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Our 2023 Outlook Part II

Manufacturing Revolution in the New Energy Age

One of the key themes in 2022 is the New Energy Revolution, which will also be the main theme for many years to come. This is further highlighted by the global concerns on energy security, especially after the Russia-Ukraine conflict. In the history of the world, there were two energy revolutions, where the core component was how the new power apparatuses were applied in transportation. These led to energy-rich resources' extraction and utilization, then ignited the industrial revolution for the entire economies. The current 3rd Energy Revolution also follows the same logic: the core component is how electricity, which includes battery, motor, and electricity control systems, is used in electric vehicles. And the renewable energy can be delivered by either electricity or hydrogen and applied to electric vehicles.

The traditional energy sources are typically resource based. A nation's stock of fossil fuel is a resource that's determined from millions or even hundreds of millions of years ago. The new energy source is a completely different type: it's manufacturing based. The new energy's development is an upgrade of the entire industrial chain of material, equipment, and manufacturing. For national economies, this is a comprehensive industrial revolution, a rare opportunity for upgrading transformation. For investors, this may be a historical investment opportunity.

Rosefinch has been focusing on advanced manufacturing sector in the past 15 years. We have three research teams zooming in on different areas of manufacturing activities. In this article, we interviewed the team leaders of the respective three Advanced Manufacturing teams to share their views. They will

discuss material, equipment, manufacturing, and applications of their sectors, including 2022 summary and 2023 outlook. We hope that by sharing Rosefinch's views, we can add value to your day.

Mr. HU Xiaojun, Head of Advanced Manufacturing Team #1. Team #1 focuses on hydrogen, energy storage, and new material industry chain.

Mr. YANG Yang, Deputy-Head of Advanced Manufacturing Team #1. Mr. YANG focuses on hydrogen energy.

Mr. HUANG Hao, Head of Advanced Manufacturing Team #2. Team focuses on automobile and aerospace, including electronification and intelligent industry chains.

Mr. MOU Shantong, Deputy-Head of Advanced Manufacturing Team #2. Mr. MOU focuses on metal material and traditional energy.

Mr. LI Yang is the Head of Advanced Manufacturing Team #3. Team focuses on New Energy equipment, including photovoltaic industry chain, new photovoltaic technology, electric grid equipment, and BIPV.

Ms. ZHOU Wei is the Deputy-Head of Advanced Manufacturing Team #3. Ms. ZHOU focuses on photovoltaic industry chain.

1. Material: growth and cycle are the typical characteristics of upstream materials.

Q1: When we look at New Energy upstream materials, what's the major difference compared to normal materials?
MOU Shantong: Just like any grand and tall building must use concrete and steel, all the New Energy's midstream equipment and downstream products or applications must rely on upstream material. To make New Energy sector's development truly scalable, there must be plenty of cheap supplies in raw materials. This can be achieved by extracting large quantity and refining through mature technology and scalable productions. Today, there are relative ample supply of silicon, Lithium, and light rare earth. However, some New Energy technology do rely on some materials in limited supplies such as indium, platinum, and palladium. This constraint may hold back such technology's growth.

Q2: When it comes to investment, what's the typical characteristics of upstream materials?
MOU Shantong: There are a few characteristics worth noting. First of all, as downstream demand increases, the industry scale must expand continually, which makes the producer's profits increase quickly. We saw

this growth pattern in silicon due to photovoltaic panel demands, and lithium due to lithium battery demands. Secondly, the upstream material's exploration to extraction cycle is relatively long. It's usually at least 3-5 years, which is a mismatch to the fast downstream demand increases. This mismatch creates a strong cyclical characteristic of the industry. Thirdly, any major shifts in downstream technology will cause significant impact to upstream material demands. For example, in global battery production, the cobalt-free push due to cost and sustainability reasons led to increased demand for nickel and decreased demand for cobalt. For China, domestically it lacks some key ingredients such as copper, nickel, lithium, and high-grade carbon. It'll be important to improve the supply stability by both mining existing domestic mines and increasing imports from global sources. **Given the context of global competition and protectionism on strategic raw materials, the domestic producers of such raw materials will become more valuable.**

2. Photovoltaic Equipment: photovoltaic is one of the most important areas of New Energy Revolution.

Q1: What is the most area for this energy revolution?

Ms. ZHOU Wei: For energy revolution, the two key themes are clean electricity development and satisfying growing energy demands. Because photovoltaic energy is a clean and renewable energy, it will play one of the most important roles in this energy revolution. The photovoltaic energy refers the electricity generation by capturing solar energy, using photovoltaic effects, and transforming into electricity. This electricity generating system has core components of photovoltaic module, solar inverter, mounting. For the photovoltaic module, its main production process consists of: quartz sand to industrial silicon to polycrystalline silicon to monocrystalline silicon wafer to photovoltaic cell and finally to photovoltaic module. These components and process create the typical photovoltaic industry chain.

Q2: What is the core driver of the photovoltaic development?

Ms. ZHOU Wei: **Photovoltaic is transforming the essence of energy from resource-based to manufacturing-based.** In the past, the traditional energy came in the form of coal, oil, natural gas. In these cases, the energy and the carriers of the energy are the same. This carrier is called resource, and they are called natural resources which is subject to natural distribution. Because the production and consumption occur in different places, many countries must rely on imports to satisfy their domestic needs. But photovoltaic is different: sun light is relatively abundant across the world. Its supply is, for all practical purposes, limitless. An investment on a photovoltaic module will allow you an independent power generator. EU has raised New Energy generation's strategic significance this year, with target of 40% renewable energy from previous 32% by 2030. Photovoltaic energy will play a big part in this increase. Looking forward, we believe photovoltaic will outperform in the energy revolution by growing from a secondary energy source to a major energy source. This process will rely on the fast cost-reduction of photovoltaic energy. In the past ten years, the photovoltaic energy cost has dropped 90% to where it's on par with the coal-generating cost. As photovoltaic industry chain continues to develop and mature, we may see further cost reduction ahead.

Q3: How big is the photovoltaic market?

Ms. ZHOU Wei: According to BP research, in 2021 wind and solar energy generation reached above 10% and contributed to 10.2% of global power generation for the first time in history. We have estimated that if we assume photovoltaic energy contributes 23.6% of total energy production in 2030, this will require at least 7120GW of installed capacity, which corresponds to roughly annual new installation of 700GW in the world. Currently the annual installation for photovoltaic capacity is only 230GW, which means there's still tremendous growth potential.

3. Energy Storage: in some areas, energy storage may be as essential as mobile phones.

Q1: What problem does energy storage solve?

Mr. HU Xiaojun: Energy storage mainly solves two major problems: first is the consumption of renewable energy, and the second is the energy security. Energy storage is becoming more important in China recently, especially as our domestic non-hydro renewable energy generation is now above 10%. This increase has exasperated some constraints in our electric grid system, which can be effectively addressed via energy storage applications. As for energy security, we've seen the impacts of both rotating electricity black-out in China during 2021 and the Russia-Ukraine conflict. In Europe, the consumer electricity price increased over 5 times vs last year. European energy storage needs have more than tripled, which in those areas will make energy storage as essential and as common as having a mobile phone.

Q2: What are some applications of energy storage?

Mr. HU Xiaojun: In terms of specific energy storage applications, there are two main areas. One is the supply-side energy storage, which addresses issue of new energy consumption. For this application, the demand is driven mostly by government policy. In July 2021, NDRC and Energy Bureau announced policies that require new energy proportion to reach 15%, and those achieving more than 20% have priority in connecting to the grid. Currently, over 70% of provinces have published new energy generation goals, which will be a huge driver for domestic grid-side energy storage. Another area of energy storage application is demand-side energy storage. The demand is driven by energy stability and price differentials. Currently, most of such demand are in foreign markets, where their mature electricity pricing mechanism makes energy storage a profitable adjustment. Domestically, the current electricity price differential is not yet economical, although we expect future electricity pricing gap to widen. Last July, NDRC announced the need to differentiate electricity price between peak hours and off-peak hours. In recent published electricity prices, we noticed that 22 provinces or major cities have differential of more than 0.7 RMB/kWh, with Shanghai the biggest at 1.28 RMB/kWh. We therefore expect bigger demand from domestic energy storage.

Q3: How do you see investments in domestic energy storage?

Mr. HU Xiaojun: For investments, we see energy storage as a long-sloped track. In the short-term, there's currently not sufficient financial drivers. So the demand is still policy-driven for now. However, we have noticed a number of government initiatives to promote better profitability models for energy storage. For

example, there's now an electricity spot-price market. As service sector and electricity compensation mechanism continue to improve over the next 2-3 years, we'll likely see the energy storage profit-model to be more mature and streamlined to the point of true transformational and explosive growth. **From a market perspective, the investment potential of the energy storage is similar to that of the new energy vehicles.**

4. Hydrogen Energy: the two major issues holding back hydrogen energy development.

Q1: What are the factors holding back hydrogen energy development?
Mr. YANG Yang: Hydrogen energy development faces two major obstacles: one is the traditional hydrogen generation did not remove deeply its carbon footprint; another is the hydrogen generation has high cost. The renewable energy developments saw wind and solar energy cost dropping quickly. Since electricity cost is roughly 60%-70% of green hydrogen production cost, this can lead to rapid development of hydrogen energy. In fact, as solar and wind power generation capacity increases, the green hydrogen energy cost may reach parity with traditional hydrogen cost of roughly 10 RMB/kg by 2030. This is an important condition that can promote using green electricity to produce green hydrogen.

Recently, more and more nations are creating their national hydrogen energy strategy. In March 2022, our national hydrogen strategy was formally launched, which identified hydrogen energy as a crucial component to our future national energy infrastructure. Hydrogen is an important carrier for the ultimate goal of green low-carbon transformation. Hydrogen energy deals with electrochemistry, thermodynamics, mechanical engineering, material sciences, and other disciplines and industry chains. It is therefore a major developmental area for strategic emerging industries. We believe hydrogen is an effective carrier of high-quality low-carbon green/clean industrial material. **Hydrogen energy is widely applicable across transportation, industrial production, construction, electricity, refinery, and hydrogen energy storage areas.**

Q2: How big is the hydrogen energy demand in the market?
Mr. YANG Yang: Looking forward to 2060, the estimated global hydrogen demand will be between 600 to 800 million tons. If all of these are to be produced via electrolysis, it'd require 3 trillion kWh, or the entire current global electricity consumption. If the electricity comes from green electricity, the hydrogen energy development will promote growth of wind and solar energy, increase renewable energy consumption, and form mutually beneficial development between hydrogen and other renewable energy.

5. Application: the biggest applications of the energy revolution.

Q1: what is the role of automobile in the energy revolution?
Mr. HUANG Hao: In the last two energy revolutions, the core theme was how power generation is applied in transportation systems, which in turn brought about energy resource extraction and industrial revolution. The first industrial revolution revolved around steam engine and its application in railroad. The energy

was coal. The second energy revolution revolved around internal combustion engine and its application in cars and train engines. The energy was oil and natural gas. The current third energy revolution revolves around electricity system and its applications in electric cars. The energy is renewable energy in forms of green electricity and hydrogen. As of Oct 2022, the domestic market share of electric vehicle is over 30%, which is a sizeable increase from the 5% in beginning of 2020. The fast acceleration is mainly due to improvements in the cost/benefit ratio where the operating cost of EV is cheaper than traditional cars. In addition, the newer car models, intelligent cockpits, and driver-assistance systems are bringing enhanced product experiences.

Q2: How much room is there in the further development of electric cars?
Mr. HUANG Hao: Currently there are about 310 million vehicles in China with about 10 million New Energy Vehicles or roughly 3.2% of total. From the global perspective, there are about 2 billion vehicles including 20 million New Energy Vehicles or less than 1%. This means the New Energy Vehicle is still in its infant stage, with huge room for future developments.

Q3: Does New Energy Vehicle really have a carbon-reduction effect?
Mr. HUANG Hao: That is certainly the case. Take US for example: even though New Energy Vehicles only account for 7% of total increases, it's already reduced the annual car fuel consumption by 0.5%, generating a saving of over 1.3 billion USD. It'll be exciting to see the future carbon-reduction and cost-saving effects of New Energy Vehicles.

6. Some key questions for 3060+ developments:

Q1: As new energy develops, what is its relation to the traditional energy?
Mr. MOU Shantong: Let's start by defining traditional energy by fire-generated energy, which is typically coal fire and some natural gas, and hydro-powered, nuclear-powered energy, while new energy is defined to be main renewable energies like wind or solar power. When we look at 3060 goals, which are China's goals to reach carbon-peak by 2030 and carbon-neutral by 2060, there are three main stages where the traditional and new energy relate to each other. First stage is from now to 2030 when the carbon-peak is reached. In this period, new energy is gradually replacing traditional energy. In this period, the traditional energy will still be the dominate energy generator, accounting for 80-85% of total generation, though will slow annual increases of about 1-3%. The new energy is a small overall percentage but with faster annual growth of 20-30%. The second stage is between 2030 carbon-peak time to 2060 carbon-neutral time, where there's large scale replacement of traditional energy by new energy. The absolute level of traditional energy generation will decrease, so that we can reduce carbon emission and eventually reach carbon neutrality. The third stage is after 2060 carbon neutrality, where new energy will be the dominate generator for energy supply, accounting for ½ to 2/3 of total generation. The traditional energy like coal-firing capacity will still account for about 20-30%, and will be useful in stabilizing electricity supply and managing peak demand periods. The carbon emitted by traditional energy will be offset by carbon-absorption measures, thus allowing some fire-generating capacity in China even under carbon-neutral status.

Overall, in the foreseeable future, new energy complex still needs traditional energy's support, while traditional energy companies will actively develop new energy capacities. **The new vs traditional energy relationship is not a confrontational relationship, but a co-dependent and complementary relationship.** China's energy complex will gradually shift towards a new energy centered carbon neutral situation. From the investment perspective, new energy is a great opportunity for 3060+. For traditional energy companies, because of industry's reduced investment and controlled capacity, some market leaders may have temporary favorable outlooks and present periodic investment opportunities.

Q2: How do we view the retracement of New Energy companies, and how does technology innovation impact the industry overall?
Mr. LI Yang: I'll focus on the photovoltaic investment views. The retracement is temporary, while the long-term outlook remains strong in photovoltaic industry. In 2020 wind and solar energy are only about 10% of total power generation. In future, this percentage can grow to at least 60%. As global economy grows naturally, its electricity consumption will also grow. **Thus in the next 10-20 years, the annual installed new capacity will likely grow by 10 times. If we incorporate the likely cost-reduction, the market value of annual installed capacity will still have 5-7 times of growth potential.** This massive upgrade means change and opportunity. The core driver of the photovoltaic energy is cost-reduction and increased efficiency. New technology is the most direct way to realize both. In terms of the industry chain, the different technology will bring about new equipment or material demands, thus driving new investment opportunities.

Mr. HU Xiaojun: There are many paths for energy storage technology. Currently the electrochemical energy storage is the most robust approach, which allows milli-second voltage shift requirements and hourly peak time demands. Its low cost and high efficiency also make us very confident that it'll remain the main technology for the coming 3-5 years. In this industry, from the valuation perspective, the battery accounts for over 70%, while converter accounts for 10-15%. This is why we focus on these two areas. As energy storage's requirements increases for safety, life cycle, cost-reduction, we'll see more complexity emerging in this industry. We have accumulated substantial expertise through our existing research on lithium battery in new energy vehicle and converter in photovoltaic industry chain. These will help us greatly to uncover great investment opportunities.

Q3: what are the opportunities for upstream materials in the energy industry?
Mr. MOU Shantong: Photovoltaic energy uses primarily silicon material from the upstream industrial silicon to midstream polycrystalline silicon, silicon wafer, silicon panel. Silicon is the 2nd most plentiful element in the earth's crust, which provides ample supply for the silicon-based photovoltaic development. But some specific material such as high-purity quartz sand are relatively rare, so how to establish stable supply is an important question. As for electric vehicle's battery, it'll require metals such as lithium, nickel, platinum, palladium, copper, etc. These metals are generally available in the earth's crust, though their extraction costs exceed that of the silicon. In addition, these metals are rarer in China which requires global imports to obtain supply and increase reserve.

The new energy development has increased the utilization of electricity where 70%-80% of the total energy will be related to electricity by the time we achieve carbon-neutrality. There'll be also strong demand for electromagnetic materials, including the copper-based conductors, Neodymium magnets, and super conductor material such as low-temperature metal or high-temperature porcelain materials. Previously, we discussed how for investments, the upstream material present growth and cyclical characteristics which evolves along with the downstream technological innovations. We focus on the main theme of industry and company growth, and analyze the long-term demand for the industry. By using the estimated growth rates of market size, relative competitiveness of the company within the industry, and the market share of the company, we can build a good basis for the company's future growth rate for our investment forecasts. At the same time, we will consider cyclical factors, track downstream technology advances, and dynamically adjust raw material demand forecasts.

Q4: How competitive is the domestic intelligent cars in the global market?
Mr. HUANG Hao: Overall, the Chinese intelligent cars are getting more competitive constantly. If we look at the export data, there were 2.138 million units exported in 2021 which is a growth of 102% yoy. In the Jan-Oct 2022 period, there were 2.62 million units exported, which is a yoy growth rate of 52%, another very strong performance. When it comes to new energy vehicles, the growth rate is even higher. In 2020, the total export was 223k new energy vehicles; and in Jan-Oct 2022, the YTD export was 850k. Another perspective is to view the intelligent cars from the smart chips. According to Mobileye, the 1H22 sales to China was 27%, which is 8% higher than 2021 and makes China the single biggest market. Nvidia disclosed in its quarterly report a number of new projects, all of which were from Chinese car manufacturers. So from the hardware perspective, China has the most aggressive growth.

Even though intelligent cars have achieved amazing results so far, it's still at L2 or L3 level of assisted driving. Take the market leader Tesla: during some complex situations such as roads without guiding lines, FSD system can still surprisingly achieve smooth passing, turning, or crossing intersections. In some simple situations, such as shifting within lanes or changing lanes, more work is still needed to make the assisted driving be smoother. From investment perspective, to achieve L3 level of intelligent driving, single car value is around 10k RMB, which makes the global market a trillion RMB market, which will usher in the rise of industrial chain companies.

We may see a slowdown in growth rate next year which will bring two results: firstly the upstream supply bottleneck will ease, which in turn will see supply outpace demand and decrease the raw material cost; secondly the industry chain competition will increase, where the aggregate capability of car manufacturers will be under pressure. The companies must deal with new model development, raise overall branding power, and compete against electrification and intelligent car technology. There will be tremendous demand and stress on the R&D and organizational agility. We must follow the companies closely to filter and identify the best companies for our industry chain portfolio, so we can present the best of the best for our investors.

Q5: What are some of the future technologies for the 3060+ industries?

Mr. HU Xiaojun: In the long term, by 2025 the non-hydro renewable energy should generate close to 20% of energy output. This will push for energy storage capacity of over 4 hours. By the time such renewable energy exceeds 50%, we'll need even longer energy storage capacity of over days or weeks. The current electrochemical technology can't do the long-term energy storage efficiently yet, which means we must develop the technology. We believe the most promising energy storage technologies include hydrogen energy storage, liquid battery energy storage, and compressed air energy storage. There are now prototype operational units for all these types which we're following closely.

Mr. YANG Yang: In future hydrogen can be seen more as an energy source than as an industrial material. Large-scale hydrogen production and energy storage is a core developmental track. In terms of hydrogen production, Alkaline electrolysis is a more mature and valuable process. We are also following Polymer Electrolyte Membrane (PEM), Anion-Exchange Membrane (AEM) and other electrolysis methods. In terms of energy storage and transportation, aside from high-pressure method, green hydrogen, liquid hydrogen, green methanol, and solid hydrogen are also developing fast.

Mr. HUANG Hao: The most precise self-driving technology will bring about upgrades in chips and AI technology, as well as extend its application to robotic and ultimately to internet of things. To achieve self-driving, the key is to merge the computational power, calculation method, and data. The computational power determines the data processing capability. From Mobileye to Nvidia Thor chip, the computational power goes from 5 teraflops to 2000 teraflops. As for calculation method, the autonomous driving provided rich and fertile ground for AI development. Tesla has trained over 75,000 neural networks in the past year, with 281 model applied to Tesla cars. In addition, large number of sensors are adding oceans of data for the entire car industry, forming a strong foundation for future improvements.

LI Yang: Photovoltaic industry will pay close attention to the development of laminated battery. The key is to achieve energy-conversion efficiency of over 28%. The domestic industry is still at early stages of creating industrialization of such panels. Once achieved, this will create an existential impact to all the silicon industry chains. It may even further increase silicon battery's energy conversion efficiency by laminating crystalline silicon and perovskite.

ZHOU Wei: Heterojunction technology is worth following for Photovoltaic industry. Recently a market leader just announced energy-conversion efficiency of 26.81% based on the heterojunction technology. This is the first advance of the energy-conversion efficiency in over 5 years. We will follow this efficiency ratio closely to see how the industry develops.

We hope that by sharing Rosefinch's views, we add value to your day.