wastewater treatment by 50%.
2. Invent processes and membranes that can reduce desalination operating expenses by 50%.
3. Develop AI algorithms that contribute to reducing the energy consumption of water distribution systems by 50%.

Innovation Goals

- Develop chemically assisted membrane-based wastewater treatment systems (anaerobic ammonia oxidation and membrane bioreactor) that reduce energy consumption by 50%
- Develop a minimal liquid discharge desalination process coupled with fouling-resistant membranes that will reduce the operating expenses by 50%
- Develop AI-based control systems for enhancing the energy consumption efficiency of KSA's water supply systems and management by 50%



KFUPM will invent technologies and develop systems that will achieve the following by 2030:

1. Contribute to reducing carbon emissions in KSA by 30%.
2. Reduce the cost of CO₂ capture to less than \$40/C-ton.
3. Reduce the cost of carbon storage to less than \$10/C-ton.
4. Produce applications and materials that utilize 70% of captured carbon.
5. Contribute to Net zero building.

Innovation Goals

- Develop dynamic building envelopes and an optimized hybrid energy system that reduce building and industrial sectors' energy consumption by 70% by 2030
- Achieve 50% reduction of carbon emissions from combustion-based systems (e.g., steel and cement production, flaring) by 2040
- Target 10% performance improvement in combustion technologies by 2040
- Develop self-sustaining building energy generation by on-site renewables, storage, and an advanced management system by 2030
- Develop software solutions for identifying the factors responsible for emissions and emissions estimation, modeling, and prediction at national and corporate levels by 2028
- Reduce direct air capture (DAC) cost to <\$100/C-ton by 2040
- Reduce point-source carbon capture cost to <\$20/C-ton by 2035
- Identify geological formations suitable for large-scale CO₂ storage by 2025
- Develop technologies for the conversion of CO₂ to value-added chemicals by 2030
- Invent applications for carbon utilization (construction of roads, buildings, storage tanks, etc.) by 2030
- Develop advanced materials for improved integrity of minimum CO₂ emissions combustion by 2030

REUSE OF MATERIALS AND PRODUCTS IN INDUSTRY

KFUPM will develop innovative methods to achieve the following by 2030:

1. Create technologies and processes for increasing the reuse of waste materials to 30%.
2. Enable conversion of polymeric wastes into valuable products.
3. Produce graphene from petroleum coke.

Innovation Goals

- Recycle/reuse 30% of construction and demolition (C&D) waste in the construction sector by 2030
- Divert 20% of municipal solid waste (MSW) to be utilized in the construction sector by 2030
- Utilize 20% of KSA's industrial waste materials in the construction sector by 2030
- Set national battery recycling policies and develop combined techniques to achieve 75% recycling efficiency by 2030
- Develop cost-effective technology to convert at least 60% of plastic waste into valuable products (aromatics, olefins, paraffins, etc.) by 2030
- Develop cost-effective processes with a high conversion rate to produce graphene and carbon-based materials using petroleum coke derived from oil slurry by 2030
- Develop cost-effective technologies to make natural fibers and pulp from date palm waste by 2026

KFUPM will develop the following by 2030:

1. A smart tools-based mapping strategy to enable KSA to conserve 30% of the biodiversity of marine and coastal habitats
2. AI-based algorithms and applications for automated taxonomical identification of KSA's wildlife
3. An environmental surveillance network that enhances the ecosystem status assessment and management response by 50%.

Innovation Goals

- Develop a smart tools-based mapping strategy to enable KSA to conserve 30% of the biodiversity of its marine and coastal habitats by 2030
- Develop AI-based algorithms and applications for automated taxonomical identification of KSA's wildlife by 2030
- Develop an advanced, integrated, and smart environmental surveillance network that will enhance ecosystem status assessment and management response by 50% by 2030

An underwater photograph of a coral reef. In the foreground, there is a large, branching, yellowish-brown coral. To its left, a blue starfish is visible on the sandy bottom. Further left, there is a smaller, rounded, porous coral. The background shows more coral and some small fish swimming in the clear water. The word "BIODIVERSITY" is overlaid in large, white, bold, sans-serif capital letters on the left side of the image.

BIODIVERSITY



COGNITIVE CITIES

KFUPM will develop the following for cognitive cities by 2030:

1. Next-generation, energy-conscious backbone communications and sensing systems
2. Models based on cognitive skills for secure, privacy-preserving, and personalized cyber-physical-social systems
3. Decision-making algorithms based on cognitive skills to create smart mobility services and carbon-free smart transportation modes
4. Automation based on cognitive skills for optimizing services and improving quality of life.

Innovation Goals

- Develop the backbone that supports cognitive cities based on terrestrial and airborne integrated communication and sensing systems with 10× capabilities by 2030
- Develop cognitive sensing networks for cognitive cities (cognitive wireless sensor networks) in one major city by 2030
- Develop next-generation security operations centers (SOCs) with 10× capabilities for cognitive cities by 2030
- Develop cyber-physical infrastructure that is 5× more trustworthy, resilient, and secure for cognitive cities by 2030
- Develop five secure and privacy-preserving human-centered AI-based systems for cognitive cities by 2030
- Develop five quantum technologies with applications in cognitive cities by 2035
- Create cost-effective frameworks for digital twins of urban cities for use in planning and predicting mobility, urbanization rate, and capacity by 2030
- Work with five cities to develop technologies to map nonstandard features on geographic information system (GIS) maps by 2030
- Develop sustainable living models and decision-making algorithms for five cities by 2030
- Develop zero-emission intelligent transportation systems and mobility services by 2030



AUTOMATION OF LOGISTICS

KFUPM will develop the following:

1. Automation systems that shorten freight forwarding and delivery times and reduce transportation costs of KSA's shipments by 50% by 2030
2. AI-based routing algorithms for autonomous ground and air vehicles for last-mile delivery of shipments by 2027.

Innovation Goals

- Develop digital twins of inter-modal and multi-modal supply chains to increase KSA's logistics performance by more than 25% by 2030
- Design materials handling and shipment intralogistics models based on Internet of Things (IoT)/cloud computing that can be implemented in over 50% of KSA ports by 2030
- Develop smart path planning algorithms for last-mile delivery in order to reduce delivery time by 20% by 2027
- Develop intelligent autonomous systems (drones, automated guided vehicles, and humanoids) for automated last-mile delivery in order to reduce transportation costs by 50% by 2030

INDUSTRIAL ROBOTS

KFUPM will develop the following by 2030:

1. AI-based self-trainable industrial robots and systems for training industrial robots
2. Industrial robots possessing close-to-human tolerance-for-position capability.

Innovation Goals

- Develop AI-based industrial robots that can adapt to changing environments, including educational needs by 2030
- Develop robots highly tolerant to position variations with superior disturbance rejection by 2030
- Develop a fully functional six degrees of freedom (6-DoF) proof-of-concept demonstrator autonomous underwater vehicle capable of carrying out routine, dull, dirty, and dangerous tasks intelligently
- Develop a fully functional proof-of-concept demonstrator unmanned surface vehicle capable of carrying out routine, dull, dirty, and dangerous tasks with minimal human intervention
- Develop a fully functional 6-DoF proof-of-concept demonstrator unmanned aerial vehicle capable of carrying out routine, dull, dirty, and dangerous tasks intelligently
- Develop new concepts for robotics manufacturing, including magnetic levitation systems

KFUPM will achieve the following by 2040:

1. Drive carbon neutralization through zero-emission propulsion and sustainable aviation fuel (SAF)-compatible technologies.
2. Develop sustainable and smart technologies for aircraft control and autonomy.

Innovation Goals

- Implement alternative hydrogen, ammonia, and SAF as fuel systems by 2035
- Implement ultralight materials and innovative structural designs to reduce fuel consumption by 20% by 2040
- Develop AI-based techniques to lower fuel consumption by 20% by 2040



NET ZERO AVIATION

KFUPM will develop the following by 2030:

1. Satellite technologies for environment monitoring and formation flying
2. Indigenous launch technologies
3. Space data analytics to participate in next-gen earth observation and space exploration missions.

Innovation Goals

- Develop 10m resolution Multispectral (MS) payload for environment monitoring by 2030
- Demonstrate inter-satellite coordination and communication for formation on UAV-based platforms
- Launch fully in-house developed CubeSat of size 6/12U by 2027
- Develop re-usable smart structures and materials for launch-supporting systems by 2030
- Develop decision-supporting earth observation analytics to foster rational environmental management and support energy sector stakeholders in eastern province by 2030
- NISAR (NASA-India Synthetic Aperture Radar) mission participation for data validation and cutting-edge analytics ensuring KSA Space Sustainability by 2028



**NEW
SPACE
LEADERSHIP**

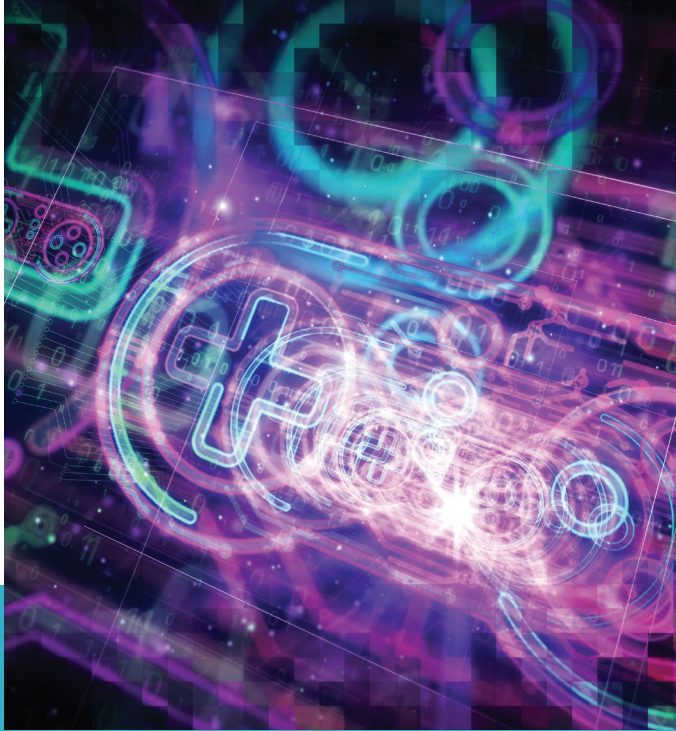
KFUPM will develop technologies and solutions that enhance the innovative competencies of 50 fintech firms and 20 consumer adoption frameworks by 2028.

FINTECH

Innovation Goals

- Develop 50 solutions that include technologies, financial instruments, and regulatory and Shariah certification mechanisms across three FinTech domains (digital payments, digital capital raising, and neo-banking) by 2028
- Develop adoption and usage research frameworks of 20 FinTech solutions across digital payment, digital capital raising, and neo-banking by 2028





GAMING AND ESPORTS

KFUPM will contribute to developing 3 gaming studios and 4 indie games by 2028.

Innovation Goals

- Support the growth of three KSA publishers to be globally recognized AAA class by 2028
- Contribute to developing four Arabic culture-based gaming applications by 2028

KFUPM will develop an AI-based early detection system utilizing a polygenic risk score for non-communicable diseases in adults, focusing on diabetes type-II, hypertension, and coronary diseases to promote preventive medicine and reduce KSA's direct and indirect healthcare costs by up to 30% by 2030.

Innovation Goals

- Develop a biodata platform (including data governance with security architecture, computing storage, and accessibility) to improve the quality of life and utilize AI-based decision-making by 2030
- Build innovative AI models/ applications to address ongoing challenges for quality of living by 2030

HEALTH AND BIOENGINEERING INNOVATION

Clean, Economic Hydrogen

IRC for Hydrogen Technologies and Carbon Management

Innovative Water Research

IRC for Membranes and Water Security

Industrial Robots

IRC for Intelligent Manufacturing and Robotics

Renewable Energy

IRC for Sustainable Energy Systems

Net Zero Emissions

IRC for Hydrogen Technologies and Carbon Management

Net Zero Aviation

IRC for Aviation and Space Exploration

Crude Oil-to-Chemical Conversion

IRC for Refining and Advanced Chemicals

Reuse of Materials and Products in Industry

IRC for Construction and Building Materials

New Space Leadership

IRC for Aviation and Space Exploration

Geoenergy Leadership

Center for Integrative Petroleum Research

Biodiversity

ARC for Environment and Marine Studies

FinTech

IRC for Finance and Digital Economy

EVs and EV Batteries

IRC for Sustainable Energy Systems

Cognitive Cities

IRC for Intelligent Secure Systems

Gaming and ESports

IRC for Finance and Digital Economy

Nuclear Energy

IRC for Industrial Nuclear Energy

Automation of Logistics

IRC for Smart Mobility and Logistics

Health and Bioengineering Innovation

IRC for Bio Systems and Machines

Energy and Industrial Leadership

Sustainable Environment and Essential Needs

Economies of the Future

Health and Wellness



**Dream Big
and
Accomplish**

Dream Big and Accomplish



for more
information

