

CASE STUDY | JUNE 2018

THEPPANA WIND POWER PROJECT, THAILAND

Pioneering private sector
utility-scale wind power



PROJECT DATA

PARTNER ORGANIZATION

Electricity Generating Public Company Limited (EGCO)
Asian Development Bank

ORGANIZATION TYPE

Private sector

DELIVERY CHALLENGES

Given the reluctance of commercial banks to provide financing with a longer-than-usual tenor for wind power, there were challenges in closing the gap in available project financing. While the legal-regulatory framework has, overall, been conducive to the project's success, the project encountered some delays when registering for the necessary permits and licenses

COUNTRY AND REGION

Thailand, Southeast Asia

PROJECT TOTAL COST

Theppana Wind Power Project
Debt financing of USD 13 million plus equity

PROJECT DURATION

2011-2013 (commercial operation since 2013)

ORGANIZATIONAL COMMITMENT

Equity financing (by EGCO/ProVentum Int'l.)
Debt financing, with ADB contributing USD 4.5 million, CTF USD 4 million, and Bank of Ayudhya USD 4.5 million

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In Brief

DEVELOPMENT CHALLENGE

Using renewable energy to provide sustainable, affordable, and reliable supply of electricity. Thailand's energy security is at risk from rapid increases in energy demand, the increasing scarcity of domestic fossil fuel resources, and uncertainty surrounding the reliability and costs of energy imports. Energy security has therefore long been a top priority for Thailand. Despite this, when the project was developed, solar and wind renewable energy had not yet been developed at scale, and the market had limited experience with project financing for the renewable sector.

DEVELOPMENT SOLUTION

Development of private sector wind power projects under the Thai government Small and Very Small Producers program to increase renewable energy supply and de-risk project financing in a region with relatively low-speed wind. Thailand has moderate

wind potential. With its Integrated Energy Blueprint 2015-2036 (TIEB), the government aims to expand the use of on-grid wind power. As part of its alternative energy strategy, it has introduced policy instruments such as tax incentives and renewable energy feed-in tariffs for independent power producers.

PROGRAM SOLUTION AND RESULTS

The 7.5 MW Theppana Wind Farm was one of the first utility-scale projects developed by the private sector in Thailand and was supported by the Asian Development Bank and Clean Investment Fund with concessional finance. The Theppana project demonstrated the viability of project financing for a utility-scale wind project in Thailand and led directly to the development of the larger 90 MW Subyai project. Today, Thailand has several credible private developers with utility-scale wind power projects and a local banking market that is familiar with lending to the renewable sector.

Executive Summary

To achieve sustainable long-term economic growth, diversify its energy mix, and reduce dependence on imported fossil fuels, Thailand is promoting alternative sources of energy. Under its alternative energy and power development plans, the government aims to have 3,002 megawatts (MW) of wind power capacity installed by 2036, up from 7.3 MW in 2011.

The state-owned Electricity Generating Authority of Thailand (EGAT) is the largest generator of power in Thailand. EGAT has the sole right to purchase power from private producers and is the only firm permitted to supply electricity to distributors and retailers. The power distribution market is under the monopoly of the Provincial Electricity Authority of Thailand (PEA) and the Metropolitan Electricity Authority of Thailand (MEA). Entities in the electric power industry are regulated by the Energy Regulatory Commission (ERC).

The Thai government supports decentralized power generation through its Small Power Producer (SPP) and Very Small Power Producer (VSPP) programs. The SPP program allows private developers to build, own, and operate 10 to 90 MW power projects and enter into power purchase agreements (PPAs) with EGAT. Under the VSPP program, developers who produce up to 10 MW may sell power to the MEA or to the PEA under a PPA with a renewable five-year term and continual automatic extensions. Renewable energy SPPs and VSPPs are also eligible for a feed-in tariff, known as an “adder.” The adder for wind power is THB 3.5 per kilowatt-hour (kWh) for ten years from the commercial operation date (COD), on top of the wholesale tariff.

The Electricity Generating Public Company Ltd. (EGCO) is a Thai-based power producer developing and operating fossil fuel and renewable energy projects in Thailand, Lao PDR, Philippines, Indonesia, and Australia. As part of its corporate strategy to have over 300 MW of renewable energy capacity installed in Thailand by 2015, EGCO developed the 7.5 MW Theppana Wind Power Project (hereafter referred to as the Theppana Project, or the Project), located in the Thepsathit district, in Thailand’s Chaiyaphum province.

The Theppana Project was EGCO’s first wind power project, the Asian Development Bank’s (ADB) first private investment in wind power in Southeast Asia, and one of the first three wind power projects financed by a local bank. Construction began in September 2012, and the wind farm began commercial operations in July 2013. The Theppana wind farm has been operating satisfactorily, with a high plant availability rate.

Theppana’s success paved the way for EGCO to continue with its plan for a 90 MW wind facility at Subyai (the Subyai Project, also known as the Chaiyaphum Wind Farm), which became operational in 2016. Both projects have the same ownership and financing structure, based on the partnership between a local commercial bank and the ADB. In the case of Theppana, the Clean Technology Fund (CTF) provided USD 4 million in financing, while the ADB and a Thai-based commercial bank, the Bank of Ayudhya, each provided THB 145.2 million.

From a business point of view, Theppana has been very successful, demonstrating the effectiveness of public-private partnerships in which the private sector’s long-term capital investments play a critical role in the development of clean energy infrastructure. Theppana’s success has established the viability and sustainability of utility-scale wind power projects, has enhanced private investors’

confidence in – and experience with – wind power in Thailand, and has led to replication on a larger scale.

This case study describes the implementation of the Theppana Project and the challenges the project encountered. The initial implementation of the Project saw some delivery challenges in the regulatory environment, which was not yet fully adapted to commercial wind power development. EGCO faced some delays during the licensing process, largely due to licensing institutions' unfamiliarity with wind power infrastructure.

The main delivery challenge for the implementation of the Project was securing project finance. When the Theppana Project was being developed, there was limited experience with commercial wind power development in Thailand, due in part to its relatively low wind speeds. Wind power is characterized by high up-front costs, and uncertainty about annual energy production and sales, given the variability of wind speeds. In view of the revenue risks involved, commercial banks were previously hesitant to provide long-tenor financing for wind energy production. Such financing can help renewable energy project sponsors spread the costs of repayment over a longer period, improving annual cash flows. In this case, the financing provided by the ADB and the CTF increased confidence in the Project, leading the Bank of Ayudhya (Krungsri) to provide a loan with a longer-than-usual tenor.

This case study also offers some lessons learned, formulated around the following questions:

Question 1

What has been the importance of the Theppana Project in showing the effectiveness of public-private partnerships in commercial wind farm development?

The most direct and immediate impact was the scaling-up from the Theppana to Subyai wind farms. The Project demonstrated the importance

and viability of public-private partnership (PPP) modalities for commercial-scale wind power development by Independent Power Producers (IPPs). The development of legislation and policy related to the renewable energy sector in Thailand has been key to the increase in the share of renewable energy in the country. Thailand has become the leader in promoting renewable energy in Southeast Asia.

Question 2

What has been the role of development finance institutions (DFIs) in addressing the risks and constraints Theppana faced as a private wind power project?

The availability of debt financing with longer-than-usual tenor through a local bank, supplemented by concessional loans, played a critical role in the development and implementation of the Project. This was especially important given the unfamiliarity of commercial banks with the high-risk profile wind power was considered to have.

Question 3

What are lessons learned for future development, replication, and upscaling?

Because of the highly regulated nature of energy markets, investment can typically only take place within a conducive framework of policy instruments, such as tax incentives, standardized PPAs, and the feed-in tariff mechanism. Without such a regulatory environment in place, private investors and financiers would not have had enough confidence in the sector.

Projects like Theppana and Subyai have helped to enhance private investors' confidence in wind power in Thailand, and private investors have been quite active in developing large wind farms across the country, increasing the total installed wind capacity in Thailand from just 7.3 MW in 2011 to around 630 MW in 2017. ■

Introduction

This case study examines the experience of the Theppana Wind Power Project, which began commercial operations in 2013. The Theppana Project aims to help increase Thailand's power supply and address a major **development challenge**: using renewable energy to provide sustainable, affordable, and reliable supply of electricity.

The case study focuses on how the project was implemented, and the delivery challenges that it confronted. Specifically, these were 1) the reluctance of commercial banks to provide loans for the project, given the perceived revenue risks and their lack of experience with financing wind projects, and 2) unfamiliarity of licensing agencies with wind power, which led to delays in acquiring permits despite Thailand's conducive regulatory framework for power production.

Debt financing from the Clean Technology Fund (CTF) and the Asian Development Bank (ADB) helped to improve the bankability of the Theppana Project, which was one of the first project-financed private sector wind power developments in Thailand. ■



Context

Thailand is the second-largest economy and the fourth-largest country by population in Southeast Asia. The country's economic success over the past decades has resulted in a steep, steady increase in its energy consumption and, consequently, a rising dependency on imported fuels. Thailand had an estimated installed power capacity of almost 46,000 megawatts (MW) in 2016 (IRENA, 2017), with natural gas-fired generation making up over 60 percent of the capacity mix. Domestic supplies of natural gas are reaching their peak, which means the country will have to look for new sources of energy and further diversify its energy portfolio. Achieving energy security while ensuring environmental sustainability and keeping energy prices low are thus key priorities in the government's energy master plan, known as the Thailand Integrated Energy Blueprint (TIEB) 2015-2036.¹ The increasing volatility of international energy commodity prices, rising concerns over energy security, and the continuing dependence on imported fossil fuels contribute to a compelling case for renewable energy, including wind energy, in Thailand.

Currently, the state-owned Electricity Generation Authority of Thailand (EGAT) owns 40 to 45 percent of Thai energy generation, the entire high-voltage transmission network, and serves as the country's central dispatcher of that energy, serving part of the retail market. In addition to its own generation, EGAT purchases electricity from Independent Power Producers (IPPs) and Small Power Producers

(SPPs), and imports electricity from other countries. Power is distributed by the Metropolitan Electricity Authority (MEA), serving Bangkok and two neighboring provinces, and the Provincial Electricity Authority (PEA), which serves the other 74 provinces.

The SPP program allows private developers to build, own, and operate power projects of 10 to 90 MW, and sell electricity directly to customers or enter into power purchase agreements (PPAs) with EGAT. In a similar program for Very Small Power Producers (VSPP), generators of up to 10 MW may sell power to the MEA or the PEA (IRENA, 2017; IEA, 2016). Under these programs, the utilities are required to offtake all of the energy generated under their standard PPA with the producer. Thailand was the first country in the Southeast Asia region to implement an "adder" feed-in-tariff for renewables: a premium on top of the wholesale electricity price, guaranteed for a period of 7-10 years. For wind power, the adder was THB3.5 per kWh.²

Thanks to these policies, renewable energy production in Thailand has increased steadily over the past decade, from 2,232 MW in 2011 to 4,712 MW in 2015 and reaching 7,331 MW in 2017.³

WIND ENERGY POTENTIAL AND RISKS

Thailand is situated near the equator, in an area characterized by low wind speeds. However, the topography of mountain ranges, canyons, and slopes helps to increase wind speeds in certain places. The areas with the greatest wind potential

2 Depending on the project size. In 2015, the "adder" mechanism was replaced by a three-part FIT policy, split according to the fuel type and location of the installation. This scheme gives THB 6.06 per kWh for wind power projects. Renewable power procurement under this program will be conducted by a competitive bidding process (see Annex A for more details).

3 IEA (2016), MoE-DEDE (2012), MoE-DEDE (2015) and DEDE (2017).

1 More on energy planning in Thailand in Annex A.

are found in the northeastern and southern parts of the country, where, depending on the time of year, wind speeds reach about 5-7 meters per second.^{4,5} A recent study (see **Box 6** in Annex A) has shown that Thailand has technical wind energy potential of up to 17,000 MW if modern low-speed wind turbines are used, and of about 6,000 MW with conventional wind turbines. These study results suggest that the government's target of 3,002 MW by 2036 can be met.

The first pilot project to generate power using wind energy in Thailand was in the 1980s, when six turbines with a combined capacity of just 160 kW were installed on Phuket Island at a research station, and later connected to the PEA grid. This was followed by the installation of wind facilities by some universities, and by the Ministry of Energy's Department of Alternative Energy Development and Energy Efficiency (DEDE), bringing the installed capacity of wind power facilities in Thailand to 7.3 MW in 2011. However, none of these installations were utility scale, functioning instead as pilot projects or research facilities.

When the project was conceived about a decade ago, Thailand had long-term wind data, but wind resource maps lacked consistency (as explained in **Box 1**). There were some data related to wind energy production and performance of small, pilot-type wind projects (see Annex A), but Thailand had no track record of utility-scale wind power projects.

⁴ This is caused by the two monsoons that affect Thailand annually, the northeast monsoon and the southwest monsoon. The northeast monsoon comes from the South China Sea during the period between November and March, producing strong wind in the Gulf of Thailand and the coastal areas of southern Thailand. The southwest monsoon comes from the Indian Sea between May and October producing strong wind at the peaks of mountain ranges in the west part of upper southern and lower northern Thailand.

⁵ MMD (2014); Average of 6 m/s measured at a height of 90 meters (IRENA, 2017).

BOX 1

LOCATION OF THEPPANA WIND FARM IN THEP SATHIT DISTRICT IN CHAIYAPHUM PROVINCE



Source: Map made by author, based on Wikimedia Commons Maps (file Thailand location map.svg and file Amphoe 3609.svg).

Wind power projects are characterized by high up-front capital costs and minimal operating costs. The variable nature of wind speeds leads to uncertainty in energy production and, when coupled with relatively low wind speeds (see **Box 6** in Annex A), results in considerable sales and revenue risks for investors.

When the Theppana Project was formulated, the local financial market's potential for financing long-term wind power projects was not yet fully developed. For example, the local financial market's maximum tenor available for wind power financing was 12 years, a key constraint on the development of the wind sector, where projects typically have 20 to 25 year lifespans.⁶

CLEAN TECHNOLOGY FUND

The CTF (administered by the Clean Investment Funds (CIF), see **Box 2**) provides concessional financing to support the rapid deployment of low-carbon technologies with significant potential to reduce and avoid greenhouse gas emissions over the long term. The CTF Trust Fund Committee approved the allocation of USD 100 million for the CTF Thailand Private Sector Renewable Energy Program in May 2012, to be utilized and administered by the ADB (ADB, 2012). ADB's Energy Policy aims at investing USD 2 billion per year in clean energy, while the ADB's Private Sector Operations Department aims to receive 25 percent of its annual approvals, by number, for clean energy projects.⁷

In the Theppana Project, the CTF funds were used, alongside the ADB's loans, to cover part of the capital costs and to take out first-mover risks, in addition to amortizing the renewable technologies' high up-front capital costs over a longer period than would otherwise have been possible. ■

BOX 2 CLIMATE INVESTMENT FUNDS

The Climate Investment Funds (CIF) provides developing and middle-income countries with urgently needed resources to manage the challenges of climate change through four programs:

- 1) Clean Technology Fund (CTF);
- 2) Pilot Program for Climate Resilience (PPCR);
- 3) Forest investment fund (FIP); and
- 4) Scaling-Up Renewable Energy in Low Income Countries Program (SREP).

The USD 5.8 billion CTF is empowering transformation in developing and emerging economies by providing resources to scale up low carbon technologies with significant potential for long-term greenhouse gas emissions savings. Over USD 3.8 billion (66 percent of CTF resources) is approved and under implementation in various countries, including Thailand.

In 2009, the Investment Plan for Thailand was approved by the CTF Trust Fund Committee to support Thailand's goal of increasing its share of alternative energy. The Plan was updated in 2012 with a CTF financing of USD 170 million, of which a component implemented by ADB of USD 100 million for private sector investments (with targeted co-financing from ADB estimated at USD 360 million and USD 960 million from private sector investors).

More information can be found at:
www.climateinvestmentfunds.org/
<https://www.climateinvestmentfunds.org/projects/private-sector-renewable-energy-program>

⁶ 12 years (including grace period) for the adder period of 10 years.

⁷ *Energy Policy*, Asian Development Bank (April 2009).



Theppana wind project: tracking the implementation process

When the Theppana Project was conceived, Thailand already had several credible private developers interested in utility-scale renewable energy projects (see Annex A). The Electricity Generating Public Co. Ltd (EGCO) is Thailand's first independent power producer operating fossil fuel and renewable energy power plants in Thailand, Lao PDR, Philippines, Indonesia, and Australia, which generate electricity using various fuel sources.⁸ EGCO planned to venture into wind power as part of its strategy to have over 300 MW of installed renewable energy capacity in Thailand by 2015.

The company's strategy was in line with the government's goal of expanding wind power in Thailand. Capitalizing on the new feed-in tariff system, EGCO began developing plans for wind power projects in 2008-2009. EGCO held discussions with international wind project developers and wind turbine manufacturers, which led to an agreement with the wind developer ProVentum International (PVI) to set up a large wind power project. As part of the project formulation, wind measurements were

carried out during a 28-month period (from January 2009 to June 2011).

The Project entailed the construction and operation of a 7.5 MW wind farm located at Theppana in Watabaek tambon (subdistrict), Thap Sathit amphoe (district) in Chaiyaphum Province (see **Box 3**).⁹ It was implemented by the Theppana Wind Farm Company (TWF), a special purpose company 90 percent owned by EGCO and 10 percent by PVI.

ARRANGING THE PROJECT FINANCING

The main **delivery challenge** for the Theppana Project has been *closing the gap in available project financing*. Commercial banks approached by the TWF project team were reluctant to provide loans with a longer-than-usual tenor, and such longer-term financing was needed to better amortize the high initial investments of the Project.

Both EGCO and the ADB had worked with the Bank of Ayudhya in the past, and based on these contacts, a financing package was drawn up in 2012. The package included USD 4 million in concessional financing, provided by the ADB-administered CTF program, and a loan provided by the ADB of USD 4.54 million (THB 145.2 million).¹⁰ This helped reduce the risk to the Bank of Ayudhya, which agreed to provide a loan of USD 4.54 million (THB 145.2 million).¹¹ With this package, it was expected that the Project's financial and equity internal rates of return would be sufficient, and enable

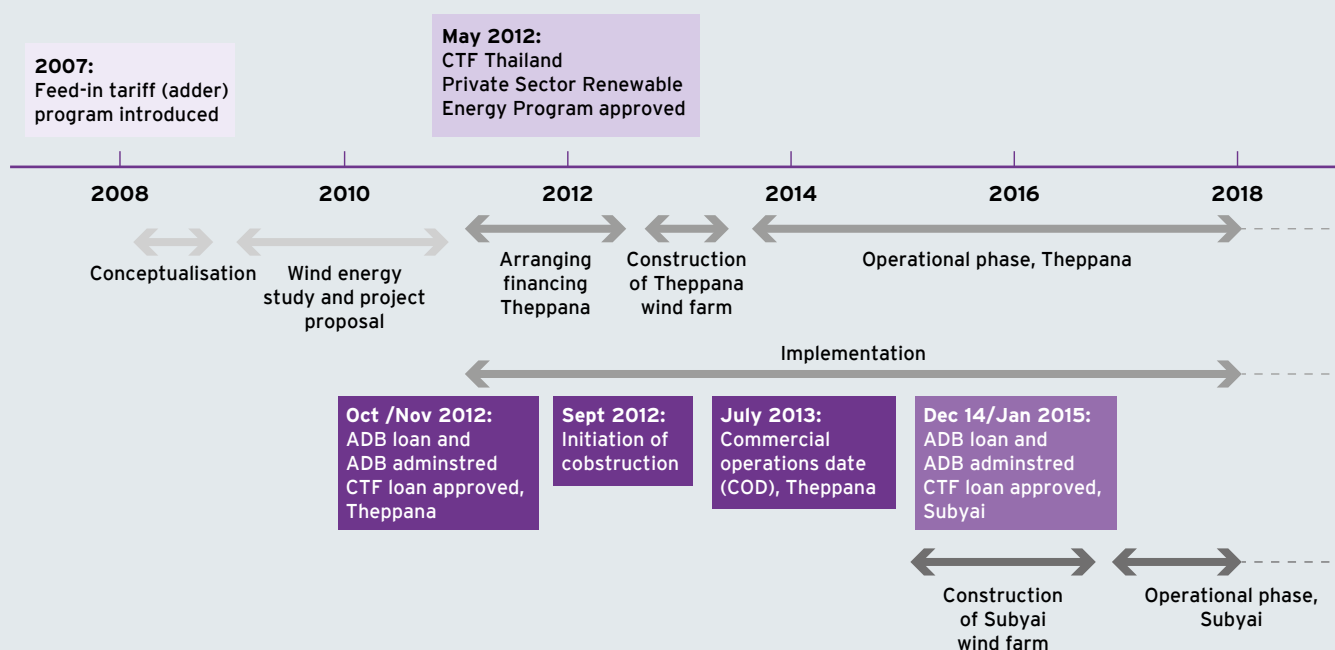
9 The wind farm uses three 2.5 MW wind turbines (with 52.5-meter blades at 90m hub height) supplied by Goldwind Science and Technology Company, a leading Chinese wind turbine manufacturer. The technology was adopted as the best solution for locations with lower wind speeds. The project was constructed under an engineering, procurement, and construction (EPC) contract with ItalThai Engineering (ITE) and Goldwind International Holdings (GWI) on a fixed-price and turnkey basis.

10 2012 exchange rate USD 1.00 = THB 32.

11 Debt financing was about 70% of total cost.

8 These include natural gas, coal, biomass, waste, hydro, solar, and wind.

BOX 3 PROJECT IMPLEMENTATION TIMELINE



Source: Based on info provided by EGCO and ADB.

debt servicing at the feed-in tariff under the adder system, and at the energy production estimates based on the P90 exceedance probability.¹² The prospective lenders were formally approached around May 2012, and agreement was reached with the Bank of Ayudhya in November 2012. The ADB loan and ADB-administered CTF loan were approved by the ADB Board in November 2012.

¹² One of the big risks for wind (and also solar) developers is the variability of the wind resource. While forecasting improves all the time, no developer can guarantee that a location with a history of strong energy estimates won't underperform for a period. Thus, lenders and investors make requirements that involve the calculation of exceedance probabilities (referred to as "P") for wind-driven energy production. The risk that an annual energy production of P90 is not reached is 10% (forecasted to exceed 90% of the time). The P90 is often preferred by commercial investors and lenders as it allows higher confidence that sufficient energy will be generated, allowing the project to safely repay their debt.

CONCLUDING AGREEMENTS AND GETTING PERMITS

A first step towards implementation was obtaining the necessary permits and licenses and securing a power purchase agreement. Since the Project occupies 0.9 hectares of land owned by the Agricultural Land Reform Office (ALRO), it required ALRO's approval.¹³

¹³ In the case of Theppana there have not been any land issues, but other wind projects have encountered problems. For example, the Supreme Administrative Court ruled in 2017 that renting out ALRO land for the 90 MW Thep Sathit wind farm in Chaiyaphum was illegal as the land has been designated for farming purposes only. The court order impacted other wind farms in the same province. Later, the government invoked Section 44 of the Interim Constitution to unlock the legal dispute on the use of ALRO land. Any companies which already had the PPA could resume their operation, but for new projects, they would be considered on a case-by-case basis.

The TWF entered into a PPA of 6.9 MW with Thailand's PEA in March 2010, at the wholesale tariff and applicable adder of THB 3.5 per kWh applicable for 10 years from the commercial operations date (COD).¹⁴

Thailand has a legal-regulatory framework with feed-in tariffs to allow the private sector to generate and sell power to EGAT or the PEA and MEA (Annex A). The process of getting an energy production license is well defined (see **Box 4** for a description). Nonetheless, the actual implementation of certain regulations within the framework posed a minor **delivery challenge**, given the novelty of wind power in Thailand.

For example, getting the Certificate of Building Construction (see **Box 4**) for the Theppana Project was hindered by the stipulation requiring tall buildings to have safety infrastructure to allow people to escape in the event of an accident or disaster. These requirements had to be waived for wind towers; although they are tall, they are no longer considered "buildings" by authorities, in the sense of a construction where people work or live, thanks to the discussions between the TWF team and the institutions involved.

Another **challenge** was formed by lags in the administration and documentation process for mortgage registrations, the completion of which was delayed for more than a year due to changes in Thailand's mortgage law and a lack of timely coordination by the administration (ADB, 2016).

While the Energy Regulatory Commission (ERC) contacted some of the licensing institutions in the

application process of the Project, the TWF project team itself had to hold time-consuming discussions with some of the institutions to explain the nature and advantages of wind power.

CONSTRUCTION, COMMISSIONING, AND OPERATION

The Project began construction in September 2012, was completed within budget and on schedule, and began commercial operations in July 2013. Operation and maintenance (O&M) are being carried out by a group jointly headed by a project manager from Goldwind and an O&M manager from EGCO, supported by technical staff, operators, and community relation officers. O&M activities consist of remote monitoring, regular inspections, minor repairs, part replacement, measurements, and data verification. No major issues with O&M have thus far been reported.

To date, the Project has produced slightly less electricity than originally forecasted, as average annual wind speeds have been lower than anticipated (see **Box 5**). However, this has not affected debt repayment, and an evaluation report (ADB, 2016) concluded that, from a business point of view, the Project has been a great success.

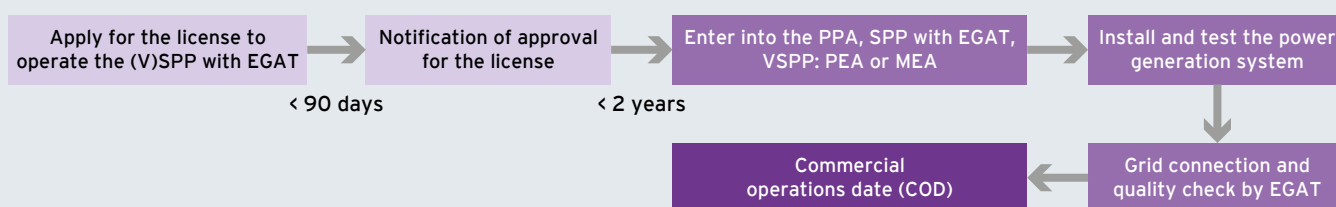
The evaluation report further mentions that there have been no noise complaints from local residents (ADB, 2016). This is in keeping with the noise measurements carried out as part of the environmental assessment of the Project, which concluded that the ambient noise was within required limits (ADB, 2015b).¹⁵

¹⁴ Currently, the wholesale tariff is THB 4.2 per kWh (peak) and THB 2.4 per kWh (off-peak), with the adder of THB 3.5/kWh gives a total tariff of about THB 5.9–7.7 per kWh. After 10 years the tariff will revert to the wholesale tariff level.

¹⁵ An initial environmental examination carried out in 2015 showed that ambient noise levels were below the minimum standards set by the Thai Environmental Board (*Environmental Monitoring Report*, prepared by Greener Consultants for EGCO and ADB, July 2015).

BOX 4 ESTABLISHMENT OF A (V)SPP

To apply for the license to operate the SPP (small power project) for the electricity generated from renewable energy, including wind projects, the applicant would be required to submit documents and relevant certificates such as a company affidavit, piping and instrument diagram, and requisite guarantee, together with a request and an offer to sell power to EGAT (SPP) or PEA/MEA (VSPP, very small power project). Within 90 days of document submission, a notification is sent to inform the applicant whether or not the license is granted (i.e. whether EGAT or PEA/MEA would purchase power to be generated by the applicant). If the license to operate the SPP is granted, the Power Purchase Agreement (PPA) shall be concluded within two years.



After obtaining the license to operate the SPP from EGAT, the SPP operator shall fulfill the additional conditions as stipulated in the Regulation on Power Purchase from the SPP for the Electricity Generated from Renewable Energy before commencing the electricity transmission, which includes (i) submitting the Environment Impact Assessment Report at least 15 days before the conclusion of the PPA (if applicable, with the *Ministry of Natural and Resources and Environment*), (ii) submitting the requisite licenses for the operation of the energy project, examples of which are provided in the table below, at least ten days before the Commercial Operation Date (COD):

- Factory license (ror ngor 4) - *Department of Industrial Works*
- Certificate of Building Construction - *District Office* (or Industrial Estate Authority, if applicable)
- Energy Industry Operation, Controlled Energy Production, Electricity Industry Operation License - *Energy Regulatory Commission*
- Certificate of Electricity Quality - *EGAT*

Apart from getting the licenses to operate as (very) small power producers and sell to the grid, other entities involved may include *ALRO* (if the site is on agriculturally designated land), *Department of Public Works*, *Dept. of Labor and Social Welfare* (employment at the wind farm and labor issues), *Dept. of Highway* (road transport of exceptionally large-sized equipment, e.g. in the case of transporting over-sized wind tower and blades elements), as well as district and local government entities (Governor's Office, Subdistrict Administration, Municipality).

Source: Based in info provided by EGCO and the article *Thailand: Setting Up Solar Business in Thailand*, by H. Obara, et.al. at: www.mondaq.com/x/555554/Renewables/Setting+Up+Solar+Business+In+Thailand

BOX 5

PLANT'S PERFORMANCE

Performance factors	Planned	2014	2015	2016	2017
Plant availability	97%	99.1%	99.8%	99.7%	99.3%
Energy output (GWh)	13.8	12.9	12.8	13.8	12.4
Average wind speed (m/s)	5.76	5.58	5.62	5.76	4.83
Plant factor	21.1%	19.7%	19.5%	21.1%	18.8%
GHG emission reduction (tCO ₂)	7,000	7,211	7,146	7,702	6,870

GWh: gigawatt-hours, m/s: meters per second, GHG: greenhouse gas; tCO₂: ton of carbon dioxide. Based on data provided by EGCO. Production in 2013 was only part of the year and has not been included in the table. Photo: author

The project's operations have been stable and maintained the plant's availability above 99%. From the start of commercial operations in July 2013 through the end of 2017, the Project sold 57.3 GWh to PEA (which translates to 31,959 tCO₂ emission reduction).

SCALING-UP THEPPANA

The Subyai wind farm project is an extension of the Theppana Project, located in the same area, and with the same ownership structure.¹⁶ The success of Theppana gave EGCO and its financiers confidence to proceed with the larger Subyai Project, for which plans had already been presented in negotiations with the Bank of Ayudhya.¹⁷

The 90 MW Subyai Project comprises 32 2.5 MW wind turbines and began operations in December 2016. Implemented under a PPA of 81 MW with EGAT

under the SPP program, it will benefit from the THB 3.5 per kWh adder for the first 10 years (ADB, 2014).¹⁸

As with Theppana, the Subyai Project acquired loans from the ADB and CTF, in this case of THB 1,807 million (equivalent to USD 53 million), and USD 30 million respectively. These were approved in 2014 with a tenor of 18 years, in addition to a loan equivalent to USD 76.4 million from a commercial bank (ADB, 2014). ■

¹⁶ Owned 90% by EGCO and 10% by ProVentum.

¹⁷ In fact, the size of Theppana (7.5 MW) is usually considered too small for project financing by commercial banks, but the combined size of 97.5 MW, between Theppana and the proposed Subyai Project (also called the Chaiphaphum Wind Farm), is sufficient (Theppana can be seen as a pilot phase, before proceeding with the bigger investment).

¹⁸ Agreed upon in December 2013. As with Theppana, the PPA for Subyai is automatically renewable every 5 years.

Lessons from the Case Study

The experiences and challenges encountered by the Theppana Project offer lessons for commercial wind power development in public-private partnerships in other countries. These lessons are reflected in the answers to the following research questions.

Question 1

What has been the importance of the Theppana Project in showing the effectiveness of public-private partnerships in commercial wind farm development?

The Theppana Project falls under the VSP program, under which the state-owned utility PEA is the contractual off-taker for energy the Project generates. One of the first project-financed wind farms in Thailand, the Project helped to confirm the importance and validity of such a PPP modality for the development of wind power projects by independent power producers in Thailand.¹⁹

Legislative and policy development in Thailand have increased the prevalence of renewable energy in the country. Though the novelty of wind energy led to some minor issues in getting the required permits and licenses for Theppana, the TWF project team persisted, and, with the help of the ERC, eventually acquired the permits and licenses needed.

¹⁹ The Project “demonstrated the effectiveness of a public-private partnership, in which the private sector’s long-term capital investment played a critical role in developing clean energy infrastructure under a robust implementation framework established by the public sector” (ADB, 2016, pg. 2).

Question 2

What has been the role of development finance institutions (DFIs) in addressing the risks and constraints Theppana faced as a private wind power project?

Until Theppana, local commercial banks were typically only willing to provide tenor of up to 12 years for wind power projects. The limited availability of long-tenor financing was a key barrier to the Project’s bankability, and commercial banks were initially reluctant to adapt loan conditions, due to the perceived risks of wind resources and technology.

The combination of the ADB and CTF co-financing improved the Project’s economic viability and bankability. Additionally, the ADB’s involvement and experience with wind power projects in other markets provided assurance to the local bank that the Project’s due diligence on technical and resource risk would be thorough. This combination of specialized skillsets and concessional finance helped local banks accept the project risk, and led to the availability of local financing on a longer tenor basis, which further improved project economics and bankability.

Question 3

What are lessons learned for future development, replication, and upscaling?

The Theppana Project has helped to enhance the business viability of utility-scale wind power projects (in an area characterized by low wind speeds) and has improved financiers’ confidence in such projects.²⁰ Private investors have since been active in developing large wind farms across

²⁰ “ADB’s catalytic role in mobilizing long-term financings, (i) enhanced private investors’ confidence in and experience with wind power in Thailand, and (ii) promoted subsequent larger scale replications of the project by private Investors” (ADB, 2016).



Thailand, and there is now a portfolio of projects in operation and development of over 1,600 MW, with wind farms from major developers such as EGCO, Energy Absolute, WEH/KPN, and Gunkul Engineering.²¹

Most of the recent ventures have been financed without the need for concessional financing (see Annex A for more details on IPP wind farms

in Thailand). This indicates that, once the first commercial wind power projects are operating successfully, financiers and investors perceive less risk in future projects, meaning that the use of concessional financing can be phased out. The availability of long-term financing aside, a transparent policy-regulatory environment conducive to renewable energy is still essential to establish and maintain private investors' confidence in the sector. ■

²¹ MMD (2014).

How this case study informs the science of delivery

The present case study examines several elements that are taken into consideration when assessing a program in line with the “know-how” delivery approach of the Global Delivery Initiative (GDI). The following are the findings of this case study with respect to the five elements of the GDI’s framework for the science of delivery.

FOCUS ON THE WELFARE GAINS OF CITIZENS

During construction, the Project provided short-term employment to around 250 local people, 20 percent of whom were women (ADB, 2016). It currently provides employment for eight people, including four operators trained by the Project.

When the TWF and ALRO entered into a lease agreement, they did so with the consent of 18 farmer beneficiaries who were using part of the project area for agricultural production (ADB, 2016) and allowed the project to use some of their lands in exchange for income.²² This aspect of the project falls under EGCO’s corporate social responsibility (CSR) policy. As part of its CSR, the Project has provided support to the local temple and has been providing

²² THB 30,000 per rai per year in the area directly occupied by the wind farm and THB 5000 per rai per year the vicinity of 200 metres receive (source: local EGCO staff, p.c.)

scholarships for students at two schools near the wind farm.²³

To maintain good relations with the communities near Theppana, the Project has appointed a community relations officer as part of its permanent staff on site. Local people can approach the officer at any time with complaints or questions.²⁴

The Project has very strong community support. For example, a newspaper article mentions the potential constructive co-existence of farming and renewable energy. It points out that “cassava and corn grow abundantly in the shadow of wind turbines and there is better infrastructure and road access” (*The Nation*, 2017). Upon the request of nearby restaurants with a view of the wind turbines, the Project lights up one of the wind towers in the evening. Similarly, wind turbines feature in the logos of a number of nearby hotels and resorts. While wind towers are sometimes perceived as intrusive and unattractive, local people see Theppana as a tourist attraction and a symbol of local prosperity.²⁵

MULTISECTOR AND MULTI-STAKEHOLDER APPROACH

The Theppana and Subyai wind power projects have involved several stakeholders, including government ministries and agencies (ERC, EGAT, PEA), private investors and developers (EGCO), private banks (Bank of Ayudhya), development finance institutions (ADB), and multilateral funding sources (CIF). This approach has provided the optimal mix of knowledge, financing, and risk mitigation, allowing actors to reinforce each

²³ Thepphonthong Temple, Monkolsueksa primary school and Thepsathit Wittaya primary-secondary school.

²⁴ Complaints are then discussed with the Project Manager and should be settled within 5 working days (see ADB, 2012b).

²⁵ Based on observation and discussions during the Theppana site visit by the author.

other's expertise. For example, the ADB's perceived status as a "neutral" expert helped the TWF team in their negotiations with the Bank of Ayudhya, with the ADB providing references and reports to corroborate the claims made by the TWF and EGCO about wind power potential.

The Project shows that with a good project team and good relations and trust between the main players (regulators, developers, financiers, and local communities), a greenfield project can be developed into a successful venture.

EVIDENCE TO INFORM LEARNING

The Project was designed as the first phase of the larger Subyai Project and, following the successful construction and operation of the Theppana Wind

Farm, developers decided to proceed with the Subyai Project. The Theppana and Subyai projects have demonstrated the viability and sustainability of utility-scale wind projects and enhanced private investors' confidence in commercial, utility-scale wind power in Thailand.

ADAPTIVE MANAGEMENT AND LEADERSHIP

The leadership of private sponsors (like EGCO) with a strategic interest in supporting renewable energy development is important for the long-term success of similar projects. The EGCO team adapted to several key regulatory bodies' unfamiliarity with wind power, while simultaneously working with the ADB and local financiers to optimize the project economics. ■

ANNEX A:

Renewable energy policy and planning in Thailand

POWER AND ALTERNATIVE ENERGY PLANNING

In the context of growing energy demand, dwindling domestic fossil fuel reserves, and uncertainty around energy imports, energy security has long been a top priority for Thailand.²⁶ These challenges will only be exacerbated by the pressures of climate change, and the Thai government has committed to reducing greenhouse gas emissions by 20 to 25 percent by 2030. However, with fossil fuels accounting for over 80 percent of the country's total energy consumption (IRENA, 2017), this will require concerted action to decarbonize the energy sector (IRENA, 2017; MoE, 2016).²⁷

With the Thailand Integrated Energy Blueprint (TIEB) 2015-2036, the government aims to achieve environmentally sustainable, low-cost energy security. The Blueprint was drafted in 2015 by combining three existing plans - the Power

Development Plan 2015-2036, the Alternative Energy Development Plan 2015-2036, and the Energy Efficiency Plan 2015-2036 - as well as two new plans, the Oil Plan and the Gas Plan, into one document, to address every dimension of energy planning.

The Blueprint includes plans to increase installed power capacity from 37,612 MW (in 2014) to 70,355 MW in 2036, to meet growing demand. The share of renewable energy in installed capacity will increase from 20 percent (7,490 MW) in 2014 to about 30 percent (19,634 MW) in 2036.^{28,29} Between 2014 and 2036, 24,736 MW of capacity will be retired and 57,459 MW will be added, of which 21,468 MW (37 percent) will be from renewable energy, either from expanded domestic capacity (12,105 MW) or hydropower imports from neighboring countries. The aim is to have 3,002 MW of wind power capacity installed by 2036, up from 224 MW in 2014.

By the end of 2017, the Ministry of Energy (MoE) expects to complete load forecast scenarios for Thailand which will set pathways for the development of updated plans, including the new PDP 2018.

LEGISLATIVE AND INSTITUTIONAL SETUP

Today's energy sector legislative framework was set up in 1992 with the National Energy Policy Council Act (amended in 2007 and 2008), the Energy Development and Promotion Act, and the Energy Conservation Promotion Act (amended 2007), to

²⁶ Electrification is high in Thailand; access reached 98% in 2000. In 2016, 60% of Thailand's energy came from imports, leaving Thailand highly dependent on global oil markets and volatile prices.

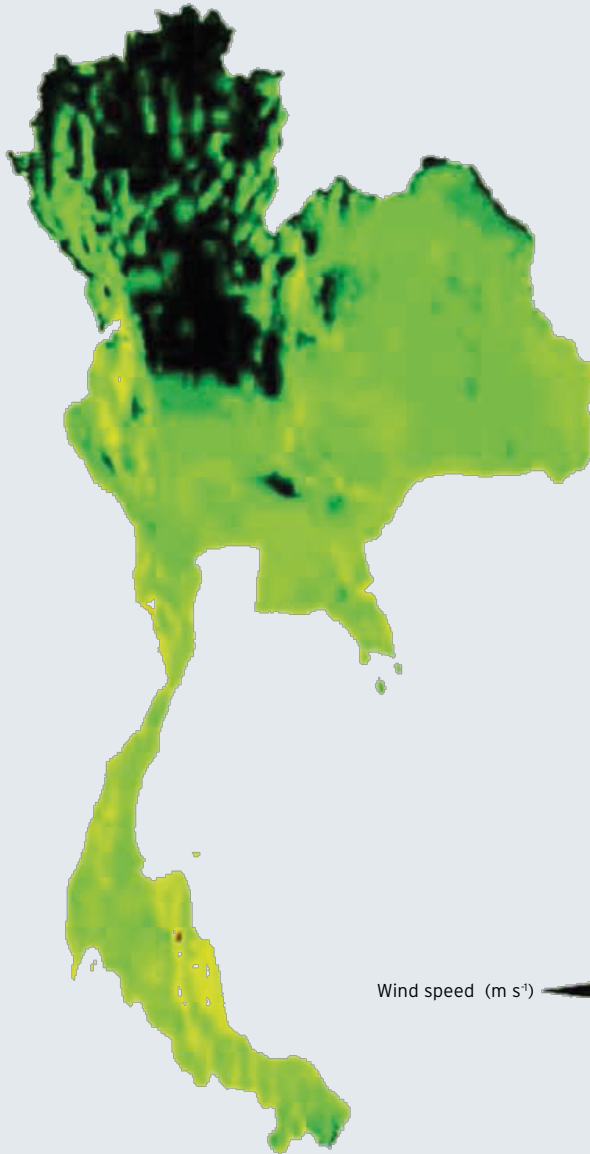
²⁷ In 2016, Thailand had an estimated installed capacity of almost 46 GW (IRENA, 2017), with natural gas-fired generation consisting of over 60% of the capacity mix, coal 20%, and renewable energy the rest.

²⁸ The share in electric energy of renewable energy was 9% (17,217 GWh out of total energy demand of 174,467 GWh) in 2014, and this share will increase to 20% (65,588 GWh out of 326,199 GWh in 2036). The latter figure assumes the impact of the Energy Efficiency Plan (savings of 22,456 GWh) without which total electric energy demand would be 393,335 GWh in 2036 (MoE-TIEB, 2015; MoE-PDP, 2015).

²⁹ Target for RE in 2036: solar 6,000 MW, biomass/biogas 6,850 MW, wind 3,002 MW, large and small hydro 3,282 MW and organic (industrial/municipal) waste 550 MW (MoE-AEDP, 2015).

BOX 6

WIND POWER POTENTIAL ASSESSMENTS, THAILAND



Data of mean wind speed from the Thai Meteorological Department (TMD) was used to produce a first wind map in the 1970s, followed by wind measurements by DEDE and the King Mongkut's Institute of Technology Thonburi (KMUTT) in the 1980s. These attempts at producing wind resource maps of Thailand all faced shortages in wind speed data, especially offshore and at high elevations. In 2001, wind resource maps were produced by DEDE using data from over 150 measurement stations, including offshore stations and high elevation stations at 10m, 30m, and 50m above ground level (with 1 km resolution). The World Bank's ESMAP produced wind maps in 2001 at 30m and 65m from global wind data and each country's geographical data using computer simulations. In 2010-11, research to improve these wind maps was conducted by Silpakorn University for DEDE, which produced meso-scale wind maps (with resolution of 3x3 km² cells) at 10m, 40m, 70m, 90m, and 110m. As each was based on different methodologies and heights, these maps did little to decrease uncertainty in wind energy planning. Recent efforts have attempted to harmonize them at common grids, heights, and other variables, which has produced a consolidated onshore wind map in a 1-km grid at 100m height. Analysis shows that technical potential equals 50-250 GW. The economic potential using conventional turbines is 5 GW; however, when using models specifically designed for low speeds the economic potential can be up to 17 GW.

Source: <http://www.asiawind.org/research-data/market-overview/thailand/> (access 2018); and Manomaiphiboon et.al. (2017).

which the Energy Industry Act (2007) was added. These Acts provide the legal foundation for the institutions that administer Thailand's energy sector:

- Thailand's policies and regulations on energy, including electric power, rural energy, and renewable energy, are drafted and proposed by the **Ministry of Energy**.
 - The *Energy Policy and Planning Office (EPPO)*, which is part of the MoE, oversees all aspects of the country's energy policies, including the oil, natural gas, and power sectors, as well as energy conservation and promotion of alternative sources of energy;
 - The *Department of Alternative Energy Development and Efficiency (DEDE)* of MoE promotes the efficient use of energy, monitors energy conservation activities, and explores alternative energy sources. It, therefore, plays a significant role in the context of growing concerns over energy security, and the climate targets set in the Paris Agreement,
- The National Energy Policy Council (NEPC), reviews and approves all proposals pertaining to energy policy and regulations.³⁰ Chaired by the Prime Minister, it works with 11 other ministries, effectively functioning as an inter-ministerial coordinator. At the operational level, EPPO acts as the NEPC's technical support body.
- The electric power and natural gas sectors are regulated by the Energy Regulatory Commission (ERC), set up under the Energy Industry Act (2007). One of its main tasks is to make sure tariffs are calculated in an appropriate and transparent manner, and procurement processes ensure fair competition in the energy marketplace.

³⁰ The National Economic and Social Development Board oversees large energy infrastructure projects and also assists in the policy planning process.

With this new energy sector legislation, Thailand moved from full state control of power generation and distribution to an "enhanced single-buyer model" in power generation. Under this model, the state-owned Electricity Generating Authority of Thailand (EGAT) is the largest generator of power, while also having the sole right to purchase power from other private producers, including neighboring countries; EGAT is also the only firm permitted to supply electricity to distributors and retailers. Thus, there is no competition in the wholesale electricity market in Thailand. The distribution and retail markets are under the monopoly of the Provincial Electricity Authority of Thailand (PEA) and the Metropolitan Electricity Authority of Thailand (MEA).³¹ Real-time coordination between EGAT, the MEA, and the PEA is managed through regional dispatch control centers and a single national control center.

In terms of specific instruments to promote independent actors and renewable energy in electricity production, Thailand enacted the Small and Very Small Power Purchase Agreements acts, which regulate the connection of small producers to the electricity grid, and the sale of their electricity. This policy is also the basis for the feed-in tariff policy.

EGAT owned approximately 41 percent of the total generation capacity in Thailand in 2014. In addition, EGAT purchases power from private power companies, divided in three categories: Independent Power Producers (IPPs, with a capacity of over 90 MW), Small Power Producers (SPPs, with a capacity between 10 and 90 MW), and Very Small Power Producers (VSPPs, with a capacity less

³¹ MEA covers Bangkok, Nonthaburi and Samut Prakarn Provinces and PEA covers all 74 other provinces.

than 10 MW).³² In 2014, EGAT's installed capacity was 15,482 MW (41.2 percent), IPPs had 13,167 MW (35 percent), SPPs 4,530 MW (5.4 percent), and VSPPs 2,029 MW (5.4 percent). With an additional 2,404 MW of imports, Thailand had a total capacity of 37,612 MW.

RENEWABLE ENERGY PROMOTION: FEED-IN TARIFFS

A variety of programmes have been put in place to promote renewable energy development. The Thailand Board of Investment (BoI) has been providing support to alternative energy projects, mostly in the form of tax exemptions, since 2004.³³ In addition, Thailand has a feed-in tariff program to promote renewable energy, with feed-in tariffs for solar, wind, biomass, and small hydro. Developers/ investors do not automatically receive the feed-in tariff; usually, the government announces purchases from renewable energy resources, with limited quotas for each opening round.

The FIP (Feed-In tariff Programme), known as the Adder Programme in Thailand, was put into effect in 2007. Under the Adder Programme, the premium rates are “added” on top of wholesale electricity prices, based on the technology and scale of installed capacity that SPPs or VSPPs adopt in their projects. For wind energy, the adder is THB 3.5 per kWh for 10 years from the start of commercial operations, after which the wholesale tariff applies.

³² IPP licences have been awarded to both international and domestic developers. Foreign investors include J-Power (Japan), GDF Suez (France), SPC Power Corporation (the Philippines), China Light and Power (Hong Kong, China), Mitsubishi (Japan), Tokyo Electric Power (Japan) and Marubeni (Japan). One large domestic developer is the Electricity Generating Public Company (EGCO), which invests in power plants both within Thailand and internationally. EGAT is a significant investor in EGCO, with an ownership stake of approximately 25% (IEA, 2016).

³³ For instance, an 8-year exemption on corporate income taxes on net profits and a 50% reduction during the following 5 years, an 8-year tax exemption on dividends as well as a 25% subsidy on capital costs in some specific cases. www.sunwindenergy.com/review/understanding-thai-renewable-energy-market

Two key issues with the Adder Programme were uncertainty associated with the computation of tariffs paid to the SPPs/VSPPs, since the basic power tariff varied with global energy commodity prices, leading to the total tariff not always reflecting the levelized cost of energy, and uncertainty around the long-term development of the tariff. Additionally, there were concerns that the “high adder and subsidized solar feed-in-tariff rates of current solar energy farms were increasing the consumer’s electricity bill in an unreasonable manner.”³⁴

To address these issues, the government has introduced a competitive bidding scheme with a new FIT (Feed-In Tariff) set as the ceiling price. The scheme aims to help the government minimize the risks of over-subsidizing renewable energy projects, while allowing the market to determine the real price at which renewable electricity should be purchased. The policy for the VSPP FIT was approved in 2015, and for the SPP FIT in 2017. The new VSPP FIT is composed of a fixed portion throughout the project support period, FIT(F), a variable portion which will be updated annually in accordance with inflation and variable feedstock cost, FIT(V), and a FIT(Premium). Apart from the new structure, the FIT lasts 20 years, instead of the 7 to 10 years guaranteed by the old Adder Programme. Additionally, a bidding process was introduced to better select projects, replacing the “first come, first served” approach of the old system. The most cost-competitive offers will be selected until the quota is reached, with the FIT(F) acting as a ceiling for the bids. For wind energy, having no volatile feedstock, the FIT(V) is zero, and the FIT(F) is set at THB 6.06 per kWh. Projects in southern provinces receive an additional FIT(Premium) of THB 0.50 per kWh (GIZ, 2018).

³⁴ <https://pugnatorius.com/solar-energy-update-2018/>

BOX 7 PAYMENT STRUCTURE

Year	Name	Capacity (in kW)
	Laem Phromthep	190
	Sating Phra	1,500
	Tha-le Pang	250
	Ka Tao	250
	Chang Hua Man	50
	Samut Green Energy	900
	DEDE	15,000
2009	Lamtakhong	2,500
2012	First Khorat	103,500
2013	K.R. Two	103,500
2013	Theppana	6,900
	Total in 2015	234,540
2016	Khao Kor	60,000
2016	Subyai	90,000
2016	Wayu, N. Ratchasima	50,000
2016	Watabak, Chaiyaphum	68,000
2017	Hadkunghan 1-3	126,000
	Total by mid-2017	628,540

Table has been compiled from data in in Bridge Tank (2017); Chandler MHM (2017); “แผนที่ตั้งโรงไฟฟ้าพลังงานทดแทนในประเทศไทย”. www4.dede.go.th (in Thai), retrieved 15 November 2015 and published on www.wikipedia.org; Snapshots in ppi.worldbank.org

Projects compete for capacity allocation under the appropriate quota, with the winning bidder offering the highest discount on the announced FIT(F) after the merit order is considered. The first round of competitive bidding will include three types of renewables: biomass, biogas (from waste/ wastewater and energy crops), and wind (IEA, 2016). The ERC will announce a quota for each type of renewable in each region.

The Small Power Producer (SPP) Hybrid Scheme is a new feed-in policy program which requires producers to combine different RE technology to achieve more consistent feed-in to the grid. Single-firm PPA contracts are awarded to power systems between 10-90 MW. The total for the program is set at 300 MW, with a FIT rate of THB 3.66 per kWh (GIZ, 2018).

Under the current FIT system, the feed-in tariff for wind is THB 6.06 per kWh (or about USD 0.19 per kWh).³⁵

Although a bit lower than the tariff under the adder system, this still compares favorably with international feed-in tariffs for wind and reflects the lower wind speeds of 5-7 m/s in Thailand at capacity factors of 20-30 percent and relatively higher cost.³⁶

PRIVATE WIND POWER PROJECTS IN THAILAND

Apart from the Theppana wind project, other examples of the first private sector wind projects in Thailand are the West Huaybong 3 wind farm, operated by the First Korat Wind Co. Ltd., and the West Huaybong 2 wind farm, operated by K.R. Two Co. Ltd.³⁷ Both companies are 60 percent owned by Aeolus Power Co. Ltd., a subsidiary of Wind Energy Holding Co. Ltd. (WEH), 20 percent owned by RATCH Plc., and 20 percent owned by Chubu Electric Korat.^{38,39,40} Each project is comprised of 45 2.3 MW

35 Based on average 15 Sept 2017 to 15 March 2018 exchange rates.

36 Typically, USD 0.10-0.13 per kWh for a 15-20 year period.

37 Located in Dan Khun Tod District and Teparak District, Nakhon Ratchasima Province.

38 Founded by the businessman Nopporn Suppipat, WEH was sold in 2015 to the KPN Group, a Thai conglomerate of various holdings.

39 Ratchaburi Electricity Generation Public Holding Co., which is owned by EGAT (45%), Thai NVDR Co. Ltd (20%) and other shareholders. It was created from the privatization of the Ratchaburi power plant by EGAT.

40 A subsidiary of the Japanese group Chubu Electric Power.

wind turbines provided by Siemens Wind Power A/S, and each has a power purchase agreement of 90 MW under Thailand's SPP program and receives THB 3.5 adder per kWh. The total investment was an estimated THB 13,053 million (Bridge Tank, 2017), equivalent to about USD 245 million.

Another project by WEH is the Khao Kor wind farm, which was initiated in 2008 and owned by the Khao Kor Wind Power Co. Ltd. (KWP), which was at that time 100 percent held by the Sustainable Energy Corporation, founded by WEH.⁴¹ After issues with ownership and shareholding of KWP, Khao Kor became operational in 2016.⁴² It was approved as a Clean Development Mechanism (CDM) project by the CDM Executive Board in 2011. Investment is an estimated USD 88.9 million, financed by the Bangkok Bank of Commerce. The 60 MW project uses 24 wind turbines of 2.5 MW each, with 120-meter rotor diameter at a hub height of 110 m, provided by General Electric (GE). Under the SPP program, electric power is provided to EGAT under a PPA, for which KWP receives an adder of THB 3.5 per kWh for 10 years (Bridge Tank, 2017). CEWA is currently preparing a feasibility study for three 90 MW wind power projects in Petchabun.⁴³

The Hadkunghan wind farm projects in the southeast of Thailand were initiated in 2012 by Energy Absolute Pcl. (EA). Hadkunghan 1 (36 MW), Hadkunghan 2 (45 MW), and Hadkunghan 3 (45 MW) began commercial operations in 2017, while studies are being conducted for a fourth Hadkunghan with a potential of 45

MW.^{44,45,46} The projects are managed by EWHK3, EA's subsidiary company. Each project uses 70 1.8 MW turbines with 110m rotor diameter provided by Vestas. Total investment in the projects is THB 10,400 million (approximately USD 293 million) of which USD 205.7 million was debt financing from Siam Commercial Bank. The project has benefited from the purchase price adder for Small Power Production (SPP) from wind power, at THB 3.50 per kWh (for a period of 10 years). Currently, EA is developing five wind power projects (called Hanuman) with a total capacity of 260 MW in Thap Sathit and Bamnet Narong Districts of Chaiyaphum Province, scheduled to be operational in 2018.⁴⁷

The 60 MW Wayu wind farm is located in Huaybong, Dan Khun Tod in Nakhon Ratchasima Province, and has been owned and operated by Gunkul Engineering since 2016, with turbines provided by Gamesa. Investment has been USD 353.6 million, of which USD 195.6 million is debt financing from Siam Commercial Bank.⁴⁸ WEH is planning five projects in Nakhon Ratchasima and Chaiyaphum Provinces, with a total of 450 MW, which would need an investment of about THB 37 billion, with the financing to be arranged by Siam Commercial Bank. The wind farms will use 60 3.0 MW turbines from Vestas with 136m diameter and a hub height of 157m, and 90 3.4 MW turbines from GE.⁴⁹ These projects were put on hold during WEH's restructuring process but will continue after the commissioning of WEH's 68 MW Watabak project, which signed a 60 MW PPA with EGAT, in 2016.

41 Located in Khao Kor District in Petchabun Province.

42 In 2009, SEC became jointly held by WEH (60%), RATCH Plc. (30%) and Demco Plc. (10%). In 2010, RATCH bought a stake from WEH and the shareholding is now RATCH 55%, WEH 34% and Demco 11%. Hence the project became known as Ratchaburi Khao Kor. After shareholding changes KWP is now owned by Charoen Energy and Water Asia Co. Ltd. (CEWA) with Demco Plc. Still holding 14%.

43 www.cewa.or.th, access 2018.

44 Ranode District, Songkhla Province.

45 Huasai District, Nakhon Si Thammarat Province.

46 Pak Panang District, Nakhon Si Thammarat Province.

47 www.energyabsolute.co.th, access 2018.

48 Snapshot at ppi.worldbank.org and www.gunkul.com

49 www.nationmultimedia.com/detail/breakingnews/30332771 and www.demco.co



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Energy Absolute Co. Ltd. (EA) is developing five wind power projects with a total capacity of 260 MW in Thep Sathit and Bamnet Narong Districts of Chaiyaphum Province.

There is a tendency to employ wind generators with larger rotor diameters and hub heights (120m or more). This has implications for the transportation of the wind turbines and towers to the project site. It may also pose capacity limits on the available

cranes in Thailand, and the use of special cranes for installation.⁵⁰ The higher hub heights and larger rotor blades may be cost-effective in terms of their ability to harvest more of the wind potential, but they can also lead to higher investment costs. ■

⁵⁰ Wheeled cranes and tower cranes instead of narrow-track cranes (MMD, 2014).

ANNEX B

People interviewed

Institution/company/organization	Name and title
Asian Development Bank - Private Sector Operations Department	Tristan KNOWLES (Climate Finance Specialist) Robert LOCKHART (Investment Specialist) Krittayamon PAOCHAROEN (Senior Investment Officer) Daniel WIEDMER (Principal Investment Specialist)
Bank of Ayudhya (Krung Sri)	Sarochoa NGAMGANOKWAN (Manager Project Finance) Nantawat NOPPARATANAWONG (Head Project Finance) Ungsumalin SUEBWONGSAN (Director Project Finance)
Electricity Generating Public Company Ltd. (EGCO)	Varong CHAROEN (Project engineer manager) Sukunya PHOKHAKUL (Senior VP - Business Development) Somkiat SUTTIWANICH (Accounting and Finance)

ANNEX C

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The Climate Investment Funds (CIF) accelerates climate action by empowering transformations in clean technology, energy access, climate resilience, and sustainable forests in developing and middle-income countries. The CIF's large-scale, low-cost, long-term financing lowers the risk and cost of climate financing. It tests new business models, builds track records in unproven markets, and boosts investor confidence to unlock additional sources of finance.

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