



Wind Farm Asset Management and ISO 55001

Maximising the Return on Wind
Energy Investments



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Wind Farm Asset Management and ISO 55001

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Report prepared for SEAI by:
ESS Ltd. - The Woodhouse Partnership Ltd



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Sustainable Energy Authority of Ireland

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Foreword

As the installed wind energy capacity in Ireland continues to grow, the balance of activity in the sector will shift from new wind farm development, to managing existing wind farms. In coming to maturity, it will be important that the wind industry adopts best practices to maximise the return on the capital employed in the sector. The Sustainable Energy Authority of Ireland (SEAI) recognises that the maturing industry may require SEAI support for the adoption of best practice in the evolving sector. It is particularly important, for achieving and maintaining the trajectory to meet national targets and avoiding fines or purchase of compliance, that existing wind farms maintain their maximum performance throughout their operational life.

Wind Energy Ireland (WEI) instituted a new Asset Management Committee to support the industry in its evolving form. SEAI engaged with the WEI Asset Management Committee to assist it in establishing its role in providing robust guidance and support in all areas of asset management to the industry.

During 2019 SEAI funded an initial scoping study on Wind Farm Asset Management to assist the WEI Asset Management Committee in formulating its strategy. A key finding of this study was that the adoption of the ISO 55001 standard, on Asset Management, would be instrumental in driving good practice throughout the life cycle of a wind farm.

The ISO 55001 standard provides the conceptual frameworks which underpin the development of a company asset management strategy. It is also coherent with other ISO standards including ISO 14001 on Environmental Management and ISO 45001 on Health and Safety. The principles of the standard may be practically applied irrespective of whether a company is seeking formal accreditation or not.

The asset management approach is a strategic, organisation-driven, initiative to maximise the return on investment across projects' life cycles. It inherently requires the commitment of senior management to be successfully implemented within a company's strategy. It is not solely the responsibility of the operations function but must span the company's whole value chain.

The SEAI and the WEI Asset Management Committee collaborated during 2020 to develop the scope of a SEAI funded study on adopting the ISO 55001 asset management standard within the wind industry. WEI Asset Management Committee members provided a considerable contribution in scoping the study, holding workshops to engage members, both before and during the study, reviewing and selecting tenders, reviewing and providing feedback on the study reports and organising follow-up training courses.

SEAI thank the WEI Asset Management Committee and members for their support in completing this report.

Kerrie Sheehan

Head of Department, Research and Technology
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1 Introduction and Background

1.1 Introduction

The wind energy sector faces continued growing demand yet ever-tightening budgets, increasing regulatory pressures and more complex operating environments. So, it is essential to optimise the management of wind assets, over their whole life cycles, with clearer, more consistent standards that ensure performance, resilience and value.

Adopting an “Asset Management” approach has demonstrated, in many capital-intensive sectors, how this can be achieved. Such an approach, consistently applied, can also yield wider benefits for the whole industry - such as providing a standard of assurance and improving its reputation. The wind sector, however, has yet to embrace the idea of asset management in a rigorous manner. As the installed base of wind energy in Ireland grows and the main arena of activity shifts from development to operation, implementing an Asset Management standard could ensure both that new projects are delivered safely and efficiently, and that existing infrastructure can be managed optimally.

The ISO, the International Organisation for Standardization, develop and publish international standards. Each standard is agreed by a panel of international experts describing best practices, covering a wide range of activities. ISO 55000 provides an overview of the subject of asset management and the standard terms and definitions, while ISO 55001 specifies the requirements for an integrated, effective management system for asset management.

ISO 55001 is a widely used Asset Management standard and, whilst it is not tailor-made for the wind industry, it provides a very suitable structured approach to manage the life cycles of wind assets. It is also designed to align and integrate with other ISO standards, such as ISO 45001 for occupational health and safety, or ISO 14001 for environmental management.

SEAI has contracted ESS Ltd, in partnership with The Woodhouse Partnership Ltd (TWPL), to produce guidance on the implementation of Asset Management and the ISO 55000 suite of standards in the wind generation sector in Ireland. This will help industry members to become familiar with the subject and provide a clear pathway towards meeting the requirements for a competent asset management system, as defined in ISO 55001.

1.2 Scope of the Guidance Document

The guidance document is intended to provide guidance on Asset Management in general and ISO 55001, for organisations in the wind sector in Ireland. It is designed to be useful to all organisations, irrespective of size or role within the sector. Asset management methods, and the use of the standard, are scalable and provide value to all wind generation organisations in Ireland: whether seeking to implement a fully ISO 55001-conforming Asset Management System or simply wanting to understand and implement selected elements of the standard. This document:

- Provides guidance on the full life cycle of a wind farm project, covering site identification through to decommissioning or repowering, including options such as project acquisition, refinancing and divestment.
- Is applicable to all wind farm assets, including the site, civil works, electrical installation, and control system.
- Reflects input from WEI members, gathered through workshops, interviews and questionnaires etc.
- Outlines the benefits to WEI members and the wind industry of implementing a standardised asset management approach, and ISO 55001.
- Presents relevant case studies covering:
 - Benefits of good asset management,
 - Consequences of failures in asset management and
 - ISO 55001 being used in the wind industry.

1.3 What is Asset Management

ISO 55000¹ defines an asset as an “**item, thing or entity that has potential or actual value to an organisation**”. This implies that assets exist to provide value to the organisation and its stakeholders. ISO 55000 goes on to define *Asset Management* as:

The coordinated activity of an organisation to realise value from assets

Realising value from assets involves delivering organisational objectives in the best possible (best value) way. This will typically involve finding the best compromise between conflicting elements such as cost, risk, and performance, over an appropriate time horizon and within any absolute, non-negotiable constraints. Of course, such aspirations are nothing new. Human beings have been managing (physical) assets from the stone age when our ancestors first started manufacturing tools and building shelters. However, the *professional discipline* of Asset Management is a much more recent concept which started to take root in the 1980s.

If humans have been managing assets for such a long time, what is the difference between Managing Assets and the modern understanding of Asset Management?

Managing Assets mainly focusses on the hands-on activities associated with the operation and maintenance of the assets during their life cycles. It is characterised by:

- Interventions driven by technical need, irrespective of business priorities, economics, or value considerations.
- Pride in technical standards, the quality of work and the efficiency of operations and work management, but not necessarily considering whether the activity is the right thing to do in the first place.
- Silos or strongly departmental structured organisations working with independent budgets and goals, often leading to conflicting priorities and resourcing demands.
- Short-termism and cost focussed, for example cutting maintenance to reduce expenditure but potentially introducing risks or shortening the asset's life.

Whereas *Asset Management* is characterised by:

- A focus on the needs of the organisation and how Asset Management can help to deliver them.
- Cross-functional teamworking, with shared goals and recognised collaborative delivery of organisational objectives.
- Considering long term effects and whole asset life cycles in investments, operations and maintenance decision-making, assuring sustainability
- Managing risk proactively and including risk and uncertainties within the decision-making
- **Establishing a number of other key 'enablers' such leadership, strategic planning, resource management, competencies management, information management and continual improvement as part of a systematic management system.**

1.3.1 Asset Management Fundamentals

ISO 55000 identifies that Asset Management is based on a set of four fundamentals, these are shown in Figure 1.



Figure 1 Fundamental of Asset Management

These are briefly explained thus:

- Value

Asset Management is concerned with the value that an asset can bring to the organisation, not simply the needs of the asset itself. Value can be either tangible or intangible and be financial or non-financial. In the context of the wind sector in Ireland, tangible value would include the revenue produced from selling energy, intangible value could be seen to include a good reputation amongst the communities in which wind farms are located and, in broader society, through the implicit reduction in carbon facilitated by wind generation.

- Alignment

Alignment is concerned with translating, in a transparent and evident manner, how organisational objectives are manifested in strategic and operational plans, in technical and financial decisions, resourcing and delivery activities during all stages of the asset life cycles. Alignment needs to be both vertical and horizontal.

Vertical alignment implies that is that there should be an unbroken thread running from the top management (and strategic direction) through all levels of the organisation, including day-to-day operational staff and their activities. This concept is shown in Figure 2. A corresponding **'bottom-up' alignment is also needed, to ensure that** operational realities (asset capabilities, risks, opportunities etc) are rolled upward into planning, objectives and strategies.



Figure 2 Vertical Alignment

Horizontal alignment is characterised by the collaborations between functions and departments responsible for different Asset Management activities, to deliver the best value combined outcomes. This involves breaking down the boundaries between departmental silos and establishing shared purpose and measures of success. An example of horizontal alignment in the context of wind generation is the real consideration (including strategy development, optioneering and acceptance testing) of operability, maintainability, reliability, logistics and asset life

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cycles during the design phase and the handling of any subsequent changes (e.g. technical modifications or changing commercial context).

- Leadership

The importance of good leadership is clear in all organisations not only those who are involved in Asset Management. However, leadership is specifically critical to good Asset Management, to ensure:

- **Clarity of objectives, priorities and risk 'appetite'.**
- Staff, contractors and stakeholders understand these, and collaborate for their delivery.
- Clearly defined roles, responsibilities and authorities.
- Resources, skills and funding are provided to deliver the required outcomes.

- Assurance

Assurance is concerned with assuring that there is effective governance, coordination, control to establish and maintain the confidence of stakeholders.

This assurance is needed for:

- The Assets
 - Providing confidence that the assets will reliably deliver the expected performance e.g., a turbine will generate the required power, based on wind conditions, reliability and sustainability.
- Asset (life cycle) activities
 - The design, construction, procurement, operations, maintenance, decommissioning etc. are being planned and executed to a good standard, in a controlled and coordinated manner. i.e., things are being done right.
- The (Asset) Management System.
 - The systems of governance, resourcing, planning, resources and competency management, risk management, information management, performance monitoring and continual improvement all combine to ensure that maximum value is being realised in a sustainable manner. i.e., the right things are being done, for the right reasons, at the right time - and that learning and improvement is an integral part of this.

1.3.2 Asset Life Cycle

Good practice Asset Management requires a whole life view of the assets. PAS 55-1: 2008² identifies four phases of an assets life for which activities are required. These are:

- Creation, acquisition or enhancement of assets
- Utilization or operation of assets
- Maintenance of assets
- End of life: decommissioning and/or disposal of assets.

These phases and specific activities are shown in Figure 3.

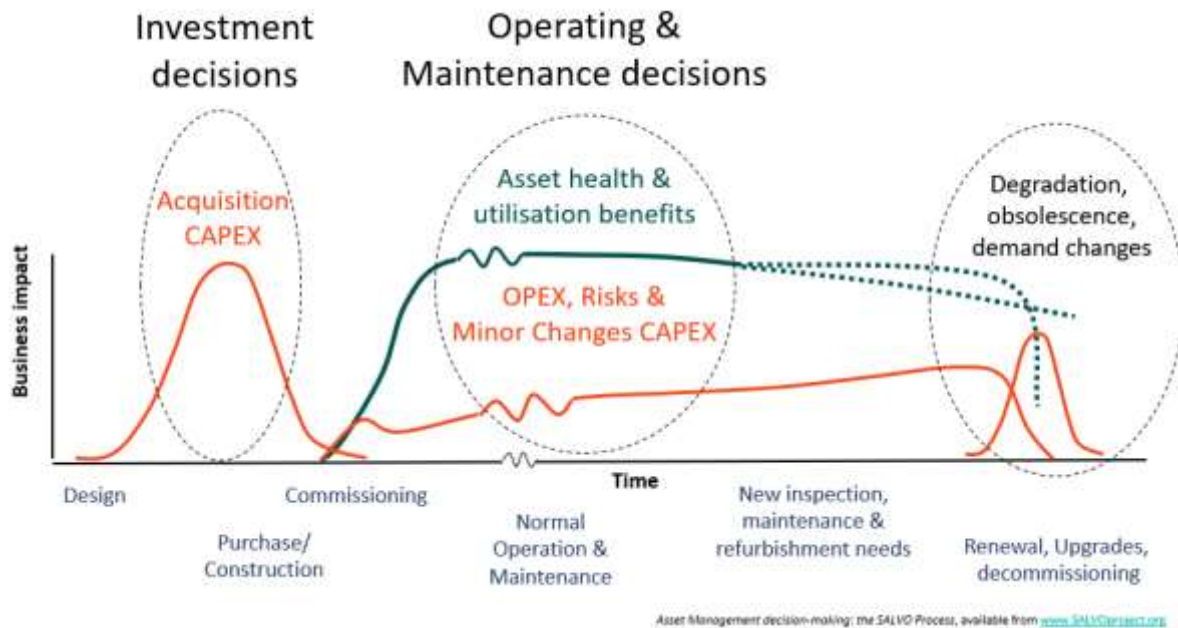


Figure 3 Asset Life Cycle: Characteristics

In Figure 3, the red curve represents expenditures and the green curves represent the benefits accrued from **utilising the assets over the phases of the asset's life**. The Creation and Acquisition Phase can represent a large, high intensity Capital expenditure. As the asset moves into the Operation & Maintenance Phase, benefits are realised, **with a positive business impact (greater than the associated operating costs, risks and other 'during life' expenditures)**. As the asset ages, degrades, or is subject to changing context (e.g. demand, economics, regulation, technology overtake), a steady state of operation and maintenance may no longer be possible. The risk of life-curtailling events (major failure), or the progressive decline in performance, or the merits of renewal/upgrade need to be considered and may introduce new capital expenditure (and resetting the clock, or repurposing, or decommissioning).

These phases do not occur in isolation from each other. The decisions made in one phase can seriously impact the performance, costs, risks and sustainability of subsequent phases. Decisions made in the design and procurement stage have a profound impact over the total life cycle and value potential – much greater than just the procurement or construction costs incurred in this phase. It is variously reported that 80% of total life cycle costs are determined at the design stage, yet only 20% of such life cycle costs are represented by the initial capital investment.

Consider a new windfarm project, there are many decisions to be made at the design stage involving alternative design options. The Capital cost implications of the decisions can impact the financial viability of the project and there may be pressure to reduce the Capital cost such that the windfarm is projected to deliver the expected return on investment. For example, the cables connecting the turbines to the substation could be either direct buried or laid in cable ducts, with direct buried being the cheaper option. This option, if chosen, however would increase the risk of cable faults in the operation and maintenance phase and may even bring forward the end of life or asset replacement phase. Once the design is chosen there is little that can be done to improve the inherent reliability of the cable system. If the financial modelling does consider the **probability of cable faults over cable's life, including** how that changes with time, and the cost of repairing the cable including lost productivity, and compares this calculation to that for the cable ducts, then the decision might be optimal. However, it is unlikely that this done currently and as a result, windfarms are risk of not delivering required availability and revenue, over their life, due to decisions made at design and construction stages.

Now consider operations and maintenance activities, there is a relationship between these and the end-of-life phase. Organisations could choose to maintain these frequently, which would increase maintenance costs and lost energy due to planned down time, in the hope that this would extend the life of the asset, whereas others could seek to minimise costs by reducing maintenance which would in turn foreshorten the assets life. Both of these approaches COULD deliver maximum value however, unless organisations consider the long term impacts of short term decisions, they risk not delivering optimal value.

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The concept is particularly relevant to the wind sector in Ireland where operations and maintenance stakeholders are at best consulted at the design stage. However, they have no decision-making authority and there is a risk that decisions are made to suit the financial model rather than achieve optimal value. Therefore, full life cycle projections should be made at creation and acquisition including probabilistic cashflow analysis for risks and asset performance overtime.

It is the case that some organisations in the wind sector do not intend to retain wind farm assets much beyond the initial years of operation but have the strategy to sell the assets. However, the organisation purchasing these assets must conduct due diligence research to provide assurance that the investment will deliver the required return. The availability of this type of whole life analysis will provide assurance to the purchaser that the assets will deliver the expected return and reduce risk associated with the purchase. This could conceivably increase the purchase price for the assets.

For those organisations whose strategy is to retain assets for the long term, such detailed cost, risk and performance analysis will enhance value over the life cycle and may result in improved arrangements with financiers and investors.

When in the operations and maintenance phase, the common model of contracting with OEMs to operate and maintain the turbines leaves little room for optimisation based on cost, risk and performance. It is possible that the **OEM could "optimise" maintenance strategies**. For example, by reducing the scope and frequency of maintenance activities during the contract period and hence realise reductions in the cost of providing the service while delivering the contracted availability target. However, the Asset Owner does not realise the reduction in cost. The optimisation of operations and maintenance plans is an area of significant opportunity for gain share agreements with mature risk and reward arrangements. This would however require a material change in the attitude to risk and is only likely to evolve as the sector matures.

Managing "end of life" is likely to be a significant challenge in the sector in the next five to ten years. Understanding the factors which drive end of life decisions and identifying the alternatives will be essential to maximise value. Typical alternative options include but are not limited to:

- Do nothing and continue with the current strategy
- Change the maintenance strategy
- Overhaul assets and retain current maintenance strategy
- Overhaul assets and change the maintenance strategy
- Replace the assets with like for like
- Replace the assets with enhanced assets, for turbines this is commonly called repowering.
- Retire the site and return to pre windfarm conditions



Figure 4 The trade-off between Cost, Risk and Performance

Each of these options could be the one which drives the maximum value. However, the organisation must be able to quantify cost, risk and performance consequences associated with each one. The methodology for this beyond the scope of the guidance document. Readers who are interested are directed to the SALVO Project (www.salvoproject.org) for more information.

1.3.3 Cost, Risk and Performance

We have already stated that good practice asset management involves optimising or getting the best trade-off between costs, risk and performance. Figure 4 illustrates the dynamic relationship.

- Costs could relate to Capital or Operational costs associated with life cycle activities over the life of the assets for example the cost associated with life extension of wind turbines.
- Risk is generally recognised as the product of multiplying the probability of an undesirable event happening by the consequences of that event. Being able to quantify risk is a key element within good decision-making. This however is not always easy. For example, how would an organisation monetize the adverse publicity or damaged relationships with the community if there are objections to a new wind farm construction? Many organisations already have corporate risk management approaches which use risk matrices and tables of potential consequences levels. In these cases, it is relatively straightforward to align reputational impacts with other quantified forms of financial impact. When considering risk with relation to assets and asset management, we are generally considering the risk of the asset failures. However, we also need to identify and deal with risks associated with asset management *activities*, business *processes* and our asset *management system*.
- Performance relates the benefits realised from the assets. For example, the amount of power generated from a wind farm which in turn produces revenue. This could be impacted by the efficiency of generation, which is perhaps influenced by the design or the effectiveness of maintenance

Whilst it might be desirable to have high performance from assets, with zero risk and low costs, this is unlikely to be realised in practice. Therefore, as we have already stated the challenge is optimising that trade off, which is nontrivial. However, when it is recognised that this relationship is not static, rather it changes with time and is influenced by: increasing risk as asset condition deteriorating with usage, changes to the value of the production and increasing operational and maintenance costs.

1.3.4 Value

If Asset Management is about realising value from assets, we need to understand what **we mean by “value”**. For example, the *capital* value of assets is different to the *functional* value derived from their usage (e.g. to generate energy that can be sold). And we also need to be clear about value *to whom*. In the pursuit of value there are many conflicting objectives, representing the needs and expectations of different stakeholders. The European MACRO Project³ in the 1990’s, and more recent SALVO Project⁴, rationalised these into a structured map (the ‘Shamrock’ diagram in Figure 5), grouping typical ‘business drivers’ into 5 primary measures of value. These, shown in the centre of the diagram, can be remembered with the acronym “RELICS”:

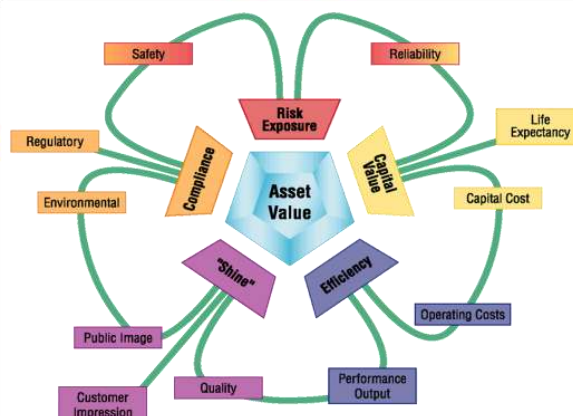


Figure 5 The ‘Shamrock’ diagram, showing different facets of Value. Ref EU1488 MACRO Project

- Minimising Risk
- Maximising operational Efficiency; the functional value *from* assets (functional benefits minus operating costs)
- Maximum economic Life (period of benefits realisation from the capital costs, ensuring that sustainability is considered).
- Compliance with legislation, regulation or other non-negotiable commitments.
- Shine or improving or retaining the intangible characteristics associated with managing assets

The business drivers shown on the Shamrock often compete. For example, we may be able to improve the reliability of assets by reducing their loading/utilisation; this would reduce operational efficiency, but, as a secondary effect may also help to extend asset life. Alternatively, we could invest more in higher grade assets, and spend more on maintaining them, but would the resulting performance, reliability and/or longer asset life be worth it? In the context of the wind industry in Ireland we might see such conflicts also in end-of-life decision-making. Operating and maintenance costs may be increasing (reducing functional value/efficiency), particularly if new technology is available and spares for the previous generation turbines are becoming more difficult to obtain. New designs may also offer performance and reliability advantages, but at a (reinvestment) capital cost. The Asset Management decisions therefore need to seek the best value or optimal mix of options, timings and trade-offs.

1.3.5 Optimisation

We have looked at the trade-off between cost, risk and performance and the facets of value. However, how do we determine what optimal is? There are many techniques available to organisations which can help determine what should be done to assets at various stages of their lives, for example the Reliability Centred Maintenance methodology is often used to establish maintenance strategies, whereas some organisations simply follow the manufactures recommendations.

Good practice Asset Management is not only about deciding what should be done but is also concerned with the timing of the activity. This is true optimisation the concept of which is shown in Figure 6.

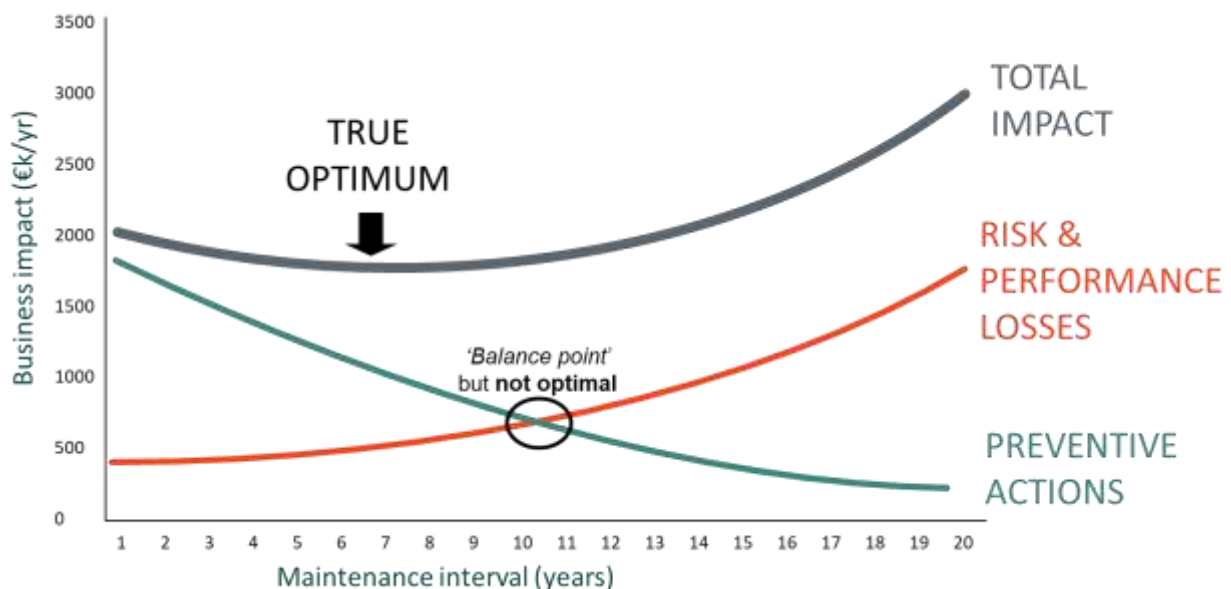


Figure 6 Optimising Intervals

This figure models the trade-off between the cost of carrying out a maintenance activity at specific intervals and the increase in risk and performance losses as the interval increases. It is important to note that the Y-axis represents the business impact in units of cost per year and the X-axis represents the interval in years. The red curve shows how the “per year” impact of deterministic performance losses and “per year” probabilistic risk values increase as the interval between activities increases. The green curve shows the “per year” cost of carrying out the activity, including lost production costs, decreasing as the interval is extended. The black curve represents the Total Business Impact which is the sum of the red and green curves.

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The optimal interval is not, as is often thought, the point at which the red and green curves cross, rather it is the point at which the black, Total Business Impact, curve is at its lowest point. This concept can be applied to determining optimal intervals; for inspections, including condition-based maintenance and planned maintenance tasks as well as establishing optimal life cycle for assets.

The ability to optimise asset strategies is an important concept in Asset Management, in relation to the wind sector in Ireland it offers significant opportunity to enhance value. However, it would require significant changes to the predominant operational model, especially with respect to turbines where the OEM provides a maintenance service contract and guarantees turbine availability.

This is a risk averse strategy which may meet the needs of Asset Owners and investors, however this could be at the expense of artificially high Capital and Operations costs. It is the case that adopting a risk-based approach can add value to organisations but requires those organisations to truly understand the concepts and accept the potential impacts.

1.3.6 Decision-making Framework

Decision-making is a key part of Asset Management. ISO 55001 requires organisations to determine and document the criteria used for Asset Management decision-making.

When determining decision-making criteria organisations should consider the following:

- Criteria which need to be considered when making decisions, this can be a wide range of things which usually relate to cost, performance and risk.
- A specific criterion against which the decision is made, these are often financial investment criteria such as.
 - **Net Present Value (NPV) which is the sum of all cashflows over the investment's life.**
 - Payback period (DPP) this is the length of time that it takes to return the initial investment taking account future cashflows.
 - Profitability Index (PI) this is ratio of the NPV to the investment costs.

However, these investment appraisal approaches are only looking at cashflows, sometimes decisions are required which to deal with intangible issues which we explored in Section 1.3.4 Value. These intangibles include items such as:

- Reputation
- Morale
- Community relations

Where possible organisations should look to monetise these factors. Typically, this can be done by drawing a correlation from the various levels with the organisations Risk Matrix. Where this is not possible the organisation should use robust subjective and qualitative measures.

A robust decision-making framework is useful to define the required methods, criteria, authorities and rigour for Asset Management decisions. Typically, this will include guidance for which evaluation and justification methods are suitable, in what circumstances. Such methods should be proportionate to the significance or potential *impact* of the decision (the consequences of getting it wrong) and the *complexity* of the decision to be taken (e.g. the number of stakeholders involved, or the trade-offs involved). This concept of proportionality in use of different decision-making methods is shown in Figure 7.

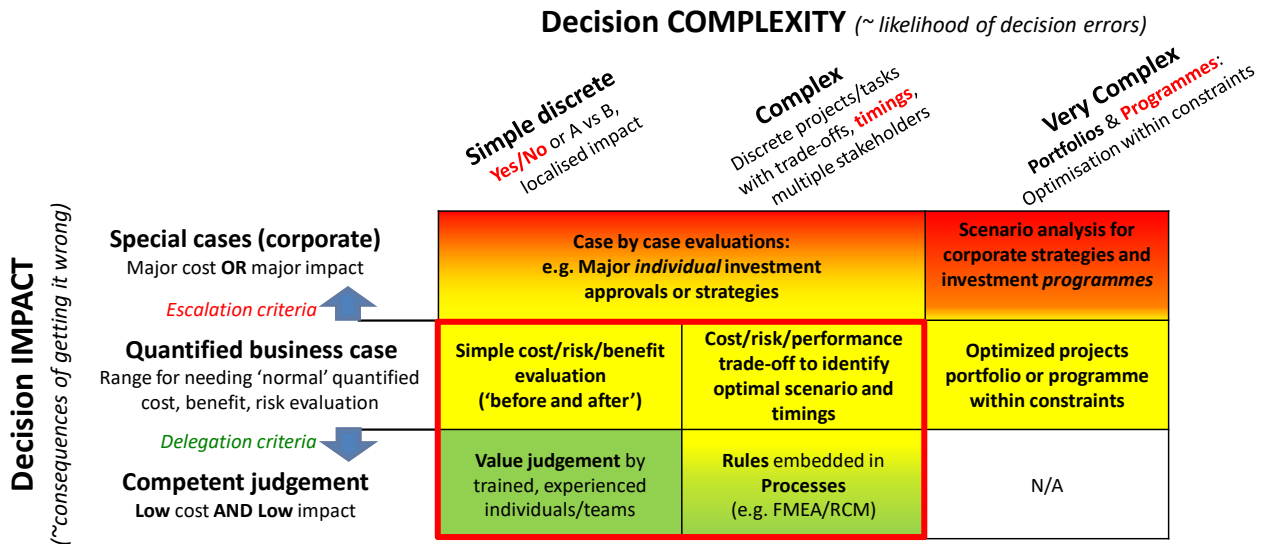


Figure 7 The need for proportionate methods in Asset Management decisions

The figure shows how the methods change as the complexity and impact increases such that for low impact simple discrete decisions “Value judgement by trained people” would be appropriate. For very complex, major cost/impact decisions “Scenario analysis for corporate strategies and investment programmes” would be appropriate. The figure also shows boundaries at which the decisions are escalated or delegated. It is important to note that most decisions in the Operation and Maintenance Phase of a windfarm would be in the lower left part of the matrix indicated by the red rectangle. Whereas when making decisions about which windfarms to develop, retain, refurbish or retire across an organisations entire portfolio “scenario analysis for corporate strategies and investment programmes” would be appropriate.

What is essential however is that the criteria used are consistent and transparent and focus on delivering maximum value from the assets and Asset Management.

1.3.7 Distinctive Features of Modern Asset Management

Modern Asset Management, as distinct from merely managing assets, has a number of distinctive features. Asset Management is...

- Holistic and cross-disciplinary, as evident in
 - Effective ‘total value’-based decision-making
 - De-siloed organisation with clear, collective goals that outweigh localised departmental interests
- Systematic, characterised by being:
 - Rigorous and controlled
 - Supported with procedures and standards
- Systemic, both at the asset, and asset management levels. i.e.
 - It considers assets in their systems context, through which value is realized
 - The management system is a structured basis for “the way we work”
- Sustainable, meaning:
 - Long-term impacts are included in decision-making
 - This includes all aspects of sustainability: e.g. financial, environmental, ecological, social and political
- Optimised, meaning:
 - Delivers, and can show that it delivers, the best value compromise between competing business drivers (e.g. cost, risk and benefits / performance over the whole asset life cycle)
- Risk-based:
 - Takes account of uncertainty and probabilistic events
- Integrated which implies:
 - All parts contribute and combine to a total desired set of goals
 - Interdependencies are understood and handled in a controlled and optimised manner

These are shown in Figure 8 which comes from BSI PAS 55-1:2008.

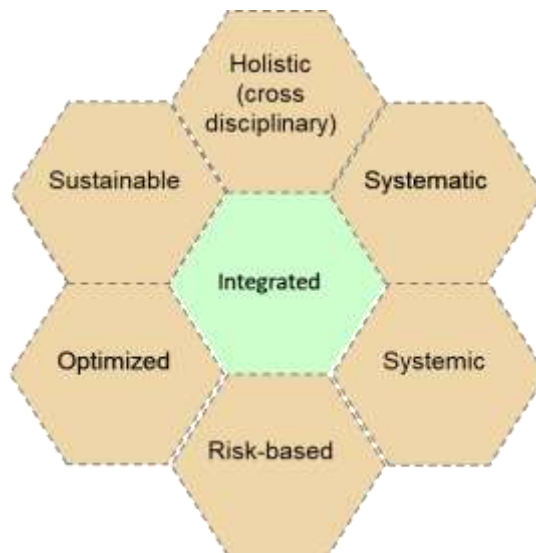


Figure 8 Distinctive Features of Modern Asset Management

1.4 Why Asset Management & ISO 55001 and why now?

Across the world in all industry sectors organisations are realising that a sustainable, risk-based approach to managing assets is crucial for ongoing realisation of value. Furthermore, there is a recognition that a structured approach based on a common framework is desirable.

ISO 55001 provides that structured framework. Published in 2014 ISO 55001 one of a suite of documents produced by the International Organisation for Standards (ISO) which relate to the field of Asset Management. The suite consists of the three core documents:

- “ISO 55000: 2014: Asset management - **Overview, principles and terminology**” which provides an overview of Asset Management, the main, principles and key terms
- “ISO 55001: 2014 Asset management - Management systems - **Requirements**” which details the requirements for an a management system for Asset Management
- “ISO 55002: 2018 Asset management - Management systems - Guidelines for the application of ISO 55001” which was first published in 2018 and has been revised and republished in 2018. This provides guidance organisations wishing to implement ISO 55001.

ISO is continually striving to improve standards in the Asset Management environment and in 2019 it published:

- “ISO/TS 55010: 2019: **Asset management** — Guidance on the alignment of financial and non-financial functions in asset management” which provides guidance on aligning financial and non-financial functions within an organisation

Whilst these documents help to establish a sustainable framework, they are very generic in nature and are not specifically aimed at any one industry sector, any one country or geographical region. This means that organisations can customise their Asset Management Systems to suit their own operational context while remaining in alignment with the requirements of the standard.

The wind energy sector in Ireland is at a **stage of its development where a “standardised approach to asset management” can add real value to all stakeholders**. However, it must be made clear that this guidance document does not seek to mandate particular techniques or methodologies, rather it seeks to provide guidance to organisations seeking to standardise their approach to Asset Management.

ISO 55001 provides a Management System for Asset Management and is broadly aligned to the Plan Do Check Act (PDCA) cycle championed by W Edwards Demming in his pioneering work in the field of quality management in post-World War 2 Japan. Figure 9 shows the elements of ISO 55001 overlaid on the Plan Do Check Act cycle.

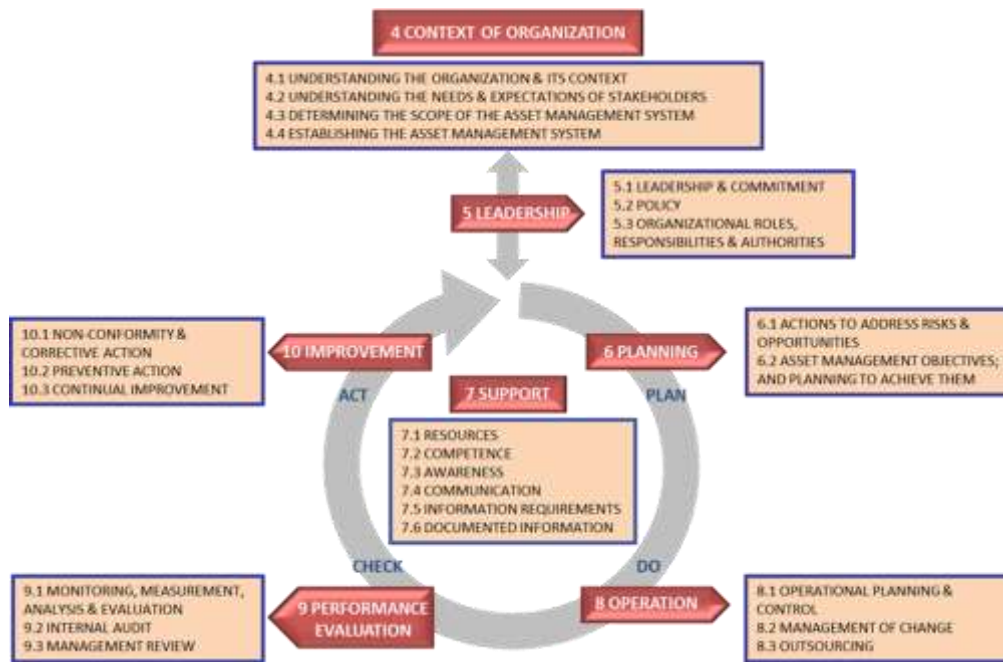


Figure 9 ISO 55001 and PDCA Cycle

The figure shows how the context of the organisation and stakeholder needs and expectations help to inform the scope of and ultimately creating Asset Management System. This then informs the leadership of the organisation which must demonstrate that it is committed to Asset Management, ultimately creating the Asset Management Policy and establishing clearly defined organisational roles and responsibilities.

Having established this foundation, the organisation should create plans for developing Asset Management capability and cover the life cycle activities of the assets i.e. Creation/Acquisition, Operation & Maintenance and End of life. The plans then need to be executed in a controlled manner through controlled processes. In addition, planned changes which can impact the delivery of objectives need to be managed as does outsourced Asset Management Activities. Performance of assets and the Asset Management System must be monitored and analysed; ISO standards require internal audits and management reviews to be undertaken to provide assurance that the Asset Management System is operating as designed and is delivering the expected outcomes. Continual improvement is another key concept in ISO Management System Standards; ISO 55001 requires that this is done through managing nonconformities, taking actions to prevent assets failing to deliver their functional requirements and to seek opportunities to continually improve.

In the centre of the diagram, we have the critical support requirements. The organisation must provide adequate resources to deliver its objectives. People doing Asset Management must be competent and aware of Asset Management, its importance to the organisation and their role in adding value through Asset Management. Communication relating to assets and Asset Management must be defined so that effective communication takes place. Asset Information requirements must be established and process put in place to manage this information. There are also requirements regarding the creation and management of documented information.

Implementing an Asset Management approach which is aligned to ISO 55001 is an important factor in the wind energy sector, supporting the delivery of Irelands strategic objective of having 70% of electricity demand satisfied by renewable sources by 2030 and being carbon neutral by 2050. This approach provides a structure upon which to build an Asset Management System. In this context an Asset Management System is the system of processes, procedures and documents which organisations implement to conduct Asset Management, it should not be confused with IT systems such as Computerised Maintenance Management Systems or Enterprise Resources. These IT systems can be important tools in Asset Management but do not constitute Asset Management Systems.

Whilst ISO 55001 provides the framework it is generic in nature. It defines what is required, not how to meet those requirements. This is because organisations must determine for themselves how they will meet the requirements. A methodology for risk management employed by a large windfarm owner operator with multiple sites and hundreds of turbines may not be appropriate for a single windfarm owner operator with less than ten turbines.

Whether implementing a complete Asset Management System or implementing key parts of ISO 55001 it is critical not to create excessive bureaucracy. The Asset Management System must work for the organisation, the organisation should not be working for the Asset Management System.

1.5 Benefits of an Asset Management Approach

ISO 55000: 2014 Asset management — Overview, principles and terminology lists the following as the benefits of Asset Management

- Improved financial performance:
 - Improving the return on investments and reducing costs can be achieved, while preserving asset value and without sacrificing the short or long-term realization of organisational objectives
- Informed asset investment decisions:
 - Enabling the organisation to improve its decision-making and effectively balance costs, risks, opportunities and performance
- Managed risk:
 - Reducing financial losses, improving health and safety, good will and reputation, minimizing environmental and social impact, can result in reduced liabilities such as insurance premiums, fines and penalties
- Improved services and outputs:
 - Assuring the performance of assets can lead to improved services or products that consistently meet or exceed the expectations of customers and stakeholders
- Demonstrated social responsibility:
 - Improving the organisation's **ability to, for example, reduce emissions, conserve resources and adapt to climate change**, enables it to demonstrate socially responsible and ethical business practices and stewardship
- Demonstrated compliance:
 - Transparently conforming with legal, statutory and regulatory requirements, as well as adhering to asset management standards, policies and processes, can enable demonstration of compliance
- Enhanced reputation:
 - Through improved customer satisfaction, stakeholder awareness and confidence
- Improved organisational sustainability:
 - Effectively managing short and long-term effects, expenditures and performance, can improve the sustainability of operations and the organisation
 - Improved efficiency and effectiveness, reviewing and improving processes, procedures and asset performance can improve efficiency and effectiveness, and the achievement of organisational objectives.

With respect to specific benefits to the wind generation sector in Ireland, in preparing for this guidance document the authors consulted a number of WEI members through interviews and a survey. The results of which indicate that there are a range of benefits from Asset Management for organisations within the wind energy sector in Ireland.

These benefits are listed in Table 1 which also details the number of organisations which have identified the benefit (note total number of respondents was 13).

Benefit statement	No. Responses	% Responses
We have seen no benefits from Asset Management in our organisation	1	7.69%
We have realised a reduction on operational costs	5	38.46%
We have realised an improvement in our management of risk	11	84.62%
We have seen an improvement in our relationship with stakeholders	8	61.54%
Our revenue has increased	6	46.15%

Our profitability has increased	7	53.85%
Our reputation has been enhanced	7	53.85%

Table 1 Benefit from Asset Management

It should be clarified that the responses were provided by practitioners of Asset Management variously interpreting value to their organisations and does not necessarily relate to full or accredited implementation of ISO550001.

1.6 Specific case studies and examples of good practice

The benefits identified in Section 1.5 were reinforced by the case study identified in the research in which DONG Energy, now Ørsted, which in 2015 was the world’s first offshore wind power operator to obtain ISO 55001 certification. The stated benefits identified include:

- It ensures we are in control of risk, economic performance, compliance and safety of our workforce.
- A useful tool to differentiate ourselves in the market.
- It gives both our current and future customers, partners, regulators and investors confidence in our capability as an Operator.
- It makes us attractive to new investors.

Specific benefits realised external to the wind sector include those shown in the case studies identified in Figures 10 and 11

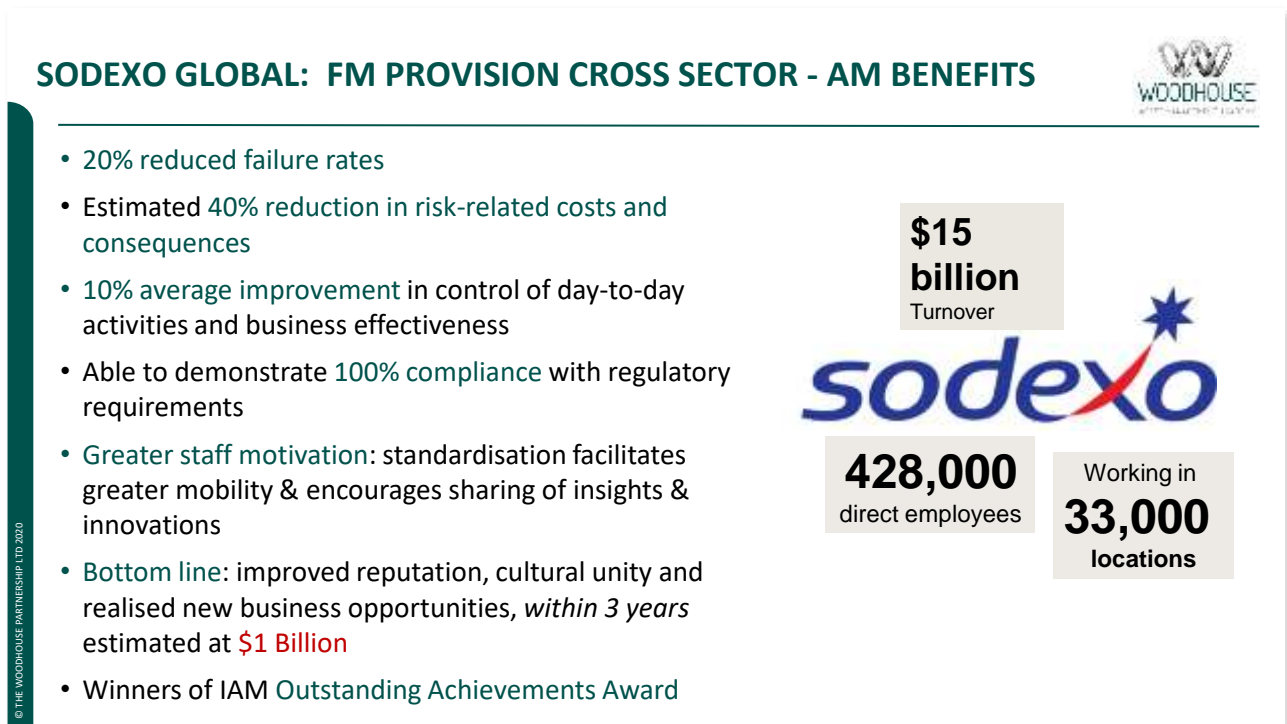



Figure 10 Sodexo AM Benefits

ICE COSTA RICA: 26 DIVERSE POWER PLANTS - AM BENEFITS



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Technical:

- **>1,000 risks analyzed**, and root causes eliminated or controlled to ALARP levels.
- **41 capital projects & 108 risk mitigation options** selected and cost/risk optimised
- Average plant reliability & availability **increased by 5%**
- Extra capacity released by project effectively **eliminated risk of regional blackouts** (in the past blackouts were normal in dry years, however no blackouts in extra dry 2012 and 2013).

Economic:

- Project payback: **total 3-year programme cost recovered within the first 6 months.**
- Life Cycle Cost/risk/performance evaluation of projects & spares saved **>US\$ 1M/year.**
- Total **measured benefits** are **US\$ 10,000,000 per year.**

Cultural:

- Greater **cooperation** in vertical and horizontal directions
- A risk & reliability-based **culture** is evident and growing.
- Knowledge sharing is growing and **teamwork is common** now.
- **Root cause problem elimination is part of the technician culture.**
- **People begin to think about economics and not only technical aspects.**

Reputational

- Awarded **“Road to Excellence”** prize by National Industry Chamber
- Awarded **1st international Asset Management Achievement Award** by IAM




Figure 11 ICE AM Benefits

In addition to these benefits the following organisations cite these benefits

- Tenet Networks, The Netherlands
 - 10% improvement in performance for each step on the AM maturity scale
- United Utilities, UK:
 - Water and Wastewater of Common Framework Asset Management estimated to have **yielded/enabled £10's of millions of regulatory benefits**
 - World Class Asset Management programme: approximate benefits £150m, against a total marginal cost over a number of years of £26m

1.7 Consequences of poor Asset Management

There are numerous examples of serious incidents which have their root cause in failures in Asset Management in one way or another. The full list would take many volumes to document; hence we have listed a few notable examples:

- Hatfield Rail Crash 17th October 2000
 - Four people were killed
 - The engineering company Balfour Beatty was found to have failed to effectively manage inspection and maintenance of track
 - Balfour Beatty was fined £10m
 - Railtrack, the infrastructure controller at the time, failed to effectively manage Balfour Beatty's work
 - This led to the transfer of operations to Network Rail & the winding up of Railtrack a London Stock Exchange listed company
- In 1998 the Auckland Power Crisis was a five-week-long power outage affecting the central city of Auckland, New Zealand. The subsequent inquiry found:
 - During the operational life of network assets, evaluation of risks must be undertaken as a systematic process.
 - Proper customer contracts are important to provide strong incentives for network energy businesses to manage security on commercial criteria.

Wind Farm Asset Management and ISO 55001: Maximising the Return on Wind Energy Investments

- In a network company with monopoly characteristics, it is essential that the board must be directly accountable to the shareholders, with a clearly defined statement of corporate intent defining common shareholder and board objectives, especially in relation to security of supply.
- The 2006 Auckland Blackout started at 08:30 AM on 12 June 2006, most areas of Auckland regaining power by 2:45 PM local time. It affected some 230,000 customers and had an impact on at least 700,000 people in and around the city
 - Investigation of this incident found that maintenance of the electricity transmission system was not adequate and that this substation had major and minor design deficiencies
- Forth Road Bridge, Scotland, connects Edinburgh to Fife
 - Bridge was designed in 1964 with a design life of 120 years meaning it should be serviceable to 2084
 - It was predicted in 2014, that by 2017, vehicles would no longer be able to safely cross the bridge due to significant deterioration and poor maintenance strategies
 - In May 2017 the Queensferry Crossing took its place alongside its illustrious neighbours, the Forth Bridge and the Forth Road Bridge - three iconic bridges spanning three centuries
 - The new bridge required a Scottish Government investment of £1.35bn

These three examples clearly show the importance of a whole life Asset Management approach which takes account of stakeholder requirements and achieves an optimum trade-off between Cost Risk and Performance to deliver maximum value from assets. This is particularly important in respect of assets such as wind farms which will, given the move to renewable generation, become national infrastructure assets with long term functional requirement.

1.8 ISO 55001 in the Context of the Wind Industry in Ireland

Every windfarm in the Island of Ireland has vast range of physical assets, all of which must meet their functional requirements for the windfarm to operate as required and deliver value to the organisation. It is clear therefore, that these assets need to be managed. The question is, should the industry manage assets or take an Asset Management approach? The case for an Asset Management approach is clear, however the extent to which a Management System aligned to ISO 55001 is required, or indeed desirable, is in question. As with all decisions relating to investing resources, the investment effort involved in implementing such as system must be surpassed by the value derived therefrom.

It would appear that there is significant effort involved in implementing an Asset Management System, however organisations are already managing assets, so they are not starting from a standstill. Often many of the requirements of ISO 55001 are being met in one form or another. Being able to consistently define how these functions are being executed may require nothing more than to document what is currently being done. Documenting these processes will have the advantage of making them sustainable i.e. they will be executed in a consistent manner even if key people leave the organisation. It may also identify opportunities to improve the effectiveness and efficiency of the process.

Depending on the context, where there are gaps in conformance with the ISO Standard, the organisation can decide if it is worthwhile fulfilling the requirement. A single windfarm with ten turbines might see no value in adding internal audit or management review processes. On the other hand, defining decision-making criteria and how risks and opportunities will be managed would undoubtedly add value. It is crucial not to develop a suite of processes and documentation that do not reflect how Asset Management is done, this creates a set of aspirational processes which will not be executed, therefore will not add value. This will be quickly picked up by auditors leading to Nonconformances. That does NOT mean that the organisation should not seek to develop its Asset Management capability through improving existing processes and implementing new processes, rather it implies these need to be introduced properly assuring training and competence development.

Given the national importance of renewables generation in Ireland, windfarm assets can be considered as CRITICAL INFRASTRUCTURE ASSETS. Adopting an Asset Management approach aligned with ISO 55001 will provide assurance that the assets are being managed in an optimal way. This will be particularly important when managing the existing assets as they approach end of certified life and in the important decisions which will be made during the creation phase of new windfarms which will be developed to meet the 70% target for renewable generation by 2030.

2 ISO 55001 Guidance Clause by Clause

2.1 Introduction

In this section we will explore the ISO55001 standard, clause by clause, explaining what is intended from the clause and how organisations, in the wind sector in Ireland, can conform with the clause. Where appropriate we will provide guidance for organisations who intend to implement a full ISO 55001 conforming Asset Management System and those who wish to implement key elements of the standard. **We will also include “Tips” and “Traps”,** which explain simple tips and potential pitfalls when adopting an Asset Management Approach.

2.2 Sections 1-3

Sections one, two and three are common to all ISO Management System Standards

Section one outlines the scope of the standard which is that it “specifies requirements for an asset management system within the context of the organisation”. Whilst it is primarily designed to be used with physical assets organisations can choose to apply it to other assets.

Section two lists the normative references. A normative reference is a document which indispensable to the application of the standard and with which the standard cannot be fully and properly utilised. The normative reference for ISO 55001 is:

ISO 55000:2014, Asset management — Overview, principles and terminology

Section three normally lists the terms and definitions which for ISO 55001 are given in ISO 55000

2.3 Section 4 Context of the organisation

This section has four sub sections which are:

- 4.1 Understanding the organisation and its context
- 4.2 Understanding the needs and expectations of stakeholders
- 4.3 Determining the scope of the asset management system, and
- 4.4 Asset management system

4.1 Understanding the organisation and its context

This section requires the organisation to understand its context, the internal and external issues which impact the delivery of its objectives and fulfilling its purpose. It also requires Asset Management objectives to be developed, which are in alignment with the organisational objectives and contained within a Strategic Asset Management Plan (SAMP).

Understanding the context involves defining the ownership and operating model of the organisations, for example, does the organisation manage assets on behalf of an asset owner or does the asset owner manage the assets? Also of consideration will be the size, complexity and criticality of the assets or portfolio of assets which will be covered by the Asset Management System.

External issues could include social, cultural, political, environmental and regulatory factors as well as the market, consumers and competition from other organisations. Internal factors include policies, objectives and strategies as **well as the organisation’s own culture and values. It is important to determine the organisation’s risk management approach including its overall risk appetite.**

Tools which can be useful for organisations, depending on the size and complexity of their operations to identify and evaluate of contextual issues include:

- Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis
- Political, Economic, Social, Technological, Legal, Environmental (PESTLE) analysis
- Simple brainstorming

ISO 55000 defines a Strategic Asset Management Plan (SAMP) as:

“Documented information that specifies how organisational objectives are to be converted into asset management objectives, the approach for developing asset management plans, and the role of the asset management system in supporting achievement of the asset management objectives.”

This has led some organisations to incorrectly assume that the SAMP is what describes how the Asset Management System works. The SAMP is a strategic document which should include Asset Management objectives and the long-term strategies for delivering them. How the Asset Management System works should be described in the Asset Management System Manual.

ISO 55000 also advises that a SAMP is derived from the organisational plan and may be contained in, or may be a subsidiary plan of, the organisational plan.

It is good practice for organisations to have a long-term strategy for success, it is unlikely that even the smallest windfarm would not have some form of strategy. It should be straightforward to include Asset Management Strategies in the organisational strategies. This will be important as windfarms approach end of life.

Tip: Create an Organisational Strategic Plan, if the organisation is small give consideration to including Asset Management Strategies in the Organisational Strategic Plan. If it is large create a discrete SAMP.

Trap: The SAMP is not the Asset Management System (AMS) Manual, create a discrete AMS Manual

4.2 Understanding the needs and expectations of stakeholders

This clause requires that organisations determine the stakeholders and their needs and expectations with respect to Asset Management. It specifically notes the requirement for recording financial and non-financial information relevant to asset management, and for reporting on it both internally and externally. This does not mean that the organisations need to meet these needs and expectations. In some cases this will be impossible since some of the needs will be in direct conflict, for example an environmental pressure group might require that a windfarm is not constructed in a specific location, whereas investors may require a certain return on investment which can only be delivered at that location.

What is important is that organisations have methodologies for identifying the stakeholders and their expectations and to determine the approach to delivering the expectations. Identifying stakeholders can be done through simple brainstorming, followed by Political, Economic, Social, Technological, Legal, Environmental (PESTLE) analysis.

Determining the approach to **delivering the expectation can be done by prioritisation models such as Mendelow's Method which allows a matrix to be formed based on the stakeholder's influence and interest on the organisation's Asset Management Objectives** as defined below:

- Interest defines how interested the stakeholder is in the organisation
- Influence define the ability of the stakeholder to influence the strategy

This matrix is shown in Figure 12:

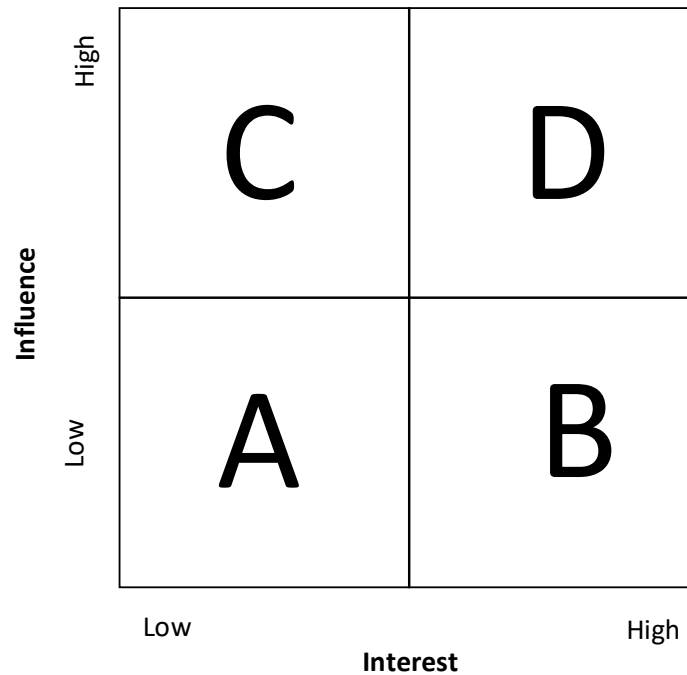


Figure 12 Mendelow's Matrix

This enables the organisation to classify stakeholders and decide the level of response to their requirements. Approaches to meeting stakeholder requirements in each category could be as follows:

- Category D stakeholder (High interest, High Influence) stakeholders:
 - Requirements will be met and the organisation will work closely with the stakeholder to demonstrate that this is the case.
- Category C stakeholder (Low interest, High Influence) stakeholders:
 - Requirements will be met where possible i.e. will actively try to meet them provided they do not **conflict with the organisation's strategic objectives and the organisation will work closely with the stakeholder to demonstrate that this is the case.**
- Category B stakeholder (High interest, Low Influence) stakeholders:
 - Requirements will be met where they are aligned with normal strategies and plans and do not conflict with organisation's **strategic objectives but the organisation will work closely with the stakeholder to demonstrate that this is the case**
- Category A stakeholder (Low interest, Low Influence) stakeholders:
 - Requirements will be met where they are aligned with normal strategies and plans and do not **conflict with the organisation's strategic objectives, the organisation will take no specific actions to demonstrate is the case but will do so as part of normal communications with stakeholders.**

This clause also requires that the decision-making criteria is established, see Section 1.3.6 for an explanation. Robust transparent value-based decision-making is essential in all functions of an organisation, not just Asset Management. In the absence of such criteria sub optimal decisions can be made. Organisations normally have some rules around business cases etc. It should therefore be straight forward to evolve these rules into a decision-making framework and associated criteria.

*Tip: Carry out a stakeholder needs analysis and establish how the needs are going to be met.
Tip: Establish clear and transparent decision-making criteria and a decision-making framework*

Trap: Making the stakeholder analysis too complicated. In many cases the stakeholder requirements will be mandated by law or regulations.

Trap: Making the decision-making criteria/framework too complicated

4.3 Determining the scope of the Asset Management System

This clause requires the scope of the Asset Management System to be defined. A clearly defined scope helps organisations focus on what is to be done and to what. When defining scope the organisation should give consideration to:

- What assets are to be covered by the Asset Management System e.g. All assets at windfarms including turbines, Electrical Balance of Plant, Civils Balance of Plant. buildings, roadways and tracks, vegetation, security fencing and gates are in scope, however the office building which houses the central operations team and vehicles are excluded from the scope.
- Stages of the assets life cycle **that are to be in the scope, e.g. an “Asset Management” company in the sector** might have responsibility for managing the windfarms and operation throughout the operations and maintenance phases but have no input to the creation/acquisition phase and only provide information to asset owners for the end of life phase. On the other hand, an organisation which develops and maintains assets should include the whole life cycle of the assets from creation through operate and maintain to end of life in the scope of its Asset Management System
- What functions are to be included in the scope e.g. the organisation may already have robust processes for managing competence, therefore the Asset Management System will not need to manage competence, however it is likely that some additional elements of competence need to be added to job roles in respect of Asset Management. In situations such as this and organisations are seeking to implement a full Asset management System the arrangements can be described in the Asset management System Manual or if **required an “interface document” can be created.**
- The presence of other Management Systems within **the organisation. ISO’s Annex SL is designed to allow** integration of Management Systems, therefore common processes such as Internal Audit, Management Review, Non-Conformance management and Continual Improvement can be covered from common processes.

There are a limited number of absolute document requirements within ISO 55001 however it is required that the scope shall be available as documented information.

Tip: Clearly define the scope of the assets to be covered.

Tip: Understand the boundaries of the functions which are to be covered by the Asset Management System

Trap: Duplicating processes in other Management Systems for the sake of it.

Trap: Implying the scope covers the whole life cycle of the asset when it clearly is limited to the operations and maintenance phase of the assets life.

4.4 Asset management system

This clause requires that an Asset Management System in accordance with the requirements of ISO 55001 is established, implemented, maintained and continually improved. The Asset Management system is required to include the processes needed and their interactions. There is a requirement for a Strategic Asset Management Plan (SAMP) which includes documentation of the role of the asset management system in supporting achievement of the asset management objectives.

Whilst not specifically required by ISO 55001, an Asset Management System Manual (or definition document) which describes how the Asset Management System works and its interaction with other functions and management systems is a powerful tool. The Manual will describe the various functions and provide direction to specific processes which have been developed to support the delivery of Asset Management Objectives. The document is useful when onboarding new staff and assuring sustainable Asset Management activities in a consistent manner. Clearly organisations not wishing to implement a full Asset Management System conforming to ISO 55001 need not create a Manual however there is value in documenting what elements of ISO 55001 are to be adopted and implemented, furthermore it would provide the foundation for developing the Asset Management System should the organisation wish to extend the scope.

It is important to consult with those who will be operating the Asset Management System and processes, in many cases this will involve merely documenting what is done now. Where gaps do occur, then what is developed to close those gaps, must be executable and not be mere aspirations which will never be realised.

Tip: Create an Asset Management System Manual

Tip: Create documents which add value i.e. the benefit derived from them is greater than the effort to implement and operate

Trap: Confusing the SAMP and the Asset Management System Manual

Trap: No high-level processes showing cross organisational roles and responsibilities

Trap: Creating new documents without clear purpose other than to 'satisfy ISO 55001'

Trap: Not keeping the 'manual' up to date – common audit failing

Trap: Documenting aspiration rather than reality

Trap: Failing to trial, communicate and embed new processes

Trap: Creating documents without proper consultation

2.4 Section 5 Leadership

This section has four sub sections which are:

- 5.1 Leadership and commitment
- 5.2 Policy
- 5.3 Organisational roles, responsibilities and authorities

5.1 Leadership and commitment

This clause requires that the organisations Top Management (the executives and senior managers holding the highest-level positions within the organisation) demonstrate leadership and commitment with respect to the Asset Management System through a number of activities such as:

- Ensuring that the asset management policy, the SAMP and asset management objectives are established and are compatible with the organisational objectives
- Ensuring that the resources for the asset management system are available
- Ensuring that the approach used for managing Asset Management risk is aligned with the organisation's approach for managing risk.

Many of these are commonly understood characteristics of good leadership for example promoting cross-functional collaboration and continual improvement will be well known to many leaders. However, in this context it is specific to the impact that it has on Asset Management performance and the delivery of value from assets. Whilst Top Management may delegate the responsibility for developing implementing and improving the Assets Management System, it is important that Top Management retains ownership of the Asset Management System.

From a mechanistic point of view many organisations could easily demonstrate compliance with this clause, **however it is essential that Top Management "walk the talk". Commitment to Asset Management can be demonstrated by including Asset Management in all communications with stakeholders and promoting the value of Asset Management.** However, perhaps the most important attribute of leadership and commitment is to ensure that processes and procedures are followed in all situations especially at times when the organisation is stressed. If Top Management permits, or even encourages processes to be circumvented then any Management System will ultimately fail and the benefits which have been realised will be eroded over time.

Tip: Believe in Asset Management and demonstrate that by actions

Tip: Promote Asset Management in all communications

Tip: Provide good leadership

Trap: Abandoning agreed processes allowing circumventions

Trap: Doing this for the certificate only, this will find you out and value will not be realised.

All organisations in the wind sector in Ireland whether intending implement ISO 55001 in its entirety or in part can benefit from improving leadership and commitment to Asset Management.

5.2 Policy

This clause requires that Top Management establish an Asset Management Policy that is appropriate for the organisation. ISO 55000 defines a policy as “the intentions and direction of an organisation as formally expressed by its top management”. So, a policy can be considered to set the direction and intentions of an organisation and looks to create the rules that must be followed by the organisation in specific circumstances.

The Asset Management Policy provides a framework for establishing Asset Management objectives and will include commitments to satisfy all applicable requirements and continually improve the Asset Management System.

The Asset Management Policy will be consistent with the organisational plan and other relevant organisational policies e.g. Environmental and Health & Safety Policies and be appropriate to the **organisation’s context e.g. the nature and scale of its assets and operations**. To be available as documented information the Asset management Policy will be communicated to internally and be available to stakeholders as appropriate.

Many Asset Management Policies are only one page in length. The Asset Management Policy is an extremely important document; it establishes the rules by which the organisation will operate. It is important to carefully consider what is included in the Asset Management Policy, things which may be easy to write down may not be easy to implement. An example of a poor Policy statement is:

- We will meet all stakeholder requirements:

Whilst this is a laudable intention life is just not that simple. Sometimes organisations are not able to meet the stakeholder requirements and in other situations it is a legal requirement that they are met and in other cases some requirements can be met and others not.

An alternative statement might be:

- We will meet stakeholder requirements where appropriate

This can then be demonstrated in by applying the stakeholder management techniques identified in Section 2.3.

Organisations not wishing to implement a full ISO 55001 compliant Asset Management System should consider carefully the value added by an Asset Management Policy, it is possible that such a policy could commit the organisation to fulfil obligations which it has no intention of fulfilling.

Tip: Make the AM Policy concise, one page if possible

Tip: Align with other Policies e.g. HS&E

Tip: Understand what is being committed to

Trap: Conflicting and impossible Policy Statements

5.3 Organisational roles, responsibilities and authorities

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This clause requires that Top Management ensures that the responsibilities and authorities for relevant roles are assigned and communicated within the organisation.

For many **organisations'** frameworks will be in place which define responsibilities and authorities. Commonly this is outlined in job or role descriptions it is also often the case that specific processes have responsibilities and authorities defined with them.

ISO 55001 however requires that responsibilities and authorities are assigned for specific elements and activities of the Asset Management System. These include establishing and updating the SAMP, including asset management objectives and ensuring that the Asset Management System supports delivery of the SAMP. Responsibilities and authorities are to be assigned for ensuring that the Asset Management System conforms to the requirements ISO 55001 and that it is suitable, adequate and effective. In addition, responsibility for establishing and updating the Asset Management plans and reporting on the performance of the Asset Management System are to be assigned.

Establishing roles responsibilities and authorities is important to assure that there are no gaps in understanding of who does what and reducing the risk that Asset Management activities are not done. Equally it reduces the risk of double effort i.e. the same activities being done by different people or functions introducing waste and confusion.

A common method of establishing roles responsibilities is the RACI approach, which is explained thus:

- Responsible:
 - The person who does the work to achieve the task. They have responsibility for getting the work done or decision made. As a rule this is one person; examples might be a Head of Asset Management, Chief Engineer, Vice President Asset Management depending on the structure of the organisation
- Accountable:
 - The person who is accountable for the correct and thorough completion of the task. This must be one person and is often the senior executive who has responsibility for the Asset Management System or part of the Asset Management System.
- Consulted:
 - The people who provide information for the activity and with whom there is two-way communication. This is usually several people, often subject matter experts e.g. Engineers
- Informed:
 - The people kept informed of progress and with whom there is one-way communication. These are people that are affected by the outcome of the activities, so need to be kept up-to-date

Taking establishing the SAMP as an example and using typical roles the following could be applied

- Responsible: Asset Management System Administrator
- Accountable: Asset Management Director
- Consulted: Staff from the following functions: Operations, Engineering, Finance, HR, Procurement
- Informed: Staff in general not involved in Asset Management as well as appropriate stakeholders

The use of a RACI approach is not a requirement of ISO 55001 however it is a powerful, effective and efficient approach. If used consistently it can be used to build a landscape view of overall roles, responsibilities and accountabilities identifying waste and improvement opportunities. However, in smaller organisations the benefit from for such an approach may not outweigh the effort of adopting it.

Clearly defining roles responsibilities and authorities has one powerful and important by product, it feeds into the establishment of Asset Management Competence requirements. This is one of the benefits of a whole management system approach. ISO Standards are designed to be integrated and work together; the synergies realised mean the whole is more than the sum of the parts.

Organisations which are not implementing the whole of the Asset Management System should still define roles, responsibilities and authorities for those elements which are being implemented. For example, if the organisation is intending to implement Clause 8.1 Operational Planning and Control, there is likely to be many people and functions involved and clearly defining who or which function is responsible for which process is important.

Tip: Use the RACI method if the organisation is large or complex

Tip: Use output as an input to the competence requirements

Tip: Define roles, responsibilities and authorities for the elements of ISO 55001 that are being implemented whether implementing the whole Asset Management System or not.

Trap: Duplicating effort

Trap: Gaps in roles, responsibilities and authorities allowing key processes to “fall between two stools”

Trap: Doing it to conform to the requirements.

2.5 Section 6 Planning

This section has the following sub clauses:

- 6.1 Actions to address risks and opportunities for the asset management system
- 6.2 Asset management objectives and planning to achieve them
 - 6.2.1 Asset management objectives
 - 6.2.2 Planning to achieve asset management objectives

Sub clause 6.1 deals with planning for the Asset Management System; sub clause 6.2 deals with planning for the assets. In both cases the concept of alignment, which was introduced in Section 1.3.1 and modelled in Figure 2 which is reproduced in Figure 13, is crucial.



Figure 3 Vertical Alignment

Section 6 of ISO 55001 links the terms risks and opportunities to clearly show that when planning for assets and Asset Management value can be realised by reducing risk and realising opportunities or a combination of both. Many organisations consider Asset Management planning to be only about managing risk. This is partially correct when considering risks which are intolerable as identified and evaluated by the risk management processes. However, when risks are in the As Low As Reasonably Practicable (ALARP) zone, organisations may choose alternative approaches for managing the risk and must consider these in terms of value. This will allow the risk management actions with those opportunities for increasing value through, for example, optimisation of plans or improving efficiency. This is important when allocating resources, which are often constrained, to Asset Management Plans. When deciding whether to invest to reduce risk or realise value a common decision-making framework with consistent criteria is essential, this concept was introduced in Section 1.3.6 of this guidance document.

6.1 Actions to address risks and opportunities for the asset management system

This clause deals with the creation of plans for the Asset Management System. It requires that organisations consider their organisational context and stakeholder requirements and determines risks and opportunities that need to be addressed. The result being that plans are produced to address these risks and opportunities and how they change with time and can integrate actions into the Asset Management System. The organisation shall evaluate the effectiveness of the planned actions to give assurance that the Asset Management System can achieve its objectives, prevent, or reduce undesired effects and achieve continual improvement.

When creating plans for the Asset Management System there are a vast range of initiatives that an organisation could consider, indeed the Asset Management marketplace is full of technologies, methodologies and tools which could add value. It is useful therefore to have a framework upon which to build the plans for the Asset Management System. Such a framework can be developed following an Asset Management gap analysis and maturity assessment, this a common approach for organisations starting their Asset Management journey.

Typically plans for the Asset Management System include activities to improve Asset Management capability in areas such as:

- Risk Management
- Asset Information Management
- Asset Management Competence
- Decision-making
- Strategic planning for Asset Management
- Control of Asset Management activities

As well as this guidance document, organisations should seek further guidance on what is possible in terms of Asset Management capability. Sources of such information are the Institute of Asset Management's **conceptual model** which is explained in its Asset Management an Anatomy document and in the series of Subject Specific Guidance documents.

As with all elements of Asset Management, these plans should be designed to maximise value. This means that the benefit realised should be greater than the effort involved to implement the initiatives. Put another way, organisations should not implement initiatives **because they are the "latest" thing or because other organisations** are implementing them. They should be implemented because they add value as determined by the decision-making criteria and decision-making framework introduced in Section 1.3.6.

Tip: Establish current state of Asset Management Capability through a gap analysis and maturity assessment

Tip: Use this to create an Asset Management Development plan or Roadmap

Tip: Only develop capability if it adds value

Trap: Don't fall for the sales pitch

Trap: Striving for excellence in all areas when competent could be good enough

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Organisations seeking to implement an Asset Management System which fully conforms with ISO 55001 should consider conducting an Asset Management gap analysis and maturity assessment against the requirements of ISO 55001. This will allow recommendations for gap closure to be made which will provide the basis of the initial capability development plan and establish the datum against which progress can be made. Organisations implementing specific elements of ISO 55001 should also assess their current capability through a gap analysis against the specific elements of ISO 55001 they wish to implement.

6.2 Asset management objectives and planning to achieve them

This subclause deals with creating plans for assets and has two sub clauses.

6.2.1 Asset management objectives

This subclause requires organisations to establish Asset Management objectives at relevant functions and levels. This involves cascading the high-level Asset Management objectives which are in the Strategic Asset Management Plan to different levels and functions.

Cascading to different levels could involve translating overall portfolio availability objectives to availability objectives for specific windfarms and then for specific turbines. Cascading across different functions could involve setting objectives for functional areas such as engineering, projects, maintenance, finance and procurement etc.

A good example of a high-level objective which spans levels and functions is Levelized Cost of Energy (LCOE) which can be thought of as the average total cost of building and operating the asset, per unit of total electricity generated over an assumed lifetime. Normally this is calculated during the creation stage of an asset's life to assess feasibility of the project. If used properly, using probabilistic cashflows for risk items can be used to track the LCOE over the asset's life.

Asset Management objectives must consider the requirements of relevant stakeholders and other organisational requirements. These can be determined using the stakeholder analysis techniques identified in Section 2.3 of this Guidance Document. The organisation is required to retain documented information on the Asset Management Objectives.

It is important to avoid absolute objectives since they may adversely impact the delivery of another objective e.g. This objective:

- We will reduce maintenance expenditure by 10% by 2025.

Could result in a drop in reliability, therefore a better objective would be:

- We will reduce maintenance expenditure by 10%, without impacting asset performance, reliability or lifespan by 2025

These frame the objective in terms of cost, risk and performance.

A functional objective for the Logistics team could be to reduce the value of inventory held in stores could result in a critical slow moving spare part being divested. This has the potential to extend downtime in the event of a failure and adversely impact the maintenance teams objective of delivering an availability of, for example, 97%

Some objectives will be enduring, e.g. we will have 100% compliance with environmental regulations. Some may be transitional, e.g. we will have an Asset Management System conforming to ISO 55001 by 2023.

The objectives must be aimed at maximising value from the assets, some objectives may not actually add value. E.g., an objective such as

- We will introduce an integrated Asset Information System by 2025

...may well deliver some benefit, however the effort required to deliver the objective may outweigh the benefit and therefore not add value.

Where the scope of the Asset Management System covers the whole life cycle of the assets and the entire portfolio, objectives could include those for portfolio and generation capacity growth. Examples of this could be:

- We will increase our generation capacity by 50% over the next 10 years
- We will increase the generation capacity per windfarm by 25% over the next 5 years

It is likely that Asset Owning organisations will aspire to these. However, if creation and acquisition of assets is not within the scope of the Asset Management System then these objectives will not be in the SAMP. However, the Asset Management organisation should be aware of the growth objectives so that it can prepare strategically for additional assets coming under its stewardship. This awareness could be assured through close liaison with the Asset Owners and through stakeholder analysis and a review of the organisational context.

Organisations seeking to implement an Asset Management System which is fully compliant with ISO 55001 should create Asset Management Objectives at appropriate functions and levels and which are relative to the scope of their Asset Management System. Organisations seeking to implement specific elements of ISO 55001 should create objectives which are relevant to that element. For example, if the intentions was to implement Section 6 Planning, objectives related planning for Asset Management activities should be developed.

Tip: Asset Management objectives should be Specific, Measurable, Achievable, Realistic and Time Based (SMART)

Tip: Objectives can be enduring and transitory

Tip: Objectives should be aligned vertically and horizontally

Trap: Over ambitious objectives: planning to fail

Trap: Objectives without resources: planning to fail

Trap: Conflicting objectives

Trap: Siloed objectives

6.2.2 Planning to achieve asset management objectives

ISO 55000 defines an Asset Management Plan as:

- “Documented information that specifies the activities, resources and timescales required for an individual asset, or a grouping of assets, to achieve the organisation’s **asset management** objectives”

ISO 55001 requires that organisations determine and document the method and criteria for decision-making, prioritising the activities and resources to achieve its Asset Management Plans and Objectives, as well as the processes and methods to be employed in managing its assets over their life cycles. This latter requirement implies a whole life cycle approach which we discussed in Section 1.3.2 of this Guidance Document, organisations can determine the scope of this Asset Management System, including which life cycle activities are included in the Asset Management Plans.

The WEI member’s research which was undertaken prior to the creation of this Guidance Document suggested that **the predominant “scope”** for Asset Management activities focussed on the operation and maintenance phases of the asset’s life. With creation/acquisition and end of life being outside of the scope, however the organisations were consulted to a greater or lesser extent in relation to these life cycle phases.

To create guidance on the development of Asset Management Plans, two scenarios are considered

- Scope 1 The whole life of the assets within a wider portfolio
- Scope 2 Restricted to the operations and maintenance phase restricted to a specific windfarm.

It is understood there are many alternative scenarios however describing all of these would be excessive and detract from the value of this Guidance Document.

Whichever scope is under consideration the principle of vertical alignment makes it clear that the Asset Management plans should be derived from the Strategic Asset Management Plan (SAMP)

The SAMP should:

- Be specific to the organisation and a cut and paste document
- Be concerned with the long-term and authorised by Top Management
- Contain references to consultation with stakeholders
- Define how the organisation will comply with the AM Policy
- Outline how regulation and corporate standards will be met
- Consider the life cycle phases, which are in scope, of the assets, including the function, performance & condition of the assets now and in future.
- Take account of asset and Asset Management related risks and asset criticality
- Identify required continuous improvement activities
- Be quantified by prioritized Specific, Measurable, Achievable, Realistic and Time Bound (SMART) objectives
- Be available as documented information
- Be communicated and implemented
- Be reviewed & kept up to date.

The SAMP should contain the following types of strategies

- Functional Strategies: These are strategies for types of activity, describing long term improvement of Asset Management capability in activities, such as; decision-making, strategic planning, asset maintenance or managing asset information
- Asset Strategies: These are strategies for types or classes of equipment
- Asset Life Cycle Strategies: These are strategies specific to specific assets over their life cycle and could include **the “operational strategy”**

These strategies feed the development of Asset Management Plans, examples of high level Asset Life Cycle Strategies which would be applicable to wind turbines are.

- The turbines will be maintained, under a Service Agreement, by the Original Equipment Manufacturer (OEM) based on its recommendations, with a guaranteed availability for a period of 15 years from commissioning and handover of the wind farm to the Asset **Owner’s** Asset Management organisation.
- Two years prior to the expiry of the Service Agreement an asset lifetime extension programme will take place. This will involve a thorough inspection of the turbine to determine any remedial action that is required to restore the asset to an acceptable condition before the expiry of the Service Agreement. Defects on items covered by warranty will be executed and funded by the OEM, items not covered by warranty will be executed by the OEM and funded by the asset owner.
- A further Service Agreement will be entered into with the OEM for a period of 8 years taking the turbines to 23 years asset life. At this point the asset owner will be consulted on the future requirements for the windfarm.

Because the asset life cycle activities are defined in the OEM, recommendations and lifetime extension programme timing and scope are defined. These can be fed into the Asset Management plans. Similar strategies for Electrical Balance of Plant and Civils Balance of Plant can be developed and fed into planning.

Scope 1

The financial modelling which takes place at the creation stage of windfarms takes account of these strategies and generally provides sufficient funding for these plans and they can be considered non discretionary. These strategies can therefore be fed into the Asset Management Planning and converted to Asset Management Plans. In reality this is likely to happen soon after commissioning and handover when the plan are fed into some form of Computerised Maintenance Management System either by the Service Provider or the Asset Manager.

There may also be initiatives designed to manage risks or realise opportunities. These may be considered discretionary and will be subject to analysis using the Decision-making Framework and criteria outlined in Section 1.3.6 of this Guidance Document, before any activities required to implement the strategies are added to the plan. Where there are constraints, for example, on resources, funding or access to the assets to carry out work the proposed, activities may be excluded from the Asset Management Plans. Where this is the case there must be a realisation, that to expect that objectives will still be delivered, when resources and activities are constrained, is unrealistic. If Asset Management Plans are constrained the Asset Management Objectives will need to be reviewed and potentially adjusted.

Scope 2

Organisations which develop Asset Management Systems covering the whole life of the assets have more to consider when creating Asset Management Plans. Consider the Objective introduced earlier regarding growth:

- We will increase or generation capacity by 50% over the next 10 years

The Asset Management Plans must include activities which support the delivery of that objectives. For example Asset Management Plans for the next five years could be as suggested in Table 2.

Year	Planned activity
1	Identify and analyse potential sites for new windfarms
2	Select preferred sites, procure and apply for planning
3	Commence construction at site 1
4	Commence construction at site 2 commission site 1 and hand over to Asset Management
5	Commence construction at site 3 commission site 2 and hand over to Asset Management

Table 2 Example Asset Management Plans

As the planning horizon extends the plans will become less detailed. The table above gives an indication of planned activities. ISO 55001 requires that Asset Management Plans detail the following:

- What will be done
- What resources will be required
- Who will be responsible
- When it will be completed
- How the results will be evaluated
- The appropriate time horizon(s) for the asset management plan(s)
- The financial and non-financial implications of the asset management plan(s)
- The review period for the asset management plan(s) (see 9.1)
- Actions to address risks and opportunities associated with managing the assets, taking into account
- How these risks and opportunities can change with time, by establishing processes for managing risk

It is important that when the Asset Management related risks are considered in the organisation’s risk management approach including contingency planning.

Integrating Asset Management Plans

Asset Management is a fundamental part of how organisations in the wind sector operate, it necessarily follows that the Asset Management Plans must be integrated and aligned with other business plans such as those for HR, Finance and Procurement etc. The development review and approval of Asset Management Plans should be integrated into the business planning processes for the organisation. It is normal for plans to be assembled by functions and for the plans to be challenged before being approved. The challenge usually comes in the form of resource constraints and is iterative in nature. The result being plans which are funded and which will deliver agreed objectives.

Implicit in this is a realisation that planning to do more than the available resource, time or access will permit is futile. Plans will never be fully executed meaning that work will not be done, some of the work that is not done could well be critical to the organisation leading to increased risk and lost performance.

Planning is a fundamental part of Asset Management and it is unlikely that an Asset Management Approach can be properly implemented without a formal approach to setting objectives, creating plans and managing risks and opportunities that all organisations whether implementing a full Asset Management System or not should consider establishing robust Asset Management Planning processes and plans.

Tip: Asset Management Plans should be derived from the SAMP

Tip: Use Decision-making Framework to help prioritise when constrained

Tip: Add sufficient detail on who does what, where, when and with what resources

Tip: The level of detail required decreases as the horizon extends

Tip: Integrate planning for Asset Management with other business functions

Trap: Planning more than can be delivered

Trap: Planning activities that add no value

2.6 Section 7 Support

This section has six sub clause which are:

- 7.1 Resources
- 7.2 Competence
- 7.3 Awareness
- 7.4 Communication
- 7.5 Information requirements
- 7.6 Documented information

Since risk and risk management is such a key aspect of ISO 55001 it is useful to clearly define how this is done within the context of ISO 55001. Some organisations create an additional sub clause in the Asset Management System Manual which, whilst not a requirement of ISO 55001, helps to explain how risk is managed and considered when creating strategies and plans.

7.1 Resources

This clause requires that organisation provide adequate resources for the development, implementation, maintenance and continual improvement of its Asset Management System. It further requires that the organisation provides sufficient resources to implement the Asset Management Plans a hence meet its Asset Management Objectives. It is useful to clarify that resources includes but are not limited to the following:

- People
- Tooling
- Finance
- Equipment
- Storage
- IT Systems
- Infrastructure

It was explained in Section 2.5 of this Guidance Document that the iterative nature of business planning where constraints are managed through a Decision-making Framework appropriate Decision-making Criteria allows for Asset Management Plans to be created which provide resources to execute the activities. Where the constraint is such that the plans cannot be executed and the objectives are not met, it may be necessary to review the objectives.

The requirements of this clause are met through robust Asset Management Planning processes integrated with business planning process and supported by the Decision-making Framework.

Organisations seeking to implement an Asset Management System which fully conforms to ISO 55001 can point to the relationship between the Asset Management Planning processes and resources to demonstrate conformance with this clause. There should be no need for a specific documented process for this since this can be detailed in the Asset Management System Manual. Organisations not seeking to implement a fully conforming Asset Management System are recommended to implement robust Asset Management Planning processes, therefore they are, by default, conforming to this clause and could make reference in the Asset Management System Manual.

Tip: The Asset Management Planning processes provide assurance that adequate resources are being provided.

Trap: Making this more complicated than it needs to be.

7.2 Competence

It is important that individuals performing Asset Management activities are competent to do so. In industries such as power generation, including renewables, competence is usually considered to relate to technical competence to work on assets to carry out maintenance and project work. Organisations take great care in assuring that this important area of competence is well managed through various certification schemes and ongoing training etc.

This clause is concerned with competences required to carry out Asset Management functions such as:

- Defining asset information standards
- Appraising and managing risks
- Optimise and rationalise assets
- Control operations
- Apply whole life costing principles
- Appraising investment options

It is often the case that highly qualified and technically competent people find themselves in job roles which require competence in these and other areas, yet have had no formal training or development let alone assessment of competence.

Many organisations have pre-existing competence frameworks which consist of a competence matrix which maps competence requirements against job roles. Individuals in these roles have their competence assessed, normally in a consultation with their line manager. If any gaps are identified these are fed through to competence development plan.

It is a logical approach to utilise these existing competence frameworks and supplement the technical competences with Asset Management competences. It was explained in Section 2.4 of this Guidance Document that properly defined roles, responsibilities and authorities can be an important input to the establishing competence requirements for the job roles.

If we have the Responsible, Accountable, Consulted and Informed roles defined for Asset Management functions competence requirements can be mapped to that role. The institute of Asset Management (IAM) has developed The IAM Competences Framework⁵ published in June 2014 which has two parts. These documents introduce generic roles and competence units which can be mapped to specific job roles within the organisation. Figure 14 shows the 7 roles and units.

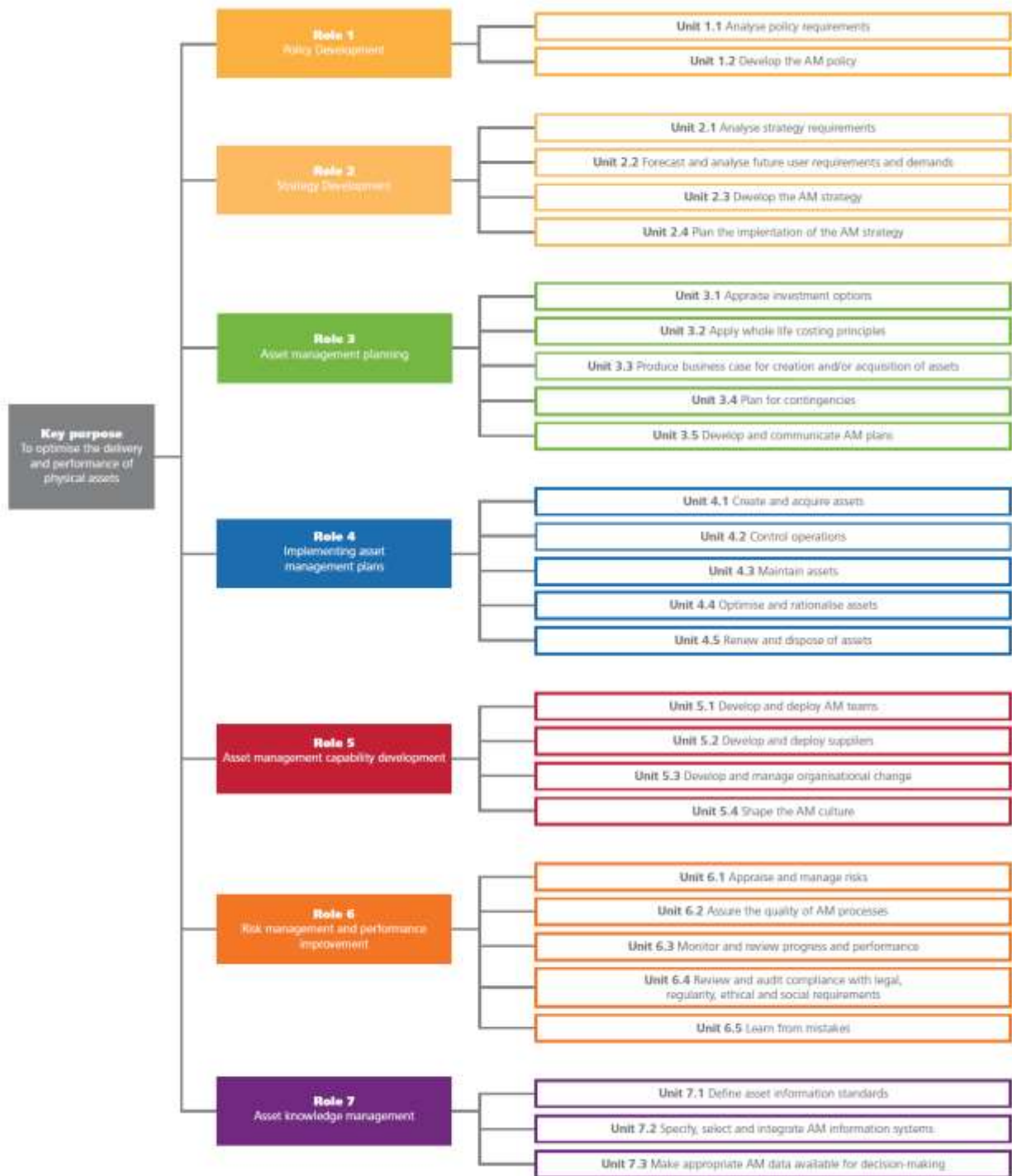


Figure 4 Asset Management Competence Roles and Units

Each generic role has a two-stage breakdown of competence requirements into Units and Elements and details the underpinning knowledge and understanding that is considered most relevant to each role.

Table 3 shows an excerpt from a competence matrix where roles and units are mapped to the position of Operations Manager in an example Asset Management company.

IAM Role	IAM Unit	Operations Manager
R1 Policy development	Unit 1.1 Analyse policy requirements	1
	Unit 1.2 Develop the AM policy	1
R2 Strategy development	Unit 2.1 Analyse strategic requirements	1
	Unit 2.2 Forecast and analyse future user requirements and demands	1
	Unit 2.3 Develop the AM strategy	1
	Unit 2.4 Plan the implementation of the AM strategy	1
R3 Asset management planning	Unit 3.1 Appraise investment options	1
	Unit 3.2 Apply whole life costing principles	1
	Unit 3.3 Produce business case for creation and/or acquisition of assets	1
	Unit 3.4 Plan for contingencies	1
	Unit 3.5 Develop and communicate AM plan(s)	1
R4 Implement asset management plans	Unit 4.1 Create and acquire assets	1
	Control operations	1
	Maintain assets	1
	Optimise and rationalise assets	1
	Renew or dispose of assets	1

Table 3 Excerpt from Example Competence Matrix

Table 4 outlines level of capability that is required for the role as suggested by the IAM's Competence Framework

Level No.	Level	Description
1	Can direct	Direct and plan the work of others and teams
2	Can guide and show	Lead the work of others
3	Can do independently	Undertake the work independently (though may receive contributions from others)
4	Can contribute	Contribute to the work of others but do not undertake it independently

Table 4 Levels of Capability

Table 5 shows the colour coding for competence levels.

Competence Level	Colour Code
Role Model	Green
Competent	Yellow
Limited/ Developing	Red

Table 5 Competence Levels Colour Coding

Table 2 indicates that, following a competence assessment, this “Operations Manager” has limited or developing competence relating to forecasting and analysing future user requirements and demands, for which it is required that they are capable of directing and planning the work of others and teams. Therefore, a competence development plan can be developed this individual. The development plan could be a blend of:

- Online training
- Face to face formal training
- Learning by doing in a controlled scenario
- Mentoring by colleagues or external parties

Much the underpinning knowledge for the IAM’s roles and units will be provided by formal training to achieve the following IAM qualifications:

- IAM Foundation Award in Asset Management: Supports evidence of the staff awareness of asset management necessary for ISO 55001 certification and the building of common purpose and vision within an organisation.
- IAM Certificate: An introductory qualification aimed at those who are new to the discipline of Asset Management or who have some initial experience
- IAM Diploma: A more advanced qualification aimed at individuals with prior asset management knowledge and experience, typically working in or preparing for specialist or management roles

With regard to outsourced Asset Management functions, all service providers should be required to provide documented evidence that all staff involved in Asset Management activities at the organisation have their competence in respect of specific functional Asset Management activities is reviewed at least annually.

Organisations seeking to implement an Asset Management system fully conforming to ISO 55001 will need to demonstrate competence in the Asset Management functions and requirements of the standard. Those seeking to implement elements of ISO 55001 are recommended to provide assurance that those individuals executing those elements are competent to do so. In both cases, the creation of a competence framework as outline above provides a practical and scalable approach to providing that assurance.

Tip: Link competence requirements to Roles and those Responsible, Accountable, Consulted and Informed in relation to Asset Management functions and activities

Tip: Use the IAM’s Competence Framework as a reference

Tip: Provide underpinning knowledge via the IAM’s qualifications or equivalent

Tip: Use a blended approach to competence development

Trap: Assuming the competence in technical and engineering activities covers all Asset Management competence

Wind Farm Asset Management and ISO 55001: Maximising the Return on Wind Energy Investments

This clause requires that individuals working on Asset Management activities under the control of the organisation are aware of the Asset Management Policy and how they contribute to the effectiveness of the Asset Management System and the benefits of improved asset performance.

In addition, they are to be aware of their Asset Management work activities and associated risks and opportunities and the implication of non-conformance to the requirements of the Asset Management System.

This Guidance Document has introduced the IAM Foundation Award in Asset Management which could support evidence of the staff awareness of asset management necessary for ISO 55001 certification and the building of common purpose and vision within an organisation.

In addition to the basic awareness provided by the Foundation Award, organisations can make staff aware of the AM Policy at least annually through an annual performance review process during which the Policy can be reviewed. This can be further reinforced by the Top Management reconfirming the AM Policy following each Management Review of the AM System. This two-pronged approach provides assurance that directly employed staff are aware of their contribution to the effectiveness of the Asset Management system, including the benefits of improved asset management performance.

Through the performance and competence management programme, directly employed staff are aware of their work activities, the associated risks and opportunities and how they relate to each other, and the implications of not conforming to the requirements of this Asset Management System. A useful mechanism for both Awareness and Leadership is the team, particularly senior managers, having including Asset Management discussion in regular meetings e.g. weekly, monthly and quarterly meetings etc.

Most organisation require that all new employees undergo an induction process. During this they can be given copies of the AM Policy and informed of the impact that their role and their individual performance can have on the Asset Management System. This is can be complemented by an initial competence assessment from which awareness of the importance of Asset Management and competence development plans can be established.

Persons not directly employed by the organisation can be made aware of the requirements of the Asset Management System through the management of outsourced services, see Section 2.8 of this Guidance Document. All service providers should provide documented evidence that all staff involved in Asset Management activities at the organisation have read the Asset Management Policy and are aware of their responsibilities with respect to Asset Management.

Tip: Include Asset Management Policy and System Manual during induction of new staff

Tip: Include Asset Management Policy review in annual appraisal.

Trap: Assuming that awareness happens automatically.

7.4 Communication

This clause requires that the organisation determine the communication requirements relevant to assets, Asset Management and the Asset Management System. This includes consideration of what will be communicated to whom, at what time and in what format.

It is useful to consider the communications requirements of stakeholders at the same time assessing their other requirements with respect to Asset Management which was explained in Section 2.4 of the Guidance Document.

Two-way communication is a critical element in making the Asset Management System effective. To do this, stakeholders should be included in an effective, structured and timely two-way communication intended to:

- Inform, influence and manage stakeholders
- Promote engagement with stakeholders
- Make stakeholders aware of the value of a structured approach to Asset Management and its achievements
- Explain the impact of the Asset Management System and Asset Management activities on stakeholders

- Improve the Asset Management System and its communications methodology

The two-way nature of communications cannot be underestimated. It is essential that the organisation checks the effectiveness of the communication by confirming the message as was received and understood in the way it was intended.

Having established the communication requirements a communication plan can be developed in respect of the Asset Management System. This should be designed to be a two-way process and feedback from stakeholders should be captured in a systematic way. Information communicated should be succinct and relevant to the stakeholder and cover areas including, but not limited to:

- Key Performance Indicators
- Statistics
- Programme of works
- Resources required
- The rationale for key decisions
- Performance levels.
- Financial and non-financial information
- Achievements such as certification to ISO 55001
- Major milestones such as completion of the Asset Management System management review
- Issuing and revising the Asset Management Policy

Methods of communication which can form part of the communication plan include but are not limited to:

- Corporate and group announcements
- Executive roadshows
- Line manager briefings
- News Releases
- Seminars
- Conferences
- Notice boards
- Email
- Written material
- Web based broadcasts
- One on one meetings
- Workplace briefings
- Toolbox talks
- Community engagement meetings and workshops

Where the organisation has a corporate or group communications team the Asset Management team should liaise closely to assure alignment of message and that Asset Management communications are included in appropriate corporate communications.

Organisations seeking to implement an Asset Management System fully conforming to ISO 55001 should create a communications plan for Asset Management. Organisations seeking to implement elements of ISO 55001 should carefully consider how they will communicate with stakeholders, internal and external, which are impacted by the Asset Management function or activity.

Tip: Create a plan for communication

Tip: Vary styles and methods for communication

Trap: Not checking the effectiveness of the communication

7.5 Information requirements

This clause requires that organisations determine their information requirements to support its assets, Asset Management and the Asset Management System to support the delivery of their organisational objectives.

This will include considering a wide range of factors such as the importance of identified risks and the Asset Management processes, procedures and activities. Consideration should be given to how quality, availability and information management will impact the ability to make Asset Management decisions. Likewise, how information will be exchanged with stakeholders such as service providers should be considered.

It is important to determine the information requirements in terms of the attributes, quality and how the information will be collected analysed and evaluated, with processes required for managing Asset Management Information. Particular attention is required in relation to the alignment of financial and non-financial terminology relevant to Asset Management throughout the organisation as well as the consistency and traceability required to meet stakeholder and legal requirements and supporting the delivery of organisational objectives.

This clause can be the most challenging for organisations seeking to implement an Asset Management approach. Many struggle with the possible scope of such a requirement. It is important to frame this in the scope of the Asset Management functions and activities. Determining the information required to execute these processes will help to frame how such information is managed. Consider the information required to manage Asset and Asset Management related risk.

Risk is generally considered to be the product of the probability of an event and the consequences of that event. For example, when assessing risk associated with a turbine gearbox, information would be required which would enable the organisation to assess the probability of the gearbox failing such as:

- Maintenance history e.g. previous failures
- Planned maintenance records e.g. was the planned maintenance carried out? And if so, what was found when the gearbox was maintained?
- Inspection reports
- Vibration monitoring information and reports

It is likely that this information is stored in different information system or repositories. The information will have different attributes and be of different quality. Information quality can be considered in terms of the Completeness, Consistency, Correctness and Clarity.

Some of the information may be held by service providers, for example the organisation could have outsourced vibration monitoring to a specialist company. This could mean that the information is not available in a timely manner.

For each piece of information outlined the organisation can conduct an assessment to establish if there are any deficiencies or gaps with the current information available. Each organisation must determine what criteria are to be utilised for when assessing Asset Management information. Table 6 shows examples:

Heading	Explanation	Example
Business Process	The process for which the information is required	Risk Management: assessing probability of failure
Requirement	The information that is required	Vibration information
Business Value	A description of the value that the information brings to the process	This information gives an indication of developing faults within the gearbox
High, Medium, Low Level Of Business importance	An assessment of the value in terms of High, Medium or Low.	High
Source/Media	The sources of the information and the media used for transmission	Paper based report from service provider. Provided annually in March
Attributes	The attributes of the information e.g., is it a data field or is it a document	Document
Frequency	How often the information is required	Annual, review or if ad hoc as issues are found
Timing	When the information is required.	December unless there is an issue
Quality (Red Amber Green)	Quality assessment of information Completeness, Consistency, Correctness and Clarity, producing a Red Amber Green score.	Red
Gap	Identify gaps in the Asset Information	The delay in providing the information and using it makes the information unreliable
Plans for improvement	What are the plans for improving the asset information	Develop an interface with the service provider to the CMMS to give real-time information on the CMMS

Table 6 Criteria for Assessing Asset Information

Carrying out such an analysis for the critical Asset Management functions and processes facilitates the development of an Assets Information requirements matrix from which plans can be developed to close any gaps.

Alignment of financial and non-financial information is important. In many organisations there are more than one **“Asset Register”** e.g. **one which sits on a financial IT system and the other which could be on a Computerised Maintenance Management System**. This could lead to discrepancies in terms of asset valuation and depreciation, leading to inappropriate decisions being made. In a similar manner, when information of a technical manner is held on a separate system it is possible that information may not be aligned, for example information from the **creation and acquisition phase of an asset may be stored on a “Project Management” IT system**. **This information** must eventually be destined for utilisation in the operations and maintenance phase, this would normally involve some form of transfer from one system to another, which has inherent risk.

Some organisations refer to a single source of truth and take this to mean an integrated IT system for Asset Management. Such an integrated system is not required. Organisations can determine which, of a range of

sources of information, is to be the source of truth within the Asset Management process. This should be supplemented by robust business processes which assure alignment between the different sources

It is important to determine how information is captured, for example, asset maintenance information could be collected using handheld devices or on paper to be input to an IT system later.

Also, how the information will be managed to assure that it does not become inaccurate or out of date should be determined, this could include auditing asset information.

The approach outlined above gives a structured method of identifying what information is NEEDED for Asset Management as opposed to what is possible. Many organisations rush to implement sophisticated IT systems to support Asset Management, not knowing what the Asset Management requirements actually are. This first principle approach can help to establish the needs and establish the specification for any Asset Management IT Systems which might be required.

Organisations seeking to implement an Asset Management System which fully conforms with ISO 55001 should establish what their Asset Management information requirements are, establish any gaps and produce plans to close those gaps. Processes for managing Asset Management information are required to provide assurance that the information is collected and maintained to an appropriate standard. Organisation seeking to implement elements of ISO 55001 should consider the Asset Management information requirements for those elements and establish processes which provide assurance that the information is collected and maintained to an appropriate standard.

Tip: Establish Asset Management information needs based on functions and processes

Tip: Establish processes for controlling and maintaining Asset Management information

Trap: Thinking the solution is all about an IT system, establish Asset Management processes then decide if you need a system

Trap: Misaligned information

7.6 Documented information

This sub clause has three further sub clauses:

7.6.1 General

This subclause requires that an organisations Asset Management System contains documented information which is required to satisfy the requirements of ISO 55001, legal and regulatory requirements and the requirements.

A review of ISO 55001 shows that the following are required to be documented:

- The scope of the system (4.3)
- The Strategic Asset Management Plan (4.4)
- The Asset Management Policy (5.2)
- Asset Management objectives (6.2.1)
- Asset Management Plans (6.2.2)
- How outsourced activities controlled (8.3)
- Evidence of:
 - Competence (7.2 and 7.6.1);
 - Processes carried out as planned (8.1);
 - Results of monitoring, measurement, analysis and evaluation (9.1);
 - Audits (9.2.2);
 - Management reviews (9.3);
 - Nonconformities or incidents and results of corrective actions (10.1)

It is possible that organisations could be found to be “technically” conforming with ISO 55001 by ONLY having these documents, however it is unlikely that this will be the case.

What is documented will be dependent upon by the scope, size and complexity of its Asset Management activities. It is not recommended that individual process documents are created for each element of ISO 55001, organisations must decide what adds value and develop processes accordingly. However, it is strongly recommended that organisations create an Asset Management System Manual. An invaluable document providing a coordinated view of how Asset Management activities are carried out and providing sustainability.

The activity of creating the Asset Management System Manual also gives an indication of what processes, function or activities may need to be documented separately. It is advisable to create a draft early on in the process of developing an Asset Management System and revising and updating it as the Asset Management System matures.

7.6.2 Creating and updating

This subclause requires that when creating and updating documented information organisations ensure documents are appropriately identified and described and are of appropriate, format and media.

7.6.3 Control of documented information

This subclause requires that where organisations have documented information it is available and suitable for use, where and when it is needed; it is adequately protected.

There are many methods and approaches available for meeting the requirements of Subclauses 7.6.2. and 7.6.3; many of the organisations in the target audience for this Guidance Document are operating other Management System Standards e.g. ISO 9001. Therefore, it is not proposed to provide detailed guidance for the creation, updating and control of documented information here.

However, with respect to Asset Management, organisations seeking to implement an Asset Management System fully conforming with ISO 55001 should commence drafting the Asset Management System Manual as early in the process as possible. This will provide guidance on which documents are specifically required and which processes can be described in the Asset Management System Manual. Organisations seeking to implement *elements* of an Asset Management System should consider creating an Asset Management System Manual since it provides coordination of disparate activities which may become misaligned due to the lack of alignment which an Asset Management System brings.

Tip: Only create documented information that adds value or is required by ISO 55001

Tip: Create the Asset Management System Manual early in the process

Trap: Working for the Asset Management System, it should work for the organisation

2.7 Section 8 Operation

This section has 3 subclauses:

- 8.1 Operational planning and control
- 8.2 Management of change
- 8.3 Outsourcing

8.1 Operational planning and control

This subclause requires organisations to have processes which manage and control the implementation of the Asset Management Plans for the assets, Asset Management and the Asset Management System. This involves establishing criteria for the required processes and implementing the control of the processes in accordance with the established criteria. It is also required that evidence, in the form of documented information, is retained which demonstrate that the processes have been carried out as planned. Risks are to be treated and monitored using the approach determined for managing Asset Management risk.

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In plain terms this means that the organisations should have processes for controlling the work outlined in Asset Management Plans. Depending on the scope of the Asset Management System this could involve processes for managing the:

- Construction of new wind farms assets
- Integration of wind farm assets, which have been acquired, to the existing portfolio
- Routine maintenance activities on wind turbines
- Routine maintenance activities for EBOP and CBOP
- Routine site inspections
- Lifetime extension programmes
- Asset improvement projects
- Asset replacement projects
- Asset decommissioning projects
- Asset Management capability development initiatives
- Emergency actions
- Planned corrective maintenance e.g. as a result of a condition indicating an incipient fault

These can be broadly characterised into the asset life cycle phases identified in Section 1.3.2 of this Guidance Document:

- Creation/acquisition
- Operate and Maintain
- End of life

In addition, planned work to improve Asset Management Capability and the Asset Management System is required to be controlled.

Creation/acquisition phase

Creation and acquisition work is generally considered to be Capital work and normally managed by a dedicated **“Projects” team and focusses on the delivery of a programme of work on time and within budget. There are** a wide range Project Management Methodologies available and it is beyond the scope of this Guidance Document to critique these, however it is the case that how Capital projects are managed does impact the VALUE realised by the assets being created or acquired. Often **decisions are made which enable the delivery of “on time and to budget”** which adversely impact whole life value. Therefore it essential that decisions made during these projects are made using agreed decision-making criteria.

Consider a windfarm construction project which is underway and experiences a situation whereby finances are constrained. This constraint means that tough decisions need to be made. The design calls for a duty standby arrangement for the circuit breaker connecting the substation to the outgoing transformer. The project manager sees an opportunity to reduce the cost of the project by not purchasing and installing the standby but having the substation configured such that a standby can be easily connected once purchased during the operations and maintenance phase. This type of scenario is not unknown in many industry sectors.

Consider now the Asset Management organisation managing the windfarm finds that there is no budget to purchase and install the standby circuit breaker. This could have the following consequences;

- Disconnecting the entire windfarm to carry out planned maintenance which would result in loss of revenue
- Increased risk of downtime through a fault on the single circuit breaker which results in loss of revenue.

Both of these could have additional consequences in terms of reputation and stakeholder engagement.

It is therefore essential that the life cycle implications of decisions made by the project team are fully evaluated and understood. This can only be done through close consultation between projects and operations teams from the from project inception through to commissioning and handover. This must be a true consultation where the views of operations are actually heard, understood, evaluated, and acted upon.

It is important that, as the project advances, certain actions are carried out including but not limited to:

- Ensuring that all the assets are fully recorded in the Asset Register
- Transcribe the agreed OEM O&M schedule into any CMMS
- Create Planned Maintenance Tasks for any activity not carried out by the OEM under a service contract such as site inspections
- Create Planned Maintenance tasks for work on EBOP and CBOP
- Collect and collate all asset and asset management related information such as
 - Operations and Maintenance manual
 - Schematic diagrams
 - As built diagrams
 - Commissioning data
- Determine and procure stock holding for critical slow moving high value, high consequence spare parts
- Determine stock levels and procure fast moving, low to medium value/impact spares and consumables
- Secure and back up any control system programmes
- Ensure service providers, internal or external are engaged and ready to commence
- Carry out Health Safety & Environmental Risk assessments for the operations and maintenance phase
- Commence execution of the O&M schedule once commissioning has been completed and the assets are handed over to the operations and maintenance
- Carry out inspection to identify snags and resolve

Following commissioning there will be a formal handover from Projects to the Operations and Maintenance teams where the Operations and Maintenance teams take responsibility for the assets. It is often the case that there are unresolved snags carried over from commissioning and handover, normally Operations and Maintenance are expected to accept responsibility and accountability for closing these out. This adds costs to the Operations and Maintenance phase and can impact value. Sometimes these snags are not addressed because of the cost which results in increased risk and/or reduction in performance, which again impacts value.

The interdependence between creation/acquisition phase and operations and maintenance phases is crucial in maximising value. Adopting a whole life Asset Management approach can help to resolve the issues identified. To do this, organisations must build upon robust project management processes and incorporate appropriate consultation with Operations and Maintenance teams. However, the major improvement is to incorporate the decision-making framework and decision-making criteria in the project management processes. That is not to say that sub optimal decisions must not be made. Rather, if the decision MUST be made, for example due to lack of resources of time, then the impact of that decision across the life of the windfarm can be quantified and provision made in the Operations and Maintenance and in planning for the end-of-life phase.

Establishing robust metrics to track the effectiveness and efficiency of the execution of the Capital plan is essential, this is discussed in Section 2.9 of this Guidance Document.

Tip: Build processes which mandate true consultation with Operations and Maintenance

Tip: Incorporate the Decision-making Framework to Project Management processes

Tip: Track number and value of snags as a metric of effectiveness and efficiency of the Capital projects processes

Tip: Determine slow moving high value stock holding based on cost risk and performance in advance

Trap: Delivering projects on time and to budget and disregarding long-term impact on value

Trap: Rewarding project managers based solely on "On time and to budget"

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As discussed in Section 2.5 of this Guidance Document, the Operations and Maintenance (O&M) plans for windfarms, especially turbine assets, are generally established at the design stage, at least for the first fifteen to twenty years. Therefore, this subclause is concerned with controlling the planning, scheduling and execution of these plans and requires that the service providers, both external e.g. OEMs and internal, carry out the agreed tasks to deliver the agreed objectives.

Despite the O&M plans being established and normally held in some form of IT system such as a Computerised Maintenance Management System, these still require to be scheduled at a tactical level for execution, within agreed timeframes, to suit site operational needs. Such scheduling should consider a number of factors such as:

- Seasonal variations in wind speed e.g. do not schedule planned maintenance in months when average wind speeds are high
- Interdependency between assets e.g. scheduling planned maintenance on turbines at the same time EBOP and CBOP maintenance such as electrical network maintenance at the same time as OEM turbine work because the OEM requires an electricity supply for lighting and site power for the lifts in the turbines.
- Risks to other service providers when working simultaneously in separate assets
- System Operator requirements
- Spot variation on dispatch
- Opportunity to bundle tasks together to take advantage of low wind speeds etc.
- Opportunity flex maintenance dates to take advantage of unseasonal wind speeds

Organisations should have processes which identify these interdependencies and facilitate the creation of schedules which are based on cost risk and performance, thereby maximising value.

Organisations managing the execution of work must be in close contact with those providing the service. Sometimes the relationship is between multiple organisations e.g. Asset Management, OEM and EBOP and CBOP service providers, in other cases the Asset Management company also delivers the service. In any event, close liaison and consultation is essential.

One way to achieve this through regular formal communications such as:

- Bi-weekly calls, and
- Quarterly face-to-face meetings

The purpose of these meetings will be to:

- Agree firm dates for PM tasks
- Agree bundling of related OEM works and minor or non-critical works
- Coordinate with other site activities
- Review effectiveness and progress of maintenance
- Manage related action plans

It is useful to have agreed Terms of Reference for these meetings, an example of which is shown in Table 7

Purpose (Terms of Reference),	To Review progress of Turbine O&M works with each OEM identify tactical issues & summary of ad-hoc contacts between meetings
Frequency,	Every 2 weeks (day agreed at previous meeting, but usually falls on a Tuesday or Friday)
Location	Dial in
Chair	Site Supervisor
Participants,	<p>For Site</p> <ul style="list-style-type: none"> • Operational Controller • Operations Engineer • H&S Officer • Performance Analyst • Engineer • Field Operations Manager • Site Managers <p>For OEM</p> <ul style="list-style-type: none"> • Nominated person • Customer Relations representative (optional)
Agenda,	<p>For OEM Portfolio:</p> <ul style="list-style-type: none"> • Turbine-specific Issues • H&S issues • Environmental issues • IT issues • Related EBOP, CBOP, vegetation etc • Progress • Preparations for work (1 day 1 week 1 month etc) • Coordination • Stakeholder issues <p>Information Sources Site document ‘OEM Tracker’ KPIs / Open Items / SCADA Grid related / Long Term Items / Closed Items</p>
Action Log	<p>Recorded in OEM Tracker</p> <p>Agree escalation to other meetings including risk management, other management levels</p>

Table 7 Bi Weekly Liaison Call Terms of Reference

Given the stable nature of the O&M plans it is reasonable to set a “short term” scheduling horizon for such work. Organisations should select their own scheduling horizon to establish control yet retain flexibility to respond to the dynamic nature of windfarm operations. Some organisations work on a thirty-day scheduling horizon.

In addition to liaising with service providers the Asset Managers must assure that the asset plans are being executed and that the assets are **being operated in the appropriate way**. This can be done through a series of “Operations Meetings” as follows:

- Daily
- Weekly
- Monthly

As with the liaison with the service providers these meetings benefit from having agreed Terms of Reference. Table 8 shows the Terms of Reference for a typical weekly meeting.

Purpose (Terms of Reference),	'Round Table' Internal Review of all O&M activities
Frequency,	Weekly - every Tuesday
Start time / duration	Start 1100h Finish 1200h
Location	Operations Office
Chair	Operations Controller
Attendees	<p>Must attend (in person or dial in)</p> <ul style="list-style-type: none"> • Operations Manager • Operational Controller • Operations Engineer • H&S Officer • Performance Analyst • Engineer <p>Dial in:</p> <ul style="list-style-type: none"> • Field Operations Manager • Site Managers
Agenda	<ol style="list-style-type: none"> 1. Apologies for absence 2. H&S briefing (from Health and Safety Officer) 3. Security briefing (from Site managers) 4. Public Relations (from relevant personnel – usually Ops Controller or Site Manager of the affected site) 5. Environmental briefing (from H&S Officer) 6. Review of Risk Register, control actions and emergent risks 7. Site Handover (from Ops Controller) 8. Grid Code (from Performance analyst) 9. IT / Systems / CMMS (from Performance analyst) 10. Certification (from Performance analyst) 11. Operational Engineering (from Ops Engineer) <ol style="list-style-type: none"> a. Issues b. Plant Modifications c. Machines/Sites out of service d. Machines under special monitoring 12. Site Supervisor Reports 13. Procurement Report (from Ops Manager) 14. Grid Outage 3 Month Ahead Plan (from Ops Controller / Ops Engineer) 15. AM System development actions 16. Exceptional Items 17. AOB <p>Information Sources</p> <ul style="list-style-type: none"> • Call trackers with OEM • CMMMS • Construction / Development / Operations Site Handover Meeting Minutes • Site supervisor downtime trackers • Grid outage notifications from TSO (email)
Action Log	Record Actions, Responsible person, target date Agree escalation to other meetings including risk management, other management levels
Minutes of Meeting	No formal minutes. Actions are assigned as necessary and recorded for review at the next meeting.

Table 8 Terms of Reference for Typical Weekly Review Meeting

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When managing, faults, non-conformities and defects these are normally rectified as early as possible, subject to risk assessment and agreement between stakeholders. Where follow on or deferred corrective work is required, it is normal to log these on some form of work request system, usually a Computerised Maintenance Management System. These “service requests” are then managed through the daily, weekly and monthly meetings, being allocated, executed and controlled within these forums.

Likewise, actions relating to Life Time Extension can be managed through this mechanism e.g. a service request to conduct Life Time Extension inspection can be raised. However the decision to do carry out any work identified in the inspection should be made using the agreed Decision-making Framework and should the work be approved through the business case, Service Requests can be raised and controlled as above.

Actions identified in the Asset Management Plans for the Asset Management System can be managed controlled **and executed using the meetings highlighted above, indeed Item 15 of the agenda in Table 7 is to discuss “AM System development actions”**.

Performance metrics associated with the execution of Operations and Maintenance Plans will be discussed in Section 2.9 of this Guidance Document.

Tip: Establish control processes which mandate liaison with key stakeholders

Tip: Appropriate Scheduling horizons which establish control yet retain flexibility

Tip: Review meetings with strong Terms of Reference

Tip: Establish understanding of scheduling constraints

Trap: Not scheduling time for corrective or improvement work

End of life

To many organisations, the Lifetime Extension work described above is considered end of life. However, it is noted **that a wind turbine’s expected life span is dependent upon a number of factors including, age, average wind speeds, peak wind speeds, geographical location, make and model etc.** Therefore, in reality, for turbines with a Lifetime **Extension review at fifteen or twenty years is not likely to result in “End of Life”, rather some minor O&M** work is likely to be recommended which can be resourced from O&M budgets or within the terms of the OEM agreement. EBOP and CBOP assets are likely to have a lifespan longer than turbines and are therefore less pressing than turbine assets.

End of Life therefor means the replacement, major overhaul and refurbishment or decommissioning and removal of assets from the site and returning it to the pre windfarm state. These are likely to be Capital projects with dedicated project managers and established project management approaches. However, as was discussed in the control of creation/acquisition plans, the successful execution of the work requires close consultation with O&M teams, particularly when dealing with refurbishment and renewals where successful integration with site operations will be crucial. Where the assets are to be retired, there may be an opportunity to harvest spare parts which may be obsolete yet still installed in other functioning windfarms within the portfolio.

As with Creation and Acquisition and Operations and Maintenance appropriate metrics should be developed and employed.

Tip: End of Life relates to major overhaul, replacement or retirement

Tip: These are likely to be Capital Projects, treat them as such

Trap: Not consulting O&M staff when assets are being decommissioned

Organisations seeking to implement an Asset Management System fully conforming to ISO 55001 should define and document the processes for controlling the execution of plans across life cycle phases of the asset which are in scope of the Asset Management System. In many cases the processes for managing Capital Projects will be established and all that is required is to supplement these with the processes which drive true consultation and mandate the use of the agreed Decision-making Framework. When managing Operations and Maintenance work defining and documenting such processes is useful since it allows the organisation to identify gaps, which represent risk to the delivery of value from the asset, and duplication of effort which represent an opportunity to remove waste and make the processes leaner improving efficiency. Organisations seeking to implement elements of ISO 55001 are strongly recommended to take steps to enable them to conform to this subclause as much as possible. There are significant benefits in terms of risk reduction and opportunities to realise efficiencies.

8.2 Management of change

This subclause requires that before implementing any planned change, permanent or temporary, that risks having an impact on achieving the asset management objectives the organisation will assesses the risk before the change is implemented. It is also required that the risks are managed in alignment with the Asset Management Risk Management approach and that it controls the planned changes, reviews unintended consequences and takes action to mitigate any adverse effects.

In this context planned change may be:

- Discretionary i.e. the organisation elects to make the change to seek an improvement
- Non-discretionary i.e. the organisation must make the change to react to a developing or urgent situation

For instance, the organisation may decide to modify an asset to improve its function or increase its capacity (i.e. a discretionary planned change) or it may have no option but to replace a failed component with a dissimilar one (i.e. a non-discretionary planned change).

Planned Change	Discretionary	Non-Discretionary
Introduce new asset type	Organisation selects a more efficient asset for a specific function	OEM withdraws support for an asset that the organisation uses
Plant modification (Hardware and/or software)	Organisation chooses to modify plant to improve function, increase capacity, reduce emissions etc	Organisation replaces failed component with non like-for-like.
All/part of the Asset Portfolio is passed to another Asset Owner	Asset Owner chooses to refocus its investment strategy	Asset Owner is required to divest as part of a larger merger deal
Additional Asset Systems are added to the existing Asset Portfolio	Asset Owner acquires Asset Portfolio of another organisation / wins additional AM Service contract(s) / builds new capacity	
Loss of staff / New staff	Organisation hires new staff in accordance with succession planning Asset Owner acquires staff of another organisation	Organisation must deal with sudden loss of key staff
Revision to industry Regulation, standards, laws, Codes of Practice	Organisation chooses to operate in new territories under different rules	Organisation must conform to newly-imposed requirements. Note that Covid19 and Brexit measures would come under this.
Rebalance In-house / Outsource mix	Organisation chooses to adopt a policy to outsource specific activities	Insolvency of key outsourced provider
Revision of Contract Terms	Third Party accepts the organisation's proposed amendments	Organisation accepts terms imposed by the Third Party
Extend service life of asset type	Organisation decides to operate assets for longer than originally planned	Organisation is prevented from replacing assets as originally planned
Revise / Enhance site security		Organisation decides that it has lost control of existing keys / passwords scheme
Introduce a revised Maintenance Strategy	Organisation decides to incorporate new technology into maintenance	Organisation must incorporate revised OEM service documentation
Restructure the Asset Management Organisation	Organisation decides to restructure to realise improvements in effectiveness and efficiency.	Organisation is subject to a merger or acquisition which requires restructuring.

Table 9 Examples of Planned Change

The table shows the range of changes that can arise in the normal operation of an organisation, encompassing Business Ownership, Procurement, Production, Maintenance, Marketing and HR. They also demonstrate that awareness of the need to change will not rest with any one part of an organisation or a single level of responsibility. It shows the need for Awareness and Communication relating to the requirements of relevant stakeholders and of other financial, technical, legal, regulatory and organisational requirements.

Managing change, refers specifically to planned changes. Unplanned changes are usually dealt with through routine risk management, including Contingency Planning, and also the measures to deal with nonconformities or incidents for instance:

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- Changes in condition and performance
- Asset failure

The guiding principle is that the organisation is required to manage the change. It is important to show that the risk of the change has been assessed and managed as appropriate before the change is implemented. This is good business practice, if an organisation introduces a change without the appropriate preparation, it may suffer unforeseen and damaging consequences.

A planned change may be relatively minor or it may be a major undertaking. The organisation must address the effort required proportionately, in accordance with its Decision-making Framework. Organisations will perform many routine planned changes in the Asset Management System and the wider organisation, including periodic and ad-hoc review and revision of processes and procedures.

It is important to avoid unnecessary administrative burden when considering how to respond to a planned change, therefore the organisation should provide guidance on a proportionate response. Proportionality is linked to the risk associated with the planned change. Consider the risk matrix shown in Figure 15

	1	2	3	4	5
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Figure 5 Example Risk Matrix

- Risk score 2 or less is tolerable with regard to Asset Management Risk and the change may proceed
- Risk score 3 to 12 is in the ALARP zone and risk associated with the change can be managed "As Low as Reasonably Practicable"
- Risk score 12 to 25 is intolerable and the risk associated with the change must be brought at least to the ALARP zone

Where the change is discretionary the cost of managing the risk may outweigh the benefits associated with the change and the organisation may decide not to make the change. Again, this will be determined through the Decision-making Framework

A change management template is useful to guide people through the approach to managing change. Elements of the template could include:

- What is the issue?
- What is the intended outcome including forecasted benefits?

- Which of our agreed AM Objectives can be affected?
- Risk Assessment, probability X consequence = risk score
- Risk Control / Mitigation action
- Risk Assessment after mitigation/control action
- Cost of risk control / mitigation
- Is the planned change discretionary or non discretionary?
- Outline the required change and resources e.g.
 - Documentation.
 - Software update or parameter changes
 - Asset Information
 - Communication
 - Instruction
 - Training
 - Supervision
 - Procurement
 - Logistics
 - Equipment
- Who will be responsible for the planned change?
- Is the change permanent or temporary?
- When will it be completed?
- How will the results be evaluated?
- Who will authorise the change?
- Who will execute the change?

Organisations seeking to implement an Asset Management System fully conforming with ISO 55001 should develop Management of Change processes and guidance which allow proportionality in response to managing risk associated with the change. The change management process must be aligned with the risk management approach and Decision-making Framework. Organisations not seeking to implement an Asset Management System fully conforming to ISO 55001 should consider how they will manage risk associated with planned changes. A fully documented process may not be required. However, it could be possible to create a business rule which requires an assessment of risk for changes which are over a financial threshold, for example greater than €100k. If such organisations have risk management processes, the management of risk associated with change should already be within its scope. This subclause of ISO 55001 points out the risk associated with planned change as an area of specific interest.

Tip: Proportional response is key

Tip: Create and implement templates to improve efficiency and effectiveness

Trap: Spending more time managing change than managing assets because proportionality is incorrect

8.3 Outsourcing

In many asset intensive industry sectors the outsourcing of Asset Management functions is a key part of the operating model. In the wind sector in Ireland a significant proportion of asset maintenance activity is outsourced although this is not universally the case.

This subclause requires that organisations assess the risk associated with outsourcing any activities that can have an impact on the achievement of its asset management objectives and that the outsourced activities are controlled. How these activities will be controlled and integrated into the organisation's **asset management system** are to be determined and documented. In doing this, the organisation must determine what is to be outsourced and how the outsourced activities interface with the organisation's **own processes and** activities. Internal responsibilities and authorities for managing outsourced activities and the approaches for sharing knowledge and information with service providers must be determined. The organisation is also required to ensure that outsourced resources are

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aware of their responsibilities with respect to Asset Management and are competent to carry out the respective functions. Performance of the outsourced activities is to be monitored.

When deciding whether to outsource, the organisation should consider the reasons for outsourcing the function. This implies that there are some benefits associated with outsourcing which will add value, however with this comes risk. Before making the decision to outsource the organisation must assess if the benefit outweighs the risk.

There are a wide range of operating models in the wind energy sector in Ireland. Some Asset Owners have appointed Asset Management companies to manage a range of service providers, generally the OEM for turbines and specialist contractors for EBOP and CBOP, whereas some Asset Owners do the majority of work inhouse only resorting to outsourced service providers in extreme circumstances such as major faults.

Items to be considered when entering into outsourced service agreements include

- Establishing the scope of service, what will be done and when and with what outcome: normally contract documents define the scope of services however in many occasions these are more legal in nature. Therefore properly defined a scope and required levels of service are essential. This allows the development of Service Level Agreements (SLA)
- Criticality of the service provided: where the service is critical the organisation may choose to focus attention in terms of supplier management.
- Competence, both technical/engineering and Asset Management functions and activities, of service providers to execute the scope,
- The capability of the service provider to execute the work, this would include any logistical issues e.g. is there a presence in the geographical location and does the service provider have the capacity within existing resource to deliver the service
- The service providers awareness of the organisations Asset Management Policy and approach
- How performance of the service providers will be measured, any metrics should be aligned with the scope and service level agreements
- Communication and transfer of information between the organisation
- Ownership of asset and Asset Management Information, this is particularly important when changing service providers or brining the function inhouse. Consider a scenario when the organisation choses to move turbine operations and maintenance from the OEM to a third part Independent Service Provider. If the information **relating to turbine condition and maintenance history is held on the OEM's information system** it may be difficult to recover it. Indeed if the information is owned by the OEM it may charge for the provision of the information.
- How the organisation will manage the transition to new service providers if it is decided to do so
- Returning the functions to the organisations inhouse teams
- Supplier management, regular meetings and performance reviews are essential to prevent divergence between what is expected and what is delivered
- Dispute resolution, whilst it is hoped that outsourcing will be successful and there will be no dispute between the parties, a mechanism for resolving disputes should be established and agreed by all parties.

As with all Asset Management decisions, the decision to outsource should be made using the Decision-making Framework based on the best trade-off between cost, risk and performance. Risks should be identified, evaluated and managed.

Organisations seeking to implement an Asset Management System fully conforming to ISO 55001 should establish processes for assessing and evaluating the value associated with outsourcing Asset Management activities and functions. Where value exists, risks should be managed in alignment with the risk management process. Organisations seeking to implement an elements of ISO 55001 should consider the risk associated with outsourcing activities versus the benefit and the availability of alternatives. For example, an asset owner who has a single windfarm with a few turbines will have little option to outsource activities, since establishing an inhouse resource would be cost prohibitive. Nevertheless, many of the issues listed above will be relevant and need to be managed.

Tip: Begin with the end in mind, agree the mechanism for ending the agreement

Tip: Clearly define what is required and what success looks like to all parties

Tip: Outsourcing should bring value

Trap: Not managing the risk

2.7 Section 9 Performance evaluation

This section has three subclauses.

- 9.1 Monitoring, measurement, analysis and evaluation
- 9.2 Internal audit
- 9.3 Management review

9.1 Monitoring, measurement, analysis and evaluation

This subclause requires that the organisation monitors, measures, analyses and evaluates the performance of its assets, Asset Management and the Asset Management System, including financial and non-financial performance in meeting the Asset Management Objective and hence the needs of stakeholders. In doing this the organisation is required to determine what will be monitored and measured, using which methods, at what time and when the results will be analysed and evaluated.

The organisation is required to evaluate and report on the effectiveness of the processes for managing risks and opportunities and retain appropriate documented information as evidence of the results of monitoring, measurement, analysis and evaluation.

To most organisations this means some establishing a suit of Key Performance Indicators (KPIs) or setting up an Asset Management score card. When establishing metrics, it is good practice to have leading and lagging metrics. An example of a leading indicator for wind turbines is planned maintenance completion to schedule which would be a leading indicator for turbine availability. Metrics should also consider effectiveness and efficiency, an example of an effectiveness metric is once again turbine availability, an example of an efficiency metric could be maintenance costs per kwh of energy produced.

Ratio based metrics provide a better method for measuring performance. Metrics such as expenditure vs budget, whilst important to account for expenditure, can lead to unintended behaviours which can impact value and delivering the organisational objectives. An example of this would be driving down maintenance expenditure with no consideration of the impact on asset reliability. Levelized Cost of Energy (LCOE), which is often calculated at the **inception and feasibility stage of a windfarm's development**, could be adapted to show how the windfarm is performing over its life. The accuracy of the forecasted LCOE versus the realised LCOE can be fed back to the models which are used to calculate LCOE for future proposed developments.

It is essential that any metric selected has a clear line of sight connection to the organisational objectives. Many organisations have a wide range of metrics and whilst this may appear to be useful it can distract attention from managing the business. A reasonable amount of KPIs would be around 12, however these are likely to be composites of other metrics for example availability is a function of reliability (Mean Time Between Failure) or how often the asset fails and maintainability (Mean Time to Repair). This ability to drill down is essential when investigating a non-conformance with expected performance.

Performance measurement needs to be done at the appropriate level and, where appropriate, in different functions. This links to the concepts of Asset Management objectives at different functions and levels which was explored in Section 2.5 when discussing sub clause 6.2 of ISO 55001 Planning to Achieve Asset Management Objectives. At a portfolio level, organisations might choose to measure overall turbine availability. This metric will be impacted by site availability which will in turn be impacted by turbine and EBOP availability. The high-level metric will be less sensitive to fluctuations in performance at asset level which may not be impacted by a single asset. However, at the site level it is important to be able to drill down to identify what is driving the poor performance.

Most organisations operating in the wind sector in Ireland have some form of metrics in place, particularly around asset availability and cost control. These are focussed mostly on the Operations and Maintenance stage of the assets life. Depending on the scope of the Asset Management System organisations should consider metrics related to the different life cycle phases e.g.:

Life cycle stages

- Creation acquisition
 - Projects delivered on time
 - Projects delivered on budget
 - Actual whole life cost vs projected whole life cost
 - Number of snags at handover
 - Value of snags at handover
 - Ratio of value of snags at handover to the Capital Project cost
 - Number of change orders during the project
 - Value of change orders during the project

- Operations & Maintenance
 - Availability of turbines
 - Reliability of turbines, MTBF
 - Maintainability of turbines, MTTR
 - System availability of wind farms, turbines, EBOP & CBOP
 - Expenditure versus budget
 - Estimated Day Ahead Production and Peak Power Output
 - Dispatch losses
 - Energy produced
 - Number of risks in intolerable zone
 - % of competence requirements met
 - Competence development plan compliance
 - Asset Management capability plan execution to schedule
 - Planned Maintenance conformance to schedule
 - Asset Management Pan execution conformance to plan
 - Compliance with requirement e.g. Grid Code
 - Realised LCOE vs projected
 - Overall risk score reduction versus target
 - Non-conformances records raised
 - Non-conformances outstanding
 - Internal audit completion vs plan
 - Service provider performance against Service Level Agreement

- End of Life
 - Projects delivered on time
 - Projects delivered on budget
 - Number of snags at handover
 - Value of snags at handover
 - Ratio of value of snags at handover to the Capital Project cost
 - Number of change orders during the project
 - Value of change orders during the project

The organisation should define the sources of information for these metrics, noting that in some cases the sources of information will be external, this links closely to the discussion on Asset Management information in Section 2.6 of this guidance document. This is another good example of the synergistic effect of the integrate whole Management System approach. The method of calculating and reporting the metrics should also be defined, in some cases these will be hard coded in IT systems, in others these will be formulae embedded in Excel spreadsheets. The absence of properly defined and recorded calculation methods is a risk in terms of staff churn and possible loss of Subject Matter Experts.

The frequency of performance monitoring, measurement, analysis and evaluation is an important issue. If this is **done too often then the organisation is likely to become “blind” to the metric which then becomes ineffective as an**

improvement tool. If this is done less frequently then the opportunity for divergence between expected and actual performance increases with larger cost and effort realign. The principles of short interval control are very powerful in this respect. The frequency of reporting will be dependent up the needs of the stakeholders, the assessment of which was discussed in Section 2.3 of this Guidance Document. Performance will be monitored, measured, analysed and evaluated in a combination of reports and meetings at daily weekly monthly, quarterly and annual intervals. It is CRUCIAL to remember that monitoring, measuring, analysing and evaluating performance is only part of the story, acting on that performance as required is what is needed to drive improvement. This is explored further in Section 2.9 of this Asset Management Manual

Organisations seeking to implement an Asset Management System fully conforming with the requirements of ISO 55001 should establish mechanisms for monitoring, measuring, analysing and evaluating performance in relation to the scope of the Asset Management i.e. the assets, life cycle phases and functions which are defined in the scope. These should be appropriately documented and records kept. Since monitoring performance is good practice organisations seeking to implement elements of ISO 55001 should establish mechanisms for monitoring performance of in respect of those elements which are being implemented. At the very least these organisations should be monitoring to confirm that they are conforming with legal, regulatory and statutory requirements and delivering on contractually agreed performance.

Tip: Keep KPI numbers as low as possible

Tip: KPIs at the right level

Tip: KPIs need to facilitate drill down

Tip: Document sources of information

Tip: Document KPI calculation formulae

Trap: Monitoring but not acting to correct poor or deteriorating performance

Trap: KPIs relating to the O&M phase only

9.2 Internal audit

This subclause requires the organisation to conduct internal audits at planned intervals to provide information to help to determine if the Asset Management System conforms to its own requirements and the requirements of ISO 55001, and that is effectively implemented and maintained. In other words, the internal audit is designed to confirm that the organisation is implementing the processes contained in the Asset Management System and that the Asset Management System is delivering the expected performance.

The concept and intent of internal audit is well understood in many organisations and indeed is mechanistic in nature. Internal audit is often seen as being concerned with finding fault and allocating blame, nothing can be further from the truth. Internal auditing is a fundamental element of continual improvements and should be seen as an enabler. It is important that those selected as internal auditors, as well as being independent of the processes they are auditing, have a good understanding the concepts of Asset Management and organisations Asset Management System.

Initially the organisation should look to carry out an internal audit on all elements of the Asset Management System at least annually. Thereafter, when creating the audit plan the organisation should consider the importance of the process risk to delivering the objectives that the processes represent in the event that they are not being followed. This will be informed by the metrics discussed above and the results of previous audits.

For example, if the Asset management Planning process was not being followed, turbine performance could be adversely affected, and costs increased. This will be identified through the metrics relating to availability and cost versus budget. A Root Cause Analysis investigation which will be discussed in Section 2.9 of this Guidance Document could identify that the process was not being followed. This would then trigger a more frequent internal audit, which would remain the case until the organisation was confident that the process was being followed and was delivering the required outcome.

Organisations which believe in the Asset Management approach and make the Asset Management System the core processes for the way they do business should be “audit ready every day”. That is an audit should not be seen as an event to be prepared for rather it is expected and indeed welcomed at any time and at short notice.

Organisations seeking to implement an Asset Management System fully conforming with the requirements of ISO 55001 should establish an internal audit program for the Asset Management System. Organisations seeking to only implement elements of ISO 55001 should establish mechanisms for monitoring performance of in respect of those elements which are being implemented, should assess the risk that these processes will not be followed or deliver the intended outcome, then decide if internal audit is required.

Tip: Asset Management internal audit is very similar to other internal audits

Tip: Base the audit plan on risk to delivering objectives

Tip: Ensure auditors are independent of the processes being audited but are aware of the concepts of Asset Management in general and the Asset Management System in particular

Trap: Seeing internal audit as a blame game, rather it is an opportunity improve

Trap: Not living the Asset Management System and having to prepare for an audit

9.3 Management review

This subclause requires Top Management to review the organisation’s Asset Management System, at planned intervals, to ensure that it continues to be suitable adequate and effective. Top Management should see the Management Review as an opportunity to demonstrate its commitment to Asset Management and the Asset Management System.

The Management review is a fundamental part of the organisations planning process in which the review should consider:

- Changes in context
- Asset and Asset Management performance including results of audits
- Asset Management activity
- Improvement opportunities
- Changes in risks and opportunities

The Management Review its inputs and outputs and integration with the planning processes is modelled in Figure 16

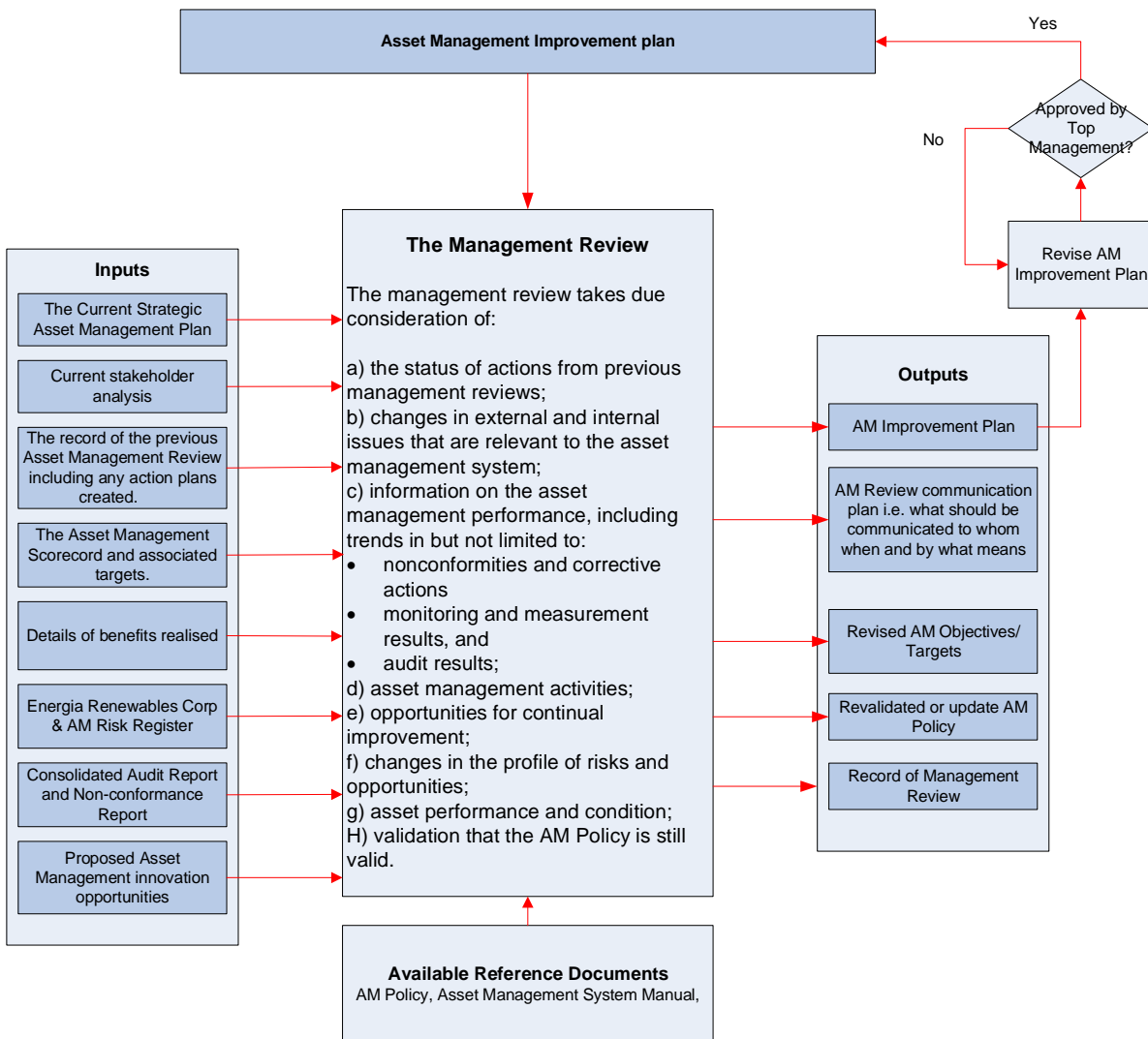


Figure 66 Management Review Model

The output from the Management Review, which must be documented, is required to include decisions related to continual improvement opportunities and any need for changes to the Asset Management System. This can then be fed into the review and update of the Strategic Asset Management Plan and creation and update of the Asset Management Plans. It is normal for the Management Review to take place at least annually as these fit well with the annual business planning cycle. If alternative frequencies are required, organisations should consider the value of more frequent Management Reviews and assess the risk of less frequent Management Reviews.

It appears that the Management Review for Asset Management MUST be a separate and distinct activity. It need not be. Most organisations have annual business reviews which discuss and review many of the consideration listed above and shown in Figure 16. It is entirely possible to adapt these business reviews to accommodate the requirements of the Management Review, it is essential that the principles and concepts of Asset Management are at the heart of the Management Review including the Decision-making Framework.

Where other Management Systems are implemented such as ISO 9001, ISO 18001 and ISO 45001 organisations could consider integrated Management Reviews, it is likely that many of the items to be considered during the review are common across the Management Systems. There will be specific technical considerations for each Management System, however the synergy of an integrated Management Review along with the efficient use of Top Management time means that a common Management Review may be worth considering.

Organisations seeking to implement an Asset Management System fully conforming with the requirements of ISO 55001 should establish a Management Review process for the Asset Management System. Where appropriate this

could be included in the annual business review and/or integrated with the Management Review for other Management Systems. Organisations seeking to only implement elements of ISO 55001 should consider introducing those elements to their annual business review.

Tip: See Management Review as the demonstration of Top Managements commitment to Asset Management

Tip: Management Review is a fundamental part business planning

Tip: Integrate Management Review with business reviews where appropriate

Tip: Consider integrated Management reviews covering multiple Management Systems

Trap: Not doing Management Reviews sends the wrong message

Trap: Box tick Management Reviews which don't change anything

2.8 Section 10 Improvement

This section has 3 subclauses

- 10.1 Nonconformity and corrective action
- 10.2 Preventive action
- 10.3 Continual improvement

10.1 Nonconformity and corrective action

ISO 55000 defines a conformity as **“fulfilment of a requirement”**. Therefore, it is implied that a nonconformity is the nonfulfillment of a requirement. It is important to express this since many organisations see nonconformity as being related to not following process and usually found following audit. In the context of an Asset Management System a nonconformity could mean not meeting the target for availability of a turbine or windfarm.

This subclause requires that when a nonconformity in assets, Asset Management or the Asset Management System occurs the organisation reacts to control and correct it and deals with the consequences. In a wind farm context this would mean a failure on the grid transformer needs to be addressed, the transformer either repaired or replaced and impact of windfarm non availability dealt with.

Once the situation is controlled then the organisations is required to assess if action is needed to eliminate the cause of the incident to prevent it reoccurring. This involves applying some form of Root Cause Analysis to identify and analyse the root cause and provide recommendations for corrective actions to eliminate of the root cause, implement those recommendations, and check the effectiveness of the recommendations. Where necessary changes to the Asset Management System are to be made. In the example of the grid transformer a Root Cause Analysis study using, for example the 5 Whys and 5 Ms approach on an “Ishikawa” or “Fishbone” diagram could be used. It is beyond the scope of this Guidance Document to give a detailed review of Root Cause Analysis techniques however a generic approach is to this is shown in Figure 17.

5Ms = 5 directions to dig Ishikawa (fishbone) diagram

5Ys = 5 levels of digging

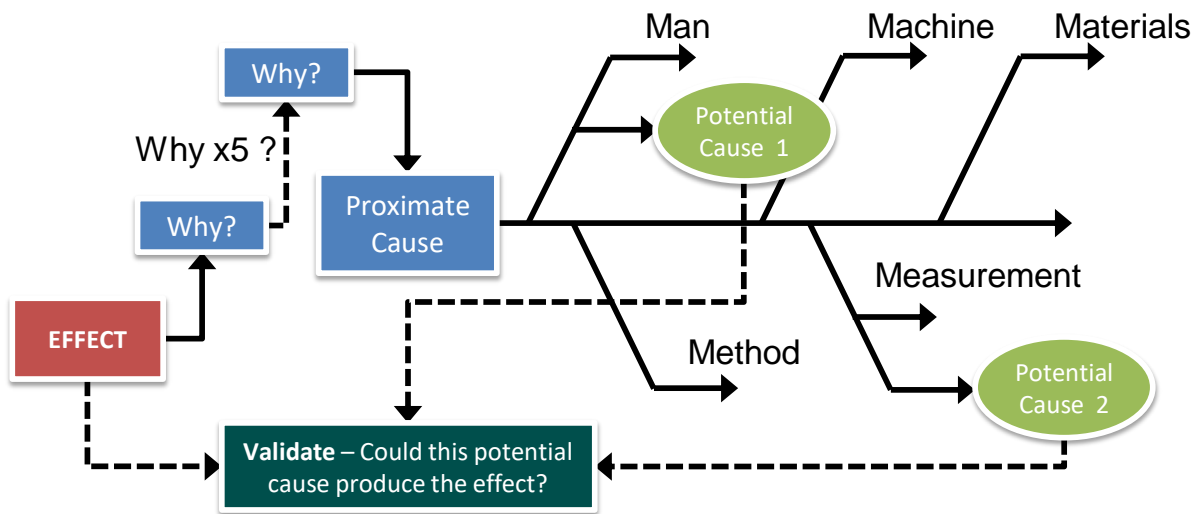


Figure 7 5Ys, 5Ms and Ishikawa Diagram

Whichever method is chosen for the investigation of nonconformities and incidents it is important that those involved are appropriately trained in the concepts processes and tools.

In the transformer example such an analysis might reveal that there is a failure mode in the transformer for which the existing planned maintenance tasks are not effective. The corrective actions could be to develop and implement a planned maintenance task to be implemented in the transformer and other similar transformers within the portfolio. A further action could be to inspect other transformers and proactively carry out any maintenance which might be required. Any corrective actions identified are required to be appropriate to the effects of the nonconformities or incident encountered.

The organisation is also required to retain details of the nonconformities and incidents, the actions taken and their results as documented evidence.

As with Management of Change, as discussed in Section 2.7 of this Guidance Document, proportionality of response is important, otherwise organisations will find that they spend more time managing nonconformities than managing assets. Therefore, the organisation must establish business rules which determine when a nonconformity or incident must be formally investigated. Examples of trigger points applicable to wind farms could be

- Windfarm unplanned outage for greater than 24 hours
- Turbine unplanned outage greater than 7 days
- **Fault with corrective maintenance costs greater than €5000**
- Asset Management KPI deviation from target by greater than 10% in any one period
- Asset Management KPI deviation from target by greater than 5% for three consecutive months

These trigger points are suggestions only and organisations should determine the trigger points which are specific to their own context. In setting up these triggers, consideration should be made of the effort in terms of resource and time to carry out the investigation and the risk associated with not doing so. Large Asset Owner Operator organisations may choose to have trained facilitators which can work with cross functional teams, Asset Management Organisations which manage a range of service provider might chose to carry out the analysis as part of the governance of the service providers whereas small windfarm asset owners may choose to rely on the service provider to manage nonconformities and incidents.

The nonconformity and incident process must also deal with nonconformities found when conducting audits of the Asset Management System.

Organisations seeking to implement an Asset Management System fully conforming with the requirements of ISO 55001 should establish a Nonconformity and Incident Process. However, it is crucial that this is proportional to the impact the delivery of the Asset Management Objectives and realising value. Careful consideration should be given to **“trigger points” for enacting the process**. Organisations seeking to only implement elements of ISO 55001 should consider the risk associated with not having a Nonconformity and Incident Process, for example an unplanned outage of 7 days on a turbine could have a serious impact on revenue on a small wind farm. The Asset Owner would be keen to ensure that the unplanned outage does not occur on other turbines. The organisation could adopt an informal approach applied to significant nonconformities and incidents

Tip: Proportionality is key, establish trigger points for enacting the processes

Tip: Select and implement a robust Root Cause Analysis methodology

Trap: Not implementing the corrective actions

10.2 Preventive action

This subclause requires that the organisation establishes processes to proactively identify potential failures in asset performance and evaluate the need for preventive action. When a potential failure is identified the organisation is follow the requirements outlined above for Nonconformity and Incidents.

Many organisations employ condition monitoring within the asset maintenance plans. Condition monitoring is designed to detect conditions which identify developing faults within assets. Where organisations have implemented condition monitoring, they have in part met the requirements of this subclause. However, identifying **a deteriorating condition wouldn't necessarily trigger a full nonconformity investigation**. This would be overly bureaucratic, would not add value and would not be done. The condition-based maintenance approach is well proven, and the organisation would normally raise a service request or work order to have the deterioration investigated. Where appropriate and proportionate a nonconformity report might be raised. For example, where the investigation identifies an incipient fault the which requires a corrective maintenance task which requires:

- Windfarm planned outage for greater than 24 hours
- Turbine planned outage greater than 7 days
- Fault with planned corrective maintenance costs greater than €5000

Potential failures can also be identified by monitoring the metrics and KPIs identified in Section 2.8. For example, trending a decrease in turbine availability which, even though not severe enough for a nonconformity report to be raised, could trigger indicate an incipient fault. This would lead to a service request or work order to investigate the matter. As above should the investigation identify a fault, with significant impact breaching one of the trigger points, a nonconformity report would be raised.

Organisations seeking to implement an Asset Management System fully conforming with the requirements of ISO 55001 should establish a process for identifying potential failures and where appropriate managing these in the same way as the Nonconformity and Incident Process. Once again it is crucial that this is proportional to the impact the delivery of the Asset Management Objectives and realising value. Careful consideration should be given to **“trigger points” for enacting the process**. Organisations seeking to only implement elements of ISO 55001 are likely to have some form of condition monitoring on the assets. Therefore, they should consider the value that a formal approach as described above would bring, consider now for example a planned outage of 7 days on a turbine to repair a fault identified on through condition monitoring, this could have a serious impact on revenue on a small wind farm. The owner would be keen to ensure that the planned outage is not required to repair similar faults on other turbines. The organisation could apply an informal approach to significant planned corrective maintenance events.

Tip: Proportionality is key, establish trigger points for enacting the processes

Tip: Link appropriate potential failures to the nonconformity and incident process

Trap: Investigating every potential failure with a full nonconformity and incident process.

10.3 Continual improvement

This clause requires that the organisation continually improves the suitability, adequacy and effectiveness of its Asset Management and the Asset Management System.

The triggers for considering continual improvement opportunities are derived from a wide and varied range of procedures and activities, including:

- Nonconformities, incidents and corrective action
- Preventive action
- Identifying trends in performance
- Evaluation of compliance with legal regulatory and statutory requirements
- The findings of audits both internal and external
- The findings of the Management Review
- Change management

In addition to the more customary process-related triggers, the organisation can provide easily-accessible channels through which staff can articulate their personal ideas. These include:

- Face-to-face communication with their line manager
- Specific discussion items in team meetings
- A suggestion box scheme (either paper or electronic).

Note that seeking improvement proposals from staff is not just limited to their specific area of work ideas may be unrelated to the job at hand.

In addition to these channels, organisations can proactively search for new and innovative Asset Management related technology and practices, including new tools and techniques, through a number of activities including:

- Active participation in professional bodies and industry associations
- Conferences, seminars, publications, forums, and industry media
- Benchmarking and technology transfer initiatives,
- Obtaining advice from specialist organisations
- Research and development
- Consultation with suppliers and clients
- Internal improvement forums

Continual improvement will be demonstrated by the metrics and KPIs which are discussed in Section 2.8 of this Guidance Document as well as increasingly challenging Asset Management objectives.

Any improvement opportunities should be assessed, evaluated and approved through the Decision-making Framework. If any idea is not approved, those who were responsible for raising the continual improvement initiative should be informed as to why the idea was not approved. Failure to do so will stifle involvement in an important activity.

Whether the organisation is seeking to implement an Asset Management System which conforms fully or in part to ISO 55001 should be seeking continual improvement. It should be embedded in the culture of the organisation. The use of the techniques identified above will assist in delivering the Asset Management objectives and maximising value.

Tip: Look for improvement opportunities everywhere

Tip: Leverage the power of the organisation's staff

Trap: Not feeding back to those who raise improvement suggestions

3 Road map to Asset Management and ISO 55001

3.1 Typical routes to conformance for differing stakeholder categories

The most common route to implementing an Asset Management System which conforms with ISO 55001 is to conduct a gap analysis and maturity assessment. The assessment normally involves:

- Review of Asset Management documentation such as the Asset Management Policy, Strategic Asset Management Plan, Risk Management and Operational Control etc.
- One to one discussions/interviews key staff
- Process presentation workshops where staff demonstrate the processes and methods utilised in Asset Management

During the interviews it is normal to utilise an assessment tool such as the Institute of Asset Management (IAM) assessment tool. Maturity scoring methods are required, again the IAM has provided guidance on these in its Asset Management Maturity Scope and Guidance Framework⁶. During the interviews, the assessors should probe the topics being discussed using their experience of Asset Management to distil evidence of conformance with the requirements which would support a certain maturity score.

It is usual to ask the organisation's team member being interviewed to score the organisation's own maturity which is used to form the organisation's own view of its Asset Management maturity. This is an important indicator of Asset Management awareness and competence within the organisation.

A key part of the assessment is a review of the Asset Management documentation, e.g., the AM Policy, AM System Manual, SAMP, AM Plans and AM performance metrics etc. The assessors will not look for discrete documentation specific to every clause of ISO 55001, rather they will use their experience and consider the organisation context when assessing the suitability of Asset Management documentation.

On completion of the document review, workshops and interviews the maturity of the organisation is assessed. Maturity levels range from Innocent to Excellence and are explained in Table 10

Scale	Description	Definition	Maturity characteristics
0	Innocent	The organisation has not recognised the need for this requirement and/or there is no evidence of commitment to put it in place	
1	Aware	The organisation has identified the need for this requirement, and there is evidence of intent to progress it.	Proposals are under development and some requirements may be in place. Processes are poorly controlled, reactive and performance is unpredictable.
2	Developing	The organisation has identified the means of systematically and consistently achieving the requirements and can demonstrate that these are being progressed with credible and resourced plans in place.	Notes: this is a 'transition state' Processes are planned, documented (where necessary), applied and controlled at a local level or within functional departments; often in a reactive mode but could achieve expected results on a repeatable basis. The processes are insufficiently integrated, with limited consistency or coordination across the organisation.
3	Competent	The organisation can demonstrate that it systematically and consistently achieves relevant requirements set out in ISO 55001.	This involves a formal documented Asset Management system embedded within the organisation. The performance of the Asset Management system elements is measured, reviewed and continually improved to achieve the Asset Management objectives.
4	Optimizing	The organisation can demonstrate that it is systematically and consistently optimizing its Asset Management practice, in line with the organisation's objectives and operating context.	Notes: this is 2nd 'transition state'. Characteristics of being in this stage will include: exploration of optimisation techniques for both assets and Asset Management practices
5	Exceller	The organisation can demonstrate that it employs the leading practices and achieves maximum value from the management of its assets, in line with the organisation's objectives and operating context.	This is a dynamic and context-sensitive state, the evidence must include demonstration of awareness of benchmarking positions against similar best in class organisations and that, in both Asset Management practices, and Asset Management results (value realisation) there are no known improvements that have not already been implemented

Table 10 IAM Maturity Scale

The results of the gap analysis and maturity assessment are normally displayed in a spider chart which quickly indicates areas with opportunities for improvement. Figure 18 shows an example of an Asset Management maturity assessment spider chart highlighting that 7.6 Documented Information has a maturity score part way between "awareness" and "development" and 4.2 Understanding the Needs and Expectations of Stakeholders has the highest level of maturity scoring just above "development".

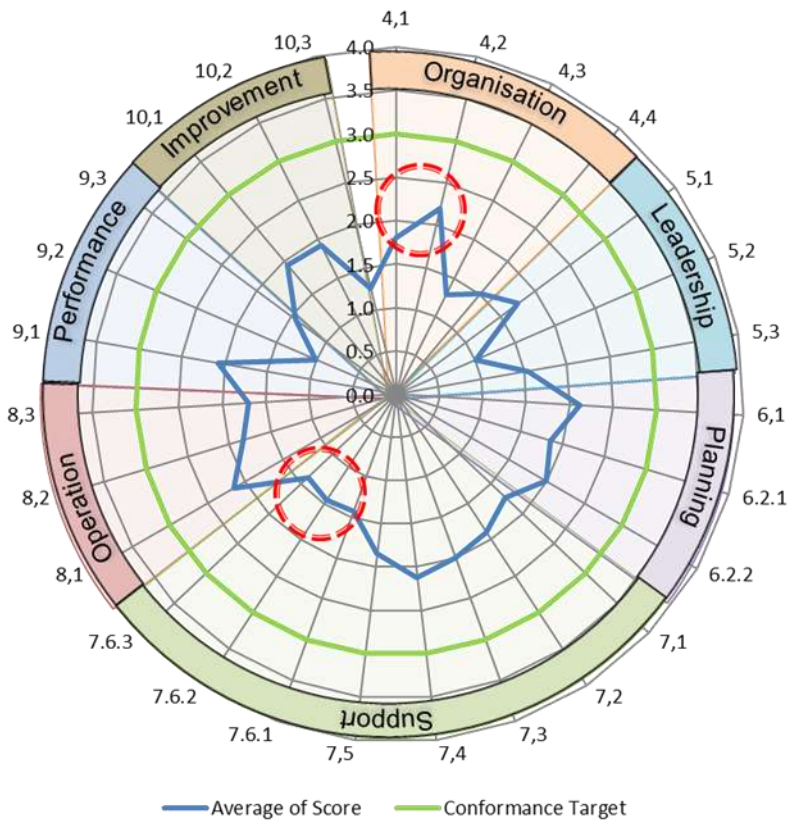


Figure 8 Maturity Assessment Spider Chart

When scoring the maturity levels gaps are identified from which level gap closing recommendations are made. These are then used as inputs to the Asset Management capability development plan, often referred to as the Asset Management Roadmap.

Creating such a roadmap would involve taking the recommendations and identifying any dependencies and efficiencies. Thereafter an estimate of calendar time for each task is made and associated resource requirements to support the delivery of the plan are identified. The output of this stage would be a Project Plan showing the Work Breakdown Structure and resource estimates. The plan would include key milestones and deliverables.

The roadmap or plan would then be executed using normal Project Management approaches. The duration of the development and implementation programme is dependent upon the availability of resource to document existing processes or develop and document existing processes and the ability of the organisation to absorb the changes to business processes.

It is recommended that the Asset Management System is implemented as it is developed. Developing the whole **system and implementing in “big bang” manner is likely to shock the organisation. Implementing the elements of the Asset Management System as it is developed facilitates organic assimilation.**

The duration of the development and implementation programme is dependent upon the availability of resource, more resource facilitates an intense development and implementation. However, the organisation must consider its ability to assimilate the new way of working, careful change and culture management approaches are required. Individuals working on Asset Management activities may feel an element of personal risk and may be personally invested in processes which may be subject to change.

Experience indicates that a realistic timeframe from creating the roadmap to completion of the Asset Management System is between 12 and 24 months.

Organisations not seeking to implement an Asset Management System which fully conforms to ISO 55001 should consider carrying out a gap analysis and maturity assessment against the standard. This will identify areas where improvement opportunities exist and provide a benchmark should it decide at a later date to implement other elements and ultimately complete its Asset Management System covering all elements of ISO 55001.

3.2 Common mistakes

The approach outlined in 3.1 is a well proven and robust method. However, there are some common mistakes that organisations make on their Asset Management maturity journey.

- Lack of support from Top Management.

Developing and implementing an Asset Management System can represent a significant change to how organisations operate. If Top Management is not fully supportive of the approach the initiative is likely to fail. Lack of support is often manifested as pressuring the organisation to circumvent agreed processes to expedite work and/or drive down costs. Once the integrity of the Asset Management System is questioned its effectiveness is likely to reduce.

- Making it too complicated

Much is made of the need for documented processes. It is explained in Section 2.6 that the level of documentation should be appropriate for the organisation and its context. Likewise developing advanced processes which are overly complicated and add little value is counterproductive. Organisations should work with the underlying principle of keeping it as simple as possible.

- Not involving the whole organisation

Developing and implementing an Asset Management system is often delegated to departments. It is then seen as an initiative restricted to that department and has no impact on other departments. This is destined to result in a dysfunctional Asset Management System. To counter this the organisation should identify departments which are directly involved in, or have an interaction with, Asset Management Activities and ensure they are fully represented in the development and implementation effort. This will ensure that the Asset Management System is sustainable across the organisation.

- Moving on to the next initiative

The “life cycle” of initiatives ranges from 9 to 24 months before being replaced by the next hot management technique. Asset Management is a sustainable core organisational function and one upon which future success and capability can be built. Organisations can embed Asset Management by using it as the foundation for future improvement initiatives such as those which will be discussed in Section 4 of this Guidance Document.

- Doing it for the certificate

Whilst there are some benefits associated with achieving a certificate of conformance with ISO 55001 the real benefit of a properly implemented Asset Management System is improved performance, delivering objectives and **maximising value**. **Organisations which focus on “getting the certificate” are likely to be superficial in approach to Asset Management**. Achieving certification should be seen as a by-product of delivering objectives and maximising value through an Asset Management System and not the objective of the implementation.

4 Opportunities for improvement beyond conformance with ISO 55001

4.1 What lies beyond conformance?

Having implemented an Asset Management System which conforms to ISO 55001 organisations are required to continually improve the performance of its assets, Asset Management and Asset Management System. The maturity scales introduced in **Section 3 states that a maturity level of “Competent” means that “The organisation can demonstrate that it systematically and consistently achieves relevant requirements set out in ISO 55001.”**. Therefore, **to advance beyond conformance means moving to first to “Optimising” and then to “Excellence”**. The **journey from “Innocence” to “Excellence” is modelled in Figure 19 which shows the Maturity Bow Tie from the The IAM Asset Management Maturity Scale and Guidance: 2015⁶**.

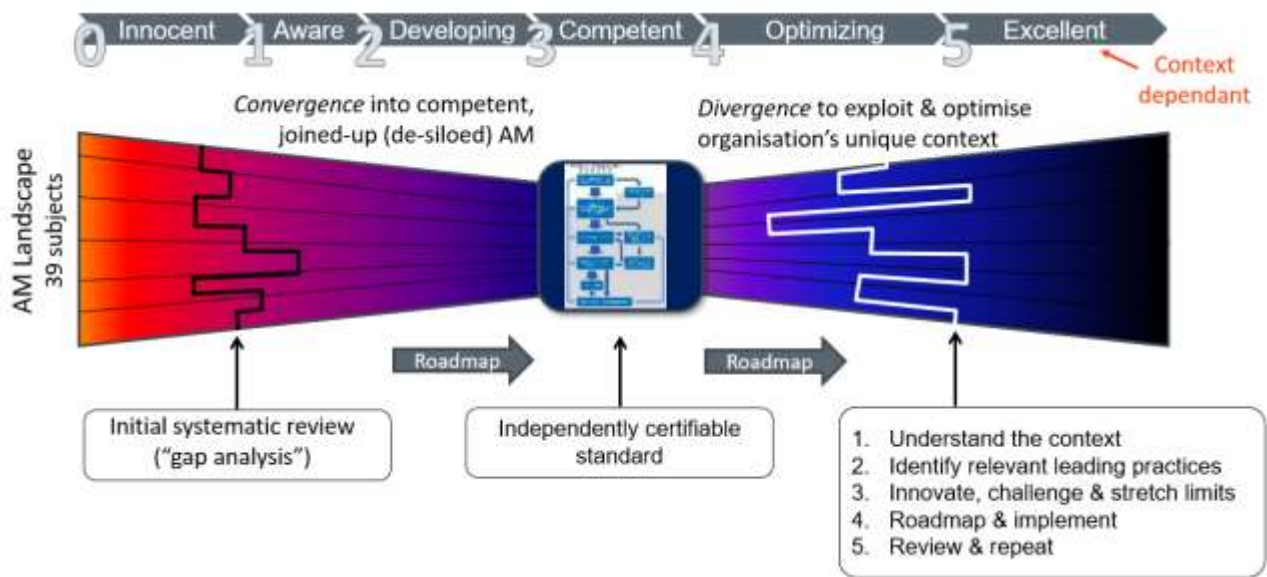


Figure 9 IAM Maturity Bowtie

This “bowtie” shows how organisations progress their Asset Management maturity through a process of alignment and integration which converges to a level of competence that is recognisable as good practice and conforms with the requirements of ISO 55001. This state of being “Competent” therefore corresponds to the coordinated, **integrated, aligned and ‘life cycle managed’** level of Asset Management maturity.

The right-hand part of the bowtie then expands acknowledging that organisations necessarily diverge i.e. have different needs and operational contexts and hence have differing requirements which setting their further target **levels of ‘best appropriate practice’**. This implies that there must be different degrees of worthwhile sophistication and optimisation which are context dependent.

The organisation should choose carefully what elements of Asset Management it will improve. Moving from Competence to Optimising or Excellence in every element may not add value and will therefore not be appropriate for that organisation.

Many organisations decide to implement initiatives which are technically and engineeringly interesting and rewarding, however they do not add value. Initiatives to move beyond Competent should be subject to analysis and approval through the agreed Decision-making Framework

4.2 Opportunities for the wind sector in Ireland

This section will explore the key opportunities for Asset Management in the wind sector in Ireland.

4.2.1 Whole life approach

The benefits for a whole life cycle approach to Asset Management was explored in Section 1.3.2 Asset Life Cycle. There is significant value to be realised from this approach. As the sector grows and the opportunity for state grants and funding decreases, organisations need to ensure that the assets will deliver maximum value over their life cycle. Indeed, licenced windfarm farm locations which could be assets in their own right, may have many cycles of repowering.

4.2.2 Alternative strategies

The current approach to determining asset whole life strategies for maintenance and “lifetime extension” generally follow the OEM recommendations, or some industry rules-based norms. Whilst on the surface this looks to be a reasonable approach there is the possibility the strategies do not deliver maximum value. They do however reduce risk to the Asset Owner and investors but do so at the possible expense of increased costs.

The principles of Cost, Risk & Performance and Optimisation which were introduced in Sections 1.3.3 and 1.3.5 respectively provide opportunities to enhance value. However, this will require changes to the risk appetite of Asset

Owners. Therefore, careful stakeholder management is required to introduce the concepts to key stakeholders, show how value can be enhanced and the impact of an increased risk appetite.

4.2.3 Ageing assets: financial models

As windfarms age it is possible that maintenance costs will increase and that reliability will decrease leading to reduced profitability. This coupled with reducing revenues due to feed in tariffs expiring, or other fluctuations in energy prices means that the current operating model would make the continued operation not financially viable. The owners will then be faced with decisions as to whether to divest the windfarm, repower the windfarm and carrying out associated EBOP and CBOP modifications, or decommissioning the windfarm with associated costs.

If organisations can adapt alternative strategies as outlined above, then alternative financial models can be considered. Asset owners who retain the assets, where original Capital costs are sunk, and adopt these new strategies could realise the following benefits:

- No Capital investment required to repower
- No Capital investment required to decommission and return the site to pre windfarm condition
- Optimised operations costs
- Profits at an acceptable level

However, to realise these benefits will, once again, require a different attitude to risk.

Organisations who chose to purchase ageing windfarm assets will require alternative financial models. These models will take account of reduced Capital acquisition costs due to the aged state of the windfarm and the whole life cost of ownership based on asset life cycle strategies optimised to deliver the best trade-off between cost, risk and performance. The organisation would be able to forecast profits and may have competitive advantage in the marketplace. This will once again require an alteration to the appetite for risk. Nevertheless, this offers a significant opportunity for lean and agile organisations in the sector.

5 Appendix 1 Asset Management Impact Practical Example

5.1 Introduction

In this example we will explore the impact of an Asset Management approach on a simple well understood challenge, which was introduced in Section 1.3.4 Asset Life Cycle, that of deciding whether to lay cables between turbines and substation in ducts or bury them directly in the ground. We will explore the alternatives following two approaches:

- The conventional approach
- The Asset Management approach

Whilst on the face of it the decision to direct bury cables or lay them in ducts is reasonably straight forward. The capital costs associated with direct buried can be considerably less than laying them in ducts. Likewise, the perception is that laying them in ducts leads to less cable faults as the cables age. Simplistically put the cheaper option at the creation phase of the asset's life is to direct bury however this will lead to increased failures and subsequent repair costs and lost revenue through unplanned outages. The question is what is the optimal decision over the whole life of the assets which drives maximum value?

This is a decision which is generally made at the creations stage of the asset's life cycle. Figure 3 which is replicated in Figure 16 for ease of reference, outlined the 4 stages of the **asset's** life:

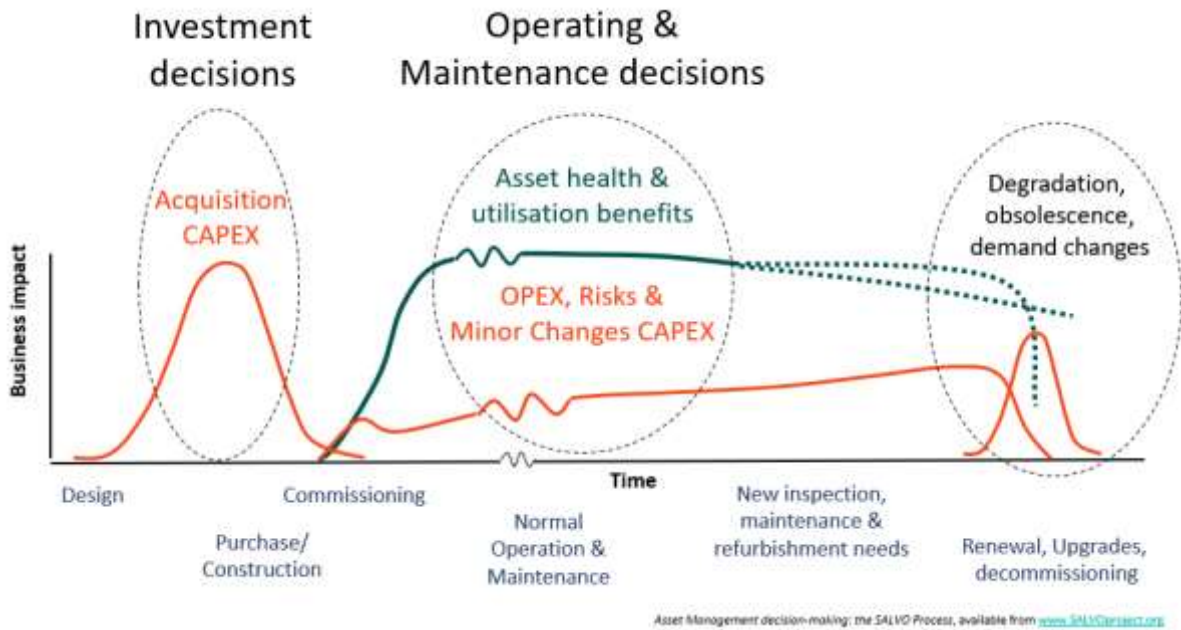


Figure 10 Asset Life Cycle: Characteristics

The decision could have serious impact on the operation and maintenance phase and ultimately end of life phase.

5.1.1 Conventional approach

The authors accept that the following could be seen as a generalisation and oversimplification of the scenario, however they believe that for the purposes of this example the scenario is largely representative of what happens.

Once the wind farm site has been identified a projects team or department is allocated the responsibility to design procure, build, commission and hand over the windfarm to an operations and maintenance team. During this creation phase the project team may consult with the operations and maintenance team on a wide range of issues including considerations such as:

- Configuration of switchgear in substations including whether or not duty/standby provisions are made
- Configuration of cables interconnecting substations e.g. radial and daisy chain or some form of mesh or ring
- Provision of integrated condition monitoring on rotating equipment e.g. vibration sensors on gearboxes and generators
- Provision of infrared windows which facilitate thermal imaging on electrical equipment
- Quality of road surfacing on the site e.g. tarmac or compressed hardcore

Broadly speaking these can be categorised as competing alternative approaches.

Under the conventional approach the operations and maintenance team might be consulted on which alternative is preferred. However, it is unlikely that the operations and maintenance team have any authority within the decision-making process. Likewise, it is likely that the operations and maintenance team will be unable to quantify WHY they prefer option A or B. It appears to be common sense to assume that cables laid in ducts will be more reliable and have longer life cycles than those directly buried in the soil. However, the question is: does the organisation gain more value from cables laid in ducts or directly buried?

There may be some “modelling” done at the creation stage to determine if the windfarm will meet the investment criteria of the asset owners. This may consider a range of factors

- Capital costs of the assets
- Ongoing maintenance costs, this is likely to be based on planned maintenance events only
- Revenue derived under various wind conditions. P50, P75 and P90

Despite the consultation between the projects/engineering team and the operations and maintenance team if the **additional costs of installing ducts “challenges” the viability of the financial model then it is likely that the cables will** be installed directly in the soil. The operations and maintenance team will be left to pick up the pieces and manage the consequences of reduced reliability, in service faults with associated repair costs and lost revenue, and ultimately early onset of end-of-life failures.

These unintended consequences are seldom quantified in any assessment during the creation an acquisition phase of the assets life.

5.1.2 Alternative approach

Consider now an alternative approach to resolving the dilemma of direct buried vs laid in ducts. In this scenario the organisation embraces true multi-functional asset management decision making. It has collected a range of asset information which can assist in the decision-making process. This information is summarised below:

- Assumed project life 24 years
- Discount rate 5%

Direct buried

- Capital costs:
 - €500k
- Planned maintenance costs
 - **Annual: €5k, every 5 years €10k every 10 years €20k**
- Corrective maintenance costs:
 - **Years 0 to 5, €0 per year, Years 6 to 10 €5k per year, Years 11 to 15 €7k, Years 16 to 20 €10k Years 21 to 24 €20k**
- Lost revenue costs due to cable failure
 - **Years 0 to 5, €0 per year, Years 6 to 10 €10k per year, Years 11 to 15 €15k, Years 16 to 20 €22k Years 21 to 24 €28k**

Laid in Ducts

- Capital Costs:
 - €750k
- Planned Maintenance Costs
 - **Annual: €5k, every 10 years €00k**
- Corrective maintenance costs:
 - No corrective maintenance costs
- Lost revenue costs due to cable failure
 - No lost revenue due to cable faults

There are a wide range of Life Cycle Costing methods available, however for the purposes of this analysis we will look at the Net Present Value method over an expected life of 24 years for the project. Life Cycle Costing methods should include an allowance for the time value of money. This takes account of the discounting of future cashflows to present value, for which we need a discount rate. The discount rate is normally issued by the organisations finance department and is used in the calculation of present values, some organisations equate this to the cost of capital but that is not always the case.

For the direct buried cable, knowledge of failure rates, repair costs, mean time to repair and Annual Energy produced enables the organisation to forecast risk i.e., the probability and consequences of direct buried cable faults as the cables age. For cables laid in ducts it is assumed that there will be no risk of cable faults cable faults. Figure 17 shows a basic Net Present Value calculation for the two options based on the assumptions above

Discount rate	5%																								
Cable Duct																									
Present Value Factor	1.000	0.952	0.907	0.864	0.823	0.784	0.746	0.711	0.677	0.645	0.614	0.585	0.557	0.530	0.505	0.481	0.458	0.436	0.416	0.396	0.377	0.359	0.342	0.326	0.310
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Capital Cost	750	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Planned Maintenance Cost		5	5	5	5	5	5	5	5	5	10	5	5	5	5	5	5	5	5	5	10	5	5	5	5
Corrective Maintenance Costs		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Maintenance Costs		5	5	5	5	5	5	5	5	5	10	5	5	5	5	5	5	5	5	5	10	5	5	5	5
Revenue Losses		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Operational Costs		5	5	5	5	5	5	5	5	5	10	5	5	5	5	5	5	5	5	5	10	5	5	5	5
PV Costs	750	4.8	4.5	4.3	4.1	3.9	3.7	3.6	3.4	3.2	6.1	2.9	2.8	2.7	2.5	2.4	2.3	2.2	2.1	2.0	3.8	1.8	1.7	1.6	1.6
NPV @ Year	750	754.8	759.3	763.6	767.7	771.6	775.4	778.9	782.3	785.5	791.7	794.6	797.4	800.0	802.6	805.0	807.3	809.4	811.5	813.5	817.3	819.1	820.8	822.4	823.9
NPV =	823.9																								
Direct Buried																									
Present Value Factor	1.000	0.952	0.907	0.864	0.823	0.784	0.746	0.711	0.677	0.645	0.614	0.585	0.557	0.530	0.505	0.481	0.458	0.436	0.416	0.396	0.377	0.359	0.342	0.326	0.310
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Capital Cost	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Planned Maintenance Cost		5	5	5	5	10	5	5	5	5	20	5	5	5	5	10	5	5	5	5	20	5	5	5	5
Corrective Maintenance Costs		0	0	0	0	0	5	5	5	5	5	7	7	7	7	7	10	10	10	10	10	20	20	20	20
Total Costs		5	5	5	5	10	10	10	10	10	25	12	12	12	12	17	15	15	15	15	30	25	25	25	25
Revenue Losses		0	0	0	0	0	10	10	10	10	10	15	15	15	15	15	22	22	22	22	22	28	28	28	28
Total Operational Costs		5	5	5	5	10	20	20	20	20	35	27	27	27	27	32	37	37	37	37	37	52	53	53	53
PV Costs	500	4.762	4.535	4.319	4.114	7.835	14.92	14.21	13.54	12.89	21.49	15.79	15.03	14.32	13.637	15.393	16.95	16.143	15.374	14.642	19.598	19.024	18.118	17.255	16.434
NPV @ Year	500	504.8	509.3	513.6	517.7	525.6	540.5	554.7	568.2	581.1	602.6	618.4	633.4	647.8	661.4	676.8	693.7	709.9	725.3	739.9	759.5	778.5	796.6	813.9	830.3
NPV =	830.3																								

Figure 11 NPV Calculations

The figure above shows a simple Net Present Value assessment of direct buried vs laid in ducts cables. The option with the lowest NPV is the option which delivers most value over the assumed 24-year life

The principle financial figures are as follows:

Direct Buried
Capital Cost: €500k
NPV: €830.3k

Laid in ducts
Capital Cost: €750k
NPV: €823.9k

Observations. Despite the “Laid in Ducts” option being more expensive upfront, when the operational costs are considered over the life cycle it is marginally cheaper in terms of Net Present Value. However, it should be noted that had the project carried an expected life of 23 years, not 24 years, then the “Direct Buried” option would have had the lower Net Present value. The future cashflows which influence this decision may be more uncertain the further into the future we look from today, this is compounded by the heavy discounting of cash flows at the end of the expected life.

The financial difference over 24 years is not significant. The organisation may choose to consider other issues such as reputation and morale. That is, whilst the laid in duct option is marginally better value, given the assumptions, it is undoubtedly more reliable, which may be important with customers beyond the value of revenue generated. From a morale standpoint, technical staff will feel frustrated constantly being called to repair faulty cables when they are aware that had they been laid in ducts then the failures would not happen, so the laid in ducts option would carry “Shine” value.

It is important therefore that the organisations Decision Making Framework be structured such that the facets of value which were first introduced in Figure 5, repeated below for ease of reference, are considered.

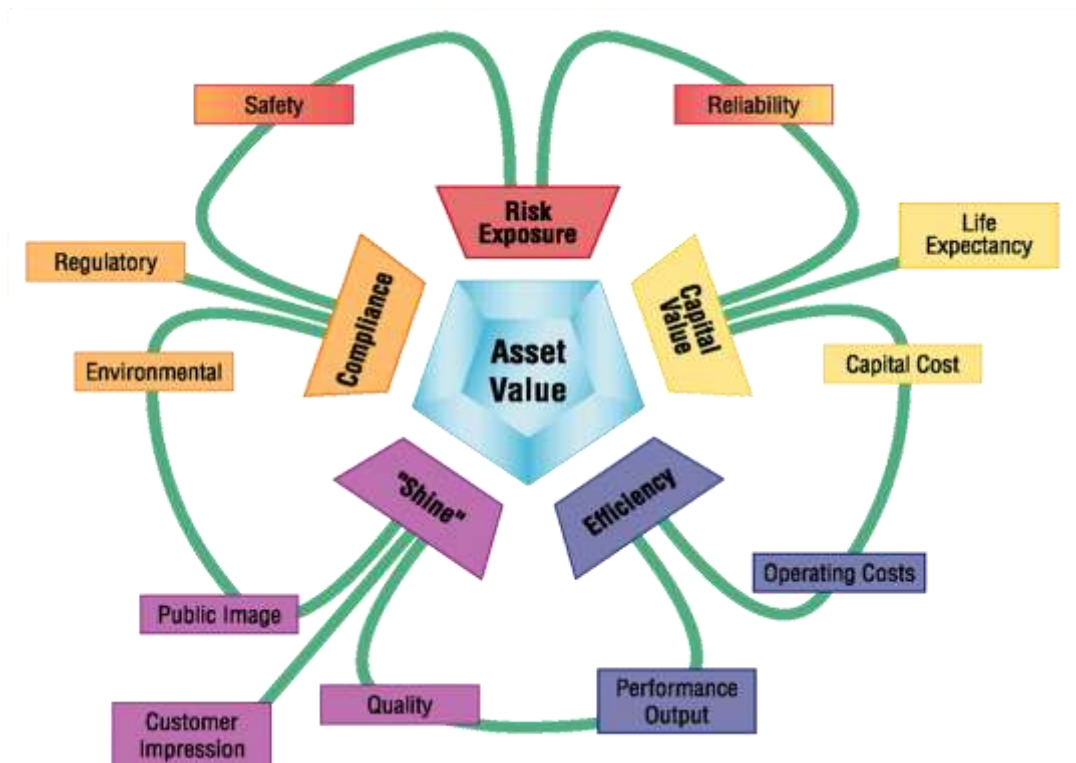


Figure 12 The ‘Shamrock’ diagram, showing different facets of Value. Ref EU1488 MACRO Project

These facets of value are shown in the centre of the diagram, can be remembered with the acronym “RELICS”:

- Minimising Risk
- Maximising operational Efficiency; the functional value *from* assets (functional benefits minus operating costs)
- Maximum economic Life (period of benefits realisation from the capital costs, ensuring that sustainability is considered).
- Compliance with legislation, regulation or other non-negotiable commitments.
- Shine or improving or retaining the intangible characteristics associated with managing assets

Should the organisation decide to bury the cables directly in the soil, the analysis carried out at the design stage will be crucial in establishing operations and maintenance strategies for the cables and the wind farm in general. Being aware that failure rates will increase within certain time frames will allow the operations and maintenance teams to be prepared for such events. This will include assuring that:

- Spare cable lengths and cable jointing kits are available.
- Cable testing and fault-finding equipment is on hand
- Staff are competent to carry out cable testing and repairs.

5.1.3 Conclusion

The conventional approach would have resulted in the cables being direct buried with little consideration for the long-term consequences. The alternative approach quantified the impact of both options and facilitated a more robust decision, which even if the direct buried option was selected allowed the organisation to plan to deal with consequences.

This brief example explained how a whole life cost risk performance decision making approach can be applied to the choice between two competing options for installation methods for cables. In the example **the “Laid in Ducts” option was marginally the better option.** For operations and maintenance specialists the small difference in NPV **may come as a surprise, since they “intuitively know” that the Laid in Ducts option is more reliable** and would be option of choice in all cases. However, it is only by quantifying the cost, risk and performance of the options that one can truly determine where the organisation can derive the optimal value.

Often what is intuitively correct is not justifiably quantified. Asset Management is not designed to drive the best engineering or technical solution, rather it is designed to deliver maximum value, which in some cases is achieved **from solutions which are not “technically” superior.**

6 References

- 1-ISO 55000: 2014: Asset management- Overview, principles and terminology
- 2-PAS 55-1: 2008 Asset Management Part 1: Specification for the optimised management of physical assets
- 3-Macro Project European Union (Eureka Project EU1488)
- 4- www.salvoproject.org/
- 5-The IAM Competences Framework Part 1 and Part 2 Version 3.0: June 2014
- 6: The IAM Asset Management Maturity Scale and Guidance: 2015

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