Renewable energy has gained great importance for obvious reasons. Among the different options, Wind Energy is considered the strongest contender due to its reliability, environmental friendliness, cost-effectiveness and its low infrastructure requirements for any remote location, all of this, thanks to the maturity of the technology. Wind power is a reality and it’s here to stay.

The continuous improvement and optimization, in all aspects, is leading the Industry to bigger Wind Turbines; this sizing increase, almost exponential in recent years, created the need to install Wind Turbines in costlier and riskier environments, being off-shore the differentiating challenge for the Industry.

Bigger turbines and costlier environments mean, among other aspects, higher potential liabilities. Increasing the energy output of a Wind Turbine requires increasing the length of the blades to obtain a much bigger swept area, increasing the size and weight of the nacelle and its components and therefore increasing the height of the supporting towers and foundation. We’re moving toward the Mega-Wind Turbine Era.

Obviously, all of this means having to withstand higher levels of centrifugal and bending forces, stresses, vibrations... affecting the fatigue life of all bolted joints: at the blades, hub, bearing, shaft, support tower and Wind Turbine foundation.

Regardless of the maturity of the technology, it’s inevitable to recognize that we’re going through a technological race, searching for the appropriate materials, resources, procedures and activities to back-up these new developments.

Needless to say, all of this means higher installation costs, but as, or even more important, are factors like reliability, maintenance and repair, which translate into the real life-cycle cost and potential liabilities that such ambitious projects represent. Off-Shore, as an example, can only be conducted by economically and financially strong entities. Who can respond for defective or damaged gearboxes, blade replacement, or any other major corrective action in the middle of the sea?

Safe bolted joints systems have to be implemented as one of the helping factors to this evolutionary process that the Wind Industry is going through, but also, its criticality affects existing wind turbines for which we still expect a long, safe and cost effective life time.

The success of a Safe Bolted Joint Program will require harmony among all players, the Turbine Manufacturer, the Contractor and the Wind Farm Owner, in a way that all benefit. Our BoltPilot System meets this requirement and it’s what we would call a Win-Win-Win Situation.
Although is not the purpose of this document to detail a complete Safe Bolted Joints Program, we believe it’s important to understand the basics of this required paradigm shift in our industry. Such a program includes the Design, Prototyping, Material Specification stages all the way to Manufacturing, Construction and Operation and Maintenance stages. Our BoltPilot System is a vital element of such a program.

As we all know, almost every joint in a Wind Turbine is held together by the clamping force created by bolts. All the continuous and extreme level of forces, which the turbine is submitted to, affect the integrity of the bolted joints, becoming a critical system. The reliability and integrity of the bolted joint will be conditioned by the stability of the loads on the bolts, the assurance of a safe fatigue life and the appropriate interaction among all elements that conform this complex system. Realities like relaxation, corrosion, fatigue, shear and vibration, among others, are enemies of the joint’s integrity. Failure of any of these joints can result in a disastrous event.

As an Industry, we should work under the following principles:

- The integrity of the joint is not only possible but a reasonable end.
- The cost of avoiding any failure will be much lower than the cost of the failure.
- We have the moral and legal obligation of assuring the integrity of the wind turbine, minimize any negative effect in the environment and assuring the safety of the people working in our industry.
- Are we aware of the cost of a bolted joint failure?

There are no reliable statistical values in our industry, but we all know and are aware of the criticality and costly expect that a joint failure means. We can go from a simple re-tightening job to a catastrophic incident. There are visible and hidden costs to such a failure. From having to repeat the job, to bolt replacement, to accidents with human fatalities and asset damage, production loss, warranty claims... to damaged company image, liability uncertainty.

Establishing a Safe Bolted Joints Program will be the single major contributor for the prevention of Wind Turbine’s joint incidents. Such a program should be embedded on the Company’s processes and departments, and so much better if it’s from initial stages, flowing from R&D, Design, Material Specifications, through Manufacturing, Construction, Inspection and Maintenance. The criteria of our program should take into account the following concepts:

- Proper and Safe use of Tools
- Procedure Understanding
- Proper Training and Qualification Assessment
- Defined and Correct Procedures
- Design for the Job to be Performed
- Calibrated Tools
- Right Tool for each Application

None of the quality programs or even guidelines in our industry, are robust enough to include the entire design – installation – operation cycle, lacking the important function of working towards Continuous Improvement through RRCA (Real Root Cause Analysis).

Also, lack of a Preventive versus a Reactive approach. Our attention to outcomes – and disregard of the processes that create them – makes solutions seem more valuable than preventive actions. A decision maker who solves a problem can be identified and rewarded, while one who takes action to avoid the same problem is far harder to spot. Prevention will be the most cost-effective and incident avoidant approach.

Something we found as common in our Industry, regardless of the stage, is a culture of Compartmentalized Working (commonly defined as Silo Working) and a lack of efforts towards Organizational Learning. Many teams or even individuals work completely isolated from each other, in the same organization, project, plant or departments.

This leads to a non-uniform way of working, where important information may not be passed on to the right people or departments, mistakes can be repeated and can create great levels of conflict.

Organizational learning implies how a company sees, shares and applies information to make improvements; if the appropriate philosophy and rules are set in a way information flows in all related directions, we will advance a big step towards a continuous learning organization, avoiding what we consider the definition of error: An error is only such if we repeat it; if we learn from it we should perceive it as an opportunity and an advantage in our search for excellence.

If you want to go into deeper detail about the implementation of a Safe Bolted Joints Program you can visit www.safeboltedjoints.com
Our BoltPilot System is a very important tool towards the implementation of a Safe Bolted Joints Program. Focused mainly on the construction phase, an under controlled activity, the fact of controlling, guiding, registering and reporting this process will not only offer all the benefits that we’ll try to detail in the following paragraphs but a big step towards historical data and as a departmental communication tool helping our search for excellence through continuous improvement.

It’s our obligation to develop and implement systems that, not only assure Safe Bolted Joints, but systems that make the job simpler, safer and faster.

Our BoltPilot System does not come to life from an idea, it comes from working together as allies with all the different players in the Wind Power Industry. It comes from sharing uncertainties, fears, problems, bottom line, from understanding the needs, the job to be done, the resources and trying to beat the technical limitations that the control of bolt tightening suffers. Therefore, BoltPilot is the result of a long journey.

The Need and Our Approach

For some years now, our industry was requiring data collection as part of their quality system that could assure a job well done during construction and, more specifically, during bolt tightening activities.

Wind Turbine manufacturers need to assure the quality of this process, the Construction Contractors were also in need of good proof of their best practices, and the Wind Farm Owner needed a relief of such uncertainty.

We, at Texas Controls, probably the most experienced company in the world (our first hydraulic bolt tensio-meter was there, this was something available from a company in the world (our first hydraulic bolt tensioner) (1988), felt this need as an obligation from our side. Our daily interaction with all departments in all players, from design to prototyping, from engineering to manufacturing, construction, maintenance and reliability, gave us the holistic perspective that a simple tool manufacturer couldn’t understand: We took this duty as our responsibility. The capability of just recording what a tool had done, was there, this was something available from a long time, but, Does, simply recording this data provide any value to our customers? No, we were in need of really solving from an industry specific perspective, taking into account needs, benefits and fears shared among all players.

We decided, as an industry expert engineering firm, to approach this project from a “Job to be Performed” complete understanding: after all, What do we do? Just Manufacture tools? No, we provide Safe Bolted Joints. This project had to take into account industry specific limitations and restrictions; we had to develop a system that not only assured the job well done and its proof, but also had to take into consideration that such activities are performed in remote and harsh environments, physically demanding scenarios guided by a stopwatch, limited resources and a long etc.

And very important, humility, being able to accept that, although we have an incredible amount of knowledge, experience and daily interaction in the field, there are many things that we can and should learn from our customers’ needs and problems.

From that starting point, we devoted all our intellectual, physical and human resources, and started a Co-Creation Project with many participants, from manufacturers, contractors, utilities to different universities and technological centers in different countries. We had to draw a complete User Journey to understand, first hand, the needs, the problems and the potential gains that the people working in our industry require.

The Holistic Approach: The Job to be Performed

The BoltPilot System focuses on the Job to be Performed: Wind Farm Construction, understanding the different processes, activities and resources required, aligning them with the field restrictions and requirements, future needs, learning experiences for continuous improvement and historic traceability.

The BoltPilot System is a Multi-Farm platform, defining the complete wind farm, each turbine and each turbine’s bolted joints. Through and easy and friendly early data input process, each activity and all key elements of a Joint Integrity Management System will be defined. From the farm, the turbine itself, the bolted joints and its components to the technicians, the tools, the procedures, bolt loads and all quality and traceability documentation required.

From that valuable information, the System will Control, Guide, Assure and Collect all bolt tightening processes without interfering with the existing procedures. The technicians won’t be required to learn new bolt tightening methods nor special tool handling skills. The BPS is designed to work with standard format tools from a operation perspective; no extra equipment to take up the towers or interfering with the operators job.

During our Long Journey, we prioritize in the needs, fears, problems; we had to take into account many factors such as:

- Understanding the need for comfortable, easy to use and safe tools.
- Understanding the importance of speed.
- The need for assuring a good job the first time.
- The lack of bolt tightening understanding and qualification.
- The amount of discrepancies and methods of proof between wind turbine manufacturers, contractors and wind farm owners.
- And a long etc.

But also, whatever solution we could come with, had to take into account that potential users already had large investments in tools, we could not come out with a closed system, forcing customers to invest heavily in new tools or other physical resources.
BoltPilot is a work system that comprises different categories of hardware and software, that unified, conform an unique tool based on knowledge, for the management of the tightening activities of all critical bolted joints.

BoltPilot bases its efficiency on the direct and clear flow of information, without manipulation, between the ‘Office’ and the ‘Job Site’, of all relevant data to enable quality and controlled bolt tightening activities on critical joints. The technology developed for the BoltPilot can even control the use of the bolt tightening tools based on validated technical information, generated wherever is appropriate and by qualified personnel.

The previous image outlines the different elements that conform the BoltPilot System. All of them are compulsory since they all play an unique and relevant role on the generation, transmission and handling of all relevant data required for the traceability and control of bolt tightening activities. We can summarize these crucial elements:

1.- Job Site Specific Elements
   • Standard bolt tightening tools and sensors: The part of the system responsible to perform the tightening activities and generate the corresponding data. The system can work with standard tools such as hydraulic bolt tensioners or torque wrenches, conventional tools in many cases. Depending on the level of sensorization required by the project, retrofit of existing tools can be performed.
   • Smart Hydraulic Power Packs: Will collect confirmation data to: (Smart Power Packs) through different wireless technologies.
   • Smartphone: Will serve as the bridge between the ‘Job Site’ and the ‘Office’ system. At this stage the Smartphone works under Android platform, through a specific App developed for the BoltPilot System.

2.- Office Elements
   • Web Application: This application is the digital repository of all data of the system. It allows to access, in real time, all the information from any point in the world and generate the corresponding reports. On this application, Wind Farms, Turbine Models, Critical Joints, Tools, Operators, etc. that form part of the project can be managed. From it, all application data is generated to be transmitted to the Field (Smart Power Packs) through different wireless technologies.
   • Servers: The Web Application can be hosted at Texas Controls’ servers or any other server that the customer decides.

All these elements interact among them and the users to transmit, capture, treat data following this simplified outline:

The useful information, for control reasons, can be classified in different categories:

A. Configuration Data
B. Quality and Traceability Data
C. Captured Data

The Configuration Data is all the information required to define and check the job to be performed. This information is associated in the system, to each one of the Critical Joints; it's a technical definition from the tightening perspective. Here we will define values as applied load, residual elongation, torque values, lubrication conditions, torque and angle, etc.

At this level, the BoltPilot can manage different bolt tightening procedures and assure compliance of these aspects. Therefore, the configuration data is the origin of the activity traceability.

Using the BoltPilot

All operating aspects have been designed to assure a simple and friendly use, the Web Application and the operation of the sensorized tools in the field. At the Web Application, through 3 simple clicks, we can reach the bolt tightening report of all critical joints of a specific turbine. At this application we can upload and manage critical joints, tools, operators, and create work orders for the appropriate configuration of the job to be performed.

The type of reports to be generated can be defined based on customer needs or requirements.

To configure the job, the operator will receive a password that he will input on this smart phone and this way download the BoltPilot Smart Power Packs. This information is saved in the system without human intervention to avoid manipulations and together with the information from Level A and B, conform the set of data to:

• Validate the bolt tightening performed.
• Guide the technicians through the process.
• Generate quality and monitoring reports.
• Guarantee the traceability of all bolt tightening operations.

The simple and friendly use, together with the data protection capabilities have been a priority during the design and development of the system.