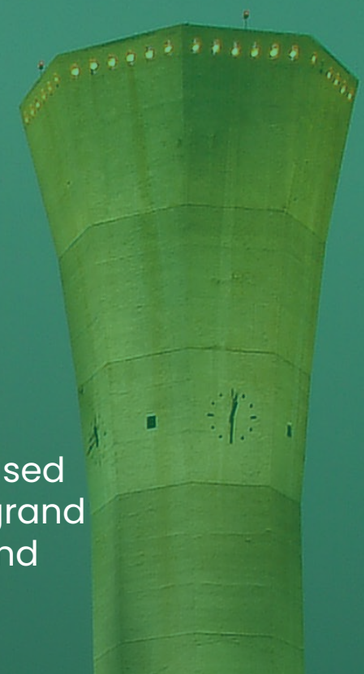
KFUPM RESEARCH STRATEGY

2024 - 2030

Content

RESEARCH & INNOVATION



Vision

To be a globally recognized innovation-based research-intensive institution that solves grand challenges for the betterment of society and diversification of economy.

Mission

To conduct interdisciplinary research in national and global priority areas in a conducive environment that attracts the best talents and provides world-class infrastructure.

Values

- Interdisciplinarity
- Collaboration
- Diversity, Equity, and Inclusion
- Openness and Transparency
- Resilience

A Message from **Dr. Muhammad Al-Saggaf** President of KFUPM

In our journey of transformation, King Fahd University of Petroleum and Minerals (KFUPM) has crafted a forward-thinking research strategy aimed at establishing itself as a global leader in scientific and technological innovation.

As part of this transformative approach, KFUPM has established twenty specialized research centers, each dedicated to pioneering advancements in key areas such as energy, engineering, environmental sustainability, and the economies of the future. KFUPM's research strategy underscores the university's commitment to addressing critical global challenges through cutting-edge research and interdisciplinary collaboration. It is designed to generate significant economic and social benefits, emphasizing the importance of partnerships with government and industry. Collaborations enhance our efforts and ensure that our research has practical applications, fostering innovation that directly contributes to societal advancement and the well-being of humanity.

The strategy also aligns well with the themes of the Research, Development, and Innovation Authority (RDIA), and emphasizes the identification and tackling of grand challenges that hold significant societal impact. By synchronizing its research agenda with national priorities, the university ensures that its initiatives are not only forward-looking but also highly relevant to the nation's strategic goals. KFUPM's research strategy is aligned with 18 national priorities, targeting 44 grand challenges. This alignment amplifies KFUPM's contribution to the Kingdom's Vision 2030 and fortifies its position within the broader scientific community. Through this synergy, KFUPM is poised to drive significant advancements and foster innovation that addresses the pressing needs of today and the future.

KFUPM invites leading researchers and industry partners from around the world to collaborate with us. Together, let's push the boundaries of scientific exploration and translate groundbreaking research into real-world solutions for a sustainable future.

As the President of the University, I proudly endorse this strategy and remain committed to supporting the initiatives that will propel KFUPM to new heights of excellence and global influence.

Foreword from **Dr. Ali Al-Shaikhi** Vice President of Research & Innovation

Embarking on the transformative journey of KFUPM's Research Strategy 2024-2030, we present this document 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 that addresses critical challenges and yields 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.

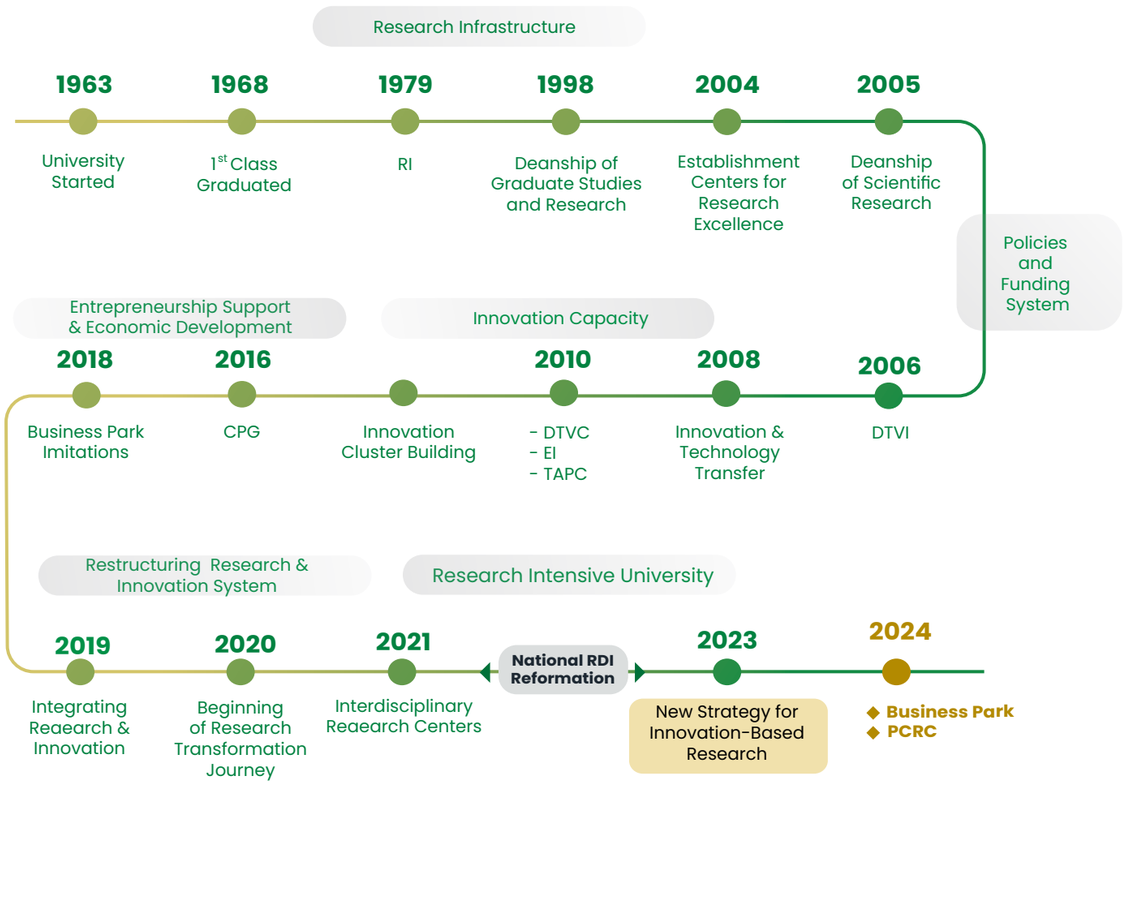
As Vice-President of Research & Innovation, I'm excited about the immense potential ahead. This strategy is our roadmap. Together, we will shape the future and leave an indelible mark on the world.

01 Legacy: Sixty Years of Excellence

KFUPM is renowned for its exemplary track record in research and innovation, which has significantly contributed to addressing global challenges and positively impacting society. The institution's fundamental mission revolves around the pursuit of novel knowledge and insights, making it an indispensable player in academia. KFUPM's research endeavors consistently yield tangible outcomes that bring substantial benefits to both local and global communities.

KFUPM collaborates with local partners to drive research initiatives, fostering active participation.

The distinguished researchers at KFUPM are dedicated to devising groundbreaking solutions for pressing challenges in Saudi Arabia and globally.
This commitment to innovation underscores KFUPM's pledge to create a meaningful and enduring impact on society and humanity. The university's standing among global research institutions is evident through international indicators. This concerted effort exemplifies KFUPM's mission to contribute significantly to the advancement of knowledge and the betterment of society on a global scale.



02 Why: Revealing Research Strategy's Rationale

The formulation of **KFUPM's innovation-based research strategy** is underpinned by four pivotal factors. First, the remarkable transformation of KFUPM in recent years has redefined its strategic priorities and aspirations. Second, the valuable insights gleaned from internal assessments of the University's research centers play a critical role in shaping the strategy. These assessments offer a nuanced understanding of the University's strengths and areas for improvement, thereby informing the strategy's development. Third, the development of the strategy is influenced by national initiatives aimed at fostering research, innovation, and overall development. These initiatives provide a compelling impetus for KFUPM to integrate its efforts with broader national goals. Fourth, the strategy is inspired by the dominant trend observed in research-intensive universities, where research strategies are structured to address grand challenges. Collectively, these four factors coalesce to guide the creation of KFUPM's research and innovation strategy that is not only attuned to its evolving landscape but also positioned to contribute significantly to local and national research and development objectives.

Innovation-based Research Strategy

KFUPM's Transformation: A Strategic Driver

The transformation of KFUPM parallels the rapid economic and technological advancements of KSA. It also reflects the heightened aspirations of Saudi Arabia, the increasing opportunities for its burgeoning youth population, and the growing global prominence of the Kingdom in many sectors. KFUPM's proactive transformation, initiated in October 2019, empowers the University to significantly contribute to Vision 2030's national development aspirations. This strategic evolution aligns KFUPM with the Kingdom's journey towards global influence, driven by the Vision's unwavering commitment to innovation and progress.

KFUPM maintains a steadfast commitment to pioneering research, with particular emphasis on various engineering fields. This endeavor encompasses the deployment of cutting-edge technology and the utilization of state-of-the-art laboratories, positioning the university at the vanguard of scientific progress. This concerted effort is aimed at making substantive contributions to economic diversification and enhancing societal well-being. In 2021, KFUPM established 15 interdisciplinary research centers. In a recent development, KFUPM inaugurated 15 interdisciplinary research centers (IRCs), 3 applied research centers (ARCs), and 3 joint research centers (JRCs). These centers are crucial in enhancing innovation, generating knowledge, and fostering collaborative exploration.

The establishment of IRCs at KFUPM is to promote interdisciplinary research and cultivate partnerships with industries. These centers are specifically designed to facilitate the convergence of researchers from diverse disciplines, with the overarching goal of creating a research engine capable of effectively addressing and overcoming grand challenges. By fostering collaboration and knowledge exchange across multiple fields, these IRCs promote a synergistic environment that enables the development of innovative and comprehensive solutions to address core issues.

On the flip side, ARCs are anticipated to partner with industries, addressing practical challenges, fostering innovation, and playing a vital role in transferring technology, developing skills, and contributing to the economic and societal impact of research.

The JRCs are founded with a dedicated mission to tackle applied research challenges, offering targeted solutions through collaborative initiatives involving KFUPM and specific government or industry partners.

12 mega research trends were identified and clustered into 5 main themes relevant to the KFUPM context

Energy, Utilities & Sustainability

Industrials & Infrastructure

Digitization and Technology

Healthcare and Biotech

Business, Finance and Economics

The research and innovation strategy at KFUPM is carefully aligned with its overarching strategic plan and is an extension of its research transformation strategy. KFUPM is dedicated to achieving research excellence across a diverse array of disciplines. Twelve major research trends are identified for KFUPM's research context.

The University is determined in its commitment to nurturing new resources within these domains, as well as across a wide spectrum of disciplines, even those that may not fall within the designated signature areas. Within this research landscape, graduate students and post-doctoral fellows play pivotal roles and contribute significantly to a successful research environment.

The newly developed research strategy is focused on addressing the national priorities related to research, development, and innovation (RDI). Furthermore, the strategic objectives outlined in this plan contribute to the achievement of the United Nations' Sustainable Development Goals.

In doing so, KFUPM reaffirms its commitment to exerting a meaningful impact on global challenges and promoting a sustainable and equitable future for society.

The strategy document is divided into four sections: the why, how, what, and implementation. It outlines the rationale, development methodology, identified grand challenges, and the proposed approach for implementation. This structured format ensures a clear and concise presentation of the university's research strategy.

Energy, Utilities & Sustainability

- Energy of the Future
- Environment and Circular Economy
- Future of Mobility
- Water Systems Evolution

Industrials & Infrastructure

- Industry 4.0/5.0
- Future of Defense Technology
- Infrastructure/ Cities of the Future
- Advancement of Materials

Digitization and Technology

- AI and Data Economy
- Future of IoT and Connectivity

Healthcare and Biotech

- Healthcare and Biotech Development

Business, Finance and Economics

- Future of Business and Financial Systems

Research Centers

Interdisciplinary

- Advanced Materials
- Intelligent Manufacturing & Robotics
- Membranes & Water Security
- Smart Mobility & Logistics
- Intelligent Secure Systems
- Sustainable Energy Systems
- Construction & Building Materials
- Communication Systems & Sensing
- Finance & Digital Economy
- Integrative Petroleum Research
- Refining & Advanced Chemicals
- Hydrogen Technologies & Carbon Management
- Aviation & Space Exploration
- Bio Systems & Machines
- Industrial Nuclear Energy

Applied

- Environment & Marine Studies
- Metrology, Standards & Testing
- Strategic Studies & Planning
- Development of Non-Profit Organization

Joint

- SDAIA Center for Artificial Intelligence
- KACST Center for Energy Efficiency
- KACARE Center for Energy Research

Internal Assessment: Strategic Insights from Management Reviews

As an integral facet of the research center performance monitoring system, a series of comprehensive management reviews are systematically undertaken to oversee and assess the ongoing progress and notable accomplishments achieved by the research centers.

The management reviews are conducted bi-annually, supplemented by a comprehensive annual review at the year's end for both research centers and support entities. These assessments identify achievements, progress, and gaps, guiding further follow-up and action items.

Over the two years following their establishment, management reviews of the research centers revealed various aspects that required planning for the formulation of the university's research strategy.

These aspects include:

1. Management reviews show successful identification of research trends, requiring a discerning approach to articulate focused priorities.
2. Reviews reveal untapped innovation potential, emphasizing the centers' capacity for groundbreaking advancements.
3. Achieving notable momentum in projects and collaborations promises synergistic outcomes. Robust innovation linkages must be established for interdisciplinary collaboration.
4. Identifying precursors to commercialization reflects the centers' viability in translating pursuits into tangible benefits.
5. Formal alignment with national research priorities is essential for coordination with broader strategic directions. Addressing these aspects enhances the effectiveness and impact of research initiatives, fostering a more cohesive and impactful research ecosystem.

KSA's National Priorities: Fueling Research and Innovation

In its unwavering commitment to fostering cutting-edge scientific research, KSA has launched a comprehensive initiative known as the "National Priorities for Research, Development, and Innovation" (referred to as "National Priorities" hereafter). This strategic framework represents a pivotal step toward driving innovation and knowledge creation within the nation. The initiative outlines the following key focus areas: energy and industrial leadership, sustainable environment and essential needs, economies of the future, and health and wellness. Each of these focus areas are significant in the context of Saudi Arabia's development and global relevance.

KFUPM played a pivotal role in influencing Saudi Arabia's national research directions, leading the way in aligning its research strategy with national trends. The four designated focus areas align seamlessly with the five main axes previously identified by KFUPM (see page 2).

This strategic consensus remains steadfast with the objectives set during the university's transformation process, ensuring research endeavors are devoted to enhancing societal well-being and promoting economic diversification. Hence, the development of the new strategy took into account the officially stated national priorities, serving as a guiding compass to identify the grand challenges across the university.

National Key Focus Areas

Pioneering Research Strategies: Grand Challenges as Inspiration

Research-intensive universities often construct their strategic research plans with a foundational focus on addressing what are commonly referred to as "grand challenges." These challenges represent multifaceted and pressing issues that greatly influence society, the environment, and the global community. They are characterized by their complexity, need for innovative and interdisciplinary solutions, and potential to bring about substantial societal and technological advancements.

KFUPM, akin to other research-intensive universities, incorporated grand challenges as a primary focus in shaping its strategic research plan. This approach aimed to identify grand challenges at the university level, emphasizing multidisciplinary research and strategic partnerships. The objective is to ensure an impactful contribution to the diversification of the Saudi economy while serving the broader needs of society and humanity.

Rationale for Grand Challenges in Research Strategies

Interdisciplinary Innovation

Uniting disciplines for innovative problem-solving approaches

Relevance to Ecomonic/ Society

Aligning research with economic/societal challenges for impact

Impact and Innovation

Pioneering Innovation in Grand Challenges

03 How: Articulating the Research Strategy

Innovative Horizons: A New Paradigm in Research Strategy

KFUPM's new strategy represents a significant departure from the past in three main aspects: its close alignment with the KSA's RDI needs, its impact-oriented focus on innovation, and its commitment to forging strategic partnerships spanning the entire research and innovation spectrum. These shifts signal a transformative approach that underscores the University's dedication to making research not only academically rigorous but also highly relevant, impactful, and collaborative in the pursuit of addressing the challenges and opportunities that matter most to the nation.

How will the new strategy make KFUPM research different from that in the past?

1

Priorities (Need/Opportunity-Driven)

Careful alignment with selected KSA's RDI needs

The new strategy aligned with the National Priorities. It emphasizes the identification and resolution of RDI priorities outlined by KSA. With such emphasis, the strategy ensures that research activities are relevant and directly contribute to addressing the challenges faced by the nation and contributing to the country's broader goals.

2

Outcomes (Economically/Socially Impactful)

Linking research to innovation (Advancing research results to the edge of commercial deployment TRL 6)

Another distinctive aspect of the new strategy is its pronounced impact-oriented focus. The current strategy places equal weight on linking research and innovation. It spans the entire Technology Readiness Level (TRL) spectrum, from the early stages of knowledge creation (TRL 1) to the later stages of technology demonstration (TRL 6). This evolution signifies a shift from research as a purely academic exercise to research as a driver of real-world innovation. It also bridges the gap between research findings and practical applications, thereby fostering a culture of innovation that can translate academic excellence into tangible solutions for societal challenges.

3

Approach (Triple-Helix Arrangements)

Partnerships:
-Technology developers and end users for innovation demand validation (TRL 1-3) and innovation execution (TRL 4-6)
-Governmental and regulatory authorities to facilitate technology advancement and deployment
-Social organizations for creating social impact

One of the most profound distinctions of the new strategy is its emphasis on strategic partnerships, which extend across multiple phases of research and innovation. This approach involves collaboration among various stakeholders, including technology developers, end users, and regulatory authorities. The new strategy also aligns research with the real-world needs and requirements of the industry and regulatory bodies, thus enhancing the practical relevance and impact of research efforts.

A Framework for Developing KFUPM Innovation-Based Research Strategy

A comprehensive strategic planning initiative was meticulously organized, characterized by active engagement and consultation with esteemed stakeholders. These stakeholders included the Research Oversight Committee (ROC); distinguished research leaders; academic leaders; dedicated researchers; esteemed faculty members; and the Vice President for Research and Innovation (VPRI), who served as the sponsor and owner of the strategy development process. The plan was further refined and enriched by weaving together the invaluable inputs furnished by the various research centers. This collaborative interaction facilitated the delineation of concrete action items imbued with purpose and strategic significance.

In essence, the strategic planning process exemplifies the harmonious orchestration of expertise and vision. The resulting product, a robust strategic research and innovation plan, serves as a testament to the efficacy of collaborative ideation, thoughtful prioritization, and the amalgamation of diverse perspectives. This strategic blueprint is poised to guide the institution toward the achievement of its research and innovation objectives with a comprehensive and well-coordinated approach.

Most successful universities in developing and implementing Grand Challenges-based research strategies:

Established elements encompass:

- Demarcated targets & goals
- Appropriate appraisal/accountability system
- Proper monitoring measures
- Plans for establishing partnerships

The approach to developing the research strategy encompasses several key steps:

1

Identification of National Priorities Relevant to KFUPM

The process commences by pinpointing the National Priorities that are relevant to KFUPM. This step ensures that the research strategy aligns with the broader national objectives.

2

Identification of Univeristy-Wide Grand Challenges

Then, the univeristy-wide grand challenges are identified. These challenges are complex issues that can best be addressed through collaboration among various research entities across the University. This step emphasizes the importance of interdisciplinary efforts to effectively tackle significant challenges.

3

Establishment of Innovation Goals

Specific innovation goals are then identified at the center level. An anchor center is designated for each innovation goal, and the supporting centers are identified to contribute to the achievement of these goals. This step sets clear objectives for innovation within the research centers.

4

Definition of Research Centers Roles

Finally, the roles of each research center are outlined in relation to their contribution to achieving the innovation goals. Hence, these research centers play a crucial role in addressing the across-campus grand challenges. This step ensures that each center is strategically positioned to make a meaningful impact and contribute to the overarching research and innovation strategy.

5

Development of the Implementation Plan (2024-2030):

Following the establishment of innovation goals and the roles of the research centers, the next crucial step is to devise a comprehensive implementation plan covering the period from 2024 to 2030. This implementation plan serves as a roadmap for the practical realization of the research strategy, allowing for precise project management and resource allocation to attain the outlined innovation goals. It also underscores the strategic partnerships that will be sought or nurtured to ensure the successful execution of these projects.

KFUPM's research strategy aligns with National Priorities, boldly addressing societal challenges through interdisciplinary collaboration and innovative pursuits within its research centers, thereby bridging the gap between research, teaching, learning, and public engagement, and contributing directly to the university's institutional mission.

04 What: Identifying the Grand Challenges

To create a robust research strategy for KFUPM, we embarked on a comprehensive process. This process began with the identification of KFUPM's grand challenges, which were carefully curated to align with the critical national research priorities. In this endeavor, we assigned paramount importance to the most relevant National Priorities.

Our research community at KFUPM then conducted an extensive examination of how they could actively contribute to addressing these National Priorities. This phase involved a deep dive into the core questions of how we could leverage our expertise, resources, and knowledge to create meaningful impact on the National Priorities.

Subsequently, we formulated specific innovation goals. These goals were designed to serve as building blocks to achieve the overarching university-wide grand challenges. Each innovation goal was anchored by a dedicated research center within our institution.

The appendix displays a matrix summarizing KFUPM's grand challenges identified for addressing selected national priorities and the associated innovation goals. Additionally, it features a heatmap illustrating the roles of participating centers in achieving each goal.

A Energy and Industrial Leadership

A1. Clean, Economic Hydrogen
A2. Renewable Energy
A3. Crude Oil-to-Chemical Conversion
A4. Geoenergy Leadership
A5. Electric Vehicles (EVs) and EV Batteries
A6. Nuclear Energy

B Sustainable Environment and Essential Needs

B1. Innovative Water Research
B2. Net Zero Emissions
B3. Reuse of Materials and Products in Industry
B4. Biodiversity

C Economies of the Future

C1. Cognitive Cities
C2. Automation of Logistics
C3. Industrial Robots
C4. Net Zero Aviation
C5. New Space Leadership
C6. FinTech
C7. Gaming and ESports

D Health and Wellness

D1. Health and Bioengineering Innovation

A. Energy and Industrial Leadership

- A.1 Clean, Economic Hydrogen
- A.2 Renewable Energy
- A.3 Crude Oil-to-Chemical Conversion
- A.4 Geoenergy Leadership
- A.5 Electric Vehicles (EVs) and EV Batteries
- A.6 Nuclear Energy

A.1 Clean, Economic Hydrogen

KFUPM Grand Challenge

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 TRL 5 by 2026	Identify the geological formations suitable for large scale hydrogen storage by 2026
Reduce the cost of electrolyzer stacks (membrane, electrode…etc.) by 50% to produce green hydrogen by 2030	Optimize the cost of local distribution of hydrogen to less than $0.3/kg by 2030
Improve the cost of hydrogen production from hydrocarbons to less than $0.5/kg by 2030	Establish a reliable, adaptable, and cost-effective hydrogen production system, fully powered by renewable energy sources by 2030
Survey 50% of the KSA's geological formations for natural hydrogen sources by 2026	Develop anticorrosion and lightweight materials for high-pressure storage tanks by 2028
Develop efficient and sustainable hydrogen storage solutions with a cost of less than $0.2/kg of H_2 by 2030	Synergize the national ecosystem in favor of hydrogen technology development by establishing the future hydrogen consortium

A.2 Renewable Energy

KFUPM Grand Challenge

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	Demonstrate operation of 10 kW redox flow batteries with a cost-effective electrolyte, enabling $100/kWh 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	Develop control and adaptive protection strategies to ensure reliable and stable power transmission and distribution systems with 30% renewable energy penetration by 2030

A.3 Crude Oil-to-Chemical Conversion

KFUPM Grand Challenge

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

A.4 Geoenergy Leadership

KFUPM Grand Challenge

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

A.5 Electric Vehicles and EV Batteries

KFUPM Grand Challenge

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

A.6 Nuclear Energy

KFUPM Grand Challenge

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

B. Sustainable Environment and Essential Needs

- B.1 Innovative Water Research
- B.2 Net Zero Emissions
- B.3 Reuse of Materials and Products in Industry
- B.4 Biodiversity

B.1 Innovative Water Research

KFUPM Grand Challenge

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%

B.2 Net Zero Emissions

KFUPM Grand Challenge

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 CO_2 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:

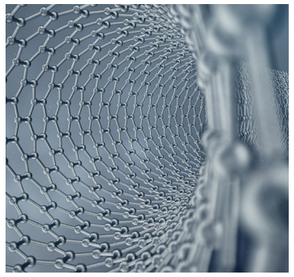
- Develop dynamic building envelopes and an optimized hybrid energy system that reduce building and industrial sectors' energy consumption by 70% by 2030
- Achieve 50% reduction of carbon emissions from combustion-based systems (e.g., steel and cement production, flaring) by 2040
- Target 10% performance 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 CO_2 storage by 2025
- Develop technologies for the conversion of CO_2 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 CO_2 emissions combustion by 2030

B.3 Reuse of Materials and Products in Industry

KFUPM Grand Challenge

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.



B.3 Reuse of Materials and Products in Industry

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 technology to make natural fibers and pulp from date palm waste by 2026

B.4 Biodiversity

KFUPM Grand Challenge

KFUPM will develop the following by 2030:

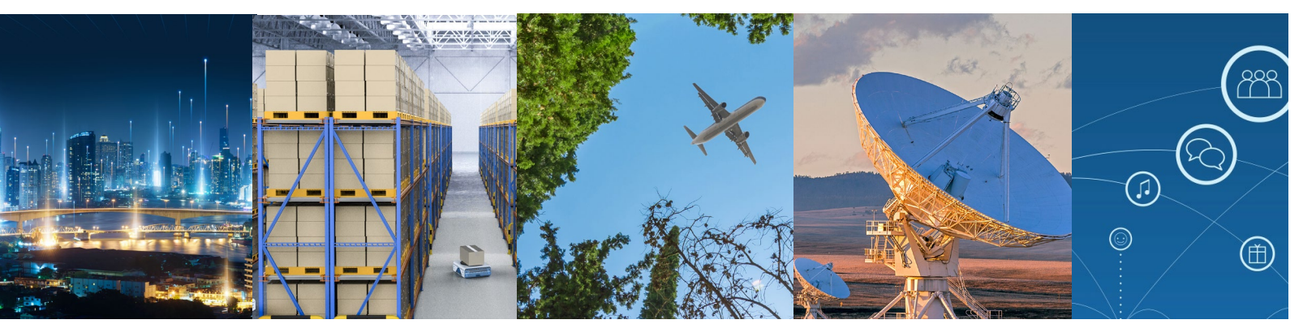
1. A smart tools-based mapping strategy to enable KSA to conserve 30% of the biodiversity of marine and coastal habitats
2. AI-based algorithms and applications for automated taxonomical identification of KSA's wildlife
3. An environmental surveillance network that enhances the ecosystem status assessment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

C. Economies of the Future

- C.1 Cognitive Cities
- C.2 Automation of Logistics
- C.3 Industrial Robots
- C.4 Net Zero Aviation
- C.5 New Space Leadership
- C.6 FinTech
- C.7 Gaming and ESports



C.1 Cognitive Cities

KFUPM Grand Challenge

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

C.2 Automation of Logistics

KFUPM Grand Challenge

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

C.3 Industrial Robots

KFUPM Grand Challenge

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

C.4 Net Zero Aviation

KFUPM Grand Challenge

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

C.5 New Space Leadership

KFUPM Grand Challenge

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

C.6 FinTech

KFUPM Grand Challenge

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

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

C.7 Gaming & ESports

KFUPM Grand Challenge

KFUPM will contribute to developing of 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

D. Health and Wellness

D.1 Health and Bioengineering Innovation

D.1 Health and Bioengineering Innovation

KFUPM Grand Challenge

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.

- 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

05 Plan: Turning Strategy into Action

KFUPM's **innovation-based research strategy** relies on innovation goals, requiring collaborative efforts across diverse centers and strong strategic partnerships for goal achievement. As a result, the implementation process requires cooperation and involvement not only from specialized research centers but also from all entities linked to the research and innovation sector for support and follow-up.

The evaluation of progress in tackling the university-wide grand challenges will be spearheaded by the Vice President for Research and Innovation (VPRI) and the Research Oversight Committee (ROC). VPRI will conduct two significant meetings each year to assess the ongoing advancements in the innovation-based research strategy.

Furthermore, the ROC will actively pinpoint emerging areas of research strength and adapt KFUPM's research strategy flexibly for optimal growth and increased impact.

The Research Excellence Office, overseen by the VPRI, plays a crucial role in executing the strategy. Operating through three distinct modalities, it guides strategy implementation, assesses requirements for innovation goals, and fosters ownership, synergy, and communication.

Dedicated to each National Priority, Champion Centers coordinate efforts to address KFUPM's grand challenges and fulfill National Priorities through fostering coordination, communication, and progress monitoring.

The Research Excellence Office will serve as a vital pillar and operate through three distinct modalities:

1

Guiding Strategy Implementation

The office will serve as the guiding force, ensuring that the research centers adhere to the strategic vision and objectives.

2

Assessing Requirements for Innovation Goals

The office will play a critical role in assessing the essential requirements for achieving the innovation goals and aligning resources with these objectives.

3

Fostering Ownership, Synergy, and Communication

The office will facilitate communication of the strategic goals among the research centers, foster synergy among various stakeholders, and ensure transparent communication to enhance collaboration.

Strategic Assignments: Championing National Research Priorities

The Champion Center dedicated to each National Priority will ensure a unified direction in addressing KFUPM's grand challenges and making significant contributions to fulfilling the relevant National Priority. In a central role, the Champion Center fosters coordination and alignment among diverse anchor centers and supporting centers striving for innovation goals. The Champion Center also facilitates transparent communication among the research centers involved in the national priority, conducts comprehensive periodic reviews of activities and projects, and monitors progress toward innovation goals, as indicated by the identified "Key Research Results." These roles are crucial for identifying and overcoming obstacles that may hinder the addressing of KFUPM's grand challenges

National Focus Area	National Priority	Champion Center
Energy and Industrial Leadership	Clean, Economic Hydrogen	IRC for Hydrogen Technologies and Carbon Management
	Renewable Energy	IRC for Sustainable Energy Systems
	Crude Oil-to-Chemical Conversion	IRC for Refining and Advanced Chemicals
	Geoenergy Leadership	Center for Integrative Petroleum Research
	EVs and EV Batteries	IRC for Sustainable Energy Systems
	Nuclear Energy	IRC for Industrial Nuclear Energy
Sustainable Environment and Essential Needs	Innovative Water Research	IRC for Membranes and Water Security
	Net Zero Emissions	IRC for Hydrogen Technologies and Carbon Management
	Reuse of Materials and Products in Industry	IRC for Construction and Building Materials
	Biodiversity	ARC for Environment and Marine Studies
Economies of the Future	Cognitive Cities	IRC for Intelligent Secure Systems
	Automation of Logistics	IRC for Smart Mobility and Logistics
	Industrial Robots	IRC for Intelligent Manufacturing and Robotics
	Net Zero Aviation	IRC for Aviation and Space Exploration
	New Space Leadership	IRC for Aviation and Space Exploration
	FinTech	IRC for Finance and Digital Economy
	Gaming and ESports	IRC for Finance and Digital Economy
Health and Wellness	Health and Bioengineering Innovation	IRC for Bio Systems and Machines

Plan: Turning Strategy into Action

Review and Monitoring

The assessment of innovation goal achievement follows the “Objectives and Key Results” methodology, a framework for setting clear, measurable objectives and specific key results to gauge progress. This methodology mirrors the approach used in developing the research strategy, where innovation goals serve as “objectives.” Key research results are systematically evaluated to ensure effective strategy execution throughout the period (2024–2030).

Semiannual reviews of overall progress with the VPRI serve as a vital mechanism for monitoring and enhancing the alignment of Champion Centers with national research priorities. This section guides the intricate process of assigning, coordinating, and overseeing Champion Centers, enabling KFUPM to effectively pursue and attain its national research priorities and innovation goals.

Plan: Turning Strategy into Action

Strategic Partnership

The updated research strategy places a strong emphasis on cultivating strategic partnerships spanning various stages of research and innovation. The Industrial and Research Partnership Office (IPRO) will play an active role in establishing these strategic alliances to support the implementation of the innovation-driven research strategy. The process of building strategic partnerships involves three key phases: Connect, Manage, and Evaluate.

In the Connect phase, IPRO will closely collaborate with research centers or a cluster of research centers to engage with relevant industry partners, including technology developers, end-users, and regulatory entities. A cluster of research centers refers to a collective of centers aligned with the overarching challenges and innovation objectives of KFUPM. A cluster may have similar industries to work with, in this case, the cluster will be treated as one entity in terms of conducting meetings and alignment workshops. Research centers are expected to provide information about existing or potential industry partners, although IPRO may also proactively identify and present potential partners. The suitability of potential partners will be assessed based on factors such as alignment of research interests, reputation, financial capabilities, technical expertise, commitment to research, communication culture, collaboration practices, and risk assessment.
Alignment workshops and frequent meetings will ensure a unified work plan addressing KFUPM’s major challenges and contributing to the national mission.
Effectively managing established partnerships is crucial for fostering and sustaining collaboration. Periodic updates on progress, milestones, and outcomes of a collaboration will be collected and communicated to the DROC, the Office of Research Excellence, and industrial partners. This proactive management approach allows for the identification and resolution of issues, providing assistance as needed, and showcasing outstanding outcomes.

Partnerships will undergo bi-annual evaluations conducted by IPRO and the Research Excellence Office. The evaluation aims to assess the impact of partnerships and their contributions to achieving KFUPM’s innovation goals. Evaluation encompasses an overall performance assessment, identifying gaps, areas for improvement, fulfillment of requirements, and the overall experience with partners. Both KFUPM and industry partners will participate in the evaluation process. Evaluation results will be communicated to the VPRI, DROC, and senior management of the industry partners. Recommendations arising from the evaluation may include the suspension or strengthening of existing partnerships or exploring new partnerships in specific domains.

The process of assessing the achievement of innovation goals is based on the “Objectives and Key Results” methodology, a goal-setting framework used to define clear, measurable objectives and specific key results that indicate progress.

Plan: Turning Strategy into Action

Fostering Social Innovation for Societal Impact

KFUPM's plan for fostering social innovation and societal impact involves the Center of Excellence in Development of Nonprofit Organizations (CNPO) supporting all Research and Innovation centers. This support includes identifying direct and indirect societal impacts and the value on humanity as identified in the UN-SDGs through a comprehensive strategy. The strategy focuses on key dimensions: i) Awareness and Engagement, ii) operational sustainability, iii) Addressing community needs, and iv) sustaining societal impact.

To ensure the success of this strategy, CNPO will carry out the following supporting activities to ensure the achievement of the four dimensions of the strategy:

- Conducting workshops to unify perceptions and confirm the involvement of all university Employees, Faculty, and researchers.
- Building institutional and Human capital capacities in research centers to provide social innovation services.
- Assisting research centers in building their operational plans according to the strategic indicators.
- Building tools and models to activate the strategy, supervise it, and measure its societal impact.

Plan: Turning Strategy into Action

Research for Humanity

KFUPM recognizes its responsibility to contribute meaningfully to the interconnected challenges facing humanity and our planet. Through the "Research for Humanity" initiative we envision a collaborative landscape where diverse minds converge to address pressing local and global issues. Our university will avail its capabilities to foster transformative interdisciplinary collaboration where engineers, geologists, social scientists, historians, and data analysts converge to solve real-world problems by fostering cross-cultural exchanges and laying the groundwork for impactful joint projects.

Our initiative aims to position KFUPM as a catalyst for interdisciplinary excellence. We encourage exploring uncharted territories, breaking down intellectual walls, and forging connections that will advance knowledge and contribute meaningfully to the world around us.

Together with this initiative, at the heart of our interdisciplinary research vision lies a commitment deeply intertwined with the United Nations Sustainable Development Goals (SDGs). Seventeen critical SDG goals form an interconnected roadmap for a sustainable future, covering issues from poverty eradication and hunger elimination to gender equality and combatting climate change. KFUPM acknowledges the pivotal role research plays in contributing to these ambitious goals. We are dedicated to harnessing the collective brilliance of diverse researchers and faculty across disciplines to generate innovative solutions that address real-world issues.

The "Research for Humanity" initiative signifies our commitment to impactful, collaborative, and interdisciplinary research that not only advances knowledge but also contributes to creating a better world for current and future generations.

Bridging KFUPM Innovation Chasms in the Areas of Capital-Intensive Technologies

Implementing this research strategy demands building weighty innovation-based partnerships (both with industrial end-users and technology developers), initiating investments reinforced by the private sector, and achieving market-fixated opportunities. Similarly, implementing effective ecosystems of research-intensive universities requires infrastructure to leverage the research outcomes jointly with the partners for programmatically arranging for:

- Shaping the technology & identifying preliminary market entry barriers (TRL 2-4).
- Scaling and piloting technology and validating the market entry barriers (TRL 4-6).

Such infrastructure will be used to further the experimental development capacities for capital-intensive technologies (hydrogen generation/storage/transportation, carbon capture, water purification, renewable energy generation, petroleum conversion, and advanced manufacturing).

Additionally, the fast-tracked growth of several new R&D fields in the new digitalization and IR4 sciences and technologies requires developing different support setups for experimentation. The presence of such setups jointly with traditional technical/engineering support capabilities (both skills and infrastructure) enhances the ability to develop IR4-based products/applications/systems.

The infrastructure for technology advancement (TRL 3-6) typically comes in one of two forms, namely, thematic centers for innovation and translational R&D facilities. Thematic centers for innovation connect existing theoretical research with corporate challenges, facilitating the adaptation of existing solutions to address practical challenges. On the other hand, the translational facilities act as partnership vehicles enabled by advanced infrastructure and talented specialists for translating separate realms of basic research into an incorporated innovative domain. Both types of infrastructure play more strategic goals beyond the mere development of new technologies, whether based on fundamental research or modified for scale from prototype and low-usage items. They have the ability to tackle some of the most difficult challenges of today across global and national strategic issues as they offer platforms for significant collaboration and alignment across diverse stakeholders and disciplines towards a common objective. They are typically multi-sectorial and part of multi-functional partnerships throughout the research value chain.

These infrastructural arrangements address and alleviate a range of other bottlenecks to facilitate the successful deployment, commercialization, and diffusion of technology into the economic system, including developing the national capability in the supply chain of the new technologies, anchoring national capacity to high-growth sectors and increasing resilience to supply shocks. Most specifically, they nurture what can often be nascent markets and work with existing companies to help them understand the potential for novel technologies emerging from the research base. Additionally, infrastructural arrangements work with the government to build the systems that deliver the skills needed for the economic development activities related to the new technologies and develop the new standards and regulations for the new economies created in areas of the deployed technologies.

To narrate a convincing story that attracts public and private funds for establishing the infrastructure, it is planned to develop:

1. **The funding and economic feasibility model of proposed thematic innovation centers/translational R&D facilities.**
2. **List of exemplary opportunities for commercializing potential KFUPM technologies through industrial partnerships that utilize infrastructure of the proposed thematic innovation centers/translational R&D facilities.**
3. **The required technical/engineering specifications of the infrastructure and skills/expertise of every proposed thematic innovation center/ translational R&D facility.**
4. **The candidate partners /clients for every proposed thematic innovation center/ translational R&D facility.**

Research Environment Enhancement

The success of university's research endeavors is not solely determined by brilliant minds and groundbreaking ideas. It hinges critically on the research environment, a complex ecosystem that nurtures, challenges, and directs the course of discovery. KFUPM is undertaking major steps to enhance the research environment in alignment with the overall research strategy to maximize research and innovation's economical and societal impacts.

KFUPM will take major steps as part of the new research and innovation strategy:

Centralize and Optimize Infrastructure: Establish state-of-the-art central research facilities equipped with cutting-edge technology and resources, accessible to all researchers across disciplines.

Streamline Policies and Regulations: Review and revise existing research policies and regulations to simplify processes, enhance transparency, and accelerate research progress.

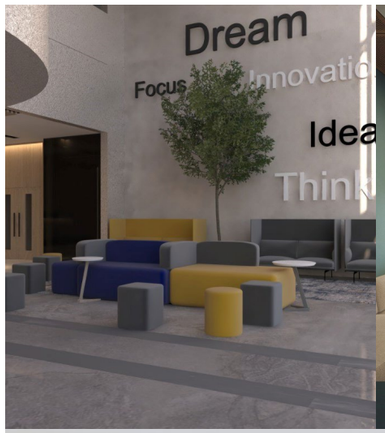
Revitalize Existing Labs: Renovate and modernize labs in buildings 15, 26, and 28, transforming them into vibrant hubs for collaboration and experimentation.

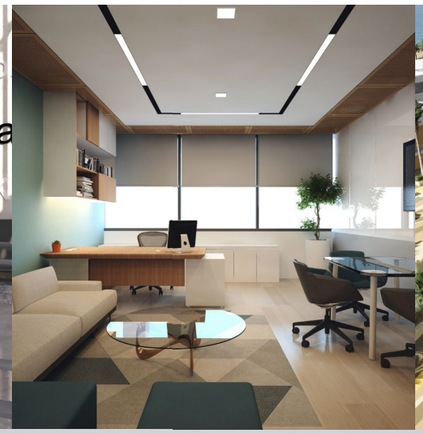
Foster Interdisciplinary Synergy: Facilitate collaboration across disciplines through dedicated programs, shared resources, and flexible research spaces.

Attract and Retain Top Talent: Develop competitive research funding programs, mentorship initiatives, and career development opportunities to attract and retain world-class researchers.

Promote Knowledge Exchange: Foster open communication and knowledge sharing through seminars, workshops, and conferences, empowering researchers to learn from and inspire each other.

Bridge Industry and Academia: Strengthen partnerships with industry leaders to translate research findings into practical applications, benefiting society and the economy.





A vibrant and supportive research environment is the cornerstone of a successful university. By understanding its impact on the overall research strategy and investing in its development, universities can foster a culture of excellence, attract top talent, generate groundbreaking discoveries, and ultimately contribute meaningfully to the advancement of knowledge and society.

As a result of the new strategy, KFUPM will invest in enhancing research and innovation environment to:

1. **Increase research impact:** High-quality facilities, efficient processes, and collaborative environments will lead to groundbreaking discoveries and economical/societal impact.
2. **Contribute to national development:** Research outcomes will address national priorities in science, technology, and industry, fostering economic growth and societal progress.
3. **Enhanced reputation and global recognition:** KFUPM will attract prominent researchers, students, postdocs, and international partnerships, positioning it as a leading research hub.
4. **Attracting and retaining top talent:** Modern facilities, streamlined processes, and competitive support will attract and retain high-caliber researchers and students.

National Focus Area	KSA's National Research Priority	KFUPM's Grand Challenges	KFUPM's Innovation Goals	Aerospace	BioSys	Chemicals	Communication	Construction	Energy	Environment	Fintech	Hydrogen	Integrative	Logistics	Manufacturing	Materials	Metrology	Nuclear	Security	SDAIA	Water
Energy and Industrial Leadership	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.	Develop the in-well hydrogen production process to TRL 5 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 H_2 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.	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.	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			■						■									■
	Geoenergy Leadership	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.	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									■	■								
	Electric Vehicles (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.	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.	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					■								■		■			
Sustainable Environment and Essential Needs	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%.	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%											■						■	■
	Net Zero Emissions	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 CO_2 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.	Develop dynamic building envelopes and an optimized hybrid energy systems 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 CO_2 storage by 2025										■								
			Develop technologies for the conversion of CO_2 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 CO_2 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.	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			■		■	■												

National Focus Area	KSA's National Research Priority	KFUPM's Grand Challenges	KFUPM's Innovation Goals	Aerospace	BioSys	Chemicals	Communication	Construction	Energy	Environment	Fintech	Hydrogen	Integrative	Logistics	Manufacturing	Materials	Metrology	Nuclear	Security	SDAIA	Water
Economies of the Future	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.	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													●					
	Biodiversity	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%.	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				■		■	●				■	■		■				
	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.	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.	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.	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												■							
	Net Zero Aviation	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.	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	●											■					■	■	
	New Space Leadership	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.	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	●																	■	
	FinTech	KFUPM will develop technologies and solutions that enhance the innovative competencies of 50 fintech firms and 20 consumer adoption frameworks by 2028.	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.	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								■									■	■	
Health & Wellness	Health and Bioengineering Innovation	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.	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		■						■											

● Anchor center ■ Supporting Center

Closing Remarks

Imagine a vast ocean of research, that KFUPM has navigated for decades, charting discoveries across diverse disciplines like engineering, science, and humanities. This rich legacy, a testament to the university's unwavering pursuit of knowledge, forms the bedrock for KFUPM's next chapter: an innovation-based research strategy. This strategy, like a series of lighthouses, illuminates the path towards impactful research. It focuses research efforts on addressing challenges relevant to both Saudi Arabia and the wider world, from sustainability and healthcare to energy and artificial intelligence.

Fueling this journey is a revitalized research ecosystem, where disciplines no longer stand as islands but unite in vibrant collaboration. Imagine physicists working with economists to develop renewable energy solutions, or computer scientists partnering with architects to design smart cities. This cross-pollination of ideas fosters innovation like never before. Energized by this collaborative spirit, KFUPM embarks on a new era of discovery. Breakthroughs in renewable energy will light up homes, while advancements in healthcare will extend lives. Imagine students developing robots to explore Mars or engineers designing sustainable desalination plants to combat water scarcity. The possibilities are endless.

The success of this ambitious journey hinges on rigorous implementation and execution. A clear roadmap guides the way, with regular monitoring and feedback mechanisms ensuring the strategy stays on course. Imagine dedicated teams meticulously tracking progress, analyzing results, and continuously adapting to optimize outcomes.

KFUPM is not content with simply reaching its destination; it aims to evolve and improve continually. Through ongoing reviews and refinements, the university strives to become a beacon of research excellence, recognized not just within the Kingdom but on the global stage. Ultimately, KFUPM's research transformation journey is driven by a dream: to become a research-intensive university that plays a pivotal role in diversifying Saudi Arabia's economy. Imagine research-driven startups flourishing, attracting talent and investment from around the world. This is the future KFUPM works towards, a future where knowledge fuels innovation and innovation drives progress for generations to come.

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