

Fundamentals of Wind Farm Development & Financing

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Course Structure

The Course is made up of 10 core modules:

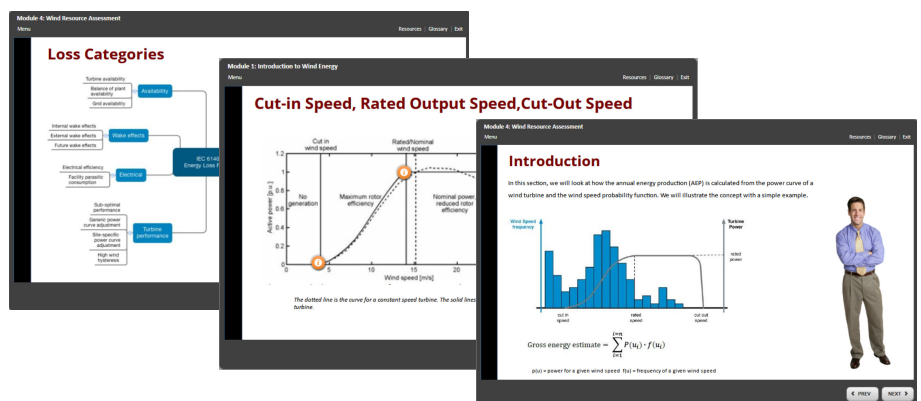
- ▶ Introduction to Wind Energy
- ▶ Wind Power Technology
- ▶ Economic Incentive Schemes
- ▶ Wind Resource Assessment
- ▶ Land Leases and Permitting
- ▶ The Financing Decision
- ▶ Power Purchase Agreements
- ▶ Construction Contracts
- ▶ O & M Agreements
- ▶ Raising Finance

Each module comes with a workbook, audio-visual content and other resources. Quizzes are used right through the modules to allow learners to test their understanding at each step of the learning process.

Who should take this Course?

- ▶ Project Sponsors and Developers
- ▶ Equity Investors
- ▶ Lenders to wind energy projects
- ▶ Law firms engaged in wind farm projects
- ▶ Investment Bankers
- ▶ Fund Managers
- ▶ Project Finance Consultants
- ▶ ECA's & Development Banks
- ▶ EPC Contractors
- ▶ Turbine Manufacturers

"Fundamentals of Wind Farm Development and Financing" comprehensively covers essential technical, commercial and financial knowledge required by those engaged in the development and financing of wind farms.



I have yet to come across a course in the market that comprehensively covers all three core areas of essential knowledge (technical, commercial and financial) required for anyone involved in the development and financing of wind farms. Most courses (depending on the background of the author) tend to favour one of the areas, leaving the learner to look elsewhere for the complete picture. This course brings together all these three core knowledge areas in a clear and concise manner. Completing this course will leave the learner with a thorough understanding of the technology and its drivers, the commercial trade-offs and the challenges that need to be overcome to conclude a successful financing. Over 10 modules, this course systematically builds essential knowledge - technical, commercial and financial, leaving the learner well equipped to engage with this exciting sector as a serious practitioner.

This course has been developed with the assistance of professionals involved in the development and financing of wind farms and includes inputs from sponsors, lenders and law firms. It is designed for anyone who is looking to become an active participant in this exciting and rapidly growing sector of the renewable energy industry.

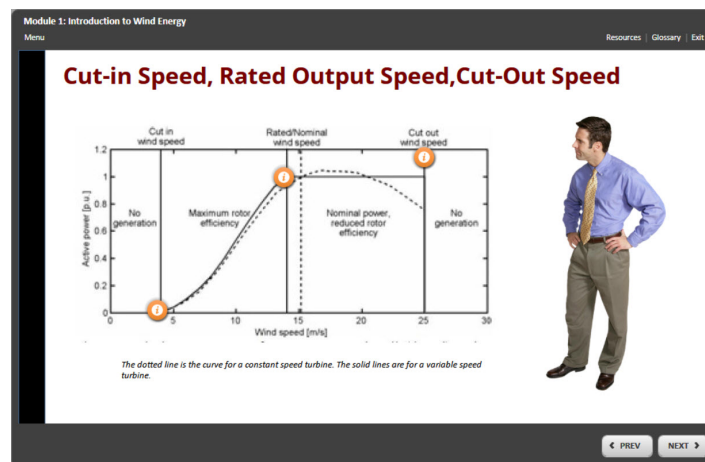
It is my sincere hope that this course will prove to be a stimulating, efficient and effective learning experience.

Atul Ahuja

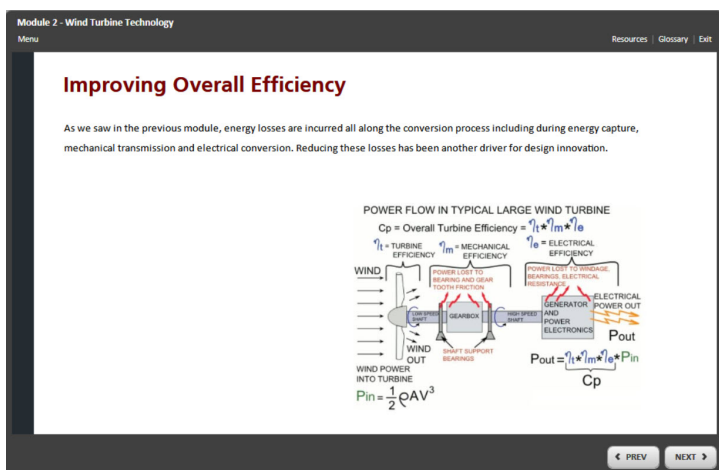
01 Introduction to Wind Energy

Objectives: The objective of this module is to introduce the learner to the world of wind energy. It provides the learner with the context required to understand the trajectory along which this sector is developing.

Topics Covered: History of wind energy; how does a wind turbine work?; differences between on-shore and off-shore wind farms; is wind power competitive with other sources of energy?; current state of play around the world; key trends & challenges in the development of wind energy.



02 Wind Power Technology



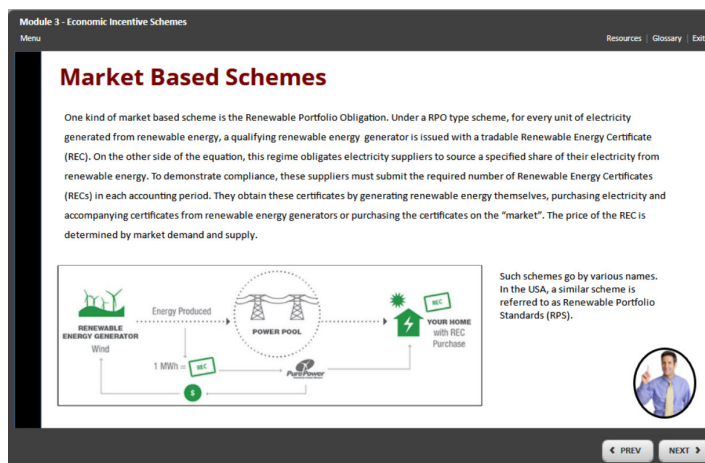
Objectives: The objective of this module is to provide the learner with a thorough understanding of all the different components of wind power technology, the reasons for their adaptation and likely future trends.

Topics Covered: Key design considerations; design innovation and trends in relation to rotor size, rotor height, drive trains, number of blades, orientation of blades, tower designs for on-shore and off-shore wind farms, control mechanisms etc.

03 Economic Incentive Schemes

Objectives: The objective of this module is to introduce the learner to various economic incentive schemes that have been deployed around the world to support the development of wind energy and highlight their pros and cons.

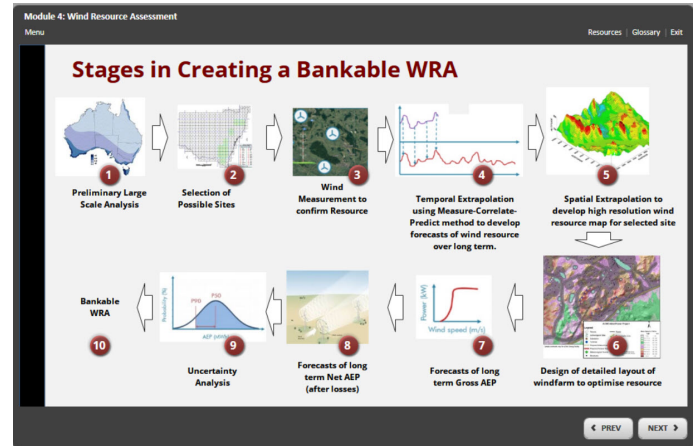
Topics Covered: Price based schemes such as "feed in tariffs" and "feed in premiums"; volume based schemes including capacity tenders and market-based schemes such as ROC, REC's etc.; tax based schemes e.g. PTC's, ITC's and accelerated depreciation; pros and cons of various schemes and stage of market development at which different schemes are appropriate.



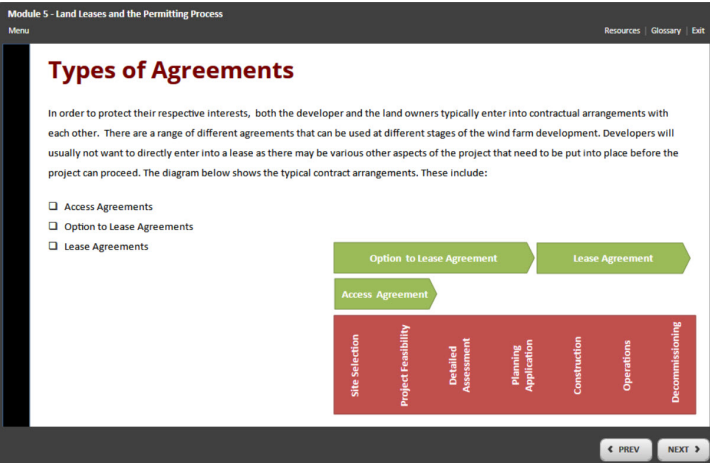
04 Wind Resource Assessment

Objectives: The objective of this module is to provide the learner with a comprehensive understanding of the science and art of wind resource assessment as well as its limits and pitfalls.

Topics Covered: Requirements for creating a bankable wind resource assessment (WRA); stages of the wind resource assessment process including large scale analysis, site selection, wind measurement at site, long term extrapolation, horizontal and vertical extrapolation, micrositing of turbines, estimation of gross AEP, estimation of Net AEP, uncertainty analysis.



05 Land Leases and the Permitting Process



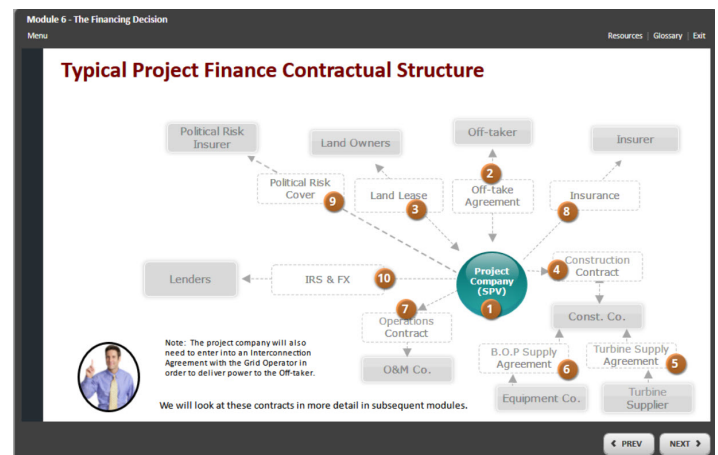
Objectives: The objective of this module is to provide the learner with an understanding of the different types of arrangements commonly entered into with land owners as well as the process and risks involved in the approval and permitting process.

Topics Covered: Access agreements; option to lease agreements; lease agreements; key commercial terms found in lease agreements; the permitting and approval process and roles played by federal, state and local authorities; When things go wrong - Cape Cod Case Study.

06 The Financing Decision

Objectives: The objective of this module is to introduce the learner to the various financing options available to different types of developers and the impact the financing decision can have on the development process.

Topics Covered: Corporate loans, project finance and tax based finance (partnership flips, sale and leaseback); pros and cons of different types of financing. Impact of financing decision on development process and contractual arrangements.



07 Power Purchase Agreements

Objectives: The objective of this module is to introduce the learner to the different types of power purchase agreements and the key commercial terms found in these agreements.

Topics Covered: Structure of the electricity supply industry, physical and virtual "Power Purchase Agreements"; key commercial terms found in a typical power purchase agreement and requirements for making the project bankable on a non-recourse/project finance basis.

Module 7 - Power Purchase Agreements

Menu Resources Glossary Exit

PPA Commercial Terms

- Term of PPA
- Facility Description
- Interconnection & Transmission
- Early Termination
- Milestones
- Conditions for Facility Completion
- Consequences of Delay
- Obligations to Sell and Purchase Output
- Environmental Attributes
- Payment for Energy Output
- Metering
- Billing and Payment
- Curtailment
- Force Majeure
- Change in Law
- Operations & Maintenance
- Assignment & Transfer Restrictions
- Insurance
- Events of Default
- Termination
- Representations & Warranties
- Indemnities and Limits on Liability
- Dispute Resolution & Choice of Law
- Other Clauses

Term

PPAs are long-term agreements. The term of a PPA is often documented as a set number of years (e.g. 20 years) from the date of "Completion".

Completion is the date on which the Seller meets a number of conditions that are specified in the PPA. Typically these conditions are those that are necessary for the Seller to demonstrate completion of construction and the capacity to deliver the contracted wind energy to the Off-taker in compliance with all codes, permits and standards. The PPA may provide the Off-taker an option to extend the contract beyond the initial term.

Can you guess what Lenders might look for in relation to the term of the Power Purchase Agreement? Click on the instructor icon to find out.

PREV NEXT

08 Construction Contracts

Module 8 - Construction Contracts

Menu Resources Glossary Exit

Types of Construction Contracts

Developers have a number of options on how to structure the construction contract. Three of the key options are shown below. We will look at the pros and cons of each in the next few slides.

- Separate Contracts for Wind Turbines and Balance of Plant**
 - Project Company contracts separately with the Turbine Supplier and Balance of Plant contractor
 - BoP is sometimes broken down into civil and electrical works
 - Each contractor is only liable for non-performance of its own contract
- EPC Wrap**
 - Project Company enters into a single contract with Turbine Supplier or BoP Contractor (EPC Contractor). The EPC Contractor enters into subcontracts with the other contractor.
 - Project Company deals directly only with the EPC Contractor who is the single point of responsibility and is solely liable for any damages.
- Contract with Unincorporated JV**
 - Project Company signs one contract with both the Turbine Supplier and BoP Contractor.
 - Turbine Supplier and BoP Contractor have joint and several liability under the contractor allowing Project Company to pursue either/both for damages

PREV NEXT

Objectives: The objective of this module is to provide the learner with a thorough understanding of the different types of construction arrangements used in the construction of on-shore and off-shore wind farms.

Topics Covered: On-shore construction contracts; key commercial terms found in an EPC Contract; off-shore construction contracts and why these contractual arrangements are different; requirements for making the project bankable on a non-recourse/project finance basis.

09 O&M Contracts

Objectives: The objective of this module is to introduce the learner to the different options available for operations and maintenance of the wind farm and their pros and cons.

Topics Covered: Different options available in relation to the operations and maintenance function; key commercial terms found in operations and maintenance Contracts; requirements for making the project bankable on a non-recourse/project finance basis.

Module 9 - Operations and Maintenance Contracts

Menu Resources Glossary Exit

O&M Contract Commercial Terms

- Term of Contract
- Scope of Services
- Owner's Obligations
- Relief Events
- Spare Parts & Warranties
- Availability Guarantee
- Liquidated Damages
- Security
- Fees
- Change in Law
- Force Majeure
- Change of Ownership
- Regulatory Compliance
- Events of Default & Termination
- Intellectual Property Rights

Term of Contract

A typical wind farm has a life of 20 years. If the project is to be financed on a non-recourse basis, lenders typically require a fixed price O&M Agreement to stretch out for most if not the full term of the debt which could be 15+ years. This is easier to achieve for on-shore wind farms. O&M activities are more complex for off-shore wind farms there is greater uncertainty around maintenance costs over the long term. This can make it more difficult to achieve a single fixed price contract for the duration of the debt.

At the end of the initial term, the Owner can usually

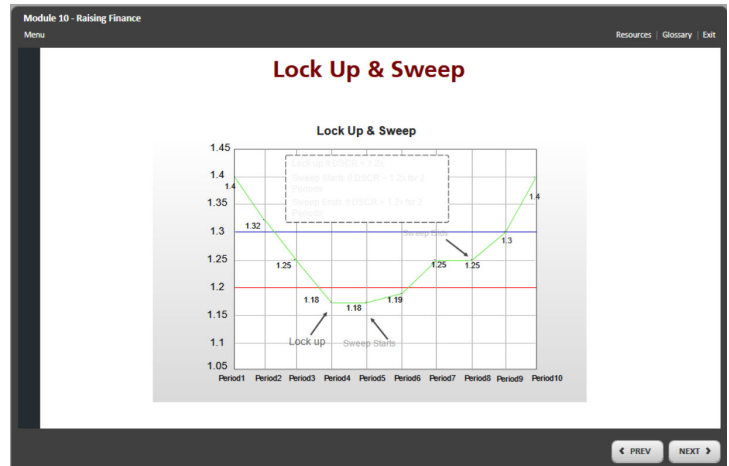
- negotiate an extension;
- appoint a third party O&M Service provider; or
- where the Sponsor is adequately resourced, carry out the O&M function in-house with specialist support from other third parties as needed.

PREV NEXT

10 Raising Finance

Objectives: The objective of this module is to provide the learner with a thorough understanding of all aspects of raising finance on a project/ non-recourse basis including risk mitigation, debt sizing, debt structuring etc.

Topics Covered: Project risks, creating bankable cashflow, lender due diligence, project finance loan package, debt metrics, debt sizing, sources of finance, Gemini financing case study, financial adviser and the financing process, key commercial terms found in a project finance loan agreement.



Example: Calculating AEP

Once the power output at different wind speeds is known, the annual energy production can be calculated by:

- multiplying the power at a given wind speed by the number of hours in a year for which the wind blows at that speed.
- adding up the energy production at each wind speed.

These calculations are shown in the table on the right.

Speed (m/s)	Power (kW)	hrs/yr	output (kWh/yr)
0	0	450	-
1	0	400	-
2	0	700	-
3	27	1200	28,400
4	81	750	60,750
5	180	1200	216,000
6	320	900	288,000
7	600	640	384,000
8	900	220	198,000
9	1274	450	573,480
10	1533	300	459,900
11	1883	200	376,600
12	1960	150	294,000
13	1990	250	497,500
14	1998	300	599,370
15	2000	100	199,990
16	2000	50	100,000

Step 1 – Calculate Revenues based on P90 Energy Output

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Energy Output (P50)	950	950	950	950	950	950	950	950
Energy Output (P90)	808	808	808	808	808	808	808	808
Energy Output (1 Year, P99)	785	785	785	785	785	785	785	785
Selected Energy Output (P90)	808	808	808	808	808	808	808	808
Availability Losses	5%	5%	5%	5%	5%	5%	5%	5%
Electrical Losses	2%	2%	2%	2%	2%	2%	2%	2%
Net Output	751	751	751	751	751	751	751	751
Electricity Price	87.5	89	91	93	95	97	99	101
Electricity Revenues (Euros)	65,710	67,025	68,365	69,732	71,127	72,549	74,000	75,480

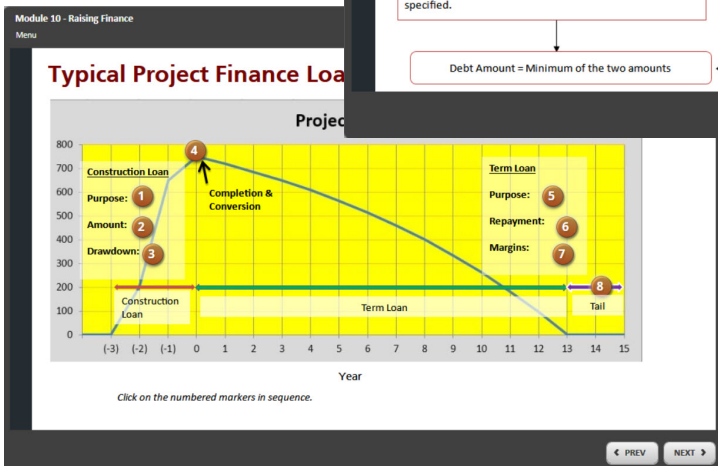
Debt Sizing

Constraint	Requirement
DSCR	>= [xxx] e.g. 1.30x based on P90 10 Yr wind forecasts
DSCR	>= 1.0x based on 1 Year P99 forecasts
LLCR	>= [xxx] e.g. 1.4x based on P90 10 Yr wind forecasts
PLCR	>= [xxx] e.g. 1.5x based on P90 10 Yr wind forecasts

The Debt Amount is determined as the amount that satisfies all specified ratio constraints. Not all the above ratios may be specified by Lenders. Often only the DSCR ratios are specified.

Debt Amount = Minimum of the two amounts

Category	Item
Gearing Constraint	Construction Costs (including starting spares)
	+ Interest and commitment fees during construction
	+ Bank Fees (Upfront fees, Agency Fees etc.)
	+ O&M Costs during construction (if any)
Total Investment Costs	+ Taxes during construction (if any)
	+ Funding of reserves
	= Total Investment Costs
Debt Amount	x Debt Amount
	= Debt Amount



Logistical Challenges of Constructing On-Shore Wind Farms

[WATCH] Remarkable maneuver of trail... Watch later Share

This video is a link to a third party website. If you are unable to view the video please inform your instructor. You can also try viewing the video at <https://youtu.be/rvvMn2MED0>

Top 10 reasons to buy this Course

1. Practitioner oriented course covering technical, commercial and financial aspects of wind farm development and financing.
2. Available anytime, anywhere, on demand. No loss of productivity/ days out of office.
3. Fantastic value for money; volume discounts and savings on travel/accommodation make it very cost effective.
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Module 4: Wind Resource Assessment

Loss Categories

Availability: Turbine availability, Balance of plant availability, Grid availability

Wake effects: Internal wake effects, External wake effects, Future wake effects

Electrical: Electrical efficiency, Facility periodic consumption

Turbine performance: Sub-optimal performance, Generic power curve adjustment, Site-specific power curve adjustment, High wind turbines

IEC 61400-15 Energy Loss Framework

Curtailments & operational strategy: Grid curtailment, Directional curtailment / wind sector management, Environmental permit curtailment, Curtailment strategies

Environments: Long-term degradation, Environmental disturbance, Exposure

Expressing Uncertainty

The overall uncertainty is expressed in the form "P-Factors" which are derived from a normal probability function which uses as inputs:

Mean (μ): This is equal to the Net AEP demand after deducting the losses from the uncertainty (as calculated on the...)

that has a "X" probability of being... probability of being... probability of being

Normal distribution curve showing P50, P68, P95 and standard deviations (σ).

$P50 = \mu$
 $P75 = \mu - 0.67\sigma$
 $P90 = \mu - 1.28\sigma$
 $P95 = \mu - 1.96\sigma$

Module 4: Wind Resource Assessment

Factors causing Uncertainty

The IEC 61400-15 working group has proposed the uncertainty categories shown below.

Other: Availability, Wake Effects, Electrical losses, Turbine Performance, Environmental, Curtailment & operational strategies

Plant performance: Wind Speed, Wind Direction, Turbine meteorological measurements

Vertical atmospheric: Turbine meteorological measurements

Model inputs: Model stress, Model Approximation

Site measurement: Wind speed measurement, Wind direction measurement, Further Meteorological Measurements, Secondary Measurement Uncertainties

Historic wind resource: Long-term Period, Reference Site, Correlation, Wind Speed Distribution, Wind Rose, On-site Data Synthesis, Measured data representativeness

Project lifetime variability: Project Lifetime Resource, Climate Change, Other variability Recursions

Four Quadrant Project Finance

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