Totaro&Associates

Current and Future Trends in Wind Turbine Technology
Results of a Patent Landscaping Exercise

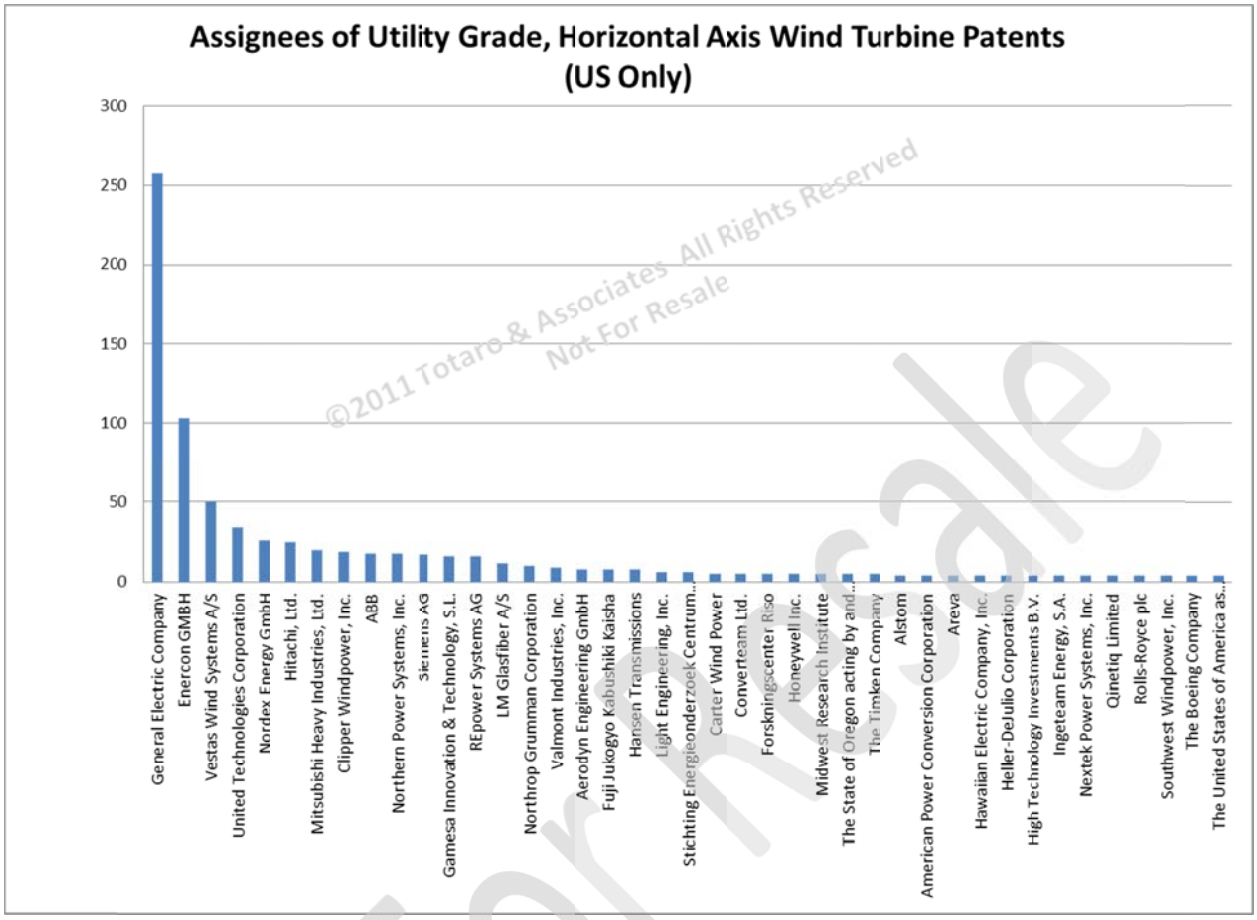
by Philip Totaro, Principal, Totaro & Associates

Utility grade wind turbines have become so technologically advanced that they have improved the cost of energy of wind enough to become more mainstream than ever before and compete with today's conventional energy sources. We have decided to conduct an investigation of the patent landscape to see what technological trends have emerged thus far and what we might be able to infer for the future direction of wind turbine technology. At this time, the assessment was limited to the most prevalent sector of wind turbine technology – utility grade, horizontal axis wind turbines.

The search was conducted utilizing a comprehensive approach, as well as thorough reading and examination of results. A patent database and search portal was used which covers 90 different patent authorities worldwide, including 20 countries which provide full-text file search as well as legal status information. We first identified a set of keywords which would provide an all-inclusive set of search results. We also identified patent classes to search in order to ensure that relevant results would not be omitted. Lastly, a set of assignees of over 100+ companies who have currently or previously produced wind turbine technology / components was searched.

Aggregation of these results and elimination of duplicates as well as false positive results has led to a total set of 1422 US patents dealing with utility grade, horizontal axis wind turbines. While the scope of these search results was limited to US issued patents, most of these have equivalent foreign filings.

The results have been grouped by Assignee, and it should come as no shock to industry watchers who the top 3 assignees are for utility grade, horizontal axis wind turbine patents. For the sake of compactness, only those with 4 or more patents were included in the chart.



The search results were read and analyzed to determine a keyword classification that indicates the specific technology and component to which the invention refers. The component literally refers to the wind turbine component which the invention deals with, i.e. blade, tower, generator, gearbox, etc. The technology refers to the nature of the improvement, and deals with such topics as performance improvement, reliability enhancement, manufacturing tools or processes, safety or grid compliance. The search results are presented in a format in which each individually issued patent was assessed and classified. Therefore, continuations and divisionals are included as separate line items in the results. The following is indicative of the keyword classification methodology.

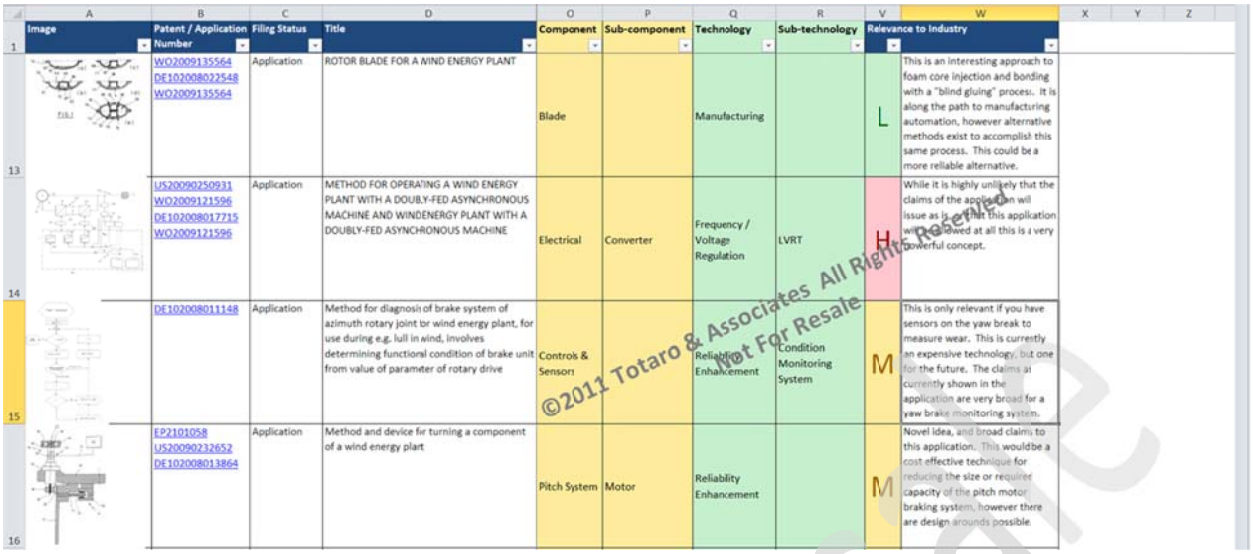


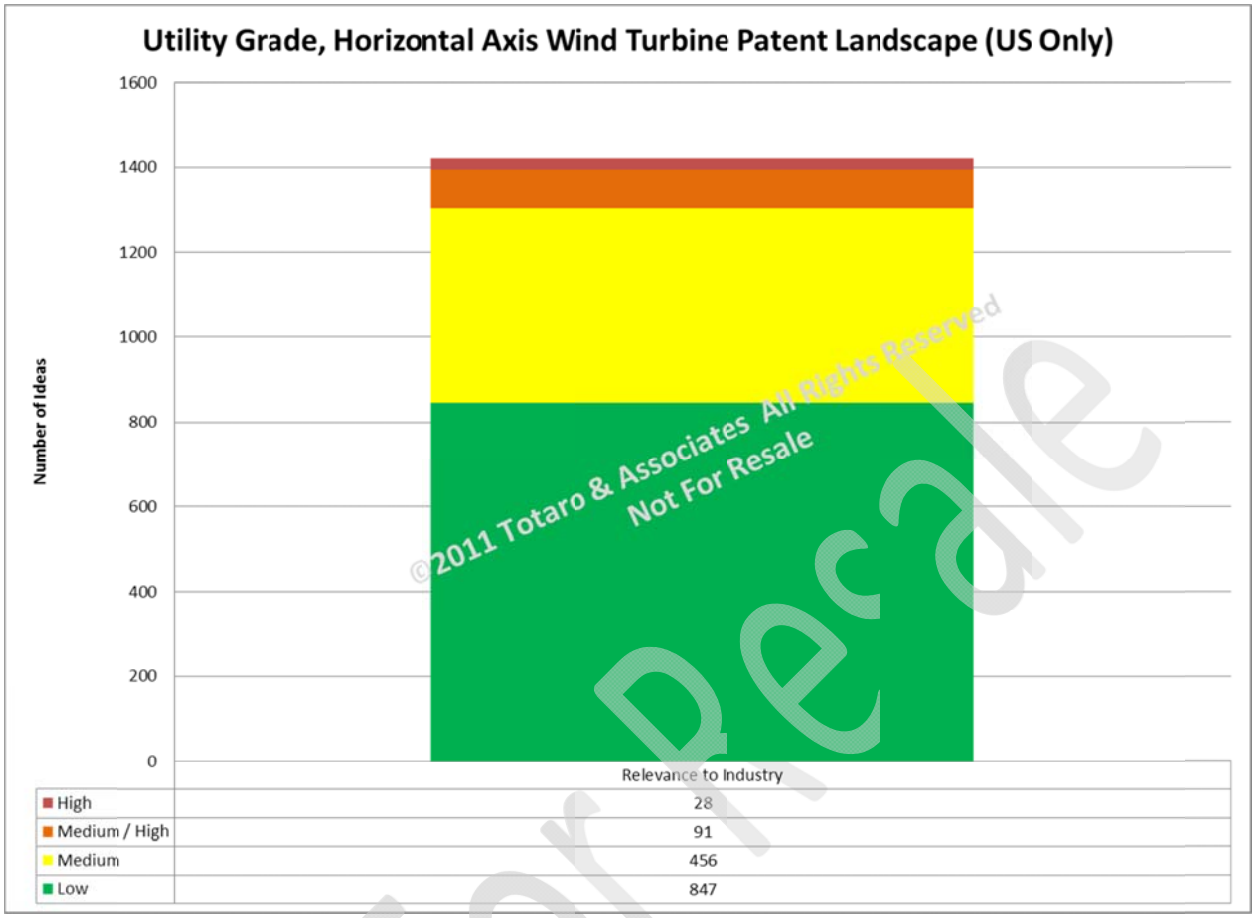
	Image	Patent / Application Number	Filing Status	Title	Component	Sub-component	Technology	Sub-technology	Relevance to Industry
13		WO2009135564 DE102008022548 WO2009135564	Application	ROTOR BLADE FOR A WIND ENERGY PLANT	Blade		Manufacturing		L — This is an interesting approach to foam core injection and bonding with a "blind gluing" process. It is along the path to manufacturing automation, however alternative methods exist to accomplish this same process. This could be a more reliable alternative.
14		US20090250931 WO2009121596 DE102008017715 WO2009121596	Application	METHOD FOR OPERATING A WIND ENERGY PLANT WITH A DOUBLY-FED ASYNCHRONOUS MACHINE AND WINDENERGY PLANT WITH A DOUBLY-FED ASYNCHRONOUS MACHINE	Electrical	Converter	Frequency / Voltage Regulation	LVRT	H — While it is highly unlikely that the claims of the application will issue as is, it is that this application will be allowed at all this is a very powerful concept.
15		DE102008011148	Application	Method for diagnosis of brake system of azimuth rotary joint or wind energy plant, for use during e.g. lull in wind, involves determining functional condition of brake unit from value of parameter of rotary drive	Controls & Sensors		Reliability Enhancement	Condition Monitoring System	M — This is only relevant if you have sensors on the yaw break to measure wear. This is currently an expensive technology, but one for the future. The claims as currently shown in the application are very broad for a yaw brake monitoring system.
16		EP2101058 US20090232652 DE102008013864	Application	Method and device for turning a component of a wind energy plant	Pitch System	Motor	Reliablity Enhancement		M — Novel idea, and broad claims to this application. This wouldbe a cost effective technique for reducing the size or required capacity of the pitch motor braking system, however there are design arounds possible.

Additionally, an assessment of the relevance of the patent to the industry was performed and results were classified as low, medium, medium/high, and high. Definitions of this classification method are below. The assessment of industry relevance serves the purpose of indicating the degree to which the patent owner has or is likely to assert their rights and seek licenses or otherwise enforce the patent. This should be an indication of the proverbial landmines to watch out for when navigating a technology and product roadmap through the landscape.

- Low - Not relevant to the currently pervasive set of technologies and products in the industry.
- Medium - May have been relevant in the past, but as technology evolves it is less prevalent. These are likely to shift to low in the future.
- Medium/High - Important items which the industry needs to be cognizant of, but these can likely be avoided / mitigated. Influence of things like technology trends and grid standards will ultimately determine relevance.
- High - Critical item which has been asserted, licensed or enforced, or else it is highly likely to be in the future.

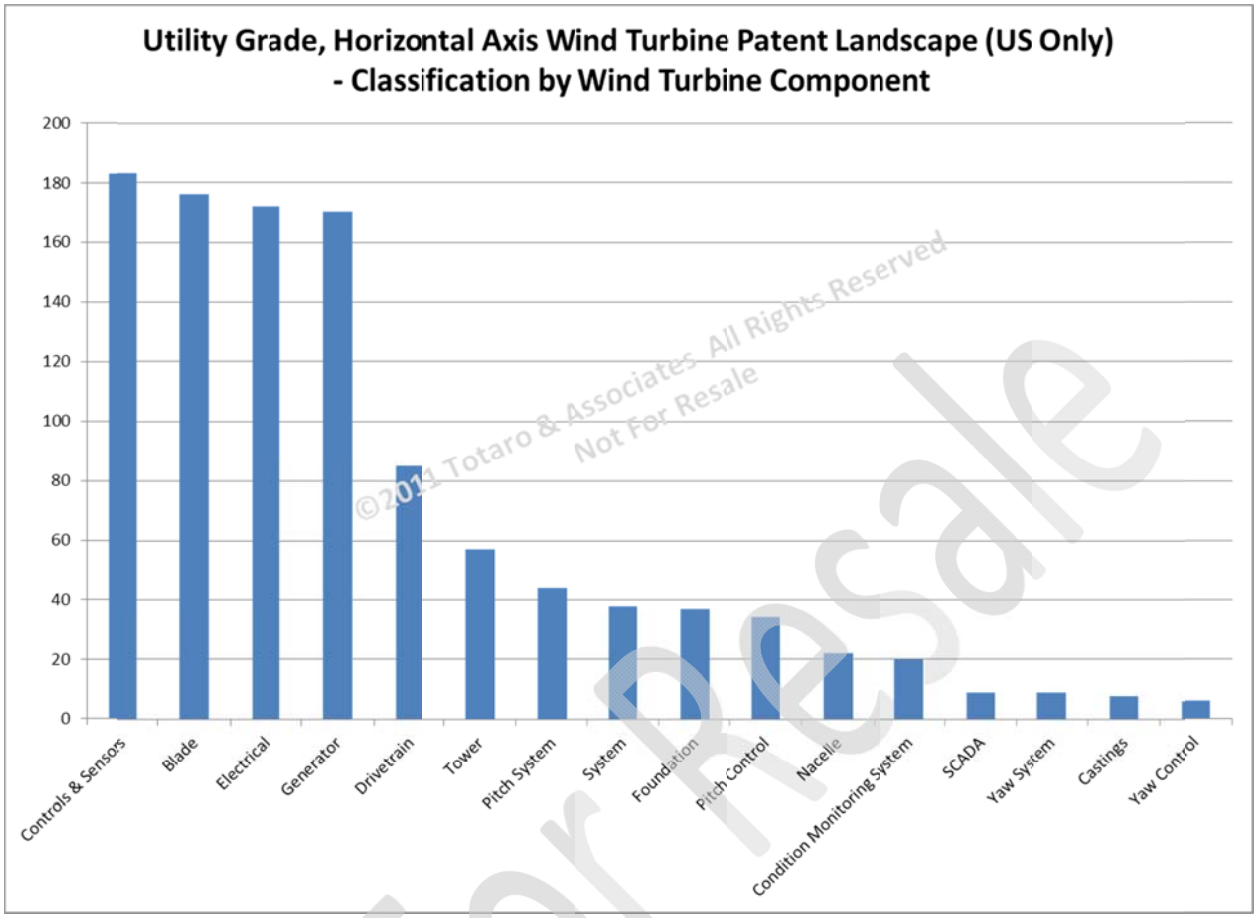
While it was not included in the set of results presented herein, two additional analysis tools can be utilized on the search results. The first is a brief synopsis of the invention that the patent is claiming, which is based on a reading of the patent and should therefore be more descriptive of the actual technology and intent of the inventor than the patent abstract. Secondly, a risk assessment can be performed according to the same methodology as the assessment of industry relevance. This will help determine the degree to which there is explicit risk of potential infringement based on technology architecture and other factors, and subsequently whether or not risk mitigation activities should be pursued.

In acknowledging that the application of these keywords, the risk assessment as well as the synopsis of the invention are all subjective, it should therefore be clear that this activity requires a certain level of technological and industry expertise.



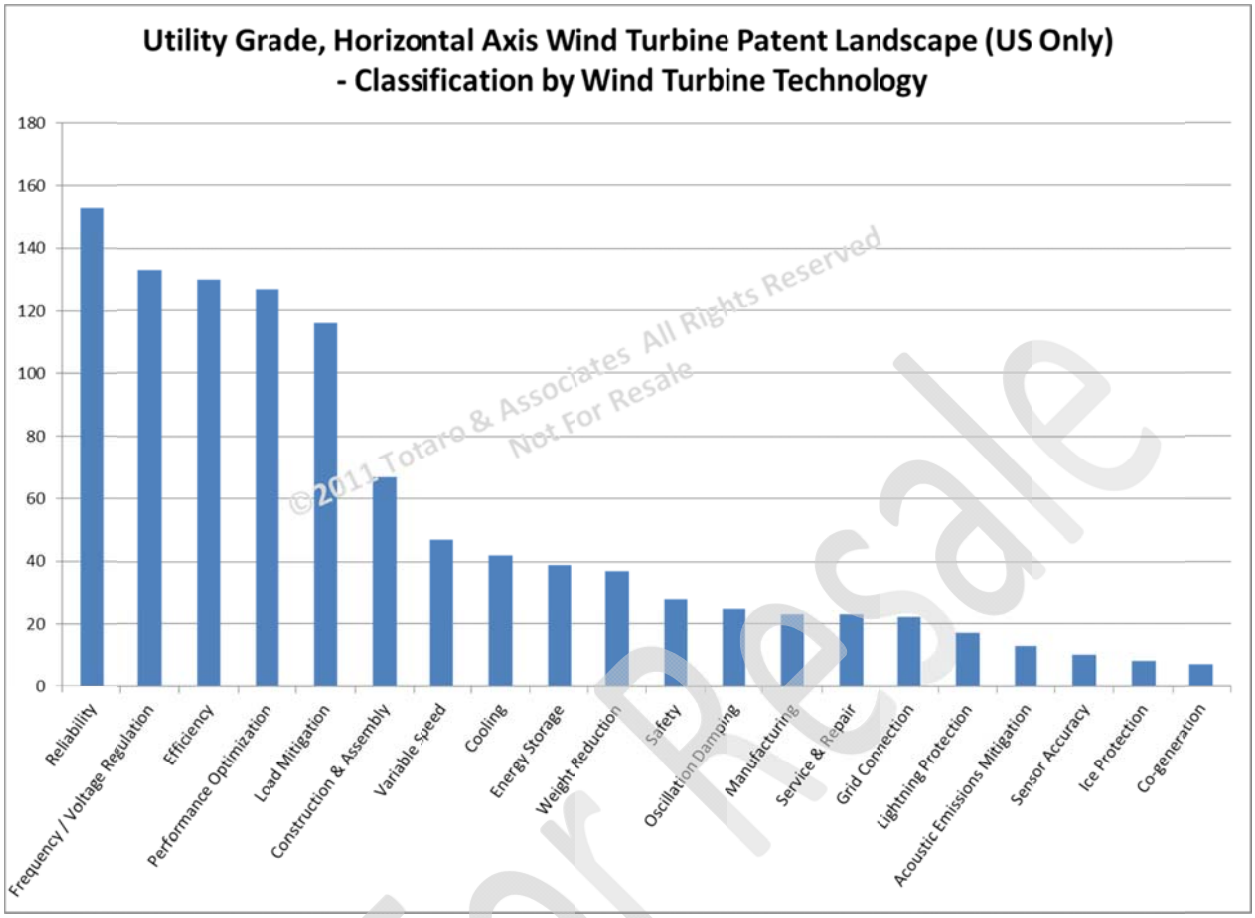
The industry relevancy results indicate that only 2% of issued patents are a high impact on the entire industry as a whole, with another 6% which may become relevant in the future. The majority of the results, the remaining 92%, are therefore providing companies with merely defensive protection. Tangible value predominately exists on the Low and Medium impact patents if those companies are seeking equity investment or sale / divestment and their patent portfolio will require valuation, or alternatively they are licensing their portfolio to a partner or third party.

The keyword classification shows interesting, albeit obvious trends to industry watchers, but it also indicates certain areas which may present "whitespace" for patent protection. Obviously the blades, generators, and electrical systems of the wind turbines are the largest areas of focus historically because ultimately the efficient conversion of mechanical energy into electrical is the intent. Beyond that, it will be seen from the technology keyword classification that these three areas have been most problematic for manufacturers when it comes to component reliability, so they have garnered a great deal of attention and innovation to improve quality and performance. The emergence of controls to the top of the list is a more recent industry trend in which turbine OEMs endeavor to optimize turbine performance while operating within the design envelope.



As previously mentioned, the trend of attempting to improve reliability and efficiency of wind energy conversion has been the predominant focus of the industry over the past 2 decades. It has been this focus which has resulted in the cost or energy reduction as well as the reliability enhancement seen in that time frame. Fleet-wide availability of wind turbines has been dramatically improved, with most OEMs now quoting a 97% availability guarantee in their turbine supply agreements.

Now with turbines getting bigger in physical size as well as nameplate rating, we can see that load mitigation and construction are emerging thrusts. Shipping turbines in modular sections and assembling on-site at a wind farm will be an important area of investigation for land based turbine manufacturers. Component size has increased to such an extent that transportation of whole blades, towers, and nacelles under bridges and through tunnels is reaching its' limits. Additionally, with commodity prices fluctuating during the current economic times we see many manufacturers attempting to take weight / material and therefore cost out of their products.



This analysis, as well as extensive analysis of forward looking competitive intelligence helps shape our view of future technology trends for the industry. The following are what we believe to be the emerging trends in technology, and therefore patent protection:

- **Component Weight Reduction** (i.e. mass / cost out to maintain tower head mass ratio) – transportation across land and sea of increasingly heavy castings, towers, blades, etc.
  - Advanced materials
  - Load mitigation / controls
- **Turbine Reliability**
  - Drivetrain architecture (fewer gearbox stages)
    - Elimination of gearbox - direct drive
- **Fleet Management**
  - Condition based maintenance solutions (CBMS) as seen in the Aerospace / Defense industry today
- **Performance Optimization** – Optimal energy production regardless of prevailing conditions
  - "Max energy all the time"
  - Derate / Uprate

  - Integration of turbine controls with the Condition Monitoring System (CMS) to determine component remaining useful life and optimal turbine operating procedures
  - Blade aero / structural performance

- **"Grid Friendly"** – requirements as identified by the Federal Energy Regulatory Commission (FERC) and other regulatory agencies to ensure wind turbines operate much like conventional energy plants today, where output can be throttled and grid fluctuations can be absorbed, etc.
  - Variable speed control with use of synchronous generator vs. induction
  - Low voltage ride-through (LVRT)
  - Energy storage

- **Size and Transportability**
  - Sectional components
  - On-site assembly procedures while maintaining component quality / integrity

Whatever the future may actually hold, the promise of clean energy is here. Innovation continues to drive change.

About the Author

Mr. Philip Totaro is the Principal at Totaro & Associates, a consulting firm focused on innovation strategy, competitive intelligence, product development and patent search. Mr. Totaro has experience in strategic planning as well as creating and protecting intellectual capital. He has worked for such companies as General Electric, United Technologies Corporation and most recently he oversaw Intellectual Property and Competitive Assessment for Clipper Windpower. He has helped cultivate and disposition over 450 innovations, and his assessment has led to over 250 issued patents. His strategic market analysis has led to the funding justification of over $500M in R&D investment and the development of multi-million dollar product and service offerings. He has provided legal and technical due-diligence for over $1B in M&A, including the recent takeover of Clipper Windpower by United Technologies Corporation. To find out more or get in touch please visit www.totaro-associates.com.