Project Finance Modelling and Analysis of Renewable Energy, Storage and Hydrogen

COURSE OVERVIEW

Economic and Financial Analysis of Renewable Energy is a programme that teaches you to work through analysis of different renewable technologies using levelised cost of energy ("LCOE"), financing models and structures, resource analysis and contract analysis. This course has been revised over many years and includes more focus on case studies and storage. Teaching will use hands-on exercises where participants take turns sharing the screen and demonstrate how you can construct renewable analysis that incorporates a variety of economic and financing issues. The course put emphasis on practical techniques with current data. The outline below is separated into different sessions.

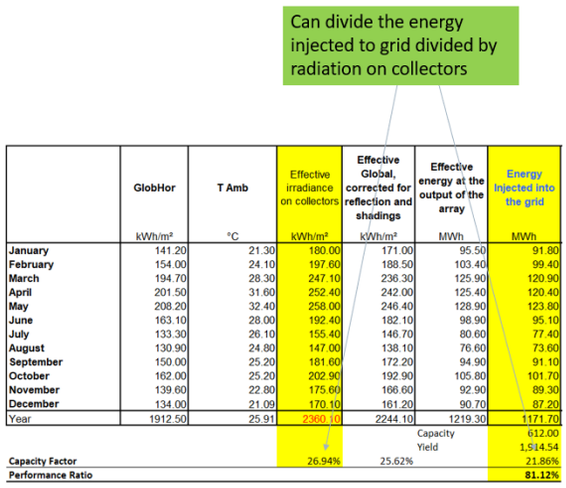
Objectives

- Discuss renewable energy issues in the context of selected case studies (Orsted and Jamica) to make the course more lively.

- Incorporate storage and battery analysis in analysis of renewable energy from an energy storage perspective and from an ancillary service point of view.

- Learn practical tools to analyse renewable energy including efficient tools to work with wind, hydro and solar data; creating flexible scenario and sensitivity analysis to evaluate resource risk, construction risk, O&M risk and debt structuring; developing techniques to resolve circular references related to funding debt and sculpting debt without copy and paste macros.

- Understand the implications of project finance features in the context of renewable energy (sculpting, debt funding, debt size, DSCR, DSRA, debt tenor, re-financing) on costs and equity returns from renewable energy.



	GlobHor	T Amb	Effective irradiance on collectors	Effective Global, corrected for reflection and shadings	Effective energy at the output of the array	Energy injected into the grid
	kWh/m²	°C	kWh/m²	kWh/m²	MWh	MWh
January	141.20	21.30	180.00	171.00	95.50	91.80
February	154.00	24.10	197.60	188.50	103.40	99.40
March	194.70	28.30	247.10	236.30	125.90	120.90
April	201.50	31.60	252.40	242.00	125.40	120.40
May	208.20	32.40	258.00	246.40	128.90	123.80
June	163.10	28.00	192.40	182.10	98.90	95.10
July	133.30	26.10	155.40	146.70	80.60	77.40
August	130.90	24.80	147.00	138.10	76.60	73.60
September	150.00	25.20	181.60	172.20	94.90	91.10
October	162.00	25.20	202.90	192.90	105.80	101.70
November	139.60	22.80	175.60	166.60	92.90	89.30
December	134.00	21.09	170.10	161.20	90.70	87.20
Year	1912.50	25.91	2360.10	2244.10	1219.30	1171.70
					Capacity	612.00
					Yield	1,914.54
Capacity Factor			26.94%	25.62%		21.86%
Performance Ratio						**81.12%**

- Develop efficient ways to quickly compute the levelised electricity cost of different technologies using carrying charge factors and alternative financial models.

- Work through resource assessments and compute probability of achieving different levels of production (P90, P75 etc.) using hands-on exercises for different types of projects in order to effectively review consulting studies.

- Create flexible and transparent financial models of renewable energy from A-Z that incorporate resource risk, financing structure, tax treatments, alternative pricing policies and other factors.

- Evaluate the economics of renewable energy (including ancillary services) in the context of merchant markets and review the structure of corporate PPA contracts.

Day 1 Morning: SOLAR AND VALUE DRIVERS, APPROPRIATE LCOE CALCULATION AND RECONCILIATION WITH FINANCIAL MODEL

- **Overview of Renewable and Storage Value Drivers with Focus on Solar Energy**
  - Value Drivers for Solar Energy
  - Calculation of LCOE from Value Drivers
  - Importance of Financing Cost and Target IRR
  - Carrying Charge Factor and PMT
  - Setting-up LCOE for Alternative Characteristics

- **Drivers of Value in Solar Energy Projects**
  - Resource Assessment, Yield and Capacity Factor from Satellite Data
  - Basic Concept of Performance Ratio
  - Evaluating Resources in Different Places and with Tracking
  - Module and Other Capital Costs
  - Operating and Maintenance Cost Categories and Benchmarking

- **Reconciling LCOE with Operating Section of Project Finance Model**
  - Setting up a Flexible Timeline
  - Modelling Operations with Degradation and Alternative Resource
  - Using Real and Nominal Prices
  - Computing Project Returns
  - Incorporating Debt

- **Economic Analysis of Intermittent Power Versus Dispatchable Power**
  - Understanding Short-Run versus Long-Run Costs
  - Incorporating Cost of Natural Gas in Cost Analysis
  - Comparing the Levelised Cost of Solar to the Variable Cost of Natural Gas
  - Comparing the Levelised Cost of Solar to Merchant Prices
  - Break-Even Cost of Storage in Comparing Solar to Dispatchable Sources

Day 1 Afternoon: ORSTED CASE STUDY AND CORPORATE VERSUS PROJECT FINANCE, RISK ANALYSIS, COST OF CAPITAL, POLITICAL UNCERTAINTY, CONTRACT STRUCTURE AND OTHER ISSUES

- **Background and Strategy**
  - Evolution from government owned utility company to aggressive player in offshore wind
  - Financial review of Orsted compared to stable utility companies.
  - Interpretation of return on investment for Orsted and Project Finance
  - Risk changes and movement from venture capital to boring and stable investment.

- **Problems with Development Projects**
  - Development Strategy in US and approach of FiD versus Financial Close in Project Finance
  - History of Project Finance and Importance of Due Diligence
  - Story of Write-off and Implications for Company Value
  - Ability to Evaluate Financial Issues with Simple (but difficult) Analysis

- **Contract Structure, Bidding and Resource History**
  - Different Contract Structures for Offshore and Onshore Wind
  - Merchant Price Exposure and Alternative Hedging Strategies
  - Interpretation of Wind Production Data Presented by Orsted
  - Summary and Discussion of Project Finance versus Corporate Finance

Day 2 Morning: WIND AND SOLAR AND ANALYSIS OF UNCERTAINTY

- **Introduction to Resource Uncertainty and Financing**
  - Concept of P50, P90, P99 etc. and Downside Cases for Financing
  - Case Study with Alternative Term Sheets
  - Understanding the Fundamental Mathematics of P50, P90, P99 and NORMINV Function
  - Application of P90 in Debt Sizing with Different Standard Deviation Assumptions in Simple Model

- **Case Study: Details of Solar Resource Analysis**
  - Reasons for Understanding Hour by Hour Resource Analysis
  - Interpreting PVSYST Output and Performance Ratio
  - Performance Ratio and Temperature with Hour-by-Hour Analysis
  - Uncertainty Estimates in PVSYST
  - Computing Uncertainty from Monthly Solar Variation
  - Addition of Uncertainty from Variance that is Independent.

- **Case Study: Wind Resource Analysis**
  - Power Curve and why Hour-by-Hour Wind Profiles Are Necessary
  - Estimates of Energy Production from Power Curves
  - Uncertainty in Wind and Uncertainty in Energy
  - One-year versus 10-year or 20-year P50, P90, P99
  - Computing Resource Uncertainty from Estimates of Standard Deviation

- **Understanding Renewable Term Sheet and Applying Concepts in Financial Model**

- Case Study on Banking Analysis
- Detailed Term Sheet Review
- Debt Sizing versus Estimates of IRR in Financial Models
- Sculpting with Different Resource Estimates
- Incorporating Debt to Capital Constraint versus DSCR Constraint

Day 2: Afternoon: PROJECT FINANCE, DEVELOPMENT FEES, RE-FINANCING AND ASSET SALE UPSIDES IN RENEWABLE ENERGY

- **Measurement of Value and Risk using Project Finance**
  - Debt Capacity and Changes in Risk for Different Projects
  - Problems with WACC in the Context of Renewable Energy with Changes in Risk
  - Changes in the Capital Structure with Project Financing
  - Debt Capacity for Hydro and Geothermal

- **Debt Capacity, Project Finance Terms and Financial Modelling**
  - Effects of Debt Service Coverage Constraint versus Debt to Capital Constraint in Sizing Debt
  - Debt Service Coverage Ratio Definition and Targets
  - Debt Tenor, Alternative Repayment Structure, Average Life
  - Credit Spreads and Target Credit Ratings in Project Finance
  - Debt Service Reserve and Maintenance Reserve
  - Covenants, Cash Flow Sweeps and Subordinated Debt

- **Development Costs, Risks and Fees in Renewable Projects**
  - Development Period and Costs in Wind and Solar Projects
  - Exploration Costs and Period in Geothermal Projects
  - Fees and Compensation for Development and Treatment of Development Fees when Computing
  - Equity IRR.
  - Probabilities of Proceeding Beyond Development
  - Compensation for Development Costs

- **Project Finance Valuation and Upside from Selling Assets in Renewable Energy**
  - Project IRR to Screen Projects
  - Equity IRR to Structure Projects
  - Minimum Required Equity IRR for Different Renewable Projects
  - Earned IRR from Selling Assets when Risk Declines
  - Modelling Alternative Estimates of Value with Alternative Risk Profile Changes
  - Modelling Different Holding Periods and Optimising IRR

- **Re-Financing for Renewable Projects**
  - Types of projects where re-financing is important – off-shore wind, wave energy, merchant hydro projects and geothermal.
  - Effects of re-financing on equity IRR and difficulty of defining the equity IRR with short-debt duration
  - Structuring project finance models and analysis to measure the effect of re-financing on equity returns.

Day 3 Morning: CASE STUDY OF SOLAR, WIND AND BATTERY STORAGE IN JAMICA WITH ALTERNATIVE USE CASES

- **Overview of Energy Costs and Potential Resources in the Country**
  - Review of Data and Resource Plan for Jamica
  - Illustration of Need for Batteries in Different cases with Ancillary Service, Storage and Other Needs
  - Levelised Cost of Alternatives and Illustration of Simple Solar Plus Battery Analysis

- **Working Through Alternative Use Cases for Battery Storage**
  - Battery Storage Duration and Cycles
  - Use of Batteries for Ancillary Services
  - Use of Batteries for Bulk Power Storage
  - Use of Batteries for Peaking Power Replacement
  - Other Uses of Batteries
  - Simulation of Batteries and Possibilities for Multiple Uses

- **Battery Characteristics and Economic Analysis**
  - Cost as a Function of both Storage Capacity and Charging/Discharging Capacity
  - Trend is Costs and Learning
  - Battery Life and Cycles
  - Operating and Maintenance
  - Battery Degradation and Effects on Cost
  - Round Trip Efficiency
    Depth of Discharge

- **Economic Analysis and Modelling of Battery Storage Plus Renewable Energy in Alternative Use Cases**
  - Definition of Alternative Use Cases and Alternative Strategies
  - Illustration of Need for Batteries in Different cases with Ancillary Service, Storage and Other Needs
  - Levelised Cost of Alternatives and Illustration of Simple Solar Plus Battery Analysis

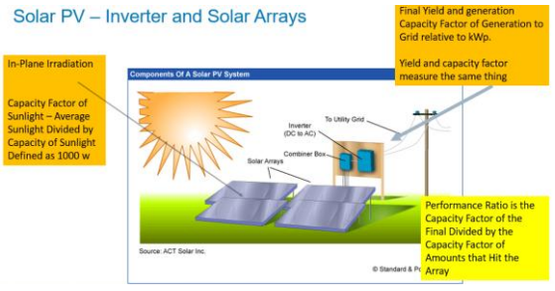
- Can Solar and Storage Compete with Other Technologies

- **Financial Analysis of Augmentation Expenditures**
  - Problem of Sculpting for Augmentation Expenditures
  - Reserve Account for Maintenance Costs and Cost of Cash Sleeping on the Balance Sheet
  - Alternative Case of Revolving Credit for Financing Expenditures and Impacts on Equity IRR.

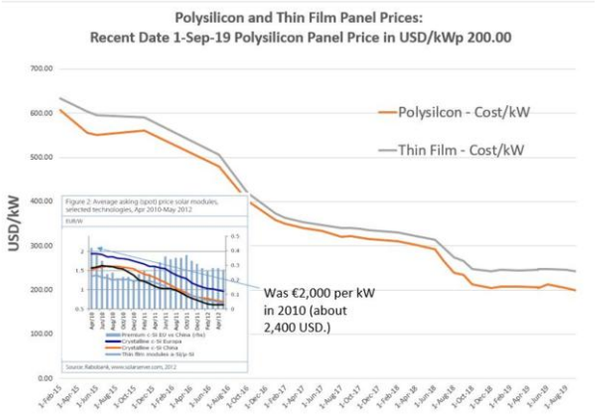
Day 3 Afternoon: PPA CONTRACT ANALYSIS FOR SOLAR PLUS BATTERY STORAGE

- **Overview of Key Concepts in PPA Contracts and History of PPAs**
  - Policy Objective of PPA Contracts – Controllable Risks, Incentives and Price/Cost of Capital Minimization
  - PPA Contracts for Renewable Energy and Performance Ratio Targets
  - PPA Contracts for Capacity Reserve and Firemen
  - General Approach for PPA Storage PPA Contracts

- **Contract Structuring in Renewable Project Finance**
  - Importance of EPC Contract in Different Projects (Off-Shore Wind and Hydro)
  - Performance Contracts in Solar Projects
  - Power Curve and Availability Guarantees in Solar and Wind Projects
  - O&M Contracts and Warranties
  - Insurance
  - Counterparty Risk in Different Projects



- **Nuanced and Ambiguous Issues with Storage PPA Contracts**
  - Fixed Capacity Over Time Versus Allowance for Degradation (Augmentation Cost)



  - Variable Energy Change and Allowance for Degradation
  - Cycles and Term of Contract
  - Basis for Capacity Change
  - Fixed and Variable O&M Costs

Day 4 Morning: RISK ANALYSIS AND INTEGRATED MODELLING OF STORAGE PLUS RENEWABLE

- **Risk Analysis Discussion and Debt Capacity**
  - Discussion of Differences in the Nature of Risks for On-Shore Wind (Wind Resource), Off-Shore Wind (Maintenance and Life Expectation), Solar (Small Risks become Big with High Leverage), Hydro (Capacity Factor and Merchant Price Risk), Wave (Refurbishment Timing), Geothermal (Development Probability).
  - Risk Matrix, Risk Classification and Risk Mitigation
  - Debt Capacity and Risk Analysis versus Risk Analysis in Corporate Finance

Modelling and Risk Presentation

  - Risk Evaluation Using Break-Even and Sensitivity Analysis
  - Risk Evaluation Using Scenario Analysis with Focus on the Manner in which Bankers Apply Downside Analysis
  - Measurement of Risk Using Structured Master Scenario Page in Excel Model with Options for Adding Sensitivity Analysis to Defined Scenarios
  - Risk Analysis Using Waterfall, Spider and Tornado Diagrams

- **Case Study of Banking Credit Analysis in Renewable Project Finance**
  - Background on Probability of Default and Loss Given Default
  - Definition and Calculation of DSCR
  - Use of DSCR in Base (P50 Cases) and Downside (P90, P95 Cases) in Determining Debt Capacity
  - Application of LLCR and PLCR

Day 4 Afternoon: HYDROGEN AND INTEGRATED ANALYSIS OF RENEWABLE, STORAGE AND AMMONIA PRODUCTION

  - General Theme: Use of Economic Analysis to Evaluate Different Business Strategies and Policy
  - Current Dichotomy Between Observed Costs and Theoretical Costs
  - Cost of Hydrogen produced from Natural Gas and From Electricity in Theory with Emissions Cost
  - Notion that Hydrogen has Low Efficiency because of Losses Compared to Battery

versus Measuring Effectiveness with Levelised Cost.
- Problem of Transport of Any Gas – Compression, Volume and Cost of Liquification and Re-gasification. Can the
- Economies of Scale in Production of Hydrogen and Modularisation
- Ultimate Storage Question – Can Effectively Store Solar and Wind in Hydrogen Tanks for a Long Time versus Storing Electricity in Car Batteries or Centralised Batteries
- Cost of Mobility with Fuel Cells Versus Batteries in the Long-Run. Fuel Cell per kW and Battery Cost per kWh.
- Hydrogen and Ammonia – Air Separator and Use of Ammonia as Fuel or Fertilizer
- Energy Value of Hydrogen and Ammonia Compared to Natural Gas, Oil and Coal in terms of Density.
- Natural Gas Cost and Electricity and Use of Merchant Prices to Pay for Electrolyzer

Levelised Cost of Upstream Hydrogen Production

- Importance of Understanding Levelised Cost Drivers including Capital Cost, Lifetime of Equipment, Inflation, Cost of Capital, Degradation and Efficiency
- Difference Between LCOH and Renewable LCOE – Importance of Efficiency in Conversion of Natural Gas or Electricity
- Challenges – Degradation on Energy Used and Different Lifetime of Stack Versus Other Equipment
- Levelised Cost Comparison of SMR and Electrolyzer Including Compression
- Modelling the Cost of Alternative Strategies Including Only Running Electrolyzer During Solar Production Periods
- Case Studies with Different Merchant Markets where Purchase Energy at Low Prices

Downstream Cost of Hydrogen Including Compression, Storage, Distribution and Dispensing

- Added Costs of Hydrogen – Compression, Storage, Transport, and Dispensing
- Hydrogen Compared to Downstream Cost of Petrol and Diesel with and Without Refining Margins
- Hydrogen Compared to Natural Gas Distribution, Transmission and Liquification Costs
- Evaluation of the Costs of Hydrogen Downstream Items Using Different Drivers Including Distance, Time of Storage, Pressure for Compression and Speed of Dispensing
- Distribution Strategies and Revised Comparison of Electrolyzer with SMR Using Alternative Storage and Distribution Strategies
- Methods of Summing Costs

Total Cost of Ownership (Levelised Cost) of Alternative Transport

- Case of Trucks and Buses – Accounting for Efficiency, Life and Use
- Illustration of Battery Versus Internal Combustion
- Evaluation of Fundamental Cost Differences Between Battery Vehicle Cost and Hydrogen Cost Including Fuel Cell Versus Battery, Cost of Hydrogen Versus Cost of Electricity
- Computing the Total Cost of Operation Including Alternative Petrol Costs, Battery Lives and Hydrogen Costs
- Calculation of Required Premium of Hydrogen Relative to Other Transport to Make Hydrogen Economic

Case Study of the Cost of Producing Green Hydrogen

- Including the Cost of Nitrogen with Air Separator
- Energy Characteristics of Ammonia versus Hydrogen and Natural Gas
- Transport of Ammonia Versus Natural Gas and Hydrogen
- Production of Energy for Shipping with Ammonia and Break-even with Electricity