Asset Management Processes in the Wind Energy Industry

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Abstract: Asset management (AM) has evolved from several industrial sectors to describe holistic application of business best practices to satisfy all stakeholders’ requirements. The processes, tools and techniques of AM are currently well-established in the mature industries. On the other hand, wind is becoming an increasingly important source of energy for countries that ratify to reduce emission of greenhouse gases and mitigate global warming. This creates a huge investment potential for the wind energy industry with a wide range of possible stakeholders. However, achieving return on investment in wind farms is affected by interrelated stakeholders’ requirements and assets technical issues. These require a well-founded Asset Management (AM) framework currently lacking in the wind industry. The main objective of this paper is to identify and transform crucial requirements for effective management of wind farms into AM processes as a first step towards developing a structured model for AM in the wind energy industry. Six fundamental processes are determined and presented with a detailed explanation.

Keywords: Asset Management, Wind Energy, Business Values, Process Modeling

1. INTRODUCTION

Electricity generated from wind is fast becoming one of the most utilised renewable energy sources [1-3] following the adoption of the Kyoto protocol as an amendment to the United Nations Framework Convention on Climate Change (UNFCCC). Improvement in the design of wind turbines [4] and the availability of wind resources in most parts of the world are contributing to the rapid development of the industry. In recent years, the industry experienced a shift in wind farms developments to offshore [5] from onshore locations due to surplus wind resources and the possibility of installing multi-mega-watts turbines. These increase substantially the potential for investment in the industry with a wide range of possible stakeholders. However, achieving maximum return on investment in wind farms is invariably affected by interrelated stakeholders’ requirements and assets technical issues. Conversely, there exists no holistic framework that combines and rationalise inherent conflicting stakeholders’ demands and ensure assets remain in a satisfactory condition over the life cycle of wind farms.

AM has evolved from several industrial sectors to describe a holistic application of business best practices to satisfy all stakeholders’ requirements and has been defined as “the systematic and coordinated activities and practises through which an organisation optimally manages its physical assets, and their associated performance, risks and expenditure over their lifecycle for the purpose of achieving its organisational strategic plan” [6]. Historically, industries developed AM processes, tools and techniques to improve the overall business performance for example, the Power Industry [7-8]; Health Service Sector [9]; Nuclear Industry [10]; Chemical Industry [11]; Oil and Gas Industry [12] etc. Successful AM organisations utilise a framework or a model [13-14] to link all the crucial requirements for effective management of assets [7]. Hitherto the application of AM to the wind energy industry has historically been poor. This necessitates a need to determine AM processes in the wind energy industry to facilitate development of an AM model to coherently harness and rationalise inherent conflicting stakeholders’ requirements and ensure assets remain in a satisfactory condition over the life cycle of wind farms.

This paper identifies business values and assets that drive the long term survival and profit generation of wind farms. Crucial requirements for effective management of these values and assets will be discussed in six structured AM processes to highlight the importance of pulling them together into a more coherent and effectively focused-whole. Finally, the conclusion and way forward are presented.

2. METHODOLOGY

AM process commences by identifying business values which govern the industry’s performance [12] and assets that are indispensable to drive and sustain the future of these values [15]. This ensures that the “strategic and tactical decisions that are required to deliver the asset management mission are clearly driven by the asset itself rather than any activity” [7]. Appropriate Key Performance Indicators and Measurement framework are formulated [12] to allow evaluation of actual performance in comparison to intended targets. Drawing from processes, tools and techniques of AM in other industries, six fundamental AM processes in the wind industry is logically represented in a flowchart. These include (I) Stakeholders requirements (II) Mission and vision statements (III) Asset classification (IV) Primary asset (V) Secondary asset and (VI) Continuous performance improvement.

3. RESULTS AND DISCUSSION

3.1 Stakeholders’ requirements

The first crucial requirement involves recognising and assembling all stakeholders’ requirements which are often conflicting [13] to unveil fundamental business values that will drive the performance and long-term survival of wind farms. This process facilitates negotiation with appropriate parties and rational trade-off between conflicting priorities.

In the wind industry, the government creates business enabling environment through appropriate law and also regulates the activities of the industry through regulatory bodies. Non-compliance with these laws and regulations result in penalties and

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subsequent withdrawal of operating license. Investors in the sector desire long-term business survival amidst competitors, increased profitability and enlarged market share in the global energy market. The end users expect lower prices of energy in comparison to other sources since wind is naturally obtained and replenished. The public expect absolute protection of the environment. Though the resort to renewable energy is to protect the environment, the process of generation should not add to environmental degradation. These varying requirements have to be harnessed to balance all the inherent conflicting needs and priorities. Figure 1 shows the flow of stakeholders’ requirements process.

3.2 Mission and vision statement
This process provides a bond between conflicting stakeholders’ requirements and overall business objectives. Unambiguous mission and vision statements are essential [15] to give clear and sustainable direction to manage business values of the wind industry. Overall business objectives to uphold these values should be defined to satisfy all the stakeholders’ requirements, which often result in conflicting objectives. Therefore, it is imperative to minimise variability in the objectives by translating them into a concise and well communicated do-ables. This will ensure that overall strategies align departmental and individual responsibilities. Overall Key Performance Measurement (KPM) system should be formulated to reflect the requirements of the stakeholders. Figure 2 shows the flow of mission and vision statements process.

3.3 Asset classification
In [16] assets are classified into five main groups, these include: Physical (e.g. equipment, property, etc), Human (e.g. Labour, skills, knowledge etc), Intellectual (e.g. data, information, patents, copy right, design, etc) Financial (e.g. money, credit, etc) and Intangible assets (e.g. public image, morale, goodwill, communication etc). A wind farm holds a variety of these assets, some are primary [7] to the core business objectives and others facilitate the performance of the primary assets. Asset classification draws attention to critical assets by elucidating boundaries and inter-dependencies. Figure 3 shows the flow of asset classification process.

3.4 Primary assets
Wind turbines convert wind kinetic energy into electrical energy which is transmitted and connected to an electricity network for distribution to consumers. This drives and sustains the survival and revenue generation of wind farms. Effective management of wind turbines and associated grid connection facilities requires the formulation of assets-based business objectives to align the overall goals [17] of the wind farms. These include effective management of Health, Safety & Environment (HSE), minimising life cycle costs, failure elimination, reliability and availability improvements. Desirable and achievable targets should be set to reflect the expected level of performance. Suitable strategies for achieving the objectives should be determined using appropriate AM tools and techniques [8].

Reliability-Centred Maintenance (RCM) is an AM technique used mostly to select suitable maintenance strategies for physical assets [18]. The approach has been applied in several industrial sectors with considerable success [19]. The wind industry is yet to explore the full potentials of RCM to determine appropriate maintenance strategies for wind turbines and associated grid connection facilities. However, [20] explain that RCM is constrained in determining which strategies are the most cost effective options available. It is therefore important to test every decision making over the life cycle of wind farms using Asset Whole Life Cycle Analysis (ALCA) technique [16]. Hence, integrating RCM and ALCA provide a sustainable method of determining appropriate (technically feasible and economically viable) maintenance strategies for wind turbines and associated grid connection facilities to maximise return on investment in wind farms.

Applicable key performance indicators and measurement systems should be formulated [8; 12] to align maintenance activities to the strategic business values. Actual performance should be evaluated periodically and checked against targets. This provides a baseline for optimisation process that will ensure best combination of costs, risks and performances. Gaps and opportunities should be identified continually and appropriate strategies to harvest the benefits should be determined and implemented. Figure 4 shows the flow of primary assets process.

3.5 Secondary assets
Data
The significance of collecting and storing the correct type of data from the commencement of the AM process was emphasised in [7-8; 21]. Improving reliability, availability and maintainability of wind turbines and associated grid connection facilities will depend on availability of useful historical failure and maintenance data. Therefore, it is important to have a comprehensive inventory (including specific location) of all wind turbines and grid connection facilities in an integrated asset register and data management system. The system should be robust to accommodate sequential recording of maintenance and failure data in an RCM format. This will keep maintenance track record of each asset in a meaningful form that is readily usable for decision making and optimisation process.

Work-force
Personnel facilitate the operation of wind turbines and associated grid connection facilities to attain the expected level of performance. The quest for excellent performance revolves around competent workforce with the right people on the right jobs [21], having manageable work backlogs and zero human error. This requires an effective training and communication scheme, clear work procedures, team work, effective shift and reward systems. Personnel performances should be evaluated periodically to identify training needs for continuous development. Figure 5 shows the flow of work-force process.

3.6 Continuous performance improvement
This process involves periodic evaluation of the overall business performance of wind farms to satisfy all the requirements of the stakeholders. The overall KPM (figure 2) will indicate the level of success or failures attained in the period under consideration, which reveal gaps and opportunities on a continuous basis. This motivates the desire to determine and implement appropriate strategies to bridge the gaps and explore new opportunities. However, if no significant improvement is achieved after applying
appropriate strategies and the root causes cannot be identified, benchmark [22] against pace-setters within or across the industry. This will yield useful success factors to drive the continuous performance improvement process. Figure 6 shows the flow of continuous performance improvement process.

3.7 Figures and tables

**Stakeholders’ requirements**

- **Government**
  - Require compliance with:
    - Regulations
    - Health, Safety and Environment (HSE)
    - Price control

- **Investors**
  - Require:
    - Business survival
    - Maximise return on investment
    - Enlarge market share

- **Consumers**
  - Require:
    - Lower price of energy
    - Increase efficiency
    - Increase quality of service

- **General public**
  - Require protection of:
    - Environment
    - Aquatic life, Birds
    - Navigation and defence facilities

**Fig. 1** Stakeholders’ requirements process flow

**Mission & vision statements**

- Consider & exceed stakeholders requirements?
- Yes
- No

- Define overall business goals
- Concise, well communicated do-able?
- Yes
- No

- Establish overall KPM:
  - Return on investment
  - Regulatory compliance
  - Revenue generated
  - Shareholder value

**Fig. 2** Mission and vision statement process flow

**Assets classification**

- Asset indispensable to core business goal?
- Yes
- No

- Secondary assets
- Primary assets

**Fig. 3** Asset classification process flow
Fig. 4 Primary assets process flow

Fig. 5 Work-force process flow
4. CONCLUSION AND WAY FORWARD

Due to the current trend of growth in the wind industry with inherent conflicting stakeholders’ requirements and the lack of a holistic frame-work to harness stakeholders’ needs with assets technical issues, crucial requirements for effective management of wind farms have been identified and transformed into structured AM processes. Each process was appropriately represented in a flowchart and discussed in detail. In the development of the processes, various AM tools and techniques existing in other industries were drawn and integrated for effective management of wind farms.

Further research work is being undertaken to integrate the results presented in this paper to develop a structured model for asset management in the wind energy industry. This model will be reported in a future paper.

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6. REFERENCES

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