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BRAINSHORING SERVICES

2023: A Year in Review

Introduction

Looking back over the year, sustainability, connectivity, and automation have emerged as highlights with significant impact across industries. The next few slides provide a summary of some of the key topics covered during the year, which can serve as a practical guide for companies on the current landscape and the outlook, providing insights to stay ahead of industry developments and lead the change to greater innovation and sustainability:

- **Hydrogen market overview: The role of clean hydrogen in decarbonization:** Examining the role of clean hydrogen, with a focus on blue and green hydrogen, this report provides key insights into demand, applications, and the infrastructure required for sustainable growth
- **Hydrogen market overview and outlook – Middle East:** Delving into the field of low-carbon hydrogen in the Middle East, this report addresses the enablers and challenges and provides an overview of regional projects, agreements, market players, and climate targets
- **Mobility 2.0: Connected, Autonomous, Sustainable:** This report analyzes the evolving trends of connectivity, autonomy, and sustainability in the mobility sector. It offers insights, assesses their impact, and provides forward-looking forecasts.
- **New City Projects: How are new cities planning to integrate technology and sustainability to create a better future?:** Examining the intersection of technology and sustainability in new city initiatives, this report explores the opportunities and challenges associated with innovative living
- **Robotics and automation: Overview, applications, and impact on the workforce:** The report focuses on the types of hardware robots, the different industry applications, including the automotive and healthcare industries, and the emerging automation trends

Meeting the 2050 Net Zero goal relies on green hydrogen (60-70% of total production), driven by demand from emerging applications

HYDROGEN DEMAND

In 2021, global hydrogen demand hit a record high of **94 Mt,** most of which was concentrated in the **refining** and **chemical** sectors

By 2030, hydrogen demand is expected **to reach 180 Mt,** in line with the Net Zero Scenario. This will necessitate a substantial surge in demand from emerging applications.

Hydrogen is poised to play a crucial role in decarbonizing sectors where emission reduction has proven to be challenging

The readiness to transition to clean hydrogen varies across sectors:

Transition from grey to clean hydrogen:

Refining, Ammonia, Methanol, Iron & Steel

Long-term development needed:

Shipping, Aviation, Power generation

Hydrogen as an alternative to electricity

LDVs, Residential and Commercial heating

HYDROGEN PRODUCTION

In 2021, 99% of the global demand was met with hydrogen produced from non-renewable sources, with clean hydrogen comprising less than 1% of the total production

In the NZE scenario by 2030, projections indicate the continued dominance of grey hydrogen, with a growing prominence of blue and green hydrogen. Looking ahead to 2050, there is a consensus that green hydrogen will dominate, accounting for 60-70% of the market.

Factors that can affect the forecasts:

- The use of carbon neutral renewable energy
- Cost reduction increasing affordability
- Wider technological innovation and adoption

From 2021 to 2023, there is a notable rise in the announced expansions of Carbon Capture and Storage and electrolyzer capacities, with an influx of new participants. However, the current deployment levels still lag behind the necessary capacity to meet the 2030 NZE forecasts.

Sources: Infomineo "Hydrogen market overview: The role of clean hydrogen in decarbonization" (2023)

As demand for hydrogen continues to grow, infrastructure challenges to transport and store hydrogen will arise

HYDROGEN INFRASTRUCTURE

Establishing a robust hydrogen infrastructure is essential for facilitating its transportation, storage, and global trade. The growing prevalence of large-scale applications necessitates efficient transportation methods and geological storage, driving additional research and development efforts to contribute to the expansion of the global hydrogen trade.

Transportation Dynamics

- Currently, **trucks and pipelines** are the primary means of hydrogen transportation due to their cost-effectiveness compared to shipping
- However, meeting future demand requires considering factors like volume, distance, final energy demand, and end-use in transportation
- Conditioning methods, such as compression, liquification, or carriers like ammonia and LOHC, are employed for more efficient transport

Storage Challenges and Solutions

- While pressurized containers are efficient for smaller projects, a shift to more affordable underground storage is crucial to meet the estimated capacity, covering **15% to 20%** of annual future hydrogen use
- This transition demands further research and development for testing and implementing underground storage

Hydrogen Trade Projections

- The trajectory of hydrogen trade is expected to **rise globally**, with the Americas holding high potential for blue and green hydrogen exports
- Germany and the Netherlands are emerging as significant hydrogen importers. Over 42 governments worldwide have released national hydrogen strategies, aiming to unlock the potential for hydrogen trade on a global scale

Sources: Infomineo "Hydrogen market overview: The role of clean hydrogen in decarbonization" (2023)

Despite its favorable conditions for renewables, the Middle East faces challenges, including high transportation costs and water scarcity

HYDROGEN HIGH POTENTIAL IN THE MIDDLE EAST

Energy Resources

- The Middle East has significant potential for low-carbon hydrogen production with its **vast natural gas reserves**, including the world's largest field, South Pars/North Dome
- **Optimal conditions for solar and wind projects**, demonstrated by projects like the Al Dhafra solar PV plant (2 GW), further enhance its prowess

Infrastructure Advantage

The GCC has robust **refining facilities** like the Ruwais ammonia plant, **abundant underground salt caverns**, and **existing natural gas pipelines that can be adapted** for hydrogen transport without requiring extensive grid reinforcement

Export Hub Potential

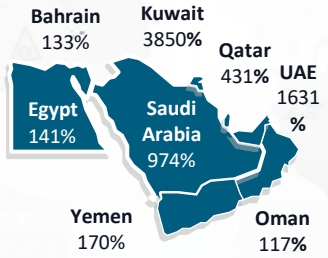
The Middle East seeks to be **a central hub for hydrogen exports**, **targeting Europe and Japan**. Challenges may arise from changing **U.S. interest in hydrogen** and **Spain's plans for hydrogen production** and import from North Africa

HYDROGEN CHALLENGES

Regulatory Challenges

The Middle East faces **regulatory gaps in hydrogen projects**, with notable progress in the UAE's hydrogen strategy, Hydrogen Oman (Hydrom) overseeing industry development, and the introduction of national hydrogen strategies in Egypt and Saudi Arabia

Water stress in the middle east region, by country (2019)[1]



Significant Water Scarcity

Green hydrogen production demands **high-purity water**, posing challenges in the **water-stressed Middle East region**. Steam reforming in **blue hydrogen** also requires **substantial water,** and desalination raises energy demands and environmental concerns

High Transportation Costs

Shipping hydrogen is expensive, impacting production and landing costs. Repurposing pipelines reduces costs but requires extensive studies. Ammonia transportation offers affordability but adds costs when hydrogen is the end product

Sources: Infomineo "Hydrogen market overview and outlook – Middle East" (2023)

Several clean hydrogen projects have been announced in the Middle East, with total production expected to reach 18 million mt by 2030

HYDROGEN MOMENTUM IN THE MIDDLE EAST

Countries in the Middle East are **actively participating in the growing hydrogen market**, making numerous project announcements and significant investments:

The UAE is at the **forefront of adopting hydrogen technology,** as exemplified by key projects like DEWA's USD 14 million green hydrogen pilot for Expo 2020 and the ADNOC Ruwais blue hydrogen plant

Qatar is actively investing in a **green hydrogen and ammonia project** in the Suez Canal Economic Zone with the aim of producing green fuel for ships and exporting, thereby capturing 1.5 million tons of CO2 annually

Egypt is actively **advancing green hydrogen** with projects like ACME Group's USD 13 billion hydrogen hub, ReNew Power's USD 8 billion project in the Suez Canal, and others

Saudi Arabia is developing **green and blue hydrogen projects**, with the biggest project being the NEOM USD 8.5 billion Green Hydrogen Project, utilizing 4 GW of renewable energy for green ammonia

Oman is actively **involved in diverse green hydrogen projects,** such as the Sumitomo-Ara Petroleum Hybrid Hydrogen Project, aiming to produce 300-400 tons of hydrogen annually

Bahrain and Kuwait are venturing into hydrogen with recent project announcements. **Kuwait** is shaping its **National Hydrogen Strategy, and Bahrain** plans a groundbreaking **4-MW green hydrogen plant** with an initial phase estimated at USD 150 million

Sources: Infomineo "Hydrogen market overview and outlook – Middle East" (2023)

The mobility industry is developing strategies to achieve net-zero by 2050 driven by regulatory pressures and economic incentives

ELECTRIC VEHICLES

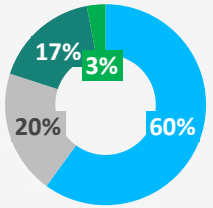
- EVs are emerging as the primary sustainable option, significantly reducing greenhouse gas emissions (**52% less for cars**, **57% less for trucks** over their lifetime)
- Major automakers are aiming for a complete transition to 100% electric vehicles by 2030:

Short Term	Medium Term	Long Term
Expected stricter emissions regulations	Advancements in EV technology enhance efficiency	EVs must match ICEV prices for full electric mobility adoption

DECARBONIZING SHIPS

- **Stringent regulations, affordable green technology, and the competitive advantage** of sustainability are driving shipping to decarbonize
- IMO* targets **a 40% emissions reduction by 2030 and 70% by 2050**, while IRENA suggests achieving net-zero by 2050 through **electrification**, **advanced biofuels**, **improved efficiency**, and **reduced sectoral demand.**

Projected Impact of Key CO2 Reduction Measures in IRENA's 1.5°C Scenario



SUSTAINABILITY IN AVIATION

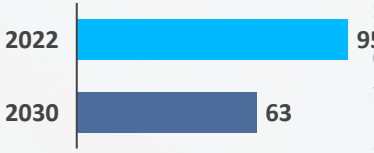
- Aviation contributes nearly **3% of global CO2 emission**s, with concerns it could reach **22% by 2050**
- To address this, airlines under **IATA aim for net-zero emissions by 2050** through:

Short Term	Medium to Long Term
CO2 offsets	Sustainable Aviation Fuels (SAFs), open fan architecture engines, and new propulsion systems

RAILWAY SYSTEMS

- Rail systems are critical to achieving a decarbonized future by 2050 due to their energy efficiency and environmental friendliness
- To meet IEA projections, rail will need to increase its **share of the transportation sector by more than 40% by 2030**, including a transition away from aviation and road transport

CO2 emissions from rail in the Net Zero Scenario



* International Maritime Organization (IMO)

Sources: Infomineo "Mobility 2.0: Connected, Autonomous, Sustainable" (2023)

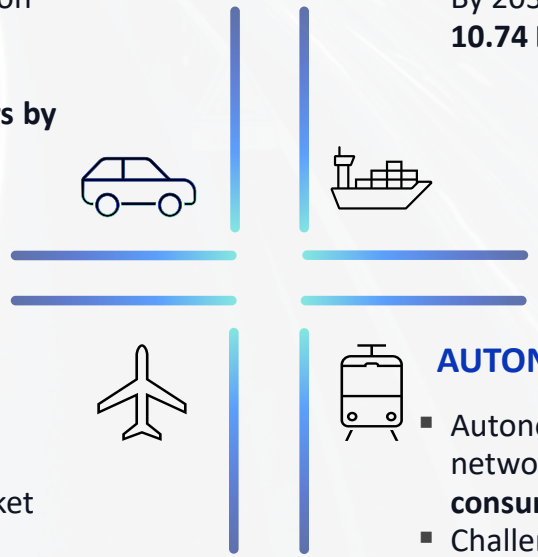
Aviation and maritime have seen significant growth in autonomous technology, while the rail industry faces integration challenges

SELF DRIVING VEHICLES

- Full automation (Level 5) is set to revolutionize mobility, but its deployment and customer adoption timelines are delayed
- Automakers diverge in focus: some prioritize partial automation for **quicker and cheaper deployment**, while others persist in developing self-driving technology
- Level 4 automation is **forecasted to be available to consumers by 2030**, while Level 5 timelines remain uncertain.

AUTONOMOUS SHIPS

- There are over 1,000 Maritime Autonomous Surface Ships (MASS) operational globally as of 2021, with 53 organizations involved
- By 2030, the global autonomous ship market is **expected to reach USD 10.74 Billion**



AUTONOMOUS AIRCRAFT

- The development of autonomous aircraft has experienced substantial growth over the past five years, characterized by:
  - ✓ new entrants and significant investments in the market
  - ✓ well-established aerospace companies announcing investments in the market
- Currently, autonomy is being introduced in smaller categories of aircraft before expanding to larger aircraft
- Widespread **commercial deployment of autonomous applications in public transportation** is expected by 2040

AUTONOMOUS RAIL

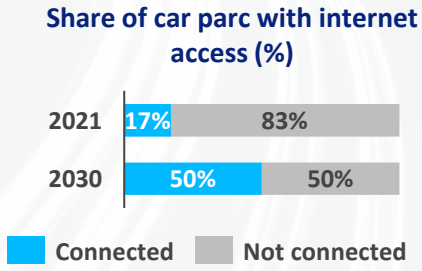
- Autonomous trains can help increase the capacity of existing rail networks by as much as 44%, leading to **up to 45% less energy consumption**
- Challenges in achieving widespread market integration of autonomous trains include **passenger skepticism** and **the need for significant infrastructure upgrades** requiring substantial investments

Sources: Infomineo "Mobility 2.0: Connected, Autonomous, Sustainable" (2023)

By 2030, connectivity is set to surge, to be featured in half of the global car fleet and double the number of aircrafts

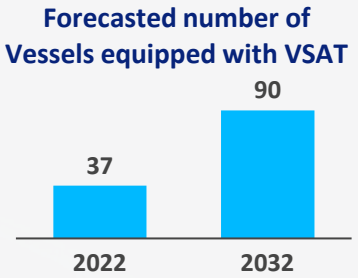
AUTOMOTIVE CONNECTIVITY

Over the last decade, automotive connectivity has evolved, with **embedded connectivity transforming the industry**. By 2030, **half of the global fleet** and **95% of new vehicles** are expected to be connected cars



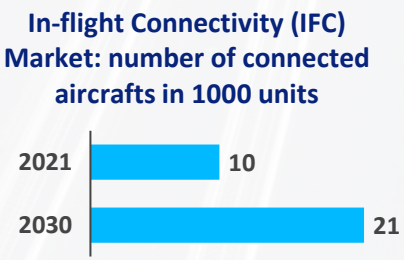
VSAT EQUIPPED VESSELS

Maritime connectivity is thriving, driven by a **207% increase in sea data usage** from June 2021 to June 2022, led by **container shipping**. The expected increase in VSAT*-equipped vessels will offer **improved safety, operational efficiency, and crew well-being**



IN-FLIGHT CONNECTIVITY

Inflight connectivity is on the rise, driven by passenger demand. By 2030, it is expected to **double** thanks to advancements like SpaceX's Starlink and OneWeb's plan for in-flight connectivity by 2024 with 648 **LEO satellites**



FRMCS CONNECTIVITY SOLUTION

Railways are shifting to digital solutions, replacing the **outdated GSM-R technology with the 5G-enabled FRMCS by 2030**. Huawei's FRMCS solution, introduced in September 2022, aims for widespread adoption, integrating IoT, AI, and ML for improved rail efficiency and safety

* Very-small-aperture terminal (VSAT)

Sources: Infomineo "Mobility 2.0: Connected, Autonomous, Sustainable" (2023)

New cities aim for convenience, sustainability, and citizen well-being via electric mobility, smart buildings, and advanced healthtech

In our analysis of emerging smart new cities, we delve into the transformative initiatives driven by the vision of a smarter and more sustainable future. We focused on how these cities tackle issues faced by existing ones, emphasizing sustainability and technology in five main themes:

MOBILITY

- New cities strategically tackle urban challenges, aiming to address growing populations and inefficient transport systems
- Solutions include **15-minute cities**, **electric and autonomous vehicles**, and **air mobility** to eliminate congestion

SMART & SUSTAINABLE BUILDINGS

- In new cities, buildings prioritize energy efficiency with **smart features** and **sustainable construction materials**
- Smart homes empower residents to control security, appliances, and lighting. Assistive robots are also integrated to aid with daily tasks and health monitoring

HEALTHCARE & WELLBEING

- New cities are set to transform healthcare by using advanced technologies for **virtual consultations, real-time diagnosis, and digital diagnostics**
- Emphasizing prevention, they prioritize early intervention with **health and research centers**, integrating advanced monitoring and analytics

SAFETY & SECURITY

- Thriving communities prioritize public safety, with new cities investing in advanced technologies to reduce crime rates through **crime prediction**, mitigate disaster risks with early warnings, and protect residents' data through **cybersecurity expertise**.

CIRCULARITY

- New cities strive to address environmental challenges through solutions like water conservation, smart agriculture, and waste recycling
- Embracing circular economy principles, they minimize pollution, waste, and resource use in the areas of **water, waste, and food**

Sources: Infomineo "New city projects" (2023)

While smart city projects aim to improve the quality of life for residents, they come at a high price, demanding substantial funding

POTENTIAL CHALLENGES FOR NEW CITIES

Project funding

Establishing new cities demands substantial investments in basic infrastructure, escalating with the expected population size.

Attracting residents

Attracting residents, especially in the early stages of the project, is a challenge as human capital determines the wealth of the city. In addition, finding decent jobs in these new cities can be difficult, even if people are willing to move.

Privacy concerns

While data-driven technologies such as cameras and sensors can improve the experience of residents, the same data can also be misused to track citizens and put their privacy at risk.

Social inclusivity

New cities must prioritize serving citizens from all socio-economic backgrounds, not just for profit. Inclusivity is crucial, involving and considering all groups beyond the affluent and technologically savvy.

OPPORTUNITIES FOR NEW CITIES

Economic development

Increased development: New city projects are structured as attractive business and investment hubs

Job creation: As technology replaces jobs, new employment opportunities are anticipated in business-centric new city projects

Testing new strategies: They aim to accelerate economic growth by enhancing the competitiveness of specific sectors

Quality of life

Efficiency: New cities feature improved architectural and mobility master plans, prioritizing convenience and accessibility

Environmental quality: They prioritize green spaces and recreational facilities while addressing emissions and improving air quality

Safety: They plan to use technological solutions for enhanced safety, ensuring the well-being of residents, which in turn improves happiness and productivity

Health: New cities prioritize healthcare accessibility through technology, adopting a proactive approach with a focus on prevention

Sources: Infomineo "New city projects" (2023)

Industries from electronics to healthcare are increasingly using robots to innovate and streamline operations

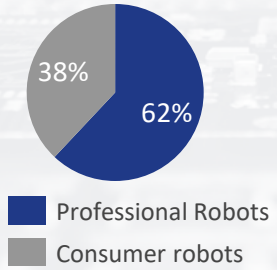
The robotics industry is composed of hardware robots and software robots. Hardware robots are divided into **service and industrial robots**:

SERVICE ROBOTS

The market for service robots is divided into consumer and professional service robotics

- **Consumer service robots:** Primarily used for domestic tasks (vacuuming, domestic floor cleaning)
- **Professional service robots:** Growth in demand for hospitality robots and professional cleaning robots.

Professional vs Consumer robots' revenues share, 2023



INDUSTRIAL ROBOTS

- Record high of 517,385 new installations in 2021, surpassing the pre-pandemic record in 2018 **by 22%**
- The electrical industry became the **largest industry for robot installations** in 2020 and 2021, surpassing the automotive industry

Annual Installations of industrial robots by 1000 units

From electronics to healthcare and beyond, industries are increasingly leveraging robotic applications to propel innovation and streamline operations

ELECTRONICS INDUSTRY

The electronics industry deploys robotics to manufacture, package, test, and repair to reduce errors, waste, and inefficiencies throughout the production cycle

AUTOMOTIVE INDUSTRY

The automotive industry, traditionally reliant on basic robotic applications, is advancing to more sophisticated uses such as assembling, welding, machine tending, and painting cars

CHEMICAL INDUSTRY

The chemical industry is increasingly leveraging robotic applications for product assembly, hazardous and non-hazardous material handling, injection molding, and chemical mixing and processing

HEALTHCARE INDUSTRY

Medical robots are helping healthcare professionals provide smarter, more comprehensive care to their patients thanks to innovations in surgery, rehabilitation, and therapeutic robots

Sources: Infomineo "Robotics and automation" (2023)

Rising robotics demand and increased accessibility will eliminate manual jobs and create more technical roles

INCREASING DEMAND FOR ROBOTS

The **e-commerce boom** has **fueled investments in robotics**, especially in retail and logistics. Thousands of mobile robots are now deployed in warehouses globally. **Labor shortages, supply chain uncertainties, the push for sustainability and reshoring** operations are key drivers

FOCUS ON AFFORDABILITY AND ACCESSIBILITY

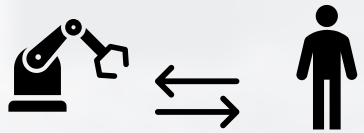
Robots are becoming **more accessible** with affordable options and **Robotics-as-a-Service (RaaS)** offerings. Companies are developing **smaller, cost-effective robots, catering to SMEs,** and breaking down barriers to entry

USER-FRIENDLY AND COLLABORATIVE ROBOTS

A trend is emerging toward intuitive and user-friendly robots, including **collaborative robots (cobots)**. Cobots collaborate safely with humans, offering flexibility and easy deployment. **Simplified user interfaces** enhance programming ease

ADVANCES IN AI FOR AUTONOMOUS ROBOTS

AI transforms robot capabilities, notably in **Autonomous Mobile Robots (AMRs)**. AMRs **navigate autonomously, detect obstacles, and adjust paths dynamically**. Warehouse AMRs optimize material handling, reduce shortages, and cut reliance on manual labor in factories.



ROBOTICS IMPACT ON THE WORKFORCE

- Automation and robotics are set to **impact the workforce**, but the **extent varies** based on numerous factors
- Despite differing views, there is a consensus that **they will both eliminate and create jobs**
- **Repetitive and manual work**, such as cashiering and stock clerking, is expected **to shift to robots**, **creating opportunities** for roles in robotics engineering, data analytics, AI, and others

Sources: Infomineo "Robotics and automation" (2023)

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