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The role of green bonds in promoting green innovation within organizations: a case study of Emirati Masdar

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Summary:

This study aims to analyze the role of green bonds as a sustainable financing tool in promoting green innovation within organizations, through a case study of the UAE's Masdar company, which is one of the leading developers of renewable energy projects. The importance of the study is to highlight how green bonds can contribute to the development of innovative business models within the enterprise, expand clean energy projects, and reduce the carbon footprint of enterprises. The study found that green bonds enhanced the innovation environment within the organization by directing resources towards research and development and encouraging clean technological solutions.It has also improved the environmental performance of the enterprise through reduced emissions and better management of Natural Resources. In general, the study confirmed that green bonds are not just a means of financing, but a strategic mechanism to stimulate green innovation and promote the transition to a low-carbon economy within enterprises.

Key words: green bonds; green innovation; Masdar; green finance; renewable energy; environmental sustainability.

Introduction:

In recent decades, the world has been witnessing a radical shift in economic and environmental policies as a result of the increasing severity of climate change, the depletion of Natural Resources, and increasing pressures to achieve sustainable development. In this context, green bonds have emerged as a financing tool aimed at supporting projects that contribute to reducing emissions and developing sustainable energy solutions. This tool has proven its ability to mobilize huge capital to finance renewable energy projects, clean infrastructure, and environmental innovation within enterprises.

Masdar is one of the most prominent Arab and international experiments in the widespread adoption of green bonds, as it has used this financial instrument to finance quality projects in renewable energies, while achieving tangible environmental impacts and a strong start towards energy transformation and the green economy.

Masdar's experience has also become a role model in how to use sustainable financing to accelerate green innovation within organizations and enhance their competitiveness in the Clean Energy Market. Despite the increasing prevalence of green bonds globally, the main question remains:

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To what extent do green bonds contribute to promoting green innovation within organizations, and what role has Masdar's experience played in this area?

The following sub-questions branch off from this main question:

1. What are green bonds And what are its principles?

2. What is green innovation What categories of green innovative projects are eligible according to the principles of green bonds ?

Objectives of the study:

1. Elucidating the theoretical foundations of green bonds and green innovation in the context of sustainability;

2. Analysis of the mechanisms of using green bonds in financing renewable energy projects at Masdar;

3. Assessment of the environmental, technical and economic impact of projects financed through green bonds;

4. Highlighting the contribution of green bonds to the development of innovative business models within the organization;

5. Highlighting the role of green bonds in promoting the path of energy transformation and the green economy.

Study structure:

To address the problematic this study was divided as follows:

- the conceptual framework of green bonds and green innovation.

- the role of green bonds in promoting green innovation "Masdar UAE case study".

The first axis: the conceptual framework of green bonds and green innovation

In this part, the concepts related to green bonds will be discussed in terms of their concept and principles, as well as the concept of green innovation will be addressed in terms of its definition and its determinants, and the category of green innovative projects qualified according to the principles of green bonds.

1. Green bonds:

1.1 evolution of the green bond market:

The green bond market appeared in 2007, with the issuance by the European Investment Bank of environmental bonds in the amount of 600 million euros, directed to financing renewable energy and energy efficiency. And later the editions began to expand after that with the first few editions of multilateral development banks. This market started with the World Bank Group issuing the first registered green bond in 2008 for a total of USD 440 million as environmental bonds. In response to the requests of major investment institutions looking for cash investments that explicitly support the financing of climate-related projects, the bank has since issued green bonds of about USD 10 billion through 130 transactions in eighteen currencies.

World Bank green bonds provide investors with the opportunity to support environmental solutions through a bond that benefits from the World Bank's excellent credit rating (AAA/Aaa).

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The value of green bonds issued until March 2016 amounted to about 19 billion dollars, Chinese companies accounted for 48% of these issues, and 2016 also saw the entry of the Korean company (Hyundai Capital Services) into the green bond market with its first issuance[1].

1.2 definition of green bonds:

Green bonds are defined as "financial debt instruments issued by companies specifically to raise capital to finance green projects". The International Capital Market Association (2023) also defines them as "financial bonds that allow raising capital for existing or new investments with environmental benefits, support an emission-free economy and green bonds provide environmental benefits, are closely linked to a sustainable financial system and a sustainable energy sector."[2]

1.3 principles of green bonds:

It consists of four principles, namely:[3]

- **Criteria for the use of proceeds**: the proceeds are used to finance or refinance green projects or to support green research and development.the principles of the bonds explicitly define the eligible categories under which projects can be integrated into the green color field, so that these projects have clear environmental benefits and contribute to achieving the Sustainable Development Goals.

- **Project submission and selection process**: green bond issuers should communicate transparently, clearly and impartially with investors to achieve sustainability goals.

- **Revenue management**: net bond yields are added to a sub-account, and the revenue management process should be carried out by an auditor or any other party in order to verify the internal tracking method and allocation of green bond yields.

- **Reports or reporting on the actual use of funds**: sources should report on the allocation and use of proceeds for eligible green projects, specify the list of projects that have been supported by bond proceeds, as well as a brief description of those projects, the amounts allocated to them and their expected impact.

2. Green innovation:

2.1 the concept of green innovation:

Green innovation has become one of the most important strategic tools for achieving effective sustainable development. in the past, investing in environmental activities was not considered necessary, but the spread of environmental awareness has changed the rules of competition in practice.

Green innovation practices are a logical response to the requirements of customers who have become willing to pay more for sustainable products, expecting companies to provide more responsible products and services.Since green innovation practices enhance the value of products and create competitive advantages through environmental differentiation, it has been emphasized that innovation is considered in the literature as the sum of “design + product”. Accordingly, green innovation can be defined as the sum of "Environmental Design + Environmental production", as it includes the development of environmentally friendly products or processes through the application of technological innovations related to energy saving, pollution prevention, and Environmental Product Design[4].

The adoption of the concept of green innovation has contributed to achieving a competitive advantage for enterprises. In addition, leading enterprises in emerging markets are taking advantage

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of the advantages of "**first leadership**" that enable them to charge higher prices for environmentally friendly products, improve their corporate image, promote their green products and services, and even open new markets.

Despite the multiplicity of benefits, they are not expected to appear immediately after the application of green innovation in the institution, they appear in the long term, and only if the institutions have the necessary conditions to apply them correctly.

Currently, the adoption of the green innovation strategy is an important support for companies to enhance their competitiveness in the changing business environment[5].

2.2 definition of green innovation:

Chen el all defined green innovation as: "innovation in hardware and software related to green products which includes technology innovation for energy saving, pollution prevention, waste recycling, green product design and environmental management. It can also show positive effects on environmental performance[6] .

" Some researchers define green innovation as: "the development of sustainable products and processes through the use or adoption of environmentally friendly raw materials during manufacturing or design processes.

This process also includes the application of the principle of ecological design or ecological production; that is, the environment is taken into account from the moment the product idea or process is conceived, and not only at the end of its life cycle".

Therefore, although green innovation has focused primarily on production processes, some companies have extended this trend to include not only the redesign of their production processes, but all their operations, including distribution channels and after-sales services .

Thus, green innovation is an innovation that includes the entire business cycle, that is, at the stages of design, production, supply and end-use of commercial products, which mainly contributes to environmental protection[7].

2.3 determinants of green innovation: Many researchers agreed that the determinants of green innovation are:

* **Innovation of green products**: these are products that use less resources in their production and have less impacts and risks on the environment and reduce the generation of waste during the product life cycle, this is by introducing new or significantly improved products in line with technological and environmental innovations. these may include improvements to the basic characteristics or technical specifications of the product, in addition to applying innovative ideas to the design, manufacture and marketing of new products in order to improve the environmental of these products.

*** Green process innovation**: refers to the modification of manufacturing processes and systems to produce environmentally friendly products that achieve environmental goals, i.e. adaptation to the manufacturing process that minimizes the negative impact on the environment during the purchase of materials, production and delivery. process innovation is the use of innovative ways to reduce the negative environmental impacts caused by production processes through the use of clean technology, new processes or technology that require raw materials and less energy. it includes activities that reduce emissions and hazardous waste during manufacturing, recycling waste and emissions for use, reducing energy consumption and raw materials[8].

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2.4 categories of green innovative projects eligible according to the principles of green bonds:

The principles recognize several general categories of green projects, which contribute to the achievement of environmental goals, such as: mitigation of climate change, adaptation to climate change, conservation of Natural Resources, Protection of biodiversity, and pollution prevention and control. Among the most common categories are:[9]

* **Renewable energy**: including production, transportation, devices and products.

*** Energy efficiency**: such as new and renovated buildings, energy storage, Central Heating, smart grids, appliances and products.

* **Pollution prevention and control**: including air emission reduction, greenhouse gas control, soil treatment, waste reduction, recycling, and waste-to-energy conversion with high energy consumption/emission efficiency.

* **Ecologically sustainable management of living natural resources and land use**: including ecologically sustainable agriculture; ecologically sustainable animal husbandry; inputs of climate-smart agriculture such as crop biological protection or drip irrigation; ecologically sustainable fisheries and aquaculture; ecologically sustainable forestry including afforestation or reforestation, landscape conservation or restoration.

* **Conservation of terrestrial, marine and aquatic biodiversity**, including the protection of coastal and marine environments and water basins.

* **Clean transportation** such as electric and hybrid cars, public transportation, railways, non-motorized transportation, multimodal transportation, clean energy vehicle infrastructure, and reducing harmful emissions.

* **Sustainable water and wastewater management including sustainable** clean drinking water infrastructure, wastewater treatment, sustainable urban drainage systems, River channeling and other forms of flood mitigation.

* **Adaptation to climate change**, including efforts to make infrastructure more resilient to the effects of climate change, as well as information support systems such as climate monitoring and early warning systems.

* **Products, technologies and production processes adapted to the circular economy** such as the design and introduction of reusable, recyclable or regenerative materials, components and products; circular tools and services; and environmentally efficient certified products.

* **Green buildings** that meet regionally, nationally or internationally recognized standards or certifications for environmental performance.

The second axis: the role of green bonds in promoting green innovation within organizations" case study of Masdar UAE company"

This part deals with the Applied study of the role of green bonds in promoting green innovation in institutions, through analyzing Masdar's experience in issuing green bonds for the years 2023 and 2024, in order to identify the impact of this financial instrument in supporting sustainable projects and environmental innovation in the UAE.

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1. The development of the green bond market in the UAE:

Green finance in the UAE is a supporting element for sustainable business models, investments and legislation, in line with the achievement of national sustainability goals in accordance with the UAE Vision 2021, the UAE green agenda 2015-2030, the Abu Dhabi Economic Vision 2030, and the United Nations Sustainable Development Goals 2030, to which the UAE has declared its commitment.

In recent years, the UAE has witnessed a remarkable development in the green bond market, as one of the green financing tools aimed at supporting the transition to a low-carbon economy. Several major financial institutions, such as the First Abu Dhabi Bank (FAB), Abu Dhabi Commercial Bank, Emirates NBD, and Abu Dhabi Future Energy Company "Masdar"have contributed to the launch of green issues aimed at financing clean energy projects, and these issues are a strategic step towards diversifying the sources of national funding, and proving the UAE's commitment to the goals of climate neutrality 2050.

2. Green bonds in the UAE and the sectors benefiting from them:

The information related to UAE green bonds and their issuers represented by banks such as FAB, ADCB, Emirates NBD for the years between 2020 and 2023 can be summarized as follows:

- In 2020, a green bond was issued by First Abu Dhabi Bank(FAB), the largest bank in the United Arab Emirates and one of the largest financial institutions in the world, with a value of 750 million Hong Kong dollars and a maturity of five years. This is the first issuance of Hong Kong dollar-denominated green bonds in the Middle East and North Africa region, and the first Hong Kong dollar-denominated green bonds by an offshore financial institution[10].

- In 2021, the First Abu Dhabi Bank(FAB)also issued a green bond worth 200 million Swiss francs (about 218 million US dollars) for a period of 5 years, with an interest rate of 0.1475%. This issue is the second green bond issued by the bank in Swiss francs in the same year in January 2021 for a value of 260 million Swiss francs for a period of 5 years, reinforcing its commitment to sustainable financing. The bank also announced the issuance of a USD 30 million 5-year green bond, bringing its total green issuance to USD 1.36 billion.

FAB bank maintains a leading position in the regional sustainable finance sector. It was the first bank in the MENA region to issue a green bond and has financed more than USD 10 billion in sustainable projects[11].

- **In 2022**, ADCB announced the completion of the pricing of the first issue of green bonds for the first time ever, where the bank raised USD 500 million to support the financing of sustainable initiatives and low-emission projects[12].

- **In 2023**, Abu Dhabi Commercial Bank (ADCB) also announced the completion of the pricing of green bonds worth 650 million US dollars to support the transition of the UAE to a zero-carbon economy[13].

- **In 2023**, the Securities and Commodities Authority revealed that the volume of green sukuk and bonds issues related to sustainability that were registered with the authority reached the equivalent of about 15.45 billion dirhams during the first 11 months of this year. It included 3 green bond issues, 3 green sukuk issues, and a sustainability-related sukuk issue.

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The authority's issuance of its decision on the regulation of green and sustainability-related bonds and sukuk allowed public shareholding companies to issue "green" bonds and sukuk, the proceeds of which are fully used to finance or refinance sustainable environmentally friendly projects[14].

- **In 2023, precisely on October 11**, Emirates NBD issued its first green bond with a total nominal value of USD 750 million, in the form of fixed-rate bonds maturing on October 11, 2028. It is the first issue of its kind for the bank. This release demonstrates the bank's commitment to sustainable finance and is an important step in its journey towards achieving its environmental goals[15].

For the sectors benefiting from the issuance of green bonds, the projects eligible for green bond financing are usually working in the renewable energy sector, energy efficiency, clean transportation, and other environmental projects.

Bond issuance yields are a key support for financing a low-emission economy, in line with the standards set out in the green bond framework, which complies with the United Nations Sustainable Development Goals and is based on the principles of green bonds issued by the International Capital Markets Association.

For example, Abu Dhabi Commercial Bank (ADCB): (2022-2023)is committed to providing AED 35 billion of green financing facilities by 2030 and financing low-emission projects in line with the aspirations of the UAE government to achieve climate neutrality. The green projects financed by ADCB bonds are projects or companies related to renewable energy and green buildings, sustainable water and wastewater treatment, sustainable transport sector, energy efficiency promotion, Pollution Control and reduction[16].

Emirates NBD's green bond issues also support projects that contribute to building a more sustainable future, with proceeds going primarily towards renewable energy, clean transportation, and green buildings. Which amounted to the percentage of allocation (i.e. allocated from the issuance of green bonds) as follows:

- Renewable energy is 40% of the allocation, represented by the NEOM green hydrogen project. in 2024, Emirates National Bank of Dubai(ENBD)committed an amount of approximately USD 119,086,175 to contribute to financing the NEOM green hydrogen project in Neom city in the kingdom of Saudi Arabia, which represents 15.88% of the issuance and 16.66% of the amount allocated until June 2024.

The NEOM green hydrogen project is the world's largest utility-scale commercial hydrogen production facility, powered entirely by renewable energy, based on innovative technologies that integrate a total capacity of about 3.9 GW of renewable energy generated from onshore solar, wind and storage.

- Clean transportation 18% of the allocation is represented in the acquisition of electric vehicles. between 2021 and 2024, Emirates National Bank of Dubai (ENBD) financed the private acquisition of 3,075 electric vehicles, with a total loan value of about USD 136,256,555.70, with maturities ranging from one to five years. this financing represents 18.17% of the total issue and 19.06% of the allocated amount, until June 2024.

- Green buildings 37%of the allocation, where in 2022, Emirates NBD financed the construction of a series of green buildings in Istanbul, Turkey, with a total loan value of about USD 91,857,138.75, which represents about 12.25% of the issue and 12.85% of the allocated amount until June 2024[17].

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3. Case study of Abu Dhabi Future Energy Company "Masdar":

3.1- Masdar company profile:

A global leader in the development of clean energy solutions, contributing to a prominent role in achieving the UAE's vision in the field of climate neutrality.

"Masdar" is one of the fastest growing renewable energy companies in the world and a pioneer in the field of green hydrogen, contributing to establishing the UAE's position at the forefront of efforts to achieve transformation in the energy sector.

Based on its leadership in promoting the clean energy sector, supporting the realization of the UAE's vision and dedicating its leading role in the fields of sustainability and Climate Action, "Masdar" has worked to develop projects spread in more than 40 countries on six continents, and the total capacity of the company's projects is 51 GW.

Masdar is co-owned by three prominent UAE energy companies, ADNOC, Mubadala and Taqa, which allows the company to benefit from the expertise of these partners to consolidate its position as a global leader in the fields of renewable energy and green hydrogen.

By encouraging innovation in the fields of solar, wind, energy storage, waste-to-energy and geothermal energy, Masdar has a proven track record of developing pilot projects using advanced, commercially viable and scalable clean energy technologies on a large scale[18].

3.2. Masdar green bonds:

The values of the green bond issues of Abu Dhabi Future Energy Company "Masdar", one of the world's leading companies in the field of renewable energy, can be clarified in the years 2023-2024-2025.The following are:

- **In 2023**, it was announced that the first issuance of green bonds worth 750 million dollars was completed with a ten-year term. The IPO reached record levels of 5.6 times the target value.

The proceeds of the bond value of this issue were invested in green projects including solar energy, wind energy, renewable energy transmission, energy distribution infrastructure, and energy storage battery systems.

Strict environmental, social and institutional governance criteria are applied to identify eligible projects. The "Masdar" green finance framework was launched in February 2023 and was updated in May 2023 to comply with the updates of the green finance principles[19].

- **In 2024,** Masdar announced the completion of its second issuance of green bonds worth one billion US dollars as part of the company's green financing framework. After the successful launch of its first green bonds in 2023, the second issuance of green bonds worth one billion US dollars confirms investors ' confidence in Masdar finance's capabilities, outstanding capabilities and adoption of sustainability standards. These revenues play a key role in driving Masdar's ambitious plans to expand its portfolio of renewable energy projects, and solidify the company's position as a major contributor to supporting a just transition in the energy sector by enhancing the opportunities of emerging markets and the global south to obtain additional energy resources[20].

- **In 2025**, Masdar announced the completion of its new green bond issue worth AED 3.67 billion (approximately one billion US dollars), which brings the total amount raised by the company since the launch of the green bond program to AED 10,092 billion (approximately 2.75 billion dollars), and contributes to strengthening its global leading position in the field of sustainable finance[21].

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It can be concluded that there is an upward trend and a clear growth in the volume of issues, as the issue increased from 750 million dollars in 2023 to one billion in 2024, and then stabilized at the same level in 2025. In 2023, the launch and entry of an issuer into the green bond market to finance renewable energy projects, such as solar and wind energy, was often the stage of establishment or initial entry into the market, with the aim of testing investor confidence.

In 2024, the expansion and maturity of the issue increased to one billion dollars from 750 million dollars, reflecting the success of the first issue and high demand, which encouraged an increase in the value of the bond. In 2025, the same value was maintained, which indicates the stability of investor confidence.

3.3. Green innovative projects funded by green bonds issued by Masdar:

The following table shows the green innovative projects financed by green bonds according to Masdar's green financing report for 2024:

Table 01: green innovative projects financed by Green Bonds by green financing report Source of the year2024

Project name	State	Allocated amount of 10year bond 2023 (USD American)	Allocated amount of 05year bond 2024 (USD American)	Allocated amount of 10year bond 2024 (USD American)	Total amount Custom (USD American)
Solar energy projects					
Jizzakh Solar PV	Uzbekistan	77,635,163	-	-	77,635,163
Samarkand Solar PV	Uzbekistan	75,513,521	-	-	75,513,521
Sherabad Solar PV	Uzbekistan	182,077,417	-	-	182,077,417
Garadagh Solar PV	Azerbaijan	153,653,349	-	-	153,653,349
DEWA 6 / Shuaa Energy 4	Emirates (Dubai)	519 ,97,464	52,391,141	2 52,391,141	202,246,801
Bukhara PV + BESS	Uzbekistan	9,036,000	30,905,576	30,905,576	70,847,151
Amaala Utilities PV + BESS	Saudi Arabia	-	59,842,902	59,842,902	119,685,804
Al Henikayah PV	Saudi Arabia	-	59,598,273	59,598,273	119,196,546
Al Dhafra PV	Emirates	-	18,965,041	18,965,041	37,930,081
Al Ajban PV	Emirates	-	47,305,844	47,305,844	94,611,688
Total	-	595,379,969	269,008,776	269,008,776	1,133,397,522
Onshore and offshore wind energy projects					
Zarafshan Wind Farm	Uzbekistan	154,620,031	36,424,338	36,424,338	227,468,706
Baltic Eagle Offshore Wind Farm	Germany	-	92,424,162	92,424,162	184,848,325
Čibuk 2	Serbia	-	16,704,229	16,704,229	33,408,459
Total	-	154,620,031	1 45,552,729	145,552,729	445,725,490
Projects of battery energy storage systems					
Terra Gen -	United States of	-	11,011,183	11,011,183	22,022,366

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Beaumont	**America**				
Terra Gen - Sagebrush B	**United States of America**	**-**	**6,492,600**	**6,492,600**	**12,985,200**
Terra Gen - Canyon County	**United States of America**	**-**	**1,116,241**	**1,116,241**	**2,232,481**
Arlington - Welkin Road	**United Kingdom**	**-**	**8,706,498**	**8,706,498**	**17,412,995**
Arlington - Royle Barn	**United Kingdom**	**-**	**11,147,274**	**11,147,274**	**22,294,547**
Arlington - Ipswich Road	**United Kingdom**	**-**	**10,394,313**	**10,394,313**	**20,788,626**
Arlington - Calow Green	**United Kingdom**	**-**	**4,443,371**	**4,443,371**	**8,886,741**
Total	**-**	**-**	**53,311,479**	**53,311,479**	**106,622,958**

Source: MASDAR. (2024). GREEN FINANCE REPORT Allocation and Impact 2024 MASDAR

The above table is divided by the type of technology of the projects (solar energy, wind energy, and battery energy storage systems). It can be read and analyzed through several points as follows:

- **Geographical expansion**: Masdar company has not limited to financing projects within the UAE only, but has expanded globally to include Central Asia (Uzbekistan, Azerbaijan), the Middle East(UAE, Saudi Arabia), Europe (Germany, Serbia, UK), North America (USA).This geographic expansion reflects Masdar's strategy to become a global investor in clean energy, not just locally.

- **Types of green innovations** funded by Masdar through its issuance of green bonds where we find:

* Photovoltaic solar energy projects in Uzbekistan with projects called (Jizzakh Solar PV, SamarkandSolar PV, Sherabad Solar PV), the UAE with two projects(Al Dhafra PV, Al Ajban PV), Saudi Arabia with the project (Al Henikayah PV).

* Solar energy + battery storage (PV+BESS) in Saudi Arabia (Amaala Utilities PV project)and Uzbekistan (Bukhara PV + BESS project)

* Reducing the cost of energy in Dubai with the DEWA 6 / Shuaa Energy 4 project.

* Onshore and offshore wind energy in Uzbekistan with the Zarafshan Wind Farm Project, Germany with the Baltic Eagle Offshore Wind Farm project and Serbia with the Čibuk 2 project.

* Battery-powered energy storage systems in the USA with projects (Terra Gen-Beaumont, Terra Gen-Sagebrush B, Terra Gen-Canyon County), UK with projects (Arlington - Welkin Road, Arlington - Royle Barn, Arlington - Ipswich Road, Arlington - Calow Green)

- **Financing by bond:**

* **10-year bond 2023:** financed the first major projects (mostly in Uzbekistan and Azerbaijan). With a total amount of USD 595 million, it focused on large-scale solar energy. In addition to financing the Zarafshan Wind Farm wind energy project in Uzbekistan. In an amount estimated at 154 million dollars. * **As for the 5 – year bond-2024**, new projects have been introduced in Saudi Arabia, the UAE and Europe, namely solar energy + battery storage (PV+BESS)projects with a total amount of 269 million dollars, in addition to financing onshore and offshore wind energy projects with a total amount of 145 million dollars. It also financed projects of battery energy

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storage systems in the United States and the United Kingdom with a total amount of 53 million dollars.

* **The 10-year bond – 2024** was allocated to refinance major projects and raise operating capital. The same amount of a 5-year bond269million dollars. It indicates the confidence of the markets in the ability of an issuer for long-term financing. As well as financing projects in onshore and offshore wind energy worth 145 million dollars.

By distributing the amounts allocated for projects under green bonds, it can be said that there is a diversity of Masdar's green investment portfolio, which was at a high degree of strategic maturity in green finance management, as it included projects financed through 2023 bonds and 2024 bonds covering three continents and incorporating multiple renewable energy technologies.

While the 10-year bond for 2023 focused on the establishment of major solar projects in Central Asia, which had the largest shares of allocation, with the aim of strengthening the company's international presence and demonstrating its ability to lead a large-scale energy transformation. The 2024 bond (5 and 10 years) came to promote innovation through hybrid projects combining solar energy and battery storage, as well as the expansion of offshore wind energy in Europe. This distribution reflects the transition of Masdar from a mere producer of clean energy to a developer of integrated innovative solutions, as its bonds not only played a role in financing, but also in stimulating technical innovation and building sustainable energy systems at the regional and global levels.

It supports climate neutrality goals and strengthens the UAE's position as a global hub for green finance. The following is

Table No. 02, which shows the environmental indicators of innovative projects funded by green bonds:

Table 02: environmental indicators of innovative projects financed by green bonds of the issuer According to the green finance report2024

Project name	Source ownership ratio	Contractual capacity of the project (MW)	Start of operation	Annual power generation (GWh)	Total avoided emissions of the project(tCO_2 / year)	Avoided emissions attributable to Masdar green bonds(tonnes CO_2 / year)
Solar energy projects						
Jizzakh Solar PV	%100	220	2025	577	321,966	321,966
Samarkand Solar PV	%100	220	2025	562	313,596	313,596
Sherabad Solar PV	%100	457	2026	1,078	601,524	601,524
Garadagh Solar PV	%100	230	2023	568	271,504	271,504
DEWA 6 / Shuaa Energy 4	%40	1.800	A: 2025 B: 2025 C: 2027	1,877 1,221 2,390	2,546,432	980,967
Bukhara PV + BESS	%100	250PV + 63 BESS	2025	623	(5)347,634	347,634

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Amaala Utilities PV + BESS	%43	250(147.5+)	2025	503	256,306(5)	110,211
Al Henikayah PV	%40	1,100	2026	3.249	1,657,046	662,818
Al Dhafra PV	%20	2,000	2023	4.861	2,255,597	451,119
Al Ajban PV	%60	1,500	2026	4.707	2,183,825	1,108,353
total	-	8,027	-	22.215	10,755,430	5,169,693
Onshore and offshore wind energy projects						
Zarafshan Wind Farm	%100	500	2025	1,702	949,716	711,989
Baltic Eagle Offshore Wind Farm	%49	476	2025	1,867	976,441	221,105
Čibuk 2	%81	150	2026	334	311,249	126,501
total	-	1,126	-	3,903	2,237,406	1,059,594
Projects of battery energy storage systems						
Terra Gen - Beaumont	%50	100	2024	146	51,392	7,507
Terra Gen - Sagebrush B	%50	99	2024	145	50,878	11,645
Terra Gen - Canyon County	%50	80	2025	117	41,114	1,258
Arlington - Welkin Road	%90	20	2025	29	9,344	6,827
Arlington - Royle Barn	%90	35	2025	51	16,352	10,335
Arlington - Ipswich Road	%90	50	2027	73	23,360	9,403
Arlington - Calow Green	%90	100	2027	146	46,720	4,020
Total	-	484	-	707	239,160	50,996

Source: MASDAR. (2024). GREEN FINANCE REPORT Allocation and Impact 2024 MASDAR

This table shows how Masdar projects financed through green bonds have contributed to raising the generating capacity of clean energy, generating annual renewable energy, reducing carbon

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emissions (CO_2), and the impact of green bonds directly on the climate (the percentage of emissions attributed to bonds). The above table can be read through the projects distributed into three main categories as follows:

- **Solar energy projects:** of which 9 projects reached a 100% ownership percentage in the projects of the state of Uzbekistan, the total contractual capacity was 8,027 MW, the total annual energy generation reached 22,215 GWh, as for the total avoided emissions amounted to 10.76 million tons CO_2/year, while the emissions attributed to the bonds of Masdar amounted to 5.17 million tons CO_2/year.Solar energy projects form the main pillar of Masdar's green bond portfolio (about 70% of total capacity).

- **Wind energy projects:** which amounted to 3 projects, the Zarafshan Wind Farm project took a 100% ownership rate,the total contractual capacity of the project was 1,126 MW, the total annual energy generation reached 3,903 GWh, as for the total avoided emissions amounted to 2.24 million tons CO_2year.While the emissions attributed to the bonds of an exporter were estimated AT1.06 million tons CO_2/year.Wind projects represent the second sector in Masdar's green investments with about 25% of the total renewable energy produced. It demonstrates the strategic direction towards diversifying clean energy sources and reducing dependence on a single source of renewable energy.

- **Battery energy storage projects (BESS):** the number of projects reached 7 and the total contractual capacity of the project was 484 MW, the total annual energy generation was 707 GWh, as for the total avoided emissions amounted to 239,160 million tons CO_2/year.While the emissions attributed to Masdar bonds were estimated at 51,000 million tons CO_2/ year. Although these projects are limited in terms of production capacity, their importance lies in their role supporting the stability of renewable energy systems.It also signals Masdar's move towards integrating smart energy solutions into the low-carbon economy.

Conclusion:

It can be said that sustainable financing through green bonds has become one of the most important drivers of green innovation within economic institutions, especially in sectors related to energy and the environment, such as the renewable energy sector, in which Masdar represents a leading and inspiring model at the Arab and international levels.

Results:

A case study of Masdar company showed a set of results are:

1. Green bonds represent an effective financing mechanism geared towards supporting clean energy projects, as Masdar bonds have contributed to financing strategic projects in the fields of solar energy, wind energy and energy storage, at the local and international levels. This role reflects the ability of green bonds to mobilize huge financial resources and direct them towards environmentally friendly investments.

2. The results showed that green financing was not limited to covering the investment costs of projects, but was a major catalyst for the introduction of innovative technologies, such as advanced photovoltaic conversion technologies, intelligent storage systems, hybrid solutions between solar energy and storage, in addition to the expansion of offshore and onshore wind energy technologies. These innovations have contributed to raising the efficiency of renewable energy production and improving the flexibility of electricity grids.

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3. The data proved that investing in Masdar green bonds has a significant and positive impact on reducing carbon emissions. For every million dollars invested, about 3,726 tons of carbon dioxide equivalent are avoided annually, with total avoided emissions exceeding 6.28 million tons by the end of 2024. These figures reinforce the role of green bonds as a supportive tool for the transition towards carbon neutrality.

4. The study showed that green bonds contributed to international cooperation, technology transfer, and leveraging advanced expertise in markets such as Europe and Central Asia. The bonds also supported Masdar's expansion into renewable energy projects globally, reflecting a strategic evolution in the innovation-driven business model.

5. Green bonds contributed to the development of an internal environment conducive to innovation through capacity building, the development of technical competencies, and the adoption of sustainable operational solutions, which helped the organization to enhance its competitiveness in the clean energy sector.

6. Masdar's experience confirms the integration of financing and innovation dimensions, as green bonds have contributed to providing financial resources for the development of new and efficient solutions, making them a long-term strategic tool to support sustainability and innovation in organizations.

7. Masdar's issuance of a new billion-dollar bond in 2025 reflects the continued reliance on green bonds as part of the company's strategy to promote innovation and sustainability, although there are no details about the projects of this new issue.

8. All previous results confirm that green bonds are one of the most important financial instruments supporting green innovation in enterprises, and achieving strategic directions towards a green economy.

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