The State of Renewable Energy in Mongolia

By Batbold Bayaraa
### ABBREVIATIONS

<table>
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<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
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<tr>
<td>AF</td>
<td>Adaptation Fund</td>
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<td>BEV</td>
<td>Breakthrough Energy Ventures</td>
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<td>CDM</td>
<td>Clean Development Mechanism</td>
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<td>COP</td>
<td>Conference of Parties</td>
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<td>CEF</td>
<td>Clean Energy Fund</td>
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<td>CEFPF</td>
<td>Clean Energy Financing Partnership</td>
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<td>CER</td>
<td>Certified Emissions Reductions</td>
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<td>CES</td>
<td>Central Electricity System</td>
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<td>CIF</td>
<td>Climate Investment Fund</td>
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<td>CTF</td>
<td>Clean Technology Fund</td>
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<td>CTFC</td>
<td>Climate Technology Finance Center</td>
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<td>CTNFC</td>
<td>Climate Technology Network and Finance Center</td>
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<td>DMC</td>
<td>Developing Member Country</td>
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<td>EBRD</td>
<td>European Bank for Reconstruction and Development</td>
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<td>ERC</td>
<td>Energy Regulatory Committee</td>
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<td>ESMAP</td>
<td>Energy Sector Management Assistance Program</td>
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<td>FIP</td>
<td>Forest Investment Program</td>
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<td>FiT</td>
<td>Feed-in-tariff</td>
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<td>GEIDCO</td>
<td>Global Energy Interconnection Development and Cooperation Organization</td>
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<td>GCF</td>
<td>Green Climate Fund</td>
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<td>GHG</td>
<td>Greenhouse Gas</td>
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<td>IBRD</td>
<td>International Bank for Reconstruction and Development</td>
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<td>IDA</td>
<td>International Development Association</td>
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<td>IEA</td>
<td>International Energy Authority</td>
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<td>IFC</td>
<td>International Finance Corporation</td>
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<td>INDC</td>
<td>Intended Nationally Determined Contribution</td>
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<td>IRR</td>
<td>Internal Rate of Return</td>
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<td>JCM</td>
<td>Joint Credit Mechanism</td>
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<td>JFJCM</td>
<td>Japanese Fund for Joint Credit Mechanism</td>
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<td>LCOE</td>
<td>Levelized Cost of Energy</td>
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<td>MEGDT</td>
<td>Ministry of Environment, Green Development and Tourism</td>
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<td>MOE</td>
<td>Ministry of Energy</td>
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<td>Acronym</td>
<td>Description</td>
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<td>MONSEFF</td>
<td>Mongolian Sustainable Energy Financing Facility</td>
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<td>MIGA</td>
<td>Multilateral Investment Guarantee Agency</td>
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<td>NAMA</td>
<td>Nationally Appropriate Mitigation Action</td>
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<td>NPV</td>
<td>Net Present Value</td>
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<td>PPA</td>
<td>Power Purchase Agreement</td>
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<td>PPCR</td>
<td>Pilot Program for Climate Resilience</td>
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<td>PV</td>
<td>Photovoltaic</td>
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<td>SE4All</td>
<td>Sustainable Energy for All</td>
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<td>SCF</td>
<td>Strategic Climate Fund</td>
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<td>SREP</td>
<td>Scaling Up Renewable Energy Program</td>
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<td>UNEP</td>
<td>United Nations Environmental Programme</td>
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<td>UNFCCC</td>
<td>United Nations Framework Convention on Climate Change</td>
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<td>PV</td>
<td>Photovoltaic</td>
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<td>SMSL</td>
<td>Silicon Module Super League</td>
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<td>BOS</td>
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EXECUTIVE SUMMARY

The Global State of Energy

Energy is the basis of modern life. From the food we eat to the tools we use, energy dominates our day to day life. Technological progress, population growth, increased lifespan, and the global economic shift from poor to middle class is increasing demand for energy at a pace never before seen in history. In 1990 1.85 billion people lived on less than $1.90 per day, however by 2013 that number had fallen to 767 million even though global population increased by 1.8 billion. (Worldbank)

In 2013, the IEA estimates that global energy use was 12.3TW and demand is expected to increase by at least 30% by 2040. From 2000 to 2012, coal was the source that had the biggest increase amongst the different types of energy sources. At the current rate of increase in demand, energy production from all available types of energy sources are expected to increase. Renewable energy sources are expected to make the biggest gains. $44 trillion in investments will be needed to meet this demand of which 20% will go towards renewables. An additional $23 trillion will be needed to improve efficiency. (IEA)

A Dire Situation

Greenhouse gas emissions from the use of fossil fuels are wreaking havoc on the climate. All scientists agree that it is highly unlikely that the global community can keep mean temperatures from rising above 2 degrees Celsius by 2050, although the chance for keeping it under 4 degrees Celsius by 2100 is achievable. There are even those who consider that we have already passed the tipping point to start a self-sustaining process that eventually makes human extinction a certainty, a scenario in which if it is true, not only do we need to increase our shift towards renewables at a much fervent pace, but it will also necessitate that countries start operations to actively suck and trap greenhouse gases from the atmosphere. Global CO2 emissions in 1990 were around 6 gigatonnes compared to 9.795 gigatonnes in 2014. Yearly CO2 emissions held steady in 2015 and 2016, leading many experts to believe that CO2 emissions had finally peaked.

A 2 degrees increase in mean temperature, almost unavoidable at this point will mean that the instances of extreme climate event such as hurricanes, floods, drought etc. will increase in number and severity. Rise in sea levels will make some areas uninhabitable, leading to massive population displacement. A number of crops that sustained the current global population growth will start to fail, fresh water supplies will become stressed and limited, and we will witness animal extinction on a massive scale. All these effects will lead towards global social unrest and economic collapse. The general consensus amongst the scientific community is that civilization will most likely not survive a 4 degrees Celsius in global mean temperatures and that an extinction event similar to the Cretaceous – Paleogene extinction event that happened 66 million years ago will occur. Of course all this is hypothetical, however even the best case scenario looks rather bleak at this point.
A Global Shift in Attitude

As evidence mounted regarding the effects of fossil fuels and their contribution towards global warming, those with a vested interest in the fossil fuel industry did their best to delay any action. In fact, most government still support their fossil fuel industries by providing them with huge subsidies, although this has rapidly fallen from $500 billion in 2014 to $325 billion in 2015.

The UNFCCC

The United Nations Framework Convention on Climate Change is an international environmental treaty negotiated in Rio de Janeiro in 1992. In 1997, under the UNFCCC the Kyoto Protocol was concluded which established the basis for the first tangible effort to mitigate the emissions of member countries. However, the biggest emitter of greenhouse gases the USA and the soon to be biggest emitter China did not partake in making commitments to set emission reduction targets, thus dooming the effectiveness of the Kyoto Protocol from the very beginning. China was experiencing rapid economic growth, which could have been jeopardized if cheap fossil fuel energy became restricted. As for the USA, the fossil fuel industry’s political influence prohibited American politicians from making any commitments.

The Paris Agreement

In December 2015, 195 member countries of the UNFCCC met in Paris to enter the Paris Agreement. This signaled a seismic shift in attitude and will perhaps mark the beginning of the end of the fossil fuel industry. The difference from Kyoto was that not only were the US and China active participants, but one could say they were actually leading the meeting. Chinese participation was highly notable with extremely ambitious emission reduction targets. After the Paris Agreement, the rules of business have changed for the better. From now on, to be efficient is to be low in emissions. The main takeaway from COP21 (Conference of Parties) is for all member parties to aim towards zero net emissions in the second half of the century. Currently 129 parties out of 197 have ratified.
Renewables to the Rescue

As if on cue, after the Paris Agreement the renewable energy industry and energy efficiency industry is experiencing a boom. Funding is ample, the public image is positive, technological progress and development is happening at breakneck speeds, quite frankly the renewable energy industry has become perhaps the sexiest industry to be in right now. Not a month has gone by without new news that somehow breaks previous records, and industry super stars such as Elon Musk are increasing public awareness and involvement like never before. Below are just some of the noteworthy global trends that we witnessed in 2016.

Global New Investment in Renewable Energy By Asset Class

- Global energy investments reach $286 billion to set a new record.
- Developing and emerging economies committed $156 billion.
- 118GW wind and solar PV capacity added in 2015.
- World’s 3 largest battery power stations opened in California almost at the same in 2017.
- Tesla’s $5 billion dollar battery plant starts operation.
Another major shift that we are witnessing is that renewable technologies that were once seen as a luxury has become much more affordable and in 2015 investments in developing countries actually exceeded those in developed in countries. China, India and Brazil increased their investment in renewable by 30% in 2015 compared to 2014.
A Focus on Solar

Global New Investment in Renewable Energy by Sector

Solar power was the biggest winner in 2015 with capacity investment reaching $148.3 billion, compared to wind’s $107 billion. Solar costs for PV fell from $315 per MWh in Q3 of 2009 to $122 in late 2015, a drop of 61%. In August, the bid to build the world’s largest solar power plant in Abu Dhabi came in at $0.023/kWh ($24.2MWh) for 1.2GW capacity. A Chinese glut in production, increased financing opportunities, as well as the relative ease of setup and scalability has made solar power the preferred choice amongst renewable energy investments. Solar has already become price competitive compared to traditional fossil fuel energy sources, and will become even more so if the environmental costs as well as the effects of subsidies are factored into the equation. Currently the solar industry in the US employs more people than the oil, coal and gas industries combined.
Renewables in Mongolia

Renewable energy is going to become Mongolia’s largest industry. The export revenue will eventually surpass exports in mining. Mongolia is on a course to become one of the biggest winners of the global war against GHG emissions. Not only does Mongolia have abundant sources of renewable energy, the cost for lowering emissions is extremely low compared to most countries, and the world’s most energy hungry market is right next door. As a member of the UNFCCC, Mongolia has made the following pledges in accordance with the Paris Agreement, also known as the Intended Nationally Determined Contribution (INDC).

- 14% reduction in GHG emission excluding Land use, land use change and forestry by 2030 compared to the business as usual scenario.
- Increase renewable capacity to 20% by 2020 and 30% by 2030.
- Reduce building heat loss by 20% by 2020 and 40% by 2040 compared to 2014 levels.

Compared to the targets and commitments made by most countries, Mongolia’s commitments aren’t as ambitious. This is due to the fact that Mongolia’s historical contribution to the current buildup of GHG’s in the atmosphere is almost insignificant. Total GHG emissions excluding land use and forestry were 32.88 million tons of carbon dioxide equivalence (MtCO2e) in 2012, 0.07% of the world total. However, the annual per capita emission of GHG in CO2 at 11.76 tons per person is quite high compared to other countries and is almost twice the world average.
As an interesting side note, one could make the argument that the expansion of the Mongolian Empire was the only time in modern human history to actually have seen a decrease in GHG concentration in the atmosphere.

**Resource Potential**

Mongolia also has 270-300 sunny days with 1400kWh per square meter per year. 70% of the country’s land area receives solar insolation at the rate of 5.5-6.0 kWh. The hydro potential is calculated to be at 6400MW. The US Department of Energy estimates the Mongolian side of the Gobi Desert’s renewable energy capacity to be 2600TWh, with 1100TWh for wind and 1500TWh for solar.

**Chinese Demand and Mitigation Targets**

The main reason that makes the prospect of investing in Mongolian renewable capacity so lucrative is unquestionably China. Recently a public opinions poll in a number of large Chinese cities indicated that Chinese citizens were fed up with air pollution. This is an issue which the Chinese government takes quite seriously as it directly affects the quality of life of its citizens. The following are just some of the tremendous leaps China is taking towards going green. In 2014, China produced 5’583 TWh of electricity, with 73% coming from coal powered plants. Chinese electricity demand is forecasted to reach between 7584TWh to11’154TWh in 2030.

- Peak CO2 by 2030.
- Non fossil energy sources to be at 20% of total energy production by 2030.
- 40-45% reduction in CO2 emissions per unit of GDP from 2005 level by 2020.
- In 2017, China increased its foreign investments in renewables by 60% to reach $32 billion.
- $362 billion domestic investment pledge in renewables and nuclear by 2020.
- Chinese owners control 5 of the world’s 6 largest solar manufacturing firms.
Given these underlying assumptions, developing Mongolian renewable capacity will be quite beneficial for China since it will provide cheap and reliable renewable energy at a time when the demand for it is growing the most.

The Dream: Asian Super Grid

The idea of the Asian Super Grid, also known as Gobitec is a development vision promoted by Softbank’s Masayoshi Son that envisions the creation and development of a transmission grid infrastructure (High Voltage Direct Current HVDC) connecting Russia, Mongolia, China, Japan and Korea with the intent of providing the connected countries with renewable energy from the Gobi Desert. If this vision comes to fruition, development on a massive scale can be expected to take place in the Gobi Desert.

Based on calculations to build 50GW solar and 50GW wind, it is estimated that 900,000 new jobs will be created in Mongolia alone from 2015-2030. Participating countries will reduce 187 Gt CO2 per year. A total of 7530km of transmission line will be needed to be built. The total investment cost is calculated at $293 billion with additional yearly maintenance and service cost of $7.3 billion.
Though project is nothing more than a concept at this moment, the economic, environmental as well as regional cooperation benefits of the project are clear. Promising developments to turn this dream into a reality have come in the way of the signing of the memorandum of understanding to pursue the development of the Asian Super Grid between the Russian firm Rosseti, Japanese firm Softbank, Korean firm Kepco, and the State Grid Corporation of China. The signing resulted in the creation of the Global Energy Interconnection Development and Cooperation Organization (GEIDCO). Furthermore, Softbank’s renewable energy subsidiary Energy Corp has partnered with Mongolia’s Newcom to develop a 50MW windfarm in the town of Tsetsii located in the Gobi Desert, a development that fits perfectly within the Gobitec narrative. Even if the project fails, it seems all but inevitable that a similar development albeit on a smaller scale will take its place.
Developments in Mongolia

Market

The current Mongolian energy market capacity is 1122MW and consists of 5 different networks. Renewable energy takes up only 6% while coal based power plants account for 90% of total electrical energy generation. Diesel accounts for 2%. Energy capacity forecasts indicate that Mongolia will need an electrical generation capacity of 2546MW by 2020 and 3100MW by 2030.

- Altai-Uliastai Energy System 15MW
- Central Energy System 1034MW
- Eastern Region System 36MW
- Dalanzadgad Energy System 24MW
- Western Region System 12MW

In 2015, Mongolia imported a total of 1’384 million kwh worth of energy from our neighbors, costing us a total of 129.18 million USD.

All new energy projects in Mongolia are governed by the Energy Law of Mongolia.
Wind Power Investment Case Studies

➢ Salkhit 50MW (120’000’000) Newcom, GE, EBRD, Netherlands Development Finance Company.

➢ Tsetsii 50MW (120’000’000) 25 from EBRD, 151’280 ton reduction per year. 51% Clean Energy Asia (Newcom), 49% SB Energy Corp (Softbank)

Solar Power Investment Case Studies
Darkhan Solar Power Plant 10MW

Hydro Power Investment Case Studies

- Taishir Hydro Power Plant, 11Mw, Kuweit Fund 20 million USD, Abu Dhabi Fund 13 million USD.
- Durgun Hydro Power Plant, 12Mw

Failed Projects Case Studies

- Oyu Tolgoi Wind Farm 102MW Goal of 250MW (Qleantech LLC – Endaxi Capital Partners, Suntien Green Energy Co) Investment $178’923’956. Opex starting from $2 million per year to reach $16.6 million by the end of the project. FIT $0.095/kWh. $29’212’000 income per year. 21 years. IRR 12%, payback 8 years.
- Tuul Songino Water Resources Complex 100MW (Ulaanbaatar Pumped Storage Power Station LLC). Investment $175 million. Opex $571’854 per year. FIT $0.113/kWh. Income $33.9 million per year. 20 years. IRR 18%, payback 6 years.
- Eg River Hydro Station 315MW (Transboundary issues and due diligence related to downstream environmental concerns.)
- Orkhon Hydro Station (Transboundary issues and due diligence related to downstream environmental concerns.)
- Shuren Hydro Station (Transboundary issues and due diligence related to downstream environmental concerns.)
Of all the renewable technologies currently available on the market, it is my belief that solar power has the largest potential. Not only is Mongolia known as the country of eternal blue sky, attesting to the astounding number of sunny days we get as a country, but the flat open terrain combined with the fact that we are one of the least densely populated country in the world makes solar a very lucrative prospect. The Gobi desert has the third highest solar insolation from all the deserts in the world.

**Benefits of Solar**

- **Costs**

Compared to other solutions, the capital costs for building a solar power plant is relatively low, depending on the scale of capacity needed. Furthermore, currently China is facing a glut in supply due thanks in part due to a recent bubble in investments in PV manufacturing capacity. This has caused the cost for PV to plummet globally, with demand trying to catch up to the currently existing supply. PV technology has been around long enough that most manufacturers can be said to build PV panels at almost the same quality. So the differentiating factor becomes cost.

Calculating the amount of sun a certain area will receive in any given year is much simpler to do than calculating the amount of wind, geothermal capacity, or water flow. Increased climate change makes wind and river flow ever more variable in the coming future, where as one can expect the same amount of sunshine lest there is a dramatic shift in air humidity, a highly unlikely scenario for Mongolia in climate change models.
The construction cost is also minimal, with very little HR and outsourcing requirements. For wind installations, huge global operators are required to undertake the construction process which requires extremely specialized equipment that cannot be easily found in Mongolia. Solar installation can be built within 3-6 months while wind installations usually take around 9 months, a critical fact in a country such as Mongolia with a short building season. Infrastructure requirements especially when it comes to the transportation of turbines are a nightmare. Solar on the other hand can be easily deployed utilizing mid-size local companies with experience in the energy sector.

Solar can be built almost anywhere, as long as the land is flat enough. A 45 degree tilt on the panels is optimal, since Mongolia is located relatively north from the equator. This not only save initial construction costs, but also save money on maintenance compared to motorized PV solutions.

➢ Operation

Once the power plant is up and running, staffing requirement is considerably low compared to other types of renewable energy solutions. A handful of engineers combined with security and maintenance make up most of the staff.

Maintenance is also far simpler and one could also make the argument that the investment risk is diversified among a number of small panels compared to one huge turbine for wind power.

Wind turbines also have flaws such as the devastation it cause to avian wildlife, the technical breakdown risks when the turbines are required to stop due to an overcapacity in the grid or a lack of wind, as well as any kind of damage that might compromise the structural integrity of the structure, all instances in which there is a risk that the project life cycle might decrease.

To put it in another perspective, solar has a much smaller carbon footprint during the construction phase in order to construct the same generating capacity as wind power.
Funding Opportunities

UNFCCC (United Nations Framework Convention on Climate Change)

A global pact entered into accord by 197 parties in order to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system.

CDM (Clean Development Mechanism)

The Clean Development Mechanism is a mechanism that allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol to implement an emission-reduction project in developing countries in order to earn Certified Emission Reductions (CERs). 1650 projects since 2006. Approval process must go through Designated National Authority and must provide reductions that are additional to what would otherwise have occurred. Overseen by CDM executive board.

Project Design -> National Approval -> Validation -> Registration -> Monitoring -> Verification -> CER issuance.

Adaptation Fund (AF)

A fund to finance adaptation projects and programmes in developing countries. 2% from the sale of CERs issued for CDM projects is used to finance the fund. Managed by the Adaptation Fund Board. $357.5 millions USD in 63 countries since 2010.

CTCN (Climate Technology Centre and Network) Technical Assistance upon request by NDAs.

An operational arm of the UNFCCC. Provides technical assistance at the request of developing countries to accelerate the transfer of climate technologies.

GCF (Green Climate Fund)

Following the Paris Agreement, developed economies have agreed to jointly mobilize $100 billion per year until 2020 to address mitigation and adaptation needs for developing countries. The funding will be channeled through the newly established Green Climate Fund.

Accredited Entity (Khasbank)

Khasbank has become one of the very first entities in the world to get approval from the GCF and become an accredited entity. GCF has allocated $20 million to Khasbank at the end of 2016.

CIF (Climate Investment Fund)

$8.3 Billion Climate Investment Fund provides 72 developing and middle income countries to help in areas to reduce climate change and reduce greenhouse gas emissions. The funds help to test new business models, build track records in unproven markets, and boost investor confidence for other funding sources.

➢ CTF (Clean Technology Fund)
$5.6 billion dollar fund for middle-income countries for scaling up the demonstration, deployment, and transfer of low carbon technologies in renewable energy, energy efficiency, and sustainable transport.

- SCF (Strategic Climate Fund)
  - FIP (Forest Investment Program)
    $775 million for reducing deforestation and forest degradation. To promote sustainable forest management.
  - PPCR (Pilot Program for Climate Resilience)
    $1.2 billion for developing countries to integrate climate resilience into development planning. Offers additional funding to support public and private sector investments.
  - SREP (Scaling Up Renewable Energy Program in Low – Income Countries)
    $780 million for scaling up renewable energy in low income countries.

1.2 million USD grant funding for “Mongolia: Capacity Building and Regulatory Support Technical Assistance: approved on August 9th, 2016.


**Banks**

**ADB**

- CTNFC (Climate Technology Network and Finance Center)
  ADB working with the United Nations Environment Programme with funding from the Global Environment Fund (GEF), government of Japan and Korea to operate the Climate Technology Network and Finance Center in Manila. The center focuses on climate technology transfer.
    - Technical assistance provided by CTFC for capacity building (Climate Technology Finance Center)
    - Country Partnership Strategies (CPS)

- JFJCM (Japan Fund for the Joint Crediting Mechanism)
  Japanese fund established in 2014 managed by ADB. $42.6 million contributed to the fund since the fund’s establishment.

- CEFPF (Clean Energy Financing Partnership)
Founded in 2007 to help improve energy security in developing member countries and decrease the rate of climate change by financing the development of more efficient technologies.

- CEF (Clean Energy Fund)

CEF funding is channeled through the Clean Energy Fund.

**EBRD**
- Tsetsii Wind Farm (25 million USD)
- MonSEFF (Mongolian Sustainable Energy Financing Facility) Khasbank - $10 million USD. Sustainable Energy Loan Program.
- MonSEFF Khan Bank Energy Efficiency Loan - $10 million USD. Sustainable Energy Loan Program.

**World Bank**
- Sustainable Energy for All (SE4All)

$48.6 billion for energy projects since 2008. $7 billion annual lending program, going toward 3 initiatives. The following one is the one that it relevant to Mongolia.

- The Energy Sector Management Assistance Program (ESMAP) Analytical and advisory services to low and middle income countries to increase their know how to achieve environmentally sustainable energy solutions for poverty reduction.

- IDA (International Development Association)
- IBRD (International Bank for Reconstruction and Development)
- MIGA (Multilateral Investment Guarantee Agency)

Insures against political risk for cross border investments into developing countries, thus resulting in increased FDI.

- IFC (International Finance Corporation)

$470 million invested in Mongolia since 1997 to support sustainable economic development.

**Breakthrough Energy Coalition**

A global coalition of ultra-rich entrepreneurs working together to fight climate change. They will do so by investing in companies that have promising technologies.

- Breakthrough Energy Ventures.

  The fund for channeling their investment.
The Carbon Market

Opportunities in Business Development

Assessment, Consulting, Investment, Financial Service

Currently, there is a very rapidly growing demand for support in assessing GHG emissions reduction and mitigation in all projects in Mongolia, existing and proposed. A company specializing in measuring, reporting, and validation activity that is staffed with qualified personnel and accepted by relevant organizations and authorities can expect to see a hefty load of work coming its way.

As of now, there are no Mongolian companies specializing in this field and all MRV related work is outsourced to foreign companies and are conducted at a rather expensive cost to the project owners. Capacity building in MRV related technical expertise is something any of the global organizations operating in conjunction with the UNFCCC would happily support, in terms of technical assistance as well as financial.

SHUTIS just began their first course for training certified energy Auditors. A group of students have just received the certificate in January.

Financial services for the renewable energy industry are bound to grow bigger. Although the requirements are quite difficult to attract the necessary source funding from one of the many global funds. Insuring, subsidizing and financing micro scale renewable projects has the potential to yield high returns.

Subsidized Energy Efficiency Retrofitting

Energy efficiency retrofitting in itself is not a new concept for Mongolia. However, local economic conditions make it difficult for most companies and households to actually afford this costly investment. A subsidy program not unlike those found in more developed economies can also be very beneficial for the Mongolian market. By providing a subsidy, it will allow individuals and organizations to approach the issue of efficiency with a short term mindset and will give them an opportunity to realize the benefits of their investment earlier on. One could argue that a long term investment mindset is very well established amongst Mongolians.

Subsidized Small Scale Solar Installations

Individual home solar installation for households, summerhouses, and small scale companies currently depending on diesel generators can also be a very promising sector. However, like the energy efficiency retrofitting mentioned above, this also needs a subsidy program to be effective.

Solar Power Plant Project

A solar power plant still remains one of the best bets in the renewable energy sector. Since there are already a number of projects, all under 50mw being developed in Mongolia, I propose any new project should aim for a bigger capacity. If possible, starting with 100MW would bring down the cost of kwh generation significantly. Furthermore, all the current projects use Japanese manufactured PV panels. Even though they are of very high quality and have proven to be effective in the Mongolian climate, I still believe the cheap price of Chinese panels more than make up for their shortcomings.
A solar power plant operation should preferably have both a Chinese and Japanese partner.

**Private Grid**

Until recently, it has not been possible for a private company to own an energy transmission grid infrastructure. However, this seems to be changing and the first privately held grid network is now operating in Selenge Province and the city of Darkhan. The company is called The Darkhan Selenge Electricity Transmission Network LLC. Nolgo LLC, Erchims Suljee LLC.

If we are to take the example of Germany and California as the inevitable development path of the future, a privately held grid is essential for the development of a decentralized renewable electricity generation network. A private grid will eventually enable households to sell excess renewable energy back into the network. The grid operator can prioritize the sale of electricity based on cost and source.

**Greenhouse to Supplement Solar Plant**

A greenhouse that can operate year round and which receives most of its energy from its own solar power plant is also a very idea and a number of companies are exploring this possibility. By having a readily available customer for the solar plant’s energy, a number of considerations as well as barriers for solar development become instantly mute.

It is not difficult to envision a future in which such a large scale operation not only grows food for the Mongolian market, but also makes produce for exporting to China.
Solar PV

Technology

❖ Monocrystalline
  o Oldest and most developed from all the technologies. Created from a single continuous crystal structure.
  o Highest Efficiency Rates, Space efficient.
  o Long lifespan, 25 year warranty. Probably will last longer than 25 years.
  o More efficient in ward weather.
  o Most expensive.

❖ Polycrystalline
  o A newer method compared to Monocrystalline development.
  o Costs less compared to Mono. Waste is less.
  o Lower heat tolerance means that as heat increases, efficiency falls.
  o In practice, the loss in efficiency is negligible.

❖ Thin film amorphous
  o The latest and newest technology. Totally different process and cannot be considered a mature technology. Has the lowest efficiency, but the cheapest production cost.
  o Mass production is easy.
  o Flexible.
  o High temperature and shading has very little effect.
  o 4 times less efficient than mono.
  o Degrades faster and comes with shorter warranty.

Assumptions When Calculating Solar

• Warranty is usually 90% rated power output for 10 years and 80% power output for 25 years on modules.
• Dust can reduce efficiency by 30%. Paying to clean solar panels wasn’t very cost effective. Researchers in California found that panels that hadn’t been cleaned for 145 days lost only 7.4% of their efficiency. Average loss of efficiency per day is 0.05% if not cleaned.
• Up to 95% of solar panel parts can be recycled.
• Whether related uncertainty 4%.
• Solar resource estimation uncertainty 5%.
• Irradiation in the plane of the array 3%.
• Power rating of modules 3%.
• Dust, dirt 2%.
• Snow 1.5%.
• 5% for mistakes and errors.
• Synthetic days using readily available weather data and verification using the Open Solar Outdoors Test Field make it possible to predict PV performance with high degrees of accuracy.
Solar PV Manufacturers

2016 Solar PV Manufacturing industry has seen the highest capex levels in recent years, with a hefty chunk of the capital going towards increasing capacity, which was stagnant for the last few years. The following 10 are the 10 biggest movers in the industry.

Silicon Module Super League (SM SL) – Will ship half of the world’s end-market supply in 2017.

❖ Canadian Solar

What separates Canadian Solar from its domestic peers is mostly driven by a downstream project business segment that must be the envy of all other legacy ingot-to-module suppliers that sought to copy the company’s move to diversify its revenue stream outside of pure-play manufacturing.

Manufacturing capex in 2016 is guided to be well above US$300 million with no shortage of overseas capacity additions, still however weighted mainly to modules. In this respect, Canadian Solar’s recent moves are less likely to be impactful at the technology side, confirmed further by the company still having to outsource more than 1GW of cells and modules, simply to hit module shipment targets.
❖ **Hanwha Q CELLS**

Another regular SMSL member, Hanwha Q CELLS has been undergoing one of the largest capacity expansions in Southeast Asia in the past 12 months, with Hanwha proceeding with its 2015 plans that were announced during the realignment and rebranding phase when company operations were folded under Hanwha Q CELLS.

Similar to JA Solar, Hanwha’s equipment spending in the past couple of years has been in the top tier of the industry, driven in part by the requirement to further expand capacity outside China.

As a company setting the benchmark for advanced cell processing on P-type substrates, Hanwha Q CELLS has the potential to shape technology roadmaps and cell substrate and process flow trends. Perhaps however, the first true indicator of this will be when the company fully transfers know-how and manufacturing upgrades to Hanwha’s own former Solarfun operations in China.

❖ **JA Solar**

Multi-GW expansions remain planned for 2016, spread largely across China and Southeast Asia, with capex guided well above US$300 million, putting JA Solar in the top bracket for equipment spending.

In contrast to JinkoSolar, JA Solar’s growth plans have the scope to impact on technology changes in a more profound way. This is due to the company being one of the main drivers in advanced cell technology, such as PERC, but also as an early mover in shifting from wet-etch to dry-etch for front-end texturing during cell processing: more on this as we reveal the agenda shortly for the PV CellTech 2017 conference in Penang, Malaysia, 14-15 March 2017.

However, more than JinkoSolar and some other leading Chinese module suppliers, JA Solar is potentially at risk from any downturn in 2H’16 coming from weakness in its domestic market. The lack of strong market-share in the US and Europe during 1H’16 may simply leave India as the low-cost overflow channel for China produced cells and modules over the next few months, something that will only drive down blended ASPs.

❖ **Jinko Solar** (Record efficiency at 22.61%)

Of all the members of the Silicon Module Super League (SMSL), JinkoSolar has been the most aggressive in terms of module shipment targets, in what would appear to be a move to claim the number 1 shipment badge by year end.

This is supported by a 3X growth in capex between 2014 and 2016, and - similar to other Chinese and Taiwanese midstream producers - having capacity located offshore in Southeast Asia.

Capacity expansions aside, JinkoSolar remains heavily dependent on third-party supply of cells and modules, if module shipment targets for 2016 are to be realised. Adding to this concern is the level of module shipments forecast from two countries, each with second half uncertainty; 2016 targets are dependent on shipping over 60% to end-markets in China and the US, with China also being the focus for downstream projects.
❖ Trina Solar

Trina Solar Limited is a Chinese company located in the province of Jiangsu, with numerous branches in the USA, Europe and Asia, which is listed on the PPVX solar share index on the NYSE. In the past few years Trina Solar was listed repeatedly on the Fortune list of the top 100 of the world’s fastest growing companies. The company has shipped solar modules with a total output of 11 GW until the end of 2014, with 3.66 GW shipped in 2014 alone.

❖ Yingli Green

Yingli is headquartered in Baoding, China and has more than 30 regional subsidiaries and branch offices and has distributed more than 15 GW solar panels to customers worldwide. Yingli Solar was established in 1997 and was the world’s largest PV module manufacturers in the world in 2012 and 2013. Yingli was founded by Liansheng Miao who was a pioneer in Chinese solar manufacturing. Yingli’s photovoltaic module capacity is 4 GWs. Over 15GW of Yingli solar modules are deployed worldwide.

❖ GCL

Even downgrading the plans of GCL (which are often highly ambitious), the company is simply the most important in the PV industry today.

But to say that GCL had the wisdom of foresight some years back, to end up in the position it occupies today, would be somewhat misleading. The reality is that external events have played a massive part in GCL being in the position it occupies today.

The decline in fortunes of previous wafer giant LDK Solar, coupled with the European and US based import restrictions (that allowed wafer production to be sustained within China), and the emergence of the Chinese end-market as the driving force in global PV demand, have collectively helped to create an empire that controls the benchmark for cost and ASPs for polysilicon and wafers.

However, it is GCL’s role in midstream production (cells and modules) - and module supply from GCL Systems Integration – that forms the new push in GCL’s overall industry aspirations.

Whereas adding polysilicon and ingot/wafer capacity for GCL in the past was a relatively low-risk and prescriptive exercise, making the move to multi-GW status for cells and modules is a different challenge.

In this respect, there are more questions than answers today and going into 2017, with GCL’s midstream strategy. Was it necessary to move from cell-making novice to heterojunction-champion so quickly? Should the company be adding so much capacity in China, while having global aspirations? Is the focus on India as a key overseas manufacturing location the best option?

One should never discount GCL, based on its track-record, but many have tried to shift across the value-chain and failed, and the perennial challenges of moving from China-dominant to global brand-recognized are issues not confined to solar and permeate across other consumer-based electronics and displays segments also.

❖ Longi Silicon

As we alluded to above, perhaps the main company to watch in the whole upstream supply-chain this year is Longi (including cell and module activity from its subsidiary LERRI).
What has been striking about Longi’s move today is not simply the multi-GW expansion plans across the whole ingot-to-module stages, but the dedicated focus on p-type mono production.

This commitment to p-type mono is almost unique in the industry, with many of the leading cell makers in Asia remaining focused on p-type multi. Indeed, Longi is almost setting itself up as the benchmark for mono costs across the whole value-chain.

The move is certainly a bold one, as the company is still heavily dependent on midstream competitors (mainly at the cell level) buying the surplus of mono wafers produced. Here, the company is then pitching itself against the multi wafer and cell producers’ roadmaps.

Indeed, the mono dynamic goes further. With the requirement to ship about 70% of its in-house wafer supply at the 10GW-level to third-party cell makers in 2017, this alone could sustain a market oversupply of mono wafers, bringing ASPs for mono closer to multi in a somewhat artificial situation.

The drive by Longi is actually keeping the whole mono-versus-multi debate (for p-type) a fast-moving dynamic, and one that will likely still have its share of opposing opinions going forward, but will hopefully see clarity revealed in Penang at the forthcoming PV CellTech event in March 2017.

From a module supply perspective, Longi was recently added to the SMSL, with plans to be a key player on the global stage evident to see.

❖ **Wacker Chemie**

Viewing Wacker’s strategy and market-share to the PV industry is a fascinating case-study, and has no equal across the industry; not simply confined to comparisons with other pure-play polysilicon producers.

While the rest of the pure-play polysilicon industry (outside China) continues to suffer under the weight of low market ASPs (that tempt when rebounding temporarily by 5-10%) and the barriers in place related to importing into China, Wacker is almost operating in a different world, characterized by the new plant ramp-up in the US.

In fact, there is every possibility that Wacker will regain the number 1 polysilicon supplier status in 2017 based on shipments to the solar industry, according the research included in the latest release of our PV Manufacturing & Technology Quarterly report.

❖ **First Solar**

Looking at First Solar’s manufacturing strategy today is also of significant interest. Indeed, the plaudits on offer to First Solar’s R&D team cannot be understated.

Aside from the capex and R&D assigned to technology roadmap plans, perhaps the most relevant achievement by First Solar in the past few years is putting the champion panel improvement directly into mass production lines. Few companies in the solar industry have managed this once, let alone on multiple occasions.

Including First Solar in the top-10-movers graphic above is in part due to the above, but also from the company’s decision to retain its focus on thin-film and to re-instate mothballed capacity (fully upgraded to current state-of-the-art fleet specifications). Each of these is behind the company’s plans to have module shipment levels next year approaching the 4GW level.

While the industry waits to see if large panel CdTe deposition is just a matter of increasing deposition uniformity on larger glass panel sizes, few should be betting against First Solar coming good with this chosen path. But until the panels are coming out of production with the same manufacturing metrics as
the current panel size standard, there will always be questions as to whether this move is one too many on an aggressive roadmap that has yet to disappoint.

❖ **Risen Energy**

Risen Energy (Risen Solar Technology or Risen) is another inclusion in the top-10 list that has an almost unique strategy, compared to the other grouping entrants.

Risen has a history that mimics many of the Chinese companies that were romanced by the European solar boom of yesteryear, and seeing an overseas market opportunity in Spain, Italy and Germany that was presumed to last forever.

Being one of the survivors in China-solar at the midstream manufacturing stage, Risen has been adding significant capacity in recent years, coupled with a strong growth rate in module shipment levels. And for this reason, Risen is included in the rankings list shown above.

In fact, recent updated research - undertaken by our in-house market team at Solar Media and PV-Tech - can now reveal exclusively that Risen’s module shipment volumes for 2015 and 2016 place the company firmly in the top-10 of module suppliers to the industry.

❖ **Daqo New Energy**

The inclusion of Daqo reveals a range of issues that are currently driving polysilicon supply to the industry as a whole.

Daqo is one of several polysilicon producers in China that has been able to reset its operations, benefiting from low electricity costs, a captive wafer supply in China and by expanding its plant capacity levels without any significant capex requirements.

Indeed, Daqo’s capacity (and production) increases in the past few years (that merit its inclusion in the table above) have come largely from optimizing plant productivity and debottlenecking capacity on hand.

In this respect, as we look in detail at polysilicon needed by the solar industry in 2016 and 2017, the topic of debottlenecking is of paramount importance.

Debottlenecking of polysilicon plants is currently the major source of increased productivity, eliminating the need for Siemens-based producers to break ground on new sites. Furthermore, this focus on existing capacity optimization is also serving to negate the requirement for any new capacity plans to come online during 2017.

The companies at most risk from this would appear to be those that have been hoping the market would need new polysilicon plants to meet end-market demand projections. And these would seem to be entirely concentrated on FBR announcements coming from REC Silicon (through its China based JV efforts), GCL Poly (motivated by technology differentiation), and the ever-dwindling SunEdison (through its South Korea JV aspirations).

So while the endeavours of Daqo are not seeking directly to abort competitors’ FBR plans for new polysilicon plants, the industry-wide focus on debottlenecking is certainly shifting the boundary conditions for non-Chinese polysilicon suppliers, in a way that the industry has not seen before.

Whereas, it is perhaps easy to eliminate the reality of FBR expansions coming from GCL-Poly and SunEdison (in Korea), the spotlight would appear to fall entirely on REC Silicon and whether its JV plans
in China are needed by the market until 2019, or will simply add to oversupply in 2018 (if the site comes to fruition).

**Solar PV Costs**

**Chinese manufactured PV costs being sold in different regions 2015**

Chile, China, India 0.56-0.58USD/W  
Europe 0.65USD/W  
Japan 0.67USD/W  
USA 0.72USD/W

The cost of solar PV modules is likely to fall dramatically in 2017, driven by a glut in the global manufacturing market that could deliver prices as low as $US0.30/Watt, according to a leading analyst at Bloomberg New Energy Finance.

Speaking at this week’s Solar Power International conference in Las Vegas, BNEF’s head of Americas, Ethan Zindler, said the global solar module industry was headed for one of its worst supply gluts in history, and with no booming Chinese market to mop up the excess.

“We are on the verge of a new era of substantial overcapacity,” Zindler said on Tuesday – a situation fueled by a slowdown in China’s domestic solar market while many manufacturers continue to churn out panels.”
BNEF is not the only analyst to suggest big falls. Deutsche Bank is also expecting a fall to around 40c/watt from current levels above 50c/watt. BNEF expects the same, but says there is a risk that the price could fall even further, to 30c/watt.

That would be great news for the builders of solar plants, and for people putting solar on the roofs of their homes or businesses. It is less good for the health of manufacturers, although it could spark another round of manufacturing efficiencies. Some, though, may not survive.

As many would keenly recall, the last downturn wound up contributing to the bankruptcy of dozens of PV manufacturers around the world, including major players like Germany’s Q-Cells and China’s Suntech, both later acquired by other companies.
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