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Transition to Renewable Mix — "Win-Win" Strategic Relationship between China and Chile

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Abstract:China's growing ambition in asserting its global power is being witnessed by all international actors. In 2015, China led in establishing the Asian Infrastructure Investment Bank (AIIB), which shares the identical structure with that of the US-led World Bank Group. The AIIB is widely perceived as a major vehicle through which Beijing inserts international soft power with financial aids. In addition, the 2013 launch of the Belt and Road Initiative (BRI) has only been linked with nothing but expansion in trade establishment. China also shows growing interest in Latin America for its market, resources, and geopolitical location. Chile, alongside with Ecuador and other countries, has already signed a memorandum of the BRI. China has also stepped into the local energy market - Argentina, Chile's neighbor, started the Argentine-China Joint Hydropower Project, which will construct two dams in southern Argentina and is expected to generate 4,950 MWh of electricity.

Keywords: Renewable; BRI; Expansion; Memorandum

1. Sustainable capital growth

On the other side of this spectrum, Chile's economy has been actively growing at a steady rate of 5.4% between 1986 and 2010. As an OECD member in Latin America, Chile's drastic development can have various implications. On one hand, Chilean citizens would experience strong economic and social development. On the other hand, a fast-developing country may not have the adequate capacity and resources to maintain the current economic growth rate, if no future action will be taken. Specifically, Chile faces rising concerns over its insufficient reliable energy sources to ensure its sustainable social progress, economic growth, and its population's daily demands[1]. Despite of its huge potential in renewable energy and vast reserve in lithium, Chile has not exploited its resources yet. The nation's current energy matrix cannot guarantee sufficient security which would help generate sustainable capital growth.

This paper aims to explore a "win-win" strategic relationship between China and Chile. In this strategic relationship, China would help by developing Chile's solar and wind energy infrastructures with its sufficient capital and leading expertise; Chile would engage with China in exploiting its lithium reserves and produce lithium-ion batteries for energy storage, which can also boost domestic adaptation of renewable energy[2]. In return for both countries, Chile would greatly increase its electricity generation independence and reduce risk in national energy security; China would get to secure an economic market for its technology and production, while having access to lithium[3].

2 Chile's lack of national energy security

With a growing economy that spurs energy-thirst development, Chile is the fifth largest energy consumer in South America. Nonetheless, Chile does not have the current or future capacity to produce sufficient energy and its current

power matrix still vulnerably relies on foreign imports[4]. While its total primary energy consumption boosted to 1.52 Quadrillion Btu in 2016, Chile only produced 0.45 Quadrillion Btu of energy in the same year, a more than threefold difference[5]. As the enormous difference between energy production and consumption indicates, Chile is forced to import an overwhelmingly significant amount of energy resources from a limited group of foreign suppliers. To begin with, the US has grasped the seat as the leading supplier to the country's refined petroleum products. As for crude oil, Brazil and Ecuador dominate 98% of Chile's imports. In addition, Chile owns a considerably insignificant natural gas resource. Its negligible reserve enforced the country to import vast majorities of their natural gas through pipelines and LNGs. In 2015, Chile approximately imported 127 billion cubic feet (Bcf) of natural gas and consumed a total of 163 Bcf[6]. This substantial dependence on foreign fossil fuels greatly increases Chile's electricity price through the upsurge in the marginal costs of energy generation. In addition, Chile just faced an energy crisis regarding gas supply merely over a decade ago. Argentine President Nestor Kirchner broke the 1996 natural gas exportation treaty due to a supply shortage experienced by Argentina in 2005. To solve the crisis at the time, the Chilean government had to purchase diesel gas at high costs to generate emergent power, which drove up energy prices in a volatile matter within a short period of time. Undoubtedly, if the country does not seek other measures to achieve dependable energy security, its heavy reliance on energy imports can impose overwhelming barricades to Chile's potentials. Chile's current electricity generation matrix is still led by fossil fuels, which contributes to 59% of the grid mix in 2015. In the same year, hydroelectricity chipped in 33% and renewables backed only 10%[7]. As mentioned above, Chile's fossil fuel resources still heavily rely on foreign imports, which would lead to potential energy security concerns. If any foreign supplier follows Argentina's 2005 withdrawal, Chile would instantly lose a considerable percentage of national power base load. The disruption in electricity generation would certainly distort national economic development, which can lead to a more serious aftermath. Additionally, compared to 2015's level (70,000 GWh), Chile's electricity demand is projected to increase by one-fold, reaching 140,000 GWh by 2030[8]. Besides, Chile's energy usage has been actively pushed by energy-intensive industries, including mining and cellulose production. Hence, Chile should explore the option of renewable energy to improve the security of electricity generation by exploring its abundant reserves. Despite hydroelectric power plant's technological maturity and substantial generation capacity, its negative impacts on the environment have caused numerous protests from environmental and civil rights groups in Latin America and its potential has been mostly exploited. Therefore, it is essential for the Chilean government to address on this emerging issue of the country's fragility in national energy security by exploiting the nation's rich reserves in non-conventional renewable energy, namely solar and wind energy.

3 Chile's renewable energy potential

Chile is "blessed" with abundant renewable energy reserves that have not been fully exploited to fulfil the nation's clean energy matrix potentials[9]. If Chile can optimally utilize these resources, it would hugely cut down the risk of energy deprivation due to suppliers' influence and achieve energy independence. In 2015, Chilean government announced its National Energy Policy 2050, which plans for 19% of the country's electricity to be from solar energy, 23% wind power and 29% hydroelectric power. The Southern cone nation's notable renewable energy sources include geothermal, hydropower, solar, and wind.

Among which, Geothermal power in Chile is notably underdeveloped. Chile does have massive geothermal potential, which has an estimated reserve at 16000 MW[10]. Its more than 2000 volcanoes distributes along the Andes mountain range from north to east, listing the region itself as the second largest volcano chain in the world with 15% of the global volcano assets. Although only 3600 MW of the 16000 MW geothermal power potential are extractable, the sector had never been pushed forward in commercial venture. The only geothermal power plant, Cerro Pabellon, was not initiated in the Atacama Desert until 2007, with a capacity of 48MW (Patel 2018).

Moreover, Chile shares the same traits with other Latin American countries by owning vast hydropower reserves. Hydroelectricity has been the backbone of generation in the national energy matrix, contributing more than 33% in 2015

as mentioned above. While hydropower technologies have reached technological maturity and built plants are reliable, its future attractiveness has been constantly questioned and reevaluated: hydropower plants are the major victims of recent chronic droughts in Chile[11]. The unpredictable nature of droughts substantially eradicates hydropower plants' generation consistency, which exposes Chile to significant energy risk. In addition, social movements against newly built hydropower plants prevail, see the case of Hidro Aysen. It is important to remember that hydropower plants cause vast amount of environmental and social issues, including relocation of local communities, changes to river flows and temperature, and damage to natural habitats[12]. Hence, hydroelectricity should not be prioritized as a sustainable approach to solve Chile's energy matrix security problem.

Thus, solar and wind energy have risen to claim the status of Chile's future renewable energy contributors with the largest potentials. They should be the main "weapons" to cut down Chile's electricity price. To begin with, Atacama Desert, located in Northern Chile, is blessed with one of the world's highest levels of solar radiation. Its irradiance averages at 275 MW/km^2, one of the highest solar in the world. Due to its super dry environment, there is virtually no water molecules floating in the air that diffuses the sun ray[13]. Thus, its high level of direct normal irradiation provides an outstanding environment for solar energy production. Chilean energy officials have claimed that the potential of the Atacama is so great that Chile could generate all of its electricity with merely 4 percent of the desert's surface area, if there were a way to efficiently store and distribute that energy. Hence, Chilean government should emphasize more on seeking ways to extract its rich solar potentials. Furthermore, Chile's special geographical characteristics, such as its long coastline, valleys and large mountain range, craft the conditions for air masses' movement, creating significant wind potential at multiple sites[14]. It was recently estimated that nearly 40,000 MW potentials are available. Geographically, most of wind potentials are located along the Andes mountain range or in the Southern part of Chile. Among them, the south coast of the South Pacific has huge offshore wind energy potential.

In addition, it is important to point out that most of Chile's power demands come from the central region. While the Atacama does have huge potential of producing bulks of power in the North, wind potentials in the South haven't been exploited much yet. Thus, Chile's full solar and wind potentials wouldn't be fully realized without a transmission that connects the North and the South. Fortunately, Chile has completed a $700 million, 600 km-long linking the northern and southern grids, which will approximately add 1.2GW in transmission capacity from the country's solar- and wind-rich, but sparsely populated, northern region to the industrialized central region.

4 China's expertise in solar and wind

As analyzed before, Chilean government should prioritize exploiting its rich solar and wind energy potentials, in order to drive down domestic electricity prices and reduce risk in its energy mix security. In the proposed "win-win" strategic relationship between the two countries, Chile should engage with Chinese companies in developing solar and wind plants[15]. China is currently the global leader in solar and wind technology and has been actively investing overseas in numerous renewable energy projects. To begin with, China currently owns four of the top ten wind-turbine makers and six of the top ten solar-panel manufacturers, reflecting a dominating stance in renewable energy generation's research and development capability. For wind sector, many Chinese companies chose to invest in overseas wind electricity generation projects to nurture products demands in the foreign countries, while acquiring new technologies through the approach of Merger & Acquisition. In the last decade, Chinese investors have expanded their ownership portfolios and expanded their expertise in offshore wind technology through acquisition of wind farms across nine countries in Europe, dodging away from early development costs. According to BNEF, China is now sprinting to catch up with European countries in the offshore power sector and to overtake U.K. offshore capacity by 2022. Furthermore, Chinese power companies' foreign wind investment grew considerably from US $148 million in 2015 to US $6 billion in 2016.

While Chinese wind industry relies predominantly on its massive domestic market, China's own solar industry relies on the international market for 95 percent of its sales. Besides manufacturing, sales, and service capabilities in

these investment destinations, various Chinese solar companies provide engineering, procurement and construction services, and develop solar PV plants. Upon this date, manufacturing factories in China comprise approximately sixty percent of global solar cell production, which includes companies headquartered in foreign countries who realize part or all of their manufacturing capacity in China. Among the pack, Tongwei, announced a $1.8 billion investment in November, making its solar cell manufacturing capacity the largest in the world. Further, Jinko Solar, another Chinese firm, maintained its world-leading solar module shipments position in 2017, with an approximately one tenth of global share.

Chinese renewable energy overseas investments' trajectory, predicted to increase to US $10 trillion by 2020, makes China the second-largest institutional investment in the world. More substantially, only 2 percent of current total is invested offshore, meaning that if China decides to increase this ratio to 10% by 2020, it would aggregate to US$1 trillion of new foreign investment. The abundance of financial power can enable significant advance in global renewable energy adoption, by funding necessary infrastructure construction, backing technology research and development, and reducing cost of production. In 2016, $32 billion was invested by China in large overseas deals involving renewable energy, an aggressive expansion that seems promising. According to the International Energy Agency (IEA), Chin will install 40% of all worldwide wind energy electricity generation capacity from 2015-2021. In the same period, 36% of global solar energy electricity generation capacity will be installed by China as well[16].

5 Magic of lithium and China's ambitions

One of the major barricades that stops solar and wind energy from becoming the prominent electricity generation component is their incapability of being dispatchable. Neither wind nor solar power plants can be switched on or off at the request of a power system operator or live market needs. Once there is adequate amount of sun or wind, electricity will be generated. If not, the power input remains zero. Nonetheless, a solar or wind generation plant with energy storage can easily solve this problem: batteries can preserve the generated power, which can be dispatched by system operators on demand. Furthermore, lithium is the key component in the new fleet of generation battery. Lithium-ion batteries are not only smaller than a conventional one, but also are with much higher capacity. In the 21st century, lithium-ion batteries powered numerous mobile phones, laptops and tablets, displaying its vital position in our daily lives. Moreover, lithium-based batteries' lightness and fast-charging capabilities make them competitive challengers to replenish gasoline as transportation fuel, which still remains a difficult high GHG emission sector to tackle. Perceiving that technologies in electric vehicles (EV) become more mature, EV's demand in lithium-ion batteries will skyrocket, as global climate agreements and narrowing fuel economy standards push forward its wider adaptation. Thus, many analysts have described lithium as the "white petroleum", a reliable energy resource that can boost the process of global transition to renewable energy. It is perceived as the essential medium that assists the world to gradually cut off its dependence on fossil fuels and to move into the new era of renewable energy[17]. Chile has the most lithium reserves in the world by a large amount (8,000,000 metric tons) and it was the second-biggest producer of lithium at 16,000 MT in 2018. Comparably, Australia, who owns the second largest world lithium reserves, only has one thirds of Chile's - 2,700,000 MT. Most of the country's reserves are located in Salar de Atacama, the largest salt flat lake in Chile. In addition, the nation's lithium reserves hold half of the world's most "economically extractable" reserves of the metal and can produce the raw material with the world's lowest cost. Thank to Chile's persistent sunshine, an especially efficient process drastically cut down the production cost. After the lithium-rich brine is pumped out of wells beneath the desert, it evaporates much more quickly in pools in the sun. More interestingly, Chinese company Tianqi Lithium has paid $4.07bn for a 24 per cent stake in Chilean lithium mining company Sociedad Química y Minera (SQM), who has built over 44 sq km of evaporation ponds.

Chile's abundant lithium reserves have two essential implications on forming a "win-win" strategic relationship between the Latin American nation and China. There is also a positive interacting dynamic between the two implications. First, having comparative advantages in related technologies, China can help Chile realize its rich renewable energy potential by installing energy reserve power plants alongside with more wind and solar energy

generators. Considering that the raw material is located domestically, capital cost of the newly built energy reserve plants is assumed to be comparably cheaper when part of the transportation fees can be avoided. As renewable energy becomes dispatchable with the addition of batteries, fossil fuels will be phased out eventually. Therefore, Chile can move away from national dependence on foreign energy import to owning a more secured, reliable, and self-generated electricity generation portfolio. Thus, the risk in Chile's energy mix security will be significantly reduced.

Second, lithium is seen as a raw material whose utility favors China's long-term national interests. The Chinese government has identified technological advance as a crucial dimension to strengthen its soft power in. Chinese technology companies' recent progress can be identified not only in mobile phones, EVs, and drones design, but also in the nation's widespread e-commerce adaptation. Hence, these innovations in the digital world cannot be commercialized without batteries. The mass production of electronic devices requires a reliable supply source of lithium. As the dominating electronics producer in the world, China's demand for lithium will only increase by folds. In addition, the Chinese government has set out an aggressive 2035 on-road electric vehicle ownership target of sixty percent. Currently, lithium-ion is the dominant technology in electric cars. According to Goldman Sachs, the amount needed to power an average EV is far more than which to power a small consumer device like mobile phone. While a phone device can be powered by about seven grams of lithium carbonate equivalent (LCE), the battery of a Tesla EV (Model S) consumes 63 kg of LCE, an equivalent content of almost 10000 mobile phones. In order to realize its policy goals, China needs to find a viable lithium source to supply its electronics' production and EVs' deployment, and Chile's vast economically-attractable lithium reserve can certainly qualify.

Last but not least, the increase in lithium-ion batteries production and usage will further drive down the cost per unit of energy storage, making solar and wind energy more competitive in Chile's energy mix. When economies of scale apply, Chinese enterprises obtain lithium-ion batteries production cost advantages due to the enormous scale of operation, with cost per unit of output decreasing with increasing scale. Considering that China has the largest fleet of motor vehicles in the world, with 250 million cars and growing and 60% of them have to be electric by 2035, the increase in sheer volume of demand will nurture greater efficiencies in the lithium-ion batteries manufacturing process. According to Bloomberg New Energy Finance, the costs of lithium-ion battery packs have been pulled down from $1160 per kWh in 2010 to merely $176 per kWh in 2018, an 85% decrease in eight years. One can believe that China will play a crucial role in driving down the cost of large-scale batteries for energy storage even further, resonating the same trajectory that Chinese supply brings down the price of solar photovoltaic cells. By tackling down the cost of foremost barricade to adapt solar and wind energy on large scale, Chile can gradually exploit more of its solar and wind energy and phase out fossil fuels, reducing the risk from its dependence on foreign resource. Hence, a positive dynamic can form in which: (1) Chile's untouched lithium reserve add economic value to the country; (2) cost of energy storage reduces; (3) Chile's solar and wind energy become more feasible and reliable.

6 Conclusion

The proposed "win-win" strategic relationship between Chile and China has huge potential in satisfying both countries' urgent needs. For Chile, its current high electricity price level puts on an extra layer of burden on the country's economic development, especially when considering its growing mining industries. Moreover, Chile's vast potential in solar and wind has been known for decades, yet not fully exploited. By engaging with China, Chile will receive China's generous investments and leading expertise in solar and wind energy infrastructures and research and development. It would be a great relief in fiscal budget and required expertise. Thus, Chile's self-generating renewable electricity will drive down domestic electricity price, and gradually cut off its dependence on expensive yet unreliable foreign fossil fuels imports[17]. For China, the emerging problem of its solar and wind overproduction finds a solution. Chinese projects in Chile can also be used as great collaboration examples with a Latin American country, and therefore attract future interests. Further, China can utilize Chile's rich lithium source to research and develop energy storage for Chile's solar and wind plants, making them even more competitive in the electricity generation merit order. The capital

cost of producing energy storage will be comparably much cheaper, due to Chile's efficient lithium evaporation method and low raw material transportation cost. More importantly, research and development in lithium-ion batteries will further drive down its production cost, feeding the growing global fleet of EVs.

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