

Hanwha Newsletter

01 Driving Forward

The Rays that Pay : Why Solar is an Unstoppable Power Source

02 Hanwha Commercial Video

Island in the Sun

03 Press Release

- A Comeback Story for the Ages at the Hanwha Classic 2018
- Hanwha Energy Breaks Ground on a Groundbreaking Power Plant

04 Hanwha Worldwide News

Explore this month's news of Hanwha and its affiliates, taking the initiative in all corners of the world.

05 Hanwha Profile

Hanwha Digital Brochure 2018



The Rays that Pay: Why Solar is an Unstoppable Power Source

The rays that pay

Solar of 69 : A recent study by Finland’s Lappeenranta University of Technology (LUT) has concluded that a 100% renewable energy power sector is feasible by 2050, with solar PV accounting for 69% of all energy. A bold and optimistic figure, what are the permutations behind reaching that goal?

Christian Breyer, who headed up the research at LUT, outlines the modeling process, describes how solar wins out, and explains why PV will become the lowest-cost, hardest-to-ignore energy source in the very near future - whether politicians or big business like it or not.

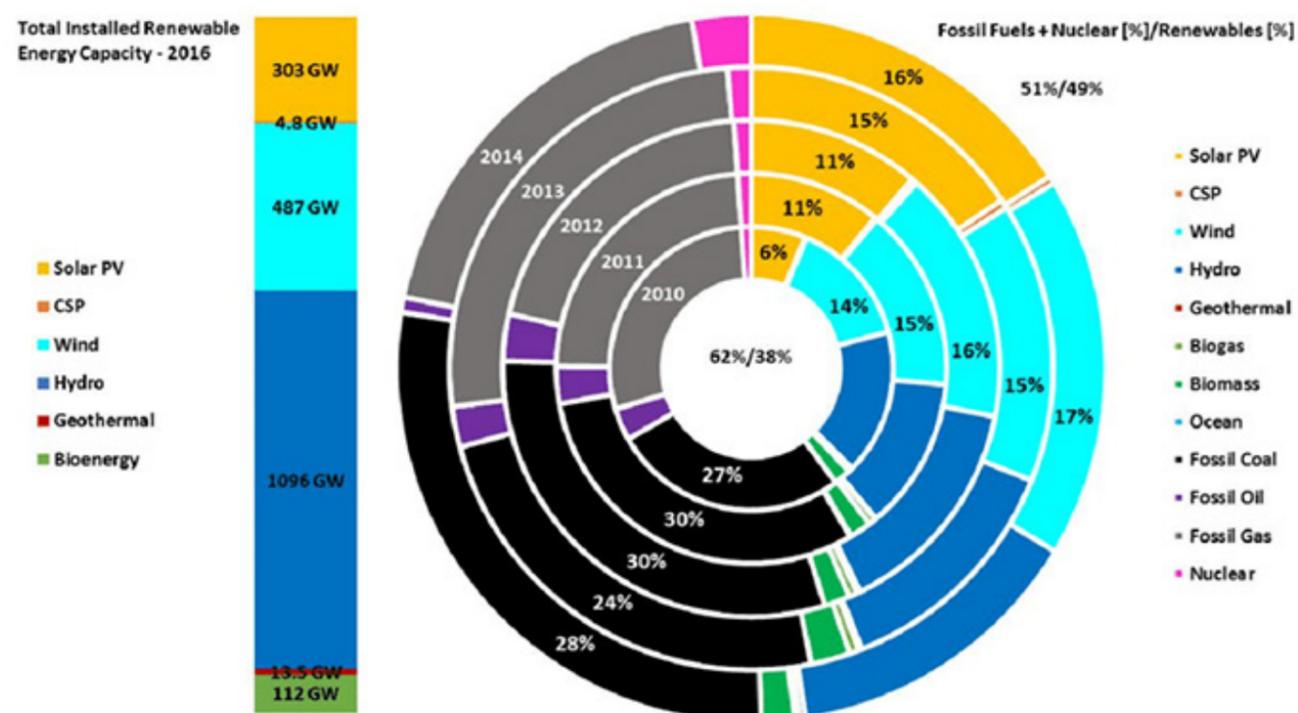
Even the harshest, oil-soaked critic of solar power will reluctantly admit that the sun is the basis of all life on the planet. However, this simple fact is one of the main reasons why it has taken so long for solar power to be taken seriously: it is an energy source that is all encompassing, inescapable, inevitable and necessary. It is too big to fail, so why pay it any notice?

The industries that have arisen from harnessing the power of the sun are not solely limited to energy. All farming, agriculture and food production is solar-powered. So is fashion, football and - yes - even the fossil fuel industries. The sun powers everything. That enough solar energy hits the earth in one hour to power the planet for an entire year is one of those well-worn facts repeated by college kids eager to earn an ‘A’ grade on their physics paper.

And it is one reason why photovoltaics (PV) has often failed to grasp the opportunities at play. Solar PV was long considered a niche energy source; an ‘alternative’ to the main pillars of power, namely coal, gas, and nuclear. All the while, anybody and everybody working in the energy sector remained acutely aware that the resources they are dealing in are finite, and such ‘alternatives’ have to be brought into the mainstream at some point.

That point is now. For the past couple of years, solar’s record-breaking growth has occurred amid a backdrop of market and political uncertainties, of falling gas and oil prices, and of uneven pricing. Yet in 2017, the world installed 98.9 GW of new PV capacity, according to SolarPower Europe - an annual increase of 29.3% on 2016 (when cumulative solar PV capacity had reached 303 GW; see graph). This figure represents 34% of total new power capacity among conventional and renewable technologies - more than any other - and is a continuation of a worldwide, decades-long upward trend.

Fig.1: Total installed renewable energy capacity in 2016 globally (left) and shares of annual power generation technologies installed globally from 2010 to 2014 (right). Source: Lappeenranta University of Technology (LUT)



Yet despite years of evidence proving that PV always gets cheaper, it always gets better, and it always gains popularity, global analysts entrusted to track and forecast the world’s future energy supply regularly underestimate solar’s potential.

Why so conservative?

The International Energy Agency (IEA) is a respected organization that publishes regular reports and forecasts on all energy

sources, and has many years of data charting just how consistent solar's rise has been. Indeed, in the latest report published in November 2017 and based on global 2015 data, the IEA found that solar overtook coal in net growth, and along with wind power and other renewables accounted for two-thirds of new power capacity added that year.

By looking back through its data, the IEA could make positive forecasts on solar PV's future growth. But the IEA remains conservative when it comes to solar.

As an example, because 2017 saw almost 100 GW of PV added, the IEA would essentially expect the same number this year. Even after years of record-breaking installations, the IEA has followed up with reports forecasting lower installations the following year. Even the IEA's more progressive approach, outlined in its Sustainable Development Scenario, does not exceed 140 GW of new PV capacity per year, despite the fact that annual PV growth has averaged 44% over the past decade. Yet a simple glance at solar development over the course of the last 20 years shows that many forecasts regarding solar out there not only could, but definitely should become more optimistic in order to be realistic.

A more positive approach

The IEA is not alone when it comes to conservatively reporting solar's potential. Following the recent decision by the Chinese government to scale back subsidies and support for its domestic PV industry, GTM Research predicted a 34% decline in module prices for the remainder of 2018. Whether that proves to be accurate or not remains to be seen, but such knee-jerk negativity is commonplace in solar.

Which is why the results of the renewable energy modeling study conducted by the Lappeenranta University of Technology (LUT) in Finland triggered a great deal of initial skepticism among even us, the researchers behind the study. The modeling - which is the only one that runs at full hourly resolution around the planet in appropriate spatial resolution - found that solar will account for 69% of the world's global electricity supply by 2050, with renewables combined meeting 100% of the earth's power needs.

We were surprised by how high the figure was. It took six months for the team to check the result, and after more than 20 model updates we concluded that whatever we did, 69% kept returning. And now it is absolutely clear why we get this number.

The LUT model calculates the amount of new power capacity investment required in a least-cost way. It does not say which type of technology should be invested in; rather, it is based on the resource quality of the region. For example, in regions with high levels of solar insolation, PV will likely be a recommended technology.

How the model works

The model used by LUT divides the world into 145 regions. Real weather data from the year 2005 is used for each region, at one-hourly intervals and 50 km distances around the world. An hourly load curve per region is overlaid with the generation available at each location sufficient to match the load curve. Flexibility options are also taken into account, such as power lines, storage, and dispatchable generation from bioenergy and hydro reservoirs.

Of course, the model considers not only the technical efficiency or technical yield, but also the financial numbers. In other words, it assesses the capital expenditure (Capex) and operational expenditure (Opex) over the lifetime of the plant, and identifies the least cost solution to cover demand. The existing power plant fleet is still in use throughout the energy transition until the end of technical life is achieved.

The figure of 69% solar coverage is a result of the same modeling process conducted throughout these 145 global regions. The model reaches this penetration figure because, quite simply, at many locations PV makes the most economic sense. Solar growth will take time, but as costs continue to decline, PV learning rates accelerate, and storage technologies keep pace, penetration grows exponentially. By 2030, for example, annual solar installations will be around 500 GW, up from ~100 GW today. In contrast, cumulative installed coal capacity will continue to shrink, falling to 1,293 GW by 2030. Gas turbine capacity, on the other hand, will increase for the next decade, before steadily declining as more and more renewable energy capacity is installed (see table below).

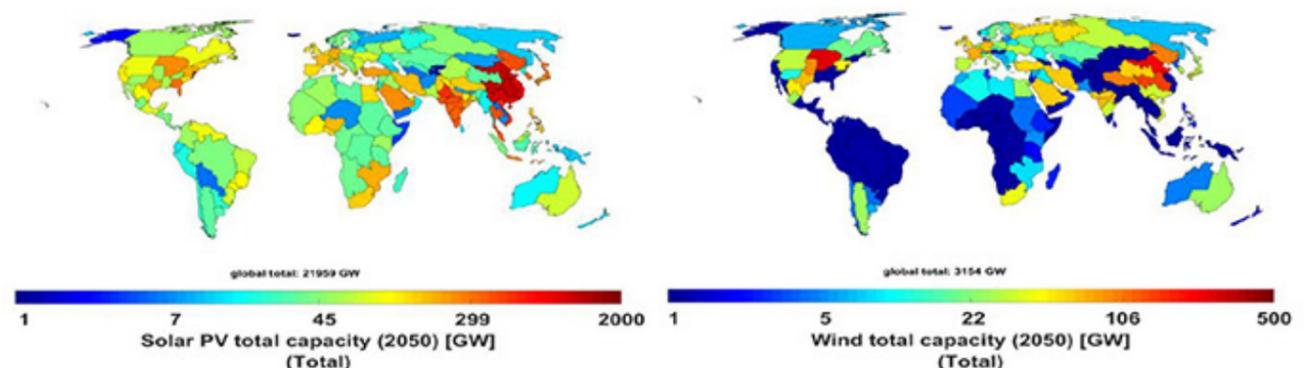
Fig.2: Global - Installed cumulative capacities and net electricity generation by various power sources; installed capacities and net output of various storage sources during the energy transition from 2015 to 2050 at 5-year intervals. Gas turbines transition in fuel use from fossil gas in 2015 to biomethane and power-to-gas in 2050. Source: Lappeenranta University of Technology (LUT)

Technology	2015	2020	2025	2030	2035	2040	2045	2050
Power Generation	Installed Capacity [GW]							
PV utility-scale	131	803	2269	4124	6312	8297	10790	13921
PV rooftop	100	365	1245	2856	4127	5508	6675	8038
Wind	372	747	2462	3293	3447	3395	3329	3154
Hydropower	1028	1137	1224	1242	1260	1267	1271	1282
Bioenergy	120	376	440	479	489	505	511	554
Geothermal	13	39	64	67	69	69	67	67
Gas Turbine	1789	1828	2763	2733	2635	2463	2136	2077
Coal PP	1896	1665	1435	1293	1181	1083	955	754
Nuclear PP	368	331	277	182	96	69	49	26
Other generation	386	243	103	94	111	87	65	98

The model's cost starting point is €70/MWh, which includes investment cost, amortization, cost of capital, cost of storage, and all losses relating to transmission and curtailment. This aggregated figure is based on 2015 data, and the model shows gradual price declines through to 2050, at which point solar electricity costs €52/MWh. Basically, by that date, the more solar installed, the lower the cost of the global energy system.

Because this modeling is conducted at hourly resolutions, results are stable. It means that for all hours of the year the model has ensured a sufficient and cheapest energy supply for the demand at any given time resulting in a total PV capacity of about 22 TW in 2050 (see map).

Fig.3: Major renewable energy capacities in 2050: For an energy system it is important to also know what the weather is doing for any given hour and location. Source: Lappeenranta University of Technology (LUT)



In pure numbers, the current 100 GW of new annual PV capacity will have to rise to nearly two terawatts (TW) annually by the middle of the century in order to reach that 69% figure and global spread seen in the map above, and also to meet energy demand in the power and transport sectors.

The vital role of storage

Those with a vested interest in seeing solar fail will ask: "What about when the sun doesn't shine?" and are willfully deaf to the answer: "That's where affordable storage comes in." Affordable storage is coming, in a big way. Because it is clear that without substantial support from storage applications we would never see such high levels of solar. Therefore, it is a precondition to have access to low-cost storage in order to get high penetration rates of solar. Otherwise we would see solar reaching its global penetration limit at maybe 20%-30% of the energy system. But with battery storage, 70% is feasible.

Current lithium-ion battery technologies are displaying learning rates comparable to solar, and growth rates that are identical. As with every technology, substantial learning rates coupled with high growth rates deliver rapid cost declines. The main difference right now is that PV is not limited in any way by raw material availability. Things are not so simple with lithium-ion batteries, some of which require cobalt, mined mainly in Congo - a country with an often unstable political and security situation.

As for lithium, the world is sitting on reserves for about the next 20-30 years, which means that, taking into account the LUT model's projections for storage growth, the industry would have to adopt alternative battery chemistries in the mid-term. The model also assumes that there will be high volumes of battery recycling, which is a must: this needs to be carved in stone.

Not just growth, but evolution

Solar power is already a vital portion of most leading nations' renewable energy industries, but penetration rates remain low when placed side-by-side with gas, for example. In Germany, solar meets around 7% of annual electricity demand on average, a figure that rises to 10% in Italy and up to 20% and 25% in California and Hawaii.

With this rising trend, more sophistication in how solar electricity is connected, stored and consumed naturally follows. Batteries, as mentioned, are vital for delivering flexibility to the grid, and solar will soon make an impact on the heating sector. Most heating demand arrives in winter, when evidently solar power is not at its strongest. However, a great deal of 24/7 heating demand comes from the industrial sector - and this is continuous all-year round. There is a substantial heat share that solar - supported by storage - can contribute to, and while the modeling is still being undertaken, it will undoubtedly reach TW scale globally.

A tiger on the path

Twists and turns are a natural part of the solar industry. Whenever the waters ahead look clear, industry veterans know it is usually time to fasten their lifebelts. Expecting the unexpected is part and parcel for PV, but as the technology builds upon its foundations, a maturing industry will be less susceptible to unforeseen shocks. It will be able to withstand external forces, which makes planning for the future far simpler.

This will not happen overnight. The LUT model is a dispassionate tool that cannot predict future economic crashes, environmental disasters or ill-advised policy decisions. It is not a crystal ball, but it is a most accurate, impartial tool for assessing future energy systems. Hence, with solar winning out as the most scalable, least-cost source of electricity by 2050, the model simply crunches those numbers without comment.

Opportunity for Hanwha Q CELLS

Solar is already beyond or close to grid-parity in many countries. Today and in the future, lobbying efforts by the clean energy industry need to become more sophisticated and engaging if solar is to grab the attention of policy-makers. For this, global leading PV companies should have a much more responsible role to play. When it comes to the global energy transition, multinational companies need to spread the message globally that adopting renewable energy is vital, and beneficial economically and environmentally. It is increasingly up to global corporations like Google, IKEA and Hanwha to teach decision-makers what the real-world options for a sustainable energy system really looks like, and to do so in language they understand. In their attempt, they need to be supported by science, environmental movements, health organizations and other social groups. A joint effort is required to fulfill the destiny of solar: to become the cleanest, cheapest and most popular energy source ever known. The time to act is now.



Christian Breyer, **PhD (Tech), Professor for Solar Economy**

Christian Breyer is Professor for Solar Economy at Lappeenranta University of Technology (LUT), Finland. His major expertise is the integrated research of technological and economic characteristics of renewable energy systems specialising in energy system modeling for 100% renewable energy, on a local but also global scale. His team published the most studies on 100% renewable energy for countries or major regions globally. Publications on negative CO2 emission options gain ground in his team. He worked previously for Reiner Lemoine Institut, Berlin, and Q-Cells (now: Hanwha Q.Cells). He is member of ETIP PV, IEA-PVPS, scientific committee of the EU PVSEC and IRES, chairman for renewable energy at the Energy Watch Group and reviewer for the IPCC. ■

Hanwha Commercial Video: Island in the Sun



Watch the latest TV spot highlighting how Hanwha Happy Sunshine provides sustainable energy solutions to community development projects.



A Comeback Story for the Ages at the Hanwha Classic 2018

- The purse for this year's tournament was the largest in KLPGA history
- Hanwha Q CELLS Golf Team members Jung-min Lee and Nelly Korda were among the prize winners



The gallery watches in excitement at the Hanwha Classic 2018

There were cheers and tears when the KLPGA's Hanwha Classic 2018 golf tournament came to a spectacular end on September 2. Jeong-eun Lee emerged victorious by not only winning the tournament but also ending her title drought with her first major crown. It was an emotional finale at Hanwha's latest golf event, where the organizers pulled out all the stops to make it a rousing success.

Last year in 2017, the name "Hanwha Finance Classic" was changed to "Hanwha Classic." The change marked a new beginning as the Hanwha Classic is now proudly on par with other international golf opens on many levels from golf management to operations to customer service. The tournament was also moved from the Golden Bay Golf & Resort to the Jade Palace Golf Club. The Jade Palace Golf Club features a course designed by Australian golf champion Greg Norman.

Rested and ready to play, ready to be rewarded

This year, the Hanwha Classic went above and beyond for the athletes by offering a total prize money of \$1.25 million, the largest purse in the KLPGA's history. And to ensure that the players were rested and ready for the tournament, they were provided with amenities like specially-built leisure facilities and unlimited practice time on the course.

Golf fans in the gallery were also taken care of, with chartered trains and buses to transport them to and from the Jade Palace Golf Club.

Milestone performances by the Hanwha Q CELLS Golf Team

Eight members of the Hanwha Q CELLS Golf Team competed in this year's Hanwha Classic. Team member Jung-min Lee sank her first professional hole-in-one, winning a brand new Range Rover Velar. Teammate Nelly Coda scored an albatross on the 18th hole in the second round and received a cash prize.

Hanwha Q CELLS Golf Team was formed only 7 years ago in 2011 but it has already

brought home 25 wins from LPGA, KLPGA, JLPGA, and LET. The wins have helped Hanwha Q CELLS promote its brand all over the world as a leading solar energy solutions provider.



Jung-min Lee of the Hanwha Q CELLS Golf Team celebrates her first hole-in-one as a professional

Hanwha golfing tradition

The Hanwha Classic was originally called the Hanwha Cup Seoul Women's Open when it was first held in 1990. It has since attracted an international array of golfers from the LPGA, KLPGA, and JLPGA looking to compete world-wide against others on different tours.

The Hanwha Classic also provides an opportunity for many young Korean golfers with their first exposure to the international stage. Legendary Korean golfer Pak Se-ri won the tournament three consecutive years from 1995 to 1997 before going on to become a world-wide sensation. ■

Hanwha Energy Breaks Ground on a Groundbreaking Power Plant

- Hanwha Energy is diversifying its product portfolio by investing in renewable energy
- The company's newest power plant will be the first in the world to run solely on hydrogen generated as an industrial byproduct



Dignitaries celebrate the groundbreaking of the world's largest hydrogen fuel cell power plant

Hanwha Energy cemented itself as an eco-friendly and comprehensive energy solutions provider by breaking ground on a 50 MW hydrogen fuel cell power plant. Located at the Daesan Industrial Complex in Seosan, South Korea, it is the largest power plant of its kind and the first in the world to be powered solely by hydrogen that is extracted as a byproduct from petrochemical production.

Construction on the USD 228 million* project is now underway on a 20,000 square meter site, to be completed by June 2020. At full capacity, the plant will be able to produce 400,000 MWh of electricity per year, enough to power 170,000 homes.

* KRW 255 billion (USD 1 = KRW 1,118)

Hanwha Total Petrochemical will supply the power plant with approximately 3.4 tons of hydrogen per hour from its refinery at the Daesan Industrial Complex. The power plant's fuel cells are expected to produce around 40,000 tons of water per year as a byproduct, which will then be sent back to be used by Hanwha Total Petrochemical's refinery.

Once the plant is completed, Hanwha Energy will have a truly diverse range of energy solutions, with traditional power plants, solar power plants, and hydrogen fuel cell power plants in its product portfolio.

"This hydrogen fuel cell power plant is an opportunity for us to expand our offerings and move further into the renewable energy market," says Doo-hyung Ryu, CEO of Hanwha Energy. "It's also a chance for us to help revitalize the local economy."

The plant will be operated by Daesan Green Energy, a special purpose company formed by Hanwha Energy, Korea East-West Power, Doosan Corporation, and SK Securities. ■



Once completed, Hanwha Energy's hydrogen fuel cell power plant will use recycled hydrogen to generate clean electricity

Hydrogen fuel cells are eco-friendly power sources as they do not generate harmful nitrogen oxide and sulfur oxide emissions. The fuel cells to be used at the Seosan plant will also use microfilters to catch any particulates before they can enter the atmosphere, further enhancing the plant's eco-friendliness.

Explore This Month's News of Hanwha and Its Affiliates, Taking the Initiative in All Corners of the World



China



Sino-Korea Life Insurance Co., Ltd.

Sino-Korea Life Insurance Wins 2018 Best Brand Image Award

Sino-Korea Life Insurance received the 2018 Best Brand Image Award at the 7th China Finance Summit, in recognition of its outstanding performance in the insurance market, its ethical management practices, and for its progressive brand image.

The China Finance Summit is one of the most important events in the Chinese business calendar. Many influential figures in the Chinese business community to discuss China's economic growth and social development. This year's event was themed: "New Generation. New Beginning of China's Economic Journey".

During this year's summit, Sino-Korea Life Insurance was highly recognized for its ethical management practices. As an example, the company operated with a special focus on critical illness insurance since a very early stage.

Sino-Korea Life Insurance began offering critical illness insurance in 2014 and saw almost immediate growth, with critical illness claims accounting for 75% of the company's payouts in 2017. The brisk sales of these policies led Sino-Korea Life Insurance to expand its product offerings and brand influence in China while also providing customers with a sense of security.



With an increasing awareness of life-threatening diseases such as cancer, the company expects critical illness insurance to become even more rapidly adopted as a necessity by China's growing middle class.



Sino-Korea Life Insurance Co., Ltd.

Sino-Korea Life Insurance Joins the National Insurance Awareness Day Celebrations

Sino-Korea Life Insurance participated in the sixth annual "7.8 National Insurance Awareness Day" organized by the IAC (Insurance Association of China).

Nearly 1,000 employees from Sino-Korea Life Insurance throughout China participated in the "7.8 Walk for Poor People's Health Insurance", collectively walking over 8,000 kilometers despite harsh weather while also espousing the importance of being insured.

Sino-Korea Life Insurance employees also went out to visit their local communities to hold "Insurance Open Days" and tell people about "The Story Behind the Insurance Guarantee". People who participated in these events got to learn more about how insurance works and why it is important to have a policy.



Lastly, the employees took part in a promotional video that was distributed through the Dou Yin mobile app, performing finger choreography set to a musical soundtrack. They used WeChat and other promotional material to further spread the word about "7.8 China Insurance Day".



Sino-Korea Life Insurance Co., Ltd.

Sino-Korea Life Insurance Prepares to Take the Next Step

On July 30, Sino-Korea Life Insurance kicked off a long-term management consulting project with PwC Consulting to successfully launch into the next phase of its business plan. The company will conduct extensive research and interviews, calling upon outside specialists, to provide recommendations on changes Sino-Korea Life Insurance should implement as it seeks to expand its business in China.

Senior stakeholders and shareholder representatives were also invited to the kick-off meeting, during which Jungpyo Hong, Managing Director of HR at Hanwha Life, assured a firm support for whatever changes Sino-Korea Life Insurance will implement once the consulting project is concluded.



Sun Jianhua, CEO of International Trade Group, also spoke during the meeting and stressed that Sino-Korea Life Insurance is ideally positioned within the China to show significant growth in the near future. He added that he wished Sino-Korea Life Insurance all possible success as the consulting project gets underway.



Hanwha Total Petrochemical Welcomes 11 New HTC Masters

On August 25, Hanwha Total Petrochemical held a ceremony at the Daesan Industrial Complex to commemorate the company's latest group of HTC Masters. Hee Cheul(Charles) Kim* heartily congratulated the 11 employees being feted and presented them with nameplates that reflect their new status.

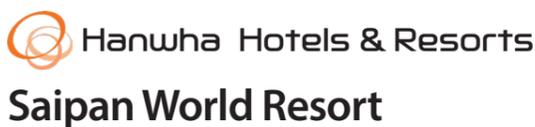
Hanwha Total Petrochemical's HTC Master program was created to encourage employees to seek professional development opportunities. It is a rigorous process where aspiring HTC Masters must successfully acquire at least three specialist certifications and also demonstrate mentorship of their juniors.

Since the program's creation in 2007, HTC Masters have become a vital part of Hanwha Total Petrochemical and the safe operation of the company's plants.



This year's incoming class of HTC Masters represents a milestone in the program, as there will now be 102 HTC Masters serving throughout Hanwha Total Petrochemical. The company looks forward to welcoming future HTC Masters and further expanding the program in the future.

*Current CEO of Hanwha Q CELLS



Hanwha Saipan World Resort Satisfies Guests' Sweet Tooth

With opening of the new Bakery and Pastry Department, Hanwha Saipan World Resort is now proudly presenting guests with world-class cake and pastries, baked fresh every day.

Signature baked goods now available on the menu include mocha cake, cloud cake, and blueberry sponge cake as well as walnut pie, chocolate tart, and honey pastry.

Starting from August 2018, these delectable sweet treats are served at every buffet and also available for purchase at the gift shop. The department's staffs went through a rigorous three-months training course in French-style baking skills, in preparation for the opening.



"Everyone worked so incredibly hard to perfect their baking skills," says Jiyoung Cho, who trained the Bakery and Pastry Department. "I hope that people from Saipan and all over the world will come and try our menu and buy some to take home and share with their families and friends." ■

Hanwha Digital Brochure 2018



Learn more about Hanwha Group from our brochure, updated for 2018. (Available for download in PDF format)

To download 2018 Hanwha Digital Brochure, please visit: <https://www.hanwha.com/en/2018hanwhaprofile> ■