RUNNING ON EMPTY

AWR Lloyd

PÖYRY

Implications of declining natural gas reserves and other key trends on the Thai power sector

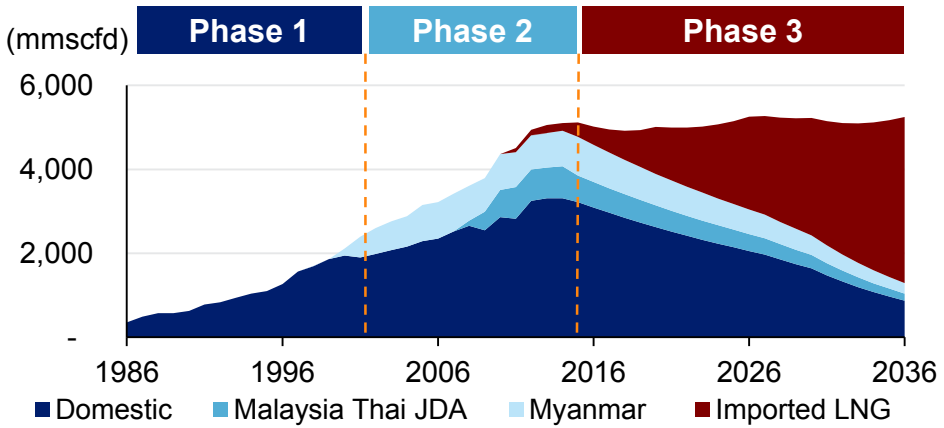
A new multi-client study
September 2017

- **Introduction to the Multi-Client Study**
- *Running on Empty*: Impacts of Thai gas supply decline
- Prospects for Thailand's energy future
- Study details and team capabilities
- Appendix

THAILAND IS ENTERING ITS THIRD AND FINAL GAS INDUSTRY PHASE

Combined with other factors this could transform the Thai power sector

Thailand Natural Gas Supply by Source



Source: Thailand 2015 power development plan and gas model

Phase 1	Domestic gas drives industrial growth
Phase 2	Imports offset waning resources
Phase 3	LNG becomes primary source of gas

Drastically increased LNG exposure combined with technology, global energy dynamics, and regulations bring unprecedented threats and opportunities to the Thai power sector and its participants

Key questions

- Can Thailand meet its PDP targets?
- What will imported LNG dependency mean?

- What will be the outcome of a wide range of important regulatory issues?

- How will this impact the power sector?
- What are the implications?

- What global forces will impact Thailand?
- What impact will technology have?

- Will LNG costs drive an RE boom?
- What would that look like?

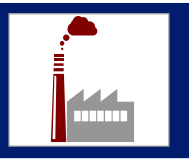
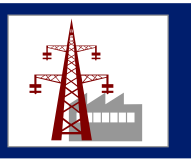
- Will retail tariffs have to change?
- Can Thailand pass LNG risk to consumers?

- What does this transformed market mean to generators?

- What areas might deliver profitable growth?
- What are the consequences for players?

CASCADING IMPACTS WILL AFFECT ALL INDUSTRY PARTICIPANTS

The study will provide insights to players across the value chain

Developers 	• A new set of preferred technologies, development risks, and regulations will determine who succeeds
Plant owners 	• Rapidly evolving energy market dynamics and regulatory risks may affect plant economics and competitiveness
Gas suppliers 	• Growing LNG demand, multiple buyers and opening of transmission and distribution will offer new opportunities
Investors 	• The transformation of the energy landscape will create new risks – and opportunities – for existing *and* future assets
Lenders 	• A new set of market & regulatory risks will affect project bankability and energy sector investment attractiveness
Others 	• Future regulatory, legal, and operational considerations will create a myriad of winners and losers

RUNNING ON EMPTY: IN-DEPTH ANALYSIS TAILORED FOR THAILAND

Structured package of deep analysis with powerful conclusions

- Multi-client structure enables the creation of a large, powerful body of analysis and conclusions that is accessible to a broad range of market participants
- Provides an integrated package of unique insights, tools, and decision support that participants in the Thai energy industry can use to manage change
- Ideal team with years of experience in the Thai gas, power, and renewable energy sectors and two existing market models
- Delivered in a set of workshops, reports, and datasets organized in three modules

Qualitative analysis

Comprehensive overview and analysis of all major factors driving Thai energy sector including markets, players, regulations, technology, and global trends

Quantitative analysis

Data-rich analysis using tested market models

- Thai natural gas supply and demand model
- Pöyry BID3 Thai power sector model

Actionable outputs and conclusions

The study will provide a carefully designed set of results, outputs, scenarios, and conclusions targeted to needs of participants

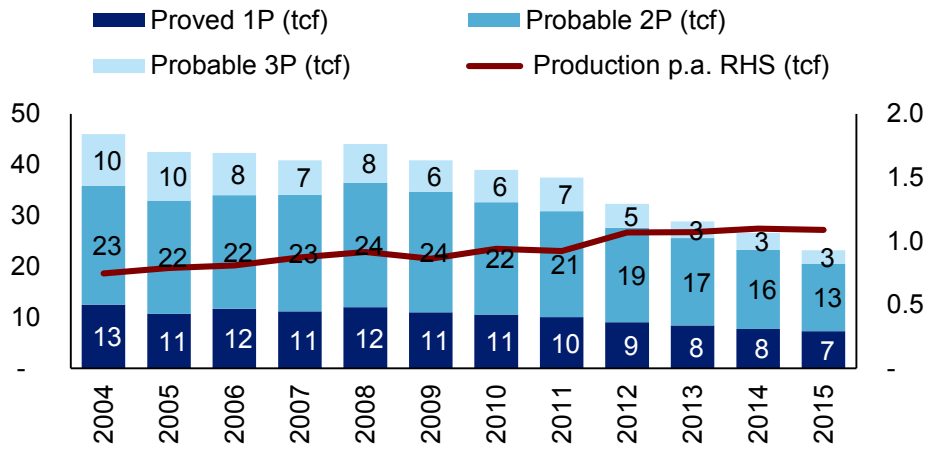
- Introduction to the Multi-Client Study
- ***Running on Empty*: Impacts of Thai gas supply decline**
- Prospects for Thailand's energy future
- Study details and team capabilities
- Appendix

DECLINING GAS RESERVES ARE A REALITY

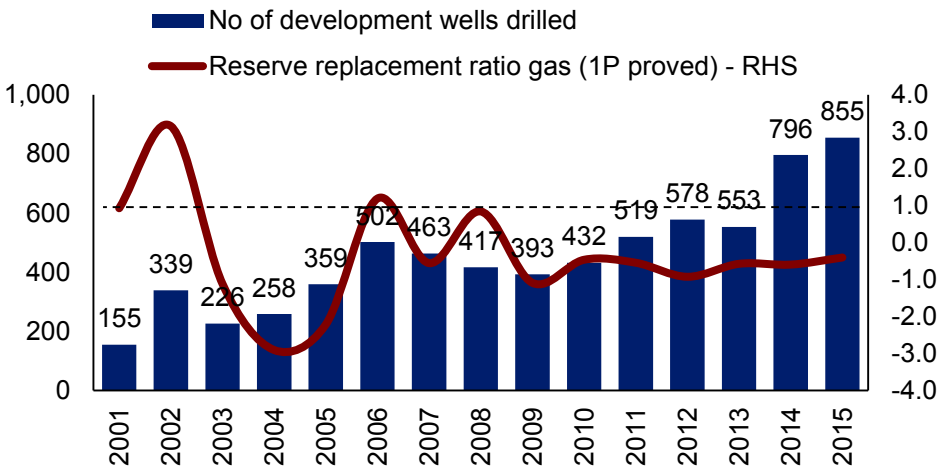
Our proprietary gas supply and demand model indicates that government forecasts for LNG imports may be underestimated

- Government forecasts imply optimistic, arguably unrealistic assumptions related to decline rates and resource replacement
  - Reserves are not being replaced – Thailand's 1P reserve life index stands at just 6.6 years and has declined by half over the last decade
  - Peak production occurred in 2014; Thailand's 2P reserve life is collapsing
  - The number of development wells drilled increased 55% between 2013-2015 to maintain production volumes – it is costing Thailand more to produce less gas
- Thailand will no longer be able to rely on piped natural gas as a cornerstone fuel, this will create unprecedented dependency on imported LNG

Thailand Natural Gas Reserves vs. Production



Development Wells Drilled

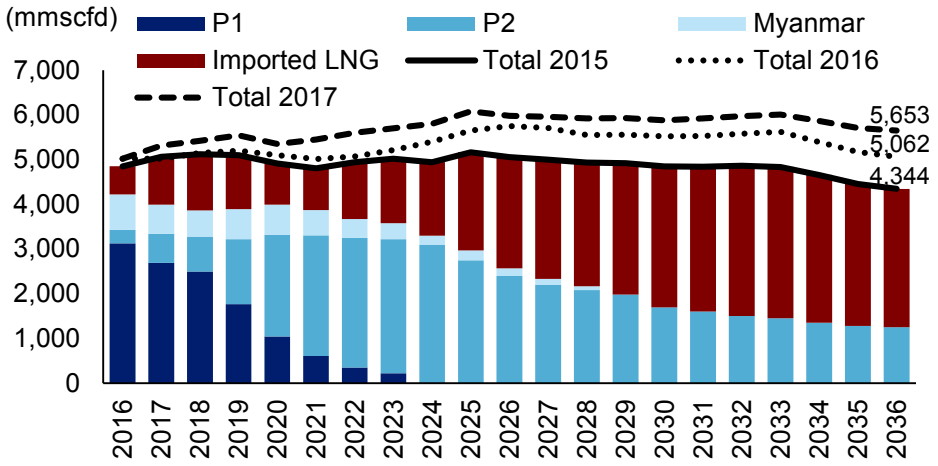


LOOMING DEPENDENCY ON IMPORTED LNG TO BE TRANSFORMATIVE

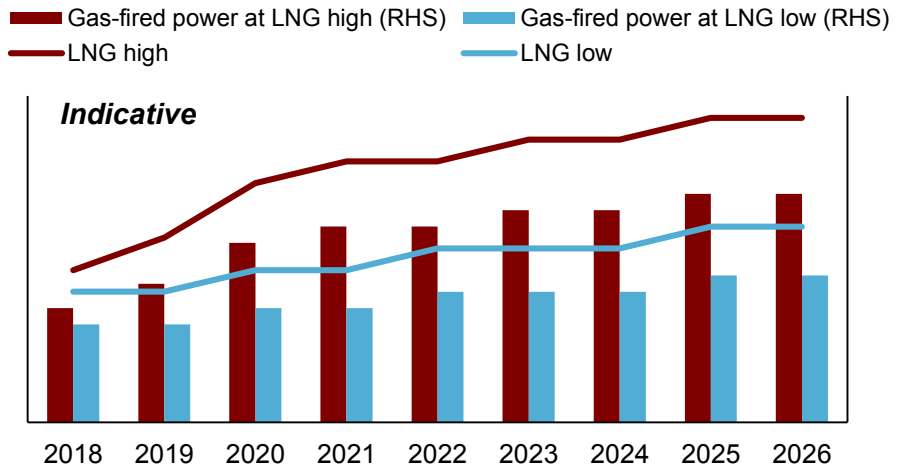
The future of Thailand's entire gas supply framework is uncertain. This includes asset ownership; risk sharing; gas pricing; volume commitments; and contract terms

- To date, the cost burden of Thailand's imported LNG has been masked by weak commodity prices and low volumes. But global LNG markets are in flux and the current favorable conditions may not be permanent
- As Thailand's LNG weighting increases, the government will lose its ability to manage natural gas pricing – exposing consumers for the first time directly to international market prices
- A range of different options to manage gas supply, including market liberalization are underway and expanding
- Competition is mounting for billions of dollars worth of investments for LNG infrastructure. A battle between major players is already underway
- New entrants continue to explore gas and LNG related opportunities

Thailand Natural Gas Supply Plan



Future LNG and gas-fired power price ranges

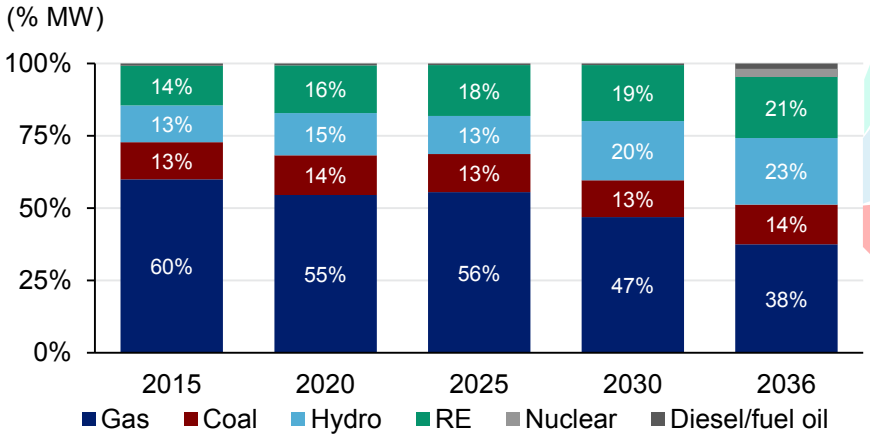


POWER SECTOR HAS LIMITED ALTERNATIVES TO GAS

Ambitious plans to minimize gas reliance suffer from: resource availability; policy structure and technological constraints

- The 2015 PDP calls for a reduction in gas consumption from 60% to 37% by 2036
- All non-gas options currently have barriers due to scale or cost
- Viable energy storage would be transformative
- Improvements to efficiency are achievable but the PDP target appear unrealistic

PDP2015: Projected Power Source by Fuel



Energy Efficiency

- PDP aims to improve efficiency from the 1.0x GDP historic average to 0.6x from 2016-2036
- This would reduce power demand by 89,672 GWh by 2036

RE

- With LNG one of two marginal sources of new power
- Intermittency caps growth – storage crucial

Hydro Imports

- Solid Lao progress and deep plans, but risks of diminishing quality
- Ability to develop projects in Myanmar unknown

Coal

- Practical low cost baseload power
- Significant public opposition, has led to decades of project delays
- Unlikely to realistically be an easy option for additional capacity

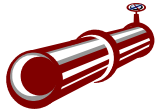
POLICY BACKDROP COMPOUNDS RISKS, SPANS VALUE CHAIN

The range of regulatory issues facing Thailand presents a "Gordian knot", the resolution of which will be fundamental to the future industry structure

Upstream gas

- **Changes to upstream fiscal policy**
  - Auction delay for new fields
  - Expiration and re-awarding of existing concession
  - Policy issues: PTT role; NOC; PSC regime introduction
- **Policy for imported piped gas**
  - Myanmar: past technical issues; future political issues

Midstream gas



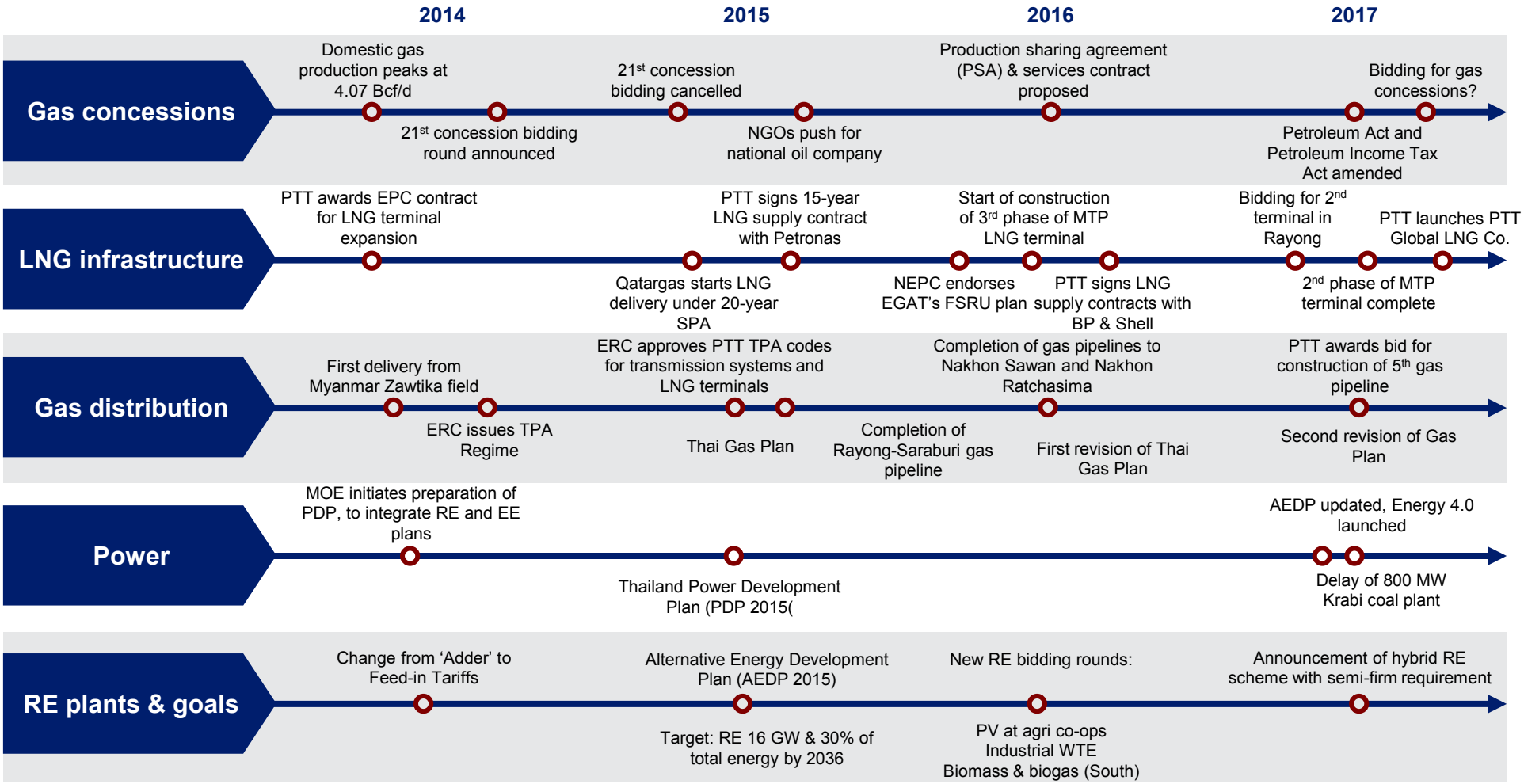
- **Changes to existing policies**
  - Third party access (TPA)
  - PTT pipeline ownership, EGAT FSRU
- **Emergence of new polices**
  - Pool pricing face possible restructuring
  - LNG risk and cost pass-through, GSA renegotiation

Power sector

- **Direction and strength of Thai RE programs**
  - Regulations and prices
- **Thai IPP concession plans**
- **Open electricity distribution network**
  - Net metering, retail liberalization, energy storage
- **Energy technology advances**

END OF THE STATUS QUO ALREADY UNDERWAY

Thailand's once stable and relatively predictable power sector is facing a dramatically different future. Changes are in their early stages



- Introduction to the Multi-Client Study
- *Running on Empty*: Impacts of Thai gas supply decline
- **Prospects for Thailand's energy future**
- Study details and team capabilities
- Appendix

DEEP DIVE INTO KEY ISSUES

***Running on Empty* will explore the most critical themes in Thailand's energy future, including the four described below and in the following slides**

1 LNG dependence threatens price stability

The Thai power industry has benefitted greatly from the stability provided by piped gas with price buffers – increased reliance on LNG shakes this up

2 Global energy changes will impact Thailand

Thailand will increasingly be impacted by global issues, including geopolitical conflicts, global environmental considerations, and general energy market dynamics

3 The government's response will be crucial

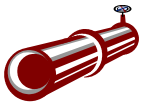
The Thai government has set forth a variety of plans and programs to enable Thailand's energy evolution, but are they appropriate and achievable?

4 Energy technology could be transformative

Continued evolution and improvement in technologies such as solar, storage, and EVs could bring Thailand tremendous benefit – but there will be both winners and losers

1 LNG DEPENDENCE THREATENS THAI PRICE STABILITY

Growing energy market exposure could threaten pass-through system



	Gas transmission & distribution	Generation assets	Consumers
Issue	• TPA moving to open access to gas pipeline • Government favours liberalization • LNG impact on pool price • Market system not yet clear • PTT will maintain dominant position	• The Thai power sector has been cushioned from energy price exposure • Higher LNG prices could make that hard to sustain • Current power sector over-capacity	• Current low LNG prices and volumes mean low impact • But now have uncertain electricity costs for industry and residential • Price sensitive and politically important
Impact	• Multiple providers could buy and sell gas • Direct private natural gas sales to industry and other users • Uncertainty over regulatory change and timing	• Variation in gas prices currently has small impact on merit order • This could change with direct gas sales • Gas market reform doesn't have to transform power sector • In high-LNG cases renewables could gain enough to impair gas assets in the long-term	• Risk of substantially higher gas prices for all consumers • Improved competition in energy supply to lower costs relative to regulated system • Solar and storage as hedge makes sense, particularly for industrial consumers

2 GLOBAL ENERGY CHANGES WILL IMPACT THAILAND

Dynamic time in global energy markets

With Natural Gas Booming, Race Is On To Export It To The World 06:49

June 13, 2017 Updated 6/13/2017 3:33 PM By Peter O'Dowd

BUSINESS NEWS | Thu Jun 8, 2017 | 9:58pm BST

Qatar Gulf row roils LNG market, Shell tanker diverted

CHEMISTRY WORLD

Energy storage prices forecast to tumble

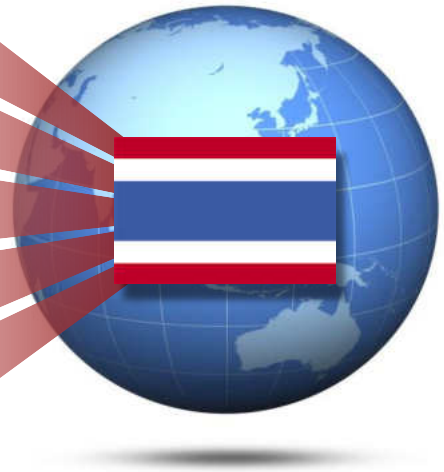
July 2017

All the vehicles in the future will be electric, says Bosch's Vijay Ratnaparkhe

The Robert Bosch Engineering head says the future of transportation is electric vehicles

NATURAL GAS WORLD June 2017

Singapore: Favorite for Asian LNG Hub



3 THE GOVERNMENT'S RESPONSE WILL BE CRUCIAL

The policy response could lead to fundamental industry changes in a range of ways

CURRENT PARADIGM	CHALLENGE	RESPONSE
Government able to manage gas prices	• As LNG dependence grows, so does exposure to volatile global markets • This has to be managed years in advance	• Use market mechanisms to guide energy planning and purchases • Relieve consumers from LNG price risk
PTT has virtual monopoly on gas distribution	• Third party access • Entrance of EGAT and other parties • Other PTT roles	• Redefine PTT role • Open gas market to a new set of suppliers, distributors, and business models
Gas-fired power assets viewed as predictable	• Thai power producers are free of supply and cost pressures • Security of availability payments	• New risks from LNG supply, government movement toward market mechanism and energy storage threaten this compact.
Strong early RE program largely stalled	• Current solar and hybrid programs are limited • Next growth stage depends on ability to compete head-to-head with LNG	• Thailand appears likely to increase RE targets and revise the AEDP • Current hybrid program experimental
Regulated power market constraining	• Current regulatory structure may not send necessary market signals or foster adequate innovation	• Future reforms could change industry structure and open new opportunities to new businesses and technologies

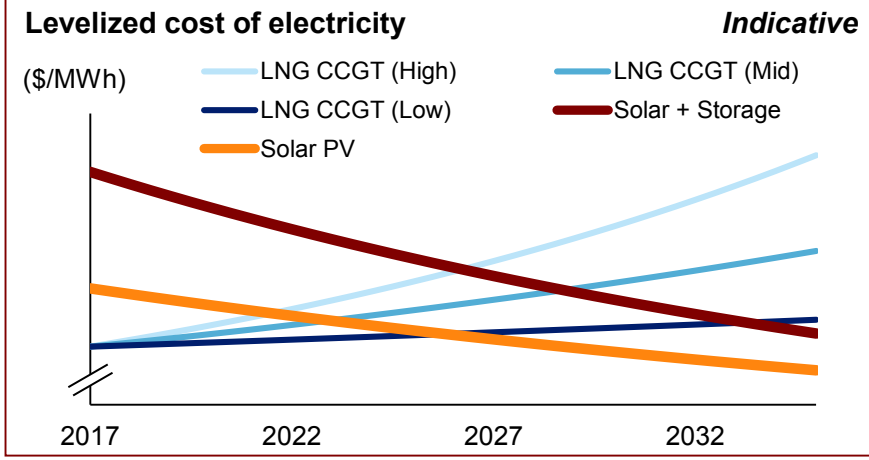
4 ENERGY TECHNOLOGY COULD BE TRANSFORMATIVE

Renewable energy is the only marginal supply of new power to reduce LNG risk

The rate of technology development continues to accelerate

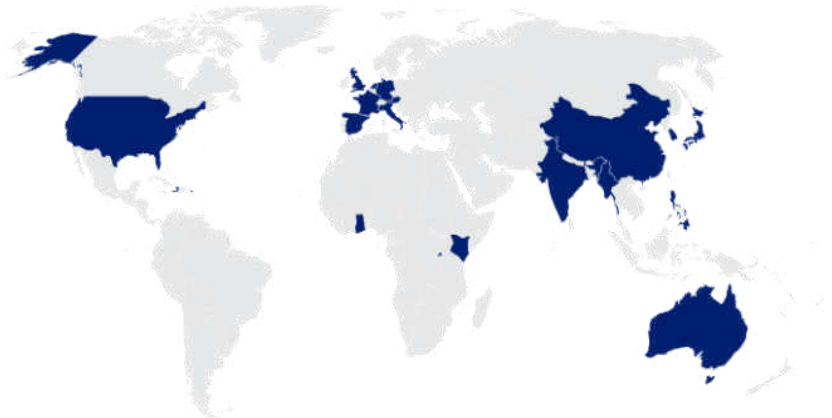
-30%	Solar PV module costs have declined by over 30% in the last year alone, down to ~USD $0.40/W	**+60%**	Electric vehicle sales around the world grew 60% in 2016, to a global total of over 2M – with some projecting up to 140 million by 2030
$230 /kWh	Battery energy storage costs have declined by over 70% in the last 6 years, from ~ USD $1,000/kWh in 2010 to $230/kWh in 2016	**$30** /MWh	Utility-scale PV project prices around the world have in some cases dipped below USD $30/MWh

Solar + Storage: Grid parity prospects



Solar + Storage: Already a reality

Currently being demonstrated and deployed in over 20 countries

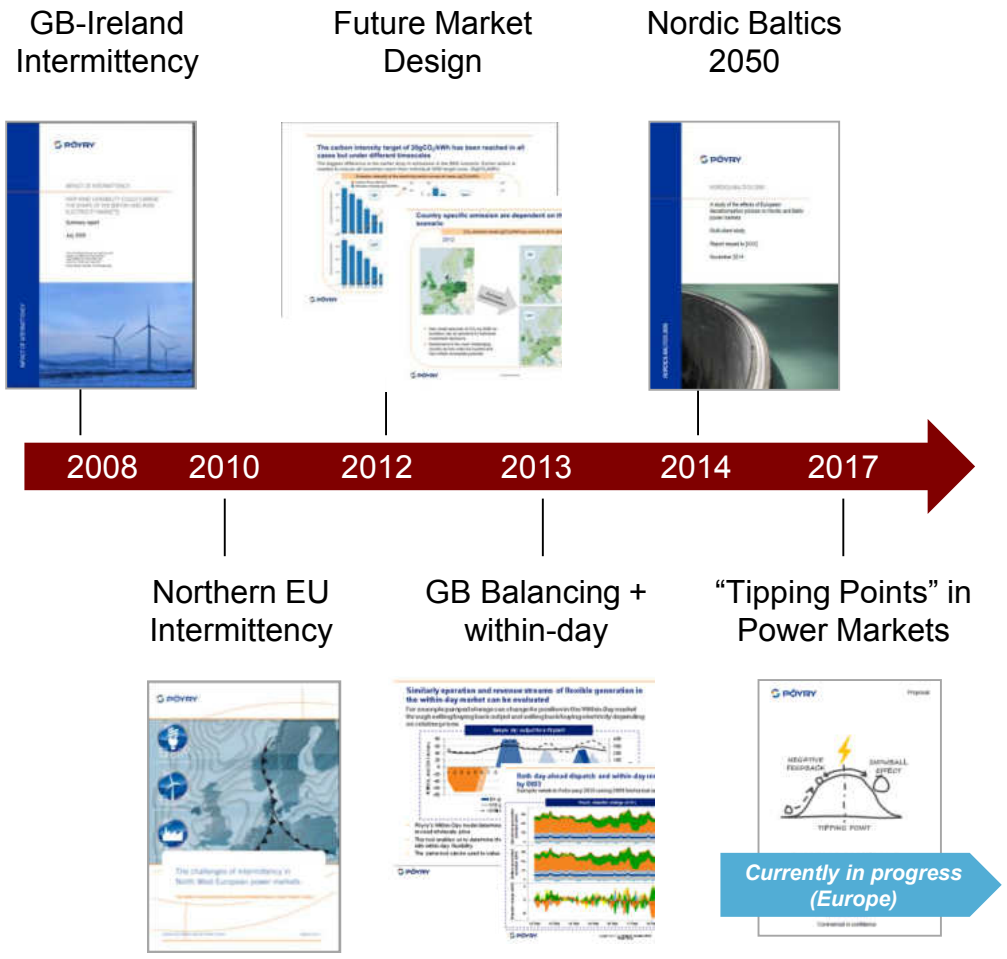


- Introduction to the Multi-Client Study
- *Running on Empty*: Impacts of Thai gas supply decline
- Prospects for Thailand's energy future
- **Study details and team capabilities**
- Appendix

VALUE OF MULTI-CLIENT STUDY

Enables broad coverage and deep dive on the critical issues that matter to clients

- Multi-client studies pool resources to enable a level of breadth and depth that would be cost-prohibitive for a single client
- Variety in stakeholder perspectives ensures balanced approach and industry-specific insights
- Emerging dynamics in Thailand require thorough examination of a wide range of issues
- Pöyry has completed several such studies since 2008
- The study team has extensive experience in gas and power projects in the region
- This new multi-client study will present a thorough and timely view into the Thai energy future, just as key drivers are emerging



RUNNING ON EMPTY: TAILORED FOR THAILAND

Provides an integrated package of unique insights, tools, and decision support that participants in the Thai energy industry can use to manage change

Module 1 Thai gas deficit	**Module 2** Impact on Thai power sector	**Module 3** Results and conclusions
In-depth analysis of gas supply decline, LNG acquisition options, and implications	Qualitative and quantitative analysis of future prospects for Thai power sector	Extensive production of conclusions including scenario analysis and forecasts
• Quantitative and qualitative assessment of Thai gas supply • Draw on Thai gas market research and input into gas supply model • Create gas supply data sets • Model gas supply volumes and prices • Develop LNG supply and pricing framework	• Modeling and analysis on impact of gas supply scenarios on Thai power sector • Use gas model output scenarios in Pöyry's BID3 Thai power market model • Create power sector-level data input sets • Produce power sector analysis	• In-depth reviews of the most important issues and how they will impact investors, developers, operators, and other Thai energy stakeholders • Create future Thai power sector scenarios • Produce conclusions and recommendations
October 1 - 31	**November 1 - 30**	**December 1 - January 31**

DESIGN OF THIS STUDY AND NEXT STEPS

- Study starts on 1 October 2017, with completion in January 2018
- Multi-client design will be adjusted and finalized based on inputs
- Steering Committee Members have more control over the study and more deliverables than Multi-client Package Members
- Currently finalizing the scope with input from participants

Contacts:

Jack Kneeland
jack@awrlloyd.com
+ 66 892 064 800

AWR Lloyd

Matt Heling
Head of Energy Consulting, Asia-Pacific
matthew.h@poyry.com
+ 66 614 163 763

PÖYRY

Running on Empty
Multi-client Package

- Module 1: **Thailand gas supply and LNG report**
- Module 2: **Thailand power market report**
- Module 3: **Results and conclusions report**
- Workshop: **Energy storage investment analysis ***

Running on Empty
Steering Committee Membership

- Module 1: **Thailand gas supply and LNG report**
- Module 2: **Thailand power market report**
- Module 3: **Results and conclusions report**
- Workshop: **Energy storage investment analysis ***
- Individual planning meeting prior to production of each module
- Individual presentation of results from each module
- Databooks from each module

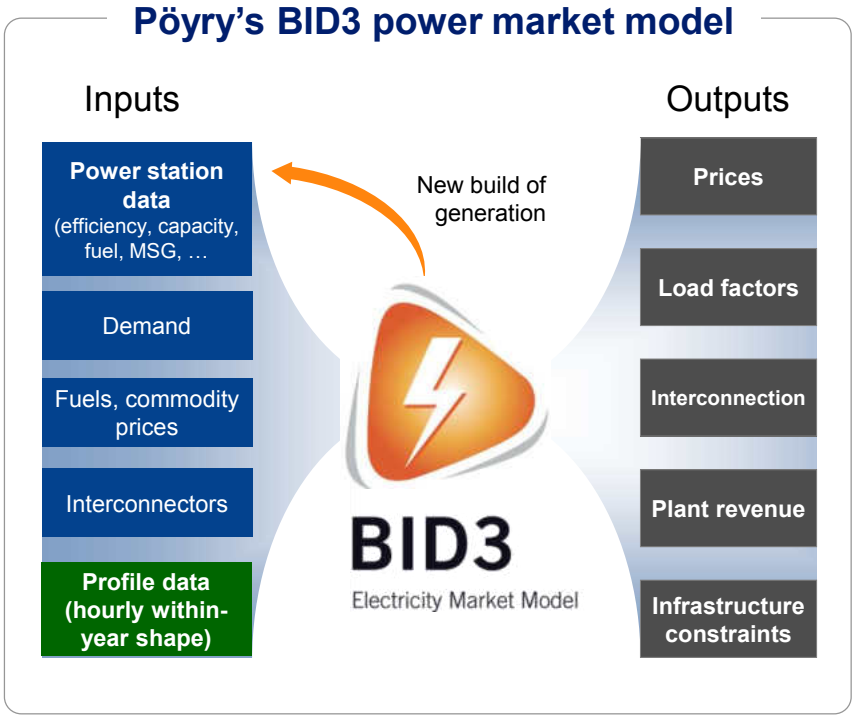
* Workshop details in the Appendix slide 31

- Introduction to the Multi-Client Study
- *Running on Empty*: Impacts of Thai gas supply decline
- Prospects for Thailand's energy future
- Study details and team capabilities
- **Appendix**

MODELING THE THAI POWER MARKET

State-of-the-art modelling

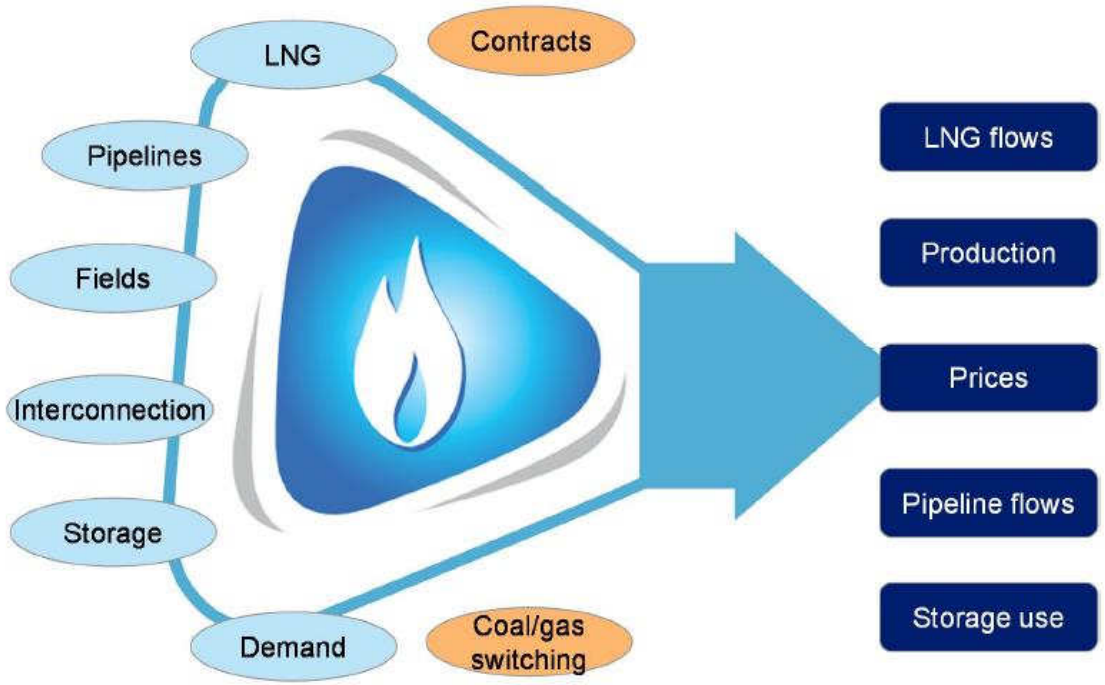
- BID3 is Pöyry's world-class power market model with Thailand capabilities
- BID3 simulates hourly supply and demand in the power market, subject to plant and system operating constraints
- Each combination of scenario and modeled year is simulated
- Key outputs include:
  - Plant dispatch factors
  - Market prices
  - Capacity development



MODELING THE GLOBAL LNG MARKET

Gas prices are projected using Pöyry's global gas model, Pegasus

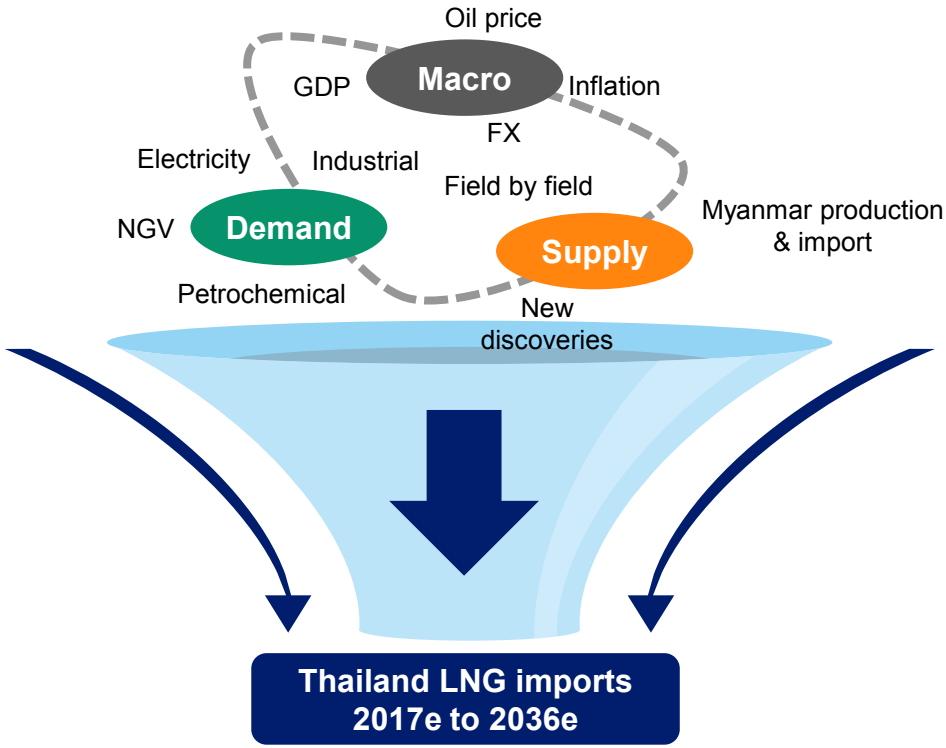
- Pegasus models gas markets around the world, including LNG flows between and among regions (including Europe, Asia, and the US), and produces price projections
- The model examines daily supply and demand across markets to give a high degree of resolution, allowing for consideration of weekday/weekend differences, flows through interconnectors and storage usage in detail
- The model considers the impact of LNG infrastructure (developments or constraints) when assessing LNG flows. The analysis for *Running on Empty* will incorporate detailed modeling of Asian LNG infrastructure
- As a core part of our modeling, we take gas demand from our electricity model, BID3, to understand the effect of changes in gas price on gas demand, and vice versa
- This ensures that assumptions about gas prices and gas demand remain realistic and reflect gas elasticity



MODELING THAILAND'S NATURAL GAS SUPPLY AND DEMAND

Granular model with both top-down demand and bottom-up supply features

- Model includes 10 year historical and 20 year forecast period
- Top down macro-economic drivers
- Modular demand section that compares historical multipliers and includes a simply growth rate override
- Supply section includes a field by field study considering factors such as reserve life, reserve replacement and decline rates
- Sections for assumptions on both piped import volumes and new discoveries
- Outputs section that easily compares model estimates to key government forecasts
- Multiple scenarios with sensitivity range for each scenario



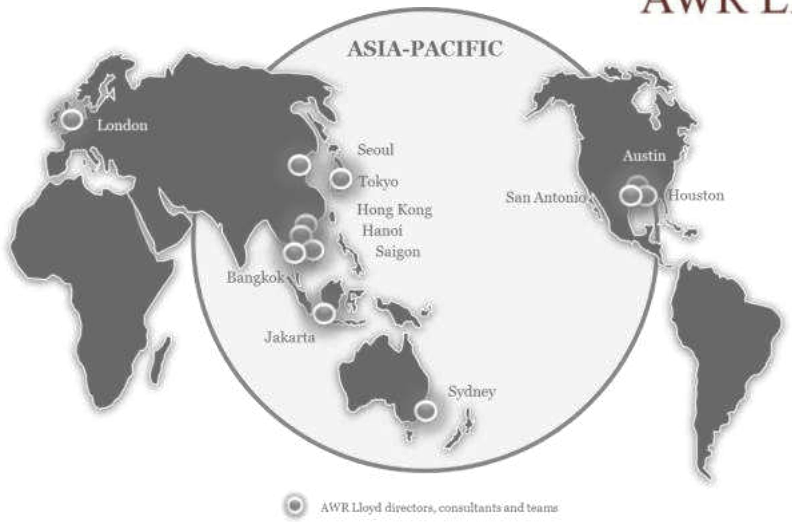
AWR LLOYD CAPABILITIES

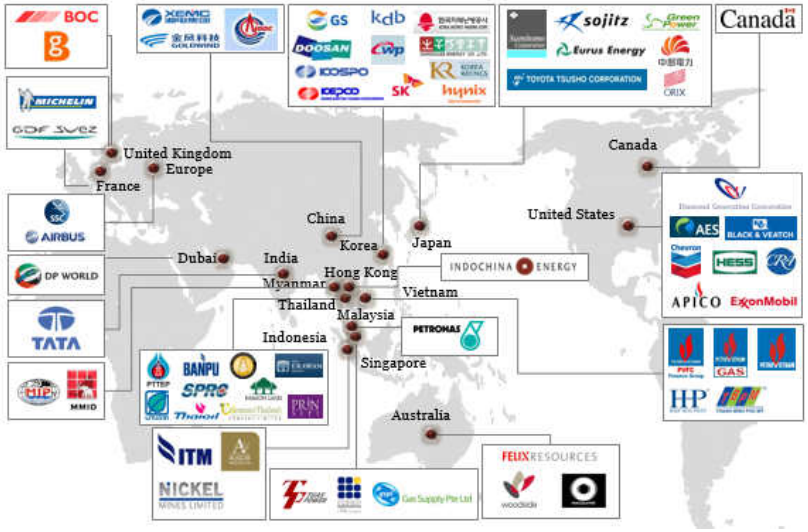
AWR Lloyd

Advisor to Asia's energy sector

AWR Lloyd is a strategy consulting and financial advisory firm that specializes in the energy, resources, and infrastructure sectors in the Asia-Pacific region

- Founded in 2000, the firm has worked with numerous Asian and global companies and investors to develop and implement strategy, M&A, investment structuring, and capital raising
- Of particular relevance to this project, AWR Lloyd's team has worked on numerous clean energy, strategic advisory and market assessment engagements





New Energy Practice

- Around the world, technological advances, regulations and economic drivers have transformed the energy sector, forcing change on existing players and providing huge opportunities to well-placed new entrants
- AWR Lloyd's New Energy Practice has developed a unique level of expertise in renewable energy, energy storage, electric vehicles and related industries that are experiencing growth
- We help clients to conceive and execute winning strategies for this complex and dynamic environment by providing a unique fusion of three core businesses - strategy consulting, financial advisory, and market research

PÖYRY CAPABILITIES

- Pöyry is an international engineering consultancy with over 5,500 employees in 40 countries – including 50 years in Asia and 250 employees in Thailand
- The leading electricity market consultant in Europe, Pöyry has provided power market advisory services in SE Asia since 2011
- Power sector experience underpinned by deep technical expertise, with over 160 GW of power generation projects worldwide, spanning including thermal, hydro, and renewables

70%

of Europe's major energy players use our electricity price projections

RANKED

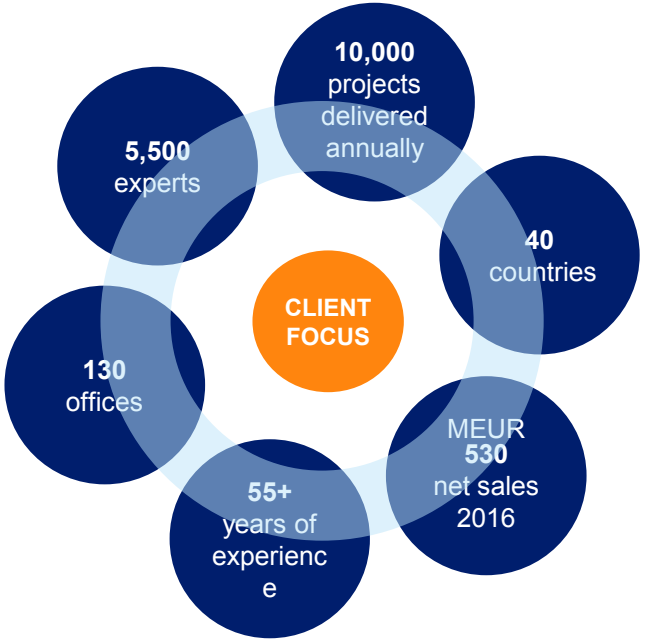
#6

in power generation globally

Source: ENR 2016 international design firms

Pöyry in Thailand

- 250 staff consisting of a mix of international and local experts
- Regional headquarters for most of Pöyry's Asia operations
- Leading consulting engineering company in power sector in Thailand
- About 50 major power plant projects and 200 power sector-related assignments executed in Thailand
- Engineering Centre for Pöyry's worldwide operations offering complete conceptual, basic and detail engineering services for contractors, suppliers and project owners for their worldwide projects
- About 100 projects executed annually from Pöyry Thailand office



SELECT RECENT THAI PROJECTS - AWR LLOYD

CLIENT	PROJECT	SCOPE OF SERVICES	YEAR
Global E&P with Thai assets (confidential)	Natural Gas Market Study	• Thailand Gas Market Study for International E&P considering regional upstream investment options. • Included investment recommendations and gas market model	2016
Thai natural gas producer (confidential)	Commercial advisory	• Commercialization advisor to Thai natural gas producer. • Key projects included transaction advisory, gas supply agreement; extensive modeling natural gas fields and investments; 2016 Thailand power market assessment	2008-2016
B.Grimm Power	Independent Market Report for power IPO	• Independent market report in support of successful IPO on Thai stock exchange • Included Thailand regulatory framework, power supply and demand analysis, SPP sector overview and competitive landscape	2016-2017
TPI Polene Power	Independent Market Report for waste-to-energy (WTE) IPO	• Independent market report in support of successful IPO on Thai stock exchange • Included regulatory framework, power supply and demand analysis, RE sector, and outlook for WTE sector	2016-2017
Total Gas & Power SA	Market Assessment for gas-fired power plant transaction	• Completed market assessment as part of FA team for the sale of a share of a Thai gas-fired power plant. • Project included a complete Thai power market model	2015

SELECT RECENT THAI PROJECTS - PÖYRY

CLIENT	PROJECT	SCOPE OF SERVICES	YEAR
Solar project developer (Confidential)	Electricity market analysis and energy storage valuation	• Provision of wholesale tariff forecast for scenarios with accelerated deployment of solar PV and battery energy storage • Assessment of value of battery energy storage to the Thai electricity system	2017 (on-going)
Solar developer / Private equity firm (Confidential)	Electricity market analysis and wholesale tariff price projections	• Market study of the Thai electricity market including infrastructure, demand, supply, price developments and regulation • Provision of wholesale tariff forecast	2017
Japanese private equity firm (Confidential)	Regulatory and market due diligence	• Assessment of regulatory and market aspects of Thai electricity market in relation to potential acquisition of wind power projects	2016
International renewable energy company (Confidential)	Wholesale tariff forecasting for Thailand	• Market study of the Thai electricity market including infrastructure, demand, supply, price developments and regulation • Provision of wholesale tariff forecast	2016
Asian investment fund (Confidential)	Market Due Diligence for CCGT plant	• Analysis of the Thai electricity market and plant dispatch as a basis for a potential investment in an existing CCGT	2016
Solar generation company (Confidential)	Electricity market analysis and wholesale tariff price projections	• Market study of the Thai electricity market including infrastructure, demand, supply, price developments and regulation. • Provision of wholesale tariff forecast.	2015

RUNNING ON EMPTY TEAM

AWR Lloyd		Pöyry	
Jack Kneeland 	• 20+ years of experience in consulting and finance specializing in renewables, natural gas & power • Head of AWR Lloyd's New Energy Practice • Senior roles with major investment banks including Head of Thai Equity Research and Energy Analyst at UBS • Master's degree in Energy and International Finance from Johns Hopkins University	**Matt Heling** 	• 10+ years of experience in the electricity sector, with expertise in markets, technologies, and project finance • Head of Pöyry Energy Consulting, Asia-Pacific • Previously at SunEdison and Pacific Gas & Electric Company in Northern California • B.S. and M.S. in Mechanical Engineering, and M.B.A. from the University of California, Berkeley
Paul Tan 	• 14 years in management consulting covering energy/power, telecommunications, private equity, financial services, and others • Previously at top tier consulting firms The Boston Consulting Group and A.T. Kearney • MBA from the Melbourne Business School and a Bachelor of Engineering (1st Class Honors) from the University of Melbourne	**Sarut Chayanupatkul** 	• Responsible for electricity market modeling, market analysis, and financial modeling for power projects • M.Phil. in Energy Technologies from the University of Cambridge, M.S. in Materials Science & Engineering from Northwestern University, and B.S. in Materials Science and Engineering from the University of Illinois
Visoot Phongsathorn 	• 20+ years of experience within the Thai energy and regulatory sector • Strong track record in strategic management for M&A, planning, and performance monitoring • MBA from Texas Christian University and BSc in Mechanical Engineering (University of Notre Dame)	**Pongpatchara Pongpiriyakan** 	• Analyst at Pöyry's Bangkok office, with experience in several market modelling projects across Southeast Asia. • M.Sc. in International Management from Bocconi University in Italy and M.Sc. in International Economics from Sussex University in United Kingdom
Joost Siteur 	• 18+ years in power and renewable energy, incl. market analysis, investment management, financial advisory • Former investment officer at clean energy investment company in Thailand • MSc in Electrical Engineering (University of Twente, the Netherlands)	**Siripoom Warathanasin** 	• Analyst in Pöyry's Bangkok office, with experience in market modelling, renewables and energy storage analysis. • Previously worked for Chevron • M.S. in Energy Systems from Melbourne University

WORKSHOP ON ENERGY STORAGE INVESTMENT ANALYSIS

AWR Lloyd and Pöyry will be conducting an Energy Storage Investment Analysis 101 Workshop at Asia Power Week in Bangkok on September 21st.

This will be the third consecutive year that AWR Lloyd holds a "101" workshop focused on investment decision-making at POWER-GEN Asia.

The workshop will also be provided separately to participants of Running on Empty at a later date.

- The workshop is designed to provide a deep and practical understanding of commercial and investment analysis with regard to battery-based energy storage applications in select Asian markets.
- The objective is to enable participants to gain the knowledge and capabilities to understand and make investment decisions regarding potential projects.
- The heart of the workshop is a structured group skills session using a battery storage case study, a customized financial model and an investment analysis exercise

AWR Lloyd's New Energy Practice (NEP) has offered a workshop series on key new energy finance topics at Asia Power Week and for audiences elsewhere:

- Solar Investment Analysis 101 (2015)
- Project Finance in Conventional Power and Renewable Energy 101 (2016)
- Energy Storage Investment Analysis 101 (September 21, 2017)

For more information on Energy Storage Investment Analysis Workshop 101 at Asia Power Week go to:

http://www.asiapowerweek.com/en/conference/awrlloyd-workshop.html

AWR Lloyd

PÖYRY