Chapter

Human Factors: The Impact on Industry and the Environment

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Abstract

New technology is evolving rapidly, creating new environmental and industrial challenges that must be considered. Technology continues to focus on the demands of industry to increase efficiency and production output. At the same time, industry must quickly adapt to new technologies in order to compete and grow and also face the increased awareness for the need to evaluate and mitigate environmental impact. Recent studies indicate that the use of automation in the workplace will nearly double in the next few years. If we look at the control room as being the core of the industrial environment, the focus was previously on the physical and automated components. Little focus has been on the humans that control this rapidly evolving technology, and there is still not enough focus on the most critical component that can not only impact production and output but also create a negative impact on the environment as a result of human error that could have been avoided. It is time to take a step back and look at what impact the humans are having on the environment as a result of the rapidly changing technology.

Keywords: human factors, human error, control room environment, control room design, control room operator

1. Introduction

If we look at the generally accepted definition of the word environment as the natural world, and industry as the processing of raw materials from this natural world, then the link between the human impact on industry and the environment can be easily understood. Industry is a man-made function developed specifically to maximize the value of raw materials. The next logical step is to examine how human error can be directly related to negative environmental impact and how this could be mitigated, if not prevented. If we look back in history at the evolution of industry, we can see a pattern emerge as industry began and continues to be more driven by technology. With Industry 4.0 focusing on the latest and greatest technology, the concern is that the human involved in developing, implementing and monitoring this technology will be overshadowed by technology itself. No matter how quickly technology advances, industry will always ultimately be controlled by humans. The risk of human error must be mitigated—one mistake can result in huge and in some cases irreversible environmental damage. The increasing need for a focus on the psycho-social work environment must be considered. How has this critical element been downplayed to a point that it is almost non-existent when it comes

to evaluating environmental risk? The purpose of this chapter is to take a step back and identify some key considerations that should be a baseline when analyzing the impact of industry on the environment.

2. Industry 4.0—how did we get here?

Industry is driven by technology which can be traced back to the beginning of the first industrial revolution in the eighteenth century. This is commonly understood as the transformation from an agrarian economy to one that was transformed by industry and machine manufacturing. The technological changes involved the use of iron and steel, new energy sources including fuel and coal, and the invention of new machines to process these sources to increase production which then led to the development of factories to house the machines [1].

This was followed by the second industrial revolution, which led to the development of automated factories, and an expansion into the use of additional resources such as different metals, as well as the start of production of other products (plastics and chemicals for example) that required the further development of automation and factories as well as the start of mass production. The third industrial revolution, brought semiconductors, computing and later on the internet—this is known as the Digital Revolution [2]. Now it is generally accepted that we are now into the fourth industrial revolution, or Industry 4.0 which can be defined as "a new era that builds and extends the impact of digitalization in new and unanticipated ways" [3]. The result is even further and quicker development of technologies, automation and factories that are developing more rapidly than we thought possible.

If we look at the advancement of industry through each of these periods, there are two key elements that need to be considered as critical, especially as they relate to human factors and the potential impact on the environment. First, as factories became more automated, the processes also became more streamlined—over time it became possible to control multiple actions within an industrial setting from one centralized area: the control room. Second, as automated and advanced these processes became (and continue to become), the human was, and today still is, involved. No matter how advanced the technology, there is always a human either watching the process or controlling the process and, in many cases, it is both. As much as technology facilitates industrial automation, it also creates new challenges. Smart and intuitive technology and the resulting requirement for increased employee expertise will have a major impact on how these new technologies are both implemented and at the same time controlled.

The control room is the core of all industrial production facilities—this is where technology is monitored, analyzed and where all processes that are taking place as part of production are operated. The humans that work in a control room are commonly referred to as operators, and for the purposes of this discussion, the term "operator" unless otherwise specified, will refer to the human who is working in the control room. Operators today are overloaded, and unless we consider all aspects to mitigate the stress of the environment in the control room, it will affect not only production but also safety and has the potential to lead to both positive and negative impact on the environment as a whole.

3. Major industrial disasters reported to be caused by human error

If we look at a few well-known major disasters that had major impact on the environment, we can see where and how human error was identified as the cause.

Take for example Union Carbide in Bhopal, India in 1984. The analysis of that accident determined two out of three safety systems in place were shut down or broken—operators were so used to hearing alarms go off, for other reasons, they did not pay attention to the one that was critical resulting in 40 tons of toxic gas and chemicals released into the environment [4]. Which raises the question of how could this have been avoided? Why was there no system in place to prevent this? It would suggest that had the safety systems been updated, repaired or at the very least maintained, this might have been avoided.

A few years later there was Chernobyl in 1986. In that case, control room operators ran the plant at very low power, without adequate safety precautions and without properly coordinating or communicating the proper procedures with other personnel, the end result being the meltdown of one of the nuclear reactors [5]. It led to the mass release of radiation that is estimated to have traveled across nearly 8000 square miles (over 20,000 square km) of Europe [6]. With both of these disasters, there is still no definitive estimate of the resulting impact on the environment; however, it is undoubtably substantial and ongoing. Many studies of both examples have been done, and many questions asked about technology and physical and mechanical failure. Yet ultimately, both were traced back to the control room and the operator—human error.

In 1989, there was the Exxon Valdez disaster, which arguably was one of the largest environmental disasters, and was seen as the worst oil spill in US history: "The impact on local wildlife was devastating: An estimated 250,000 sea birds died in the months after the spill, and 14 members of the 36 local Prince William Sound killer whale pod had disappeared by 1990. The so-called carcass count also tallied, among other creatures, 1000 dead sea otters as well as 151 dead bald eagles…" [7]. There have been many articles and analyses of this very well-known disaster, but the common underlying theme in these studies ultimately also points back to the key cause of this disaster: human error. The inquiry that followed the disaster identified "… drinking, exhaustion of depleted crews, unqualified pilots on the bridge, violations of basic sailing rules, lax Coast Guard monitoring and a blind reliance on new technology all figured in the grounding on March 24 of the Exxon Valdez" [8]. In this case, it was multiple events all leading back to the human that resulted in the disaster. Could this have been avoided?

With the explosion on the Deepwater Horizon offshore oil rig in 2010, the analysis of the cause was multifaceted. It was a combination of years of cutting corners while moving forward with technology and advances, not one careless mistake that was to blame—however, one key point in this case was that despite all the experience of the crew on the rig, combined with the technology, the operators did not see the sign of trouble until it was too late, and did not act quickly enough to contain it, in fact did not know how to [9]. Environmental impact in this case was substantial: the oil was toxic to a wide range of organisms, including fish, birds, and sea mammals such as dolphins and sea turtles, not to mention corals as well as other ecosystems [10]. The final report on the Deepwater explosion concluded that it was not mechanical failure, but human error that was the root cause of the explosion [11]. It was also stated that "… regulators, however, failed to keep pace with the industrial expansion and new technology" [11]. Not only was the actual disaster caused by an error from the operator controlling the technology, we can see that it was human error on multiple levels which led to the disaster—regulators, management focusing on cutting costs with the expectation to increase financial results, all the way down the chain to the operator who failed to react correctly in a critical situation.

In 2011, there was the Fukushima Daiichi nuclear explosion in Japan. Where the initial thought was that the blame for this incident could be directly related to an earthquake and the tsunami that followed, reality is that this disaster was also the

result of human error. An independent panel that was commissioned by the government of Japan to analyze the disaster determined that the meltdowns of reactors at the Fukushima Daiichi nuclear plant had "...less to do with the earthquake and tsunami that hit Japan ... and more to do with the plant owners' and government's failure to anticipate and prepare for emergencies on such an epic scale" [12]. Furthermore, the report to the Japanese government was that it was human error: "The crisis at the Fukushima nuclear plant was "a profoundly man-made disaster" [13]. Once again, a major disaster with ongoing effect on the environment that is still having an impact today. And once again, a multifaceted case of human error on more than one level.

A more recent example was the Columbia Gas explosions in Massachusetts in 2018. According to US Federal investigators preliminary report, customers received gas from a low-pressure distribution network, which in turn was fed from high pressure main pipeline. At the time, workers were replacing some of the piping but due to faulty procedures, faulty work orders and lack of proper communication, full pressure from the main pipeline fed into the local distribution network, which then lead to a chain reaction resulting in multiple explosions [14]. Once again, a large-scale disaster caused directly by human error. Some of the dangers of natural gas are obvious such as pollution, and the resulting impact on public health, and some are not so obvious, including but not limited to the impact on mental health as a result of major incidents such as the one in noted above as well as the fear of potential similar incidents occurring in the future. Considering that there are thousands of miles of outdated infrastructure, and no real way of predicting when the next explosion might occur [15], the concerns are very real. The outdated infrastructure not only applies to the gas industry, but undoubtably in every major industry worldwide. This not only is a concern due to the potential loss of life caused by these accidents, but also the resulting potential effects on the environment as a whole.

The above-mentioned cases further serve to highlight the fact that the human is often forgotten when major environmental disasters occur. In 1998 it was noted that "So much attention is devoted to the cost of industrial disasters in financial terms and to the technologies that fail at times, that it is possible to lose sight of the fact that disasters involve people, individually and in societal groups. Although awareness and concern about the human factor in industrial disaster has grown considerably over the last 15–20 years, many continue to see human error in a very narrow perspective" [16]. It is important to note that it is now 2019, and the risk of human error is still viewed as an afterthought. A key point to consider is that as we are now in the midst of the fourth industrial revolution, the focus is arguably even more on increasing production, combined with continuing to advance technology to aid in this goal. Yet the role of the human as an integral part of this is still being underestimated, not the least of which is the lack of focus of the direct effect of the human on the environment, and conversely, the effect of the industrial control room environment on the human.

4. Focus on the environment

As environmental impact is becoming more of a worldwide concern on a large scale, the actual physical environment where the human is monitoring and effectively tasked with preventing a major incident must also become a priority. With the ongoing and increasing demand for governments to react to increasing concerns of the effect of industry on the environment and climate change, the pressure is increasing even more on industry to actively focus on ways to contribute to the solution. The Paris Accord of 2015 states that the "... central aim is to strengthen the

global response to the threat of climate change by keeping a global temperature rise this century well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C" [17]. So what does this mean for industry?

With the push on efficiency leading to the development of even more advanced technology, the impact of this on the human as well as the role of the operator seems to be falling to the wayside. It is not simply a question of updating dated infrastructure and adding extra screens for the operator in the control room to monitor. No matter how advanced technology becomes, it will always be designed and operated by the human. The key factor being that it is the humans who are the one who will ultimately push or not push the button to prevent a future large-scale disaster. As we can see all frequently, major industrial disasters are still taking place. At what point will industry take a step back and realize that the operational environment can have a direct impact on the natural environment? As technology and automation continue to rapidly evolve, the focus of industry must now shift from not only increasing production, maximizing efficiency, and reducing environmental impact through cutting emissions among other key factors, but also analyzing the humans who are controlling the technology to achieve this, and specifically, the environment in which this technology is centered.

5. The control room environment: design is critical

As stated previously, the control room is the centralized location where all technology is monitored. It has been argued that the control room environment is effectively the heart of a production facility—it is viewed as the core of the operations, where technology is centered and the intent is to be able to operate 24 hours a day, 365 days a year [18]. The main goal of an effective control room is to ensure production is continual, uninterrupted and efficient, with as minimal downtime as possible. Creating a control room that considers the human element is one of the most challenging yet also arguably the most critical factor when contemplating not only how to optimize production, but also how to prevent serious environmental impact. The technology needs to be effective, but the human machine interface (HMI) must also be a key focus. What has been neglected previously must now be considered—the control room needs to factor in as many points as technology does when it advances. The psycho-social aspect of the control room environment and the human involvement can no longer be ignored. With up to 90% of accidents that can be attributable to human error [19], and with accidents still continuing to occur, it is apparent that changes need to be made.

There have been many papers written about specific elements of a control room, more often than not looking at ways to increase efficiency, production, and updating technology; however, the focus on the operator in this environment is still a secondary element that is not often considered when evaluating industrial advancement. There is so much technology out there today we are still learning what it does—the amount of information that is instantly available at the touch of a button is unprecedented. Another key point is that 1 week's worth of information in the news today provides more information than an average person in the seventeenth century encountered in their lifetime [20]. If you consider this within the environment of an industrial control room, the amount of information that is monitoring every aspect of production (and subsequently immediately provided to the operator) can be overwhelming to the average person. The operators are having to process massive amounts of information quickly, accurately, and safely. Unfortunately, this is not easy, and there are many challenges which are continuing to grow as fast as the advances.

There are many challenges industry is facing when considering the control room environment. When speaking to companies across various industrial environments today, there are multiple concerns that surface almost immediately. When speaking in depth with operations management, the initial conversations usually start with "management wants us to increase our production output, so we need to look at upgrading our technology". As the discussion continues, often we find out that in actual fact, the technology is causing more problems than previously thought. Referring back to the Union Carbide disaster, it was noted that there were so many alarms going off in the control room that the operators chose to ignore the one that was truly critical. What is concerning is that this is still occurring today.

Recent discussions with an oil company led to the operation manager stating that the operators in the control room were dealing with 86,000 alarms a day, which meant each operator was dealing with approximately 60 alarms per minute, or one alarm going off every second. It simply is not humanly possible for an operator to be able to process and react to that kind of situation. In this case, the alarms simply become white noise, or background noise, and are ignored as way for the operator to be able to cope with the constant barrage of notifications.

A similar situation was noted in an amino acid producing company, where the operations supervisor stated that the operators had been experiencing so many alarms, that they had simply decided to turn them all off to try to reduce the operator stress. When asked how they were monitoring to ensure there were no major indicators of serious problems, the response was they were watching the screens. When asked how many screens they had, it was determined they had more than a dozen monitors requiring constant observation. Once again, how is it possible for the operator to be able to observe and react to the critical situations when there is a massive amount of information that constantly needs to be processed?

These are only two examples of existing situations relating specifically to alarms—there are many more. However, the key underlying point in both these cases is how will it be possible for the operator to react to an actual alarm? In the first case, there are so many alarms that the operator simply cannot be capable of quickly determining which one is critical. In the second case, with no audible alarms, the operator is expected to react based on visual monitoring, requiring constant focus. And if they need to walk away from a screen, what happens if that is the moment when a critical situation occurs?

These conversations usually lead to the identification of yet another recurring theme: the ability to attract and retain operators in a control room environment. Notable comments include: "we are finding it hard to fill operator positions, I'm not sure when we will be able to find the staffing to keep up with the demands for increased production", as well as "our experienced operators are starting to retire, and taking their experience with them, how do we transfer the knowledge if we can't even fill the positions?". Add to this common comments from operators themselves: "I haven't had the time to really be trained on the new system, so I'm just doing what I can to maintain production as best as I can", along with "I have brought up concerns several times but nothing ever changes, so its getting more stressful every shift". Another common comment "I'm trying to get management to let us have a coffee machine in the control room, but so far they won't agree. I can't take the risk to go down the hall to get a coffee in case I miss something on the screen, and with the long shifts, I really need the coffee to help me stay alert." All these comments are red flags that are unfortunately too common.

The human challenge in today's industrial control room, is not only with finding more technologically advanced operators, but is also in creating workplaces that retain those skilled employees. This in and of itself presents its own challenges. How will industry attract and keep the operators required to keep up with the fast paced,

technology-driven new operational environment? Difficulties in retaining good employees needs to also be factored into industrial planning. Understanding the challenges and being aware of the obstacles from the employee/employer standpoint is of paramount importance for the workforces of the future. This increasing need for a focus on the psycho-social work environment is critical—unfortunately, this has not been the focus to date. There are solutions that are not immediately apparent, that can be applied to all industry sectors, but a start must be made to address the human factors that can affect industry and as a result, the environment.

6. Human factors in the control room

Industry is now at a point where it must consider the control room as the starting point in terms of preventing industrial disasters and the resulting environmental impact. Updating technology is only one component of that. In the examples listed previously with regards to alarms, there are solutions to reduce alarms to a manageable and acceptable level which can then help reduce the stress of the operator. It must be noted that the example of alarms is, however, only one concern. We have briefly touched on alarms, however there is also the topic of cybersecurity and the risks that can be found as a result of improper system design, and again can be directly related to the control room operator. Cybersecurity itself is a topic that can be discussed in great depth as it relates to the control room and needs to be considered.

A quick example of how critical this is can be observed when looking at the attack on the power grid in the Ukraine in December 2015. In that case, hackers were able to get into the control system being used and take the power system offline and all the operator could do was watch it happen: "The operator grabbed his mouse and tried desperately to seize control of the cursor, but it was unresponsive. Then as the cursor moved in the direction of another breaker, the machine suddenly logged him out of the control panel. Although he tried frantically to log back in, the attackers had changed his password preventing him from gaining re-entry. All he could do was stare helplessly at his screen while the ghosts in the machine clicked open one breaker after another, eventually taking about 30 substations offline. The attackers didn't stop there, however. They also struck two other power distribution centers at the same time, nearly doubling the number of substations taken offline and leaving more than 230,000 residents in the dark." [21]. What would happen if this had been a chemical company? Or oil company? Or nuclear reactor? The possibilities are frightening in terms of what could have happened. Although this specific example did not lead to an environmental disaster, it is an important point to consider as part of the human factor discussion, especially as it relates to control rooms. Another factor which will not be touched on in this discussion is the potential effect of a disgruntled employee. Yet another topic that can have a direct impact on the environment, and at the same time can be the result of the industrial environment. The increased pressure for production, cost cutting, government pressure on industry in order to be able to meet environmental obligations can all take a toll. Unfortunately, this is not something that is considered.

There are other key factors that need to be analyzed as well, such as lighting, air quality, communication, workflow analysis, traffic patterns, operator health all of which can contribute to operator fatigue and stress if not properly considered. Each one of these are topics that have been analyzed in depth and offer solid research that can directly relate to the control room. Which is why proper design of the control room must be completely evaluated. The benefits of a well-designed control room environment include increased operator awareness, alertness and quicker reaction

times in a critical situation. It can increase safety and establish more efficient operations, create a sense of unity and teamwork, and can improve data integrity and data availability by making sure the correct data is being provided as required. It also allows for the ability to expand more easily in the future. Most importantly? It can create a relaxed, safe environment where employees want to work.

If we look a little more closely at the operator which is the key focus for the purposes of this chapter, more automated systems require less but more highly educated operators that are more analytical and have the ability to quickly react when needed. This in itself requires industry to fully understand the new generation that is coming into the workforce. The new generation has a completely different set of requirements and demands that are a direct result of being brought up in the digital age. There are many surveys and statistics available that help pinpoint the requirements and demands of this new generation as well all of which need to be referred to when considering the control room environment. The start point is the human. The environment of the control room can have a major impact on how the operator is able to react in a critical situation. Keeping in mind that these rooms run 24 hours a day, and are staffed during this time, operator fatigue is a yet another concern. A recent study notes that: "All kinds of industries are finding a link between fatigue and work-related injuries: the risk of errors, accidents and injuries—especially in high-risk, safety-critical environments—jumps when workers are tired and cannot function at their peak level" [22]. So what does this mean? As noted previously, industry is finding it harder to attract operators to the control room environment. Staffing is becoming an issue, and as a result, existing operators in some cases are being required to work longer shifts.

If we examine the issues identified above, the effect of the control room environment on the human can be linked to operator error. And as a result, operator error, identified as being the cause of major industrial disasters, can then be directly related to human impact on the environment. The increase in the demand for production leads to operators having to work more efficiently and in some cases with longer hours to meet demand. Coupled with advancing technology, the operator is now facing new challenges as part of their day to day operations, as they are expected to learn these new technologies and apply them. If this technology is applied on top of existing systems, we can see that it is not necessarily making it easier for the operator to monitor (think of the alarm example), and in fact is increasing their stress. For more experienced operators, it can be a challenge to learn the technology; for the new generation, the technology itself might easier to learn, however the environment of the control room is not always suited to their expectations. With a world that is being driven by technology, what is the attraction to work in a 24/7 environment, especially the night shift, if an opportunity can be found in another market segment for similar pay? Let us take for example a large industrial production company that is based in a small town. When meeting with them to discuss their control room concerns, they mentioned several of these issues yet they could not understand why they were having so many problems attracting operators. Their experienced operators were retiring and they were concerned about how they would replace them. They were finding that they were able to hire, but within a few weeks of working in the control room, the new hires were leaving, citing the control room environment as being an unappealing work environment.

A similar situation was echoed by another large production facility—in their case, they were located in an even smaller town with access to a smaller pool of technologically qualified operators who would be able to operate the system that they had recently upgraded. To counter this, they decided the best course of action was to hire operators and train them. What they found out is that it was taking them 6–12 months to train the new operators—but often before the end of the training,

the operators were taking other positions in different market segments, citing the lack of desire to work in a very high stress environment. The remaining operators were tasked with taking on extra shifts to ensure the production output goals set by management were met. The operations manager in that example was exhausted, and had no idea how to deal with the situation or even where to start. The comment from the manager was "our system needs to be updated, the training time on the technology is limited, its so advanced that we are barely touching the surface, operators are leaving, we can't find replacements and yet we must continue to meet the production output and learn new ways to reduce our emissions as mandated by upper management—where do we start?"

If we add in the pressure to reduce environmental impact, this is leading industry to find ways of cutting corners in order to meet the requirements. The additional pressure is flowing down directly into the control room, to those who are the ones who control production. So now not only is there the pressure that was experienced previously, there are additional elements added to the list and the demand on the human is increasing even further. As noted previously, the major industrial disasters that have occurred in the past were caused by human error. As much as technology develops, the risk of another major disaster is not necessarily going to diminish unless industry is able to realize that the human will always be involved. It must become a priority.

The importance of human factors cannot be underestimated. "It has been found, after countless accidents and incidents, some including fatalities, that it is the actions (or sometimes the lack of action) of the system users who more often than not are the actual pre-cursors to the events actually occurring… As such the "Human Factor" element is an extremely important aspect…" [23]. Unfortunately, this does not seem to be the focus in many industrial environments. Although it is often discussed, it is more often ignored or relegated to a lower level on a priority list.

7. Human factors: we need to focus on the human

It would appear that there has been no real consistently implemented plan developed to ensure that the human is considered as part of the rapid developments in industry. Despite the fact there are repeated common occurrences across all different types of industry, it would seem that the combined impact of the human on the environment and the impact of the environment on the human have still not become the focus. There are however, some arguments that can be put forth that can perhaps help with the creation of a more human focused approach. If we accept that it is the human who is creating the technology that is driving the changes in industry, then we must also accept the fact that these changes in technology are also impacting the human. Yet not all of these changes are necessarily positive. As we have noted, as much as production is increasing, and information is becoming available at lightning speed, this is also leading to increased stress, fatigue, and at times lack of communication that can then lead to the potential for even more risk of human error.

If we are able to take a step back and look at the processes that require technology, the best start point would perhaps be to look at the human who is controlling the technology. Even as industry becomes more automated and artificial intelligence is becoming more prevalent in this process, ultimately the human will always be involved. Many of the processes have become easier, allowing the human to take a step back and let technology take over. But there is a risk in assuming that all new technology will run itself with no human involvement and will be free from error. As we noted in recent conversations with control room operators, there are other elements that are not being considered. The best information will always come from

the human. Considering that technology is developed based on production needs that are identified and for problems that need to be solved, a good start point would be to begin with the human.

When looking specifically at the control room as it relates to upgrades that are required, the best start always involves operator input. Why? Because as much as management identifies production goals that must be met, and engineering can identify and provide solutions for technical challenges, and information technology is able to create programming solutions to tie all the technology together, the operator can provide the best feedback on what is working, what is not working and what needs to change in the control room. Where the operator feedback at times can have the appearance of being unimportant, in actual fact it can help identify issues that can potentially lead to serious consequences if not properly addressed. This does not necessarily need to be an obvious technical requirement.

Take for example the comment noted earlier from an operator requesting a coffee maker be in closer proximity. That seems like a fairly innocuous request that has no direct impact on production. Or does it? Why would they ask for this? First of all, the operator currently has to walk out of the control room and down a hall to get a coffee. This means they are walking away from the screens and the alarms and should something come up that would need a quick reaction, they might not be able to respond quickly enough. Second, if the operator is specifically requesting coffee that would indicate that perhaps they need the caffeine to stay awake and fight off fatigue. Delving a bit deeper, it turns out that these two points were indeed the reasons for the request. The operator was not comfortable with leaving the system to run without being constantly monitored, even for a few minutes. At the same time, having to monitor every aspect of the technology running the production very closely was causing the operator to become fatigued. However, it also identified a few other points that were not immediately apparent—the technology was dated and was not running optimally, there was too much information coming in that required constant monitoring, and the operator was becoming even more stressed and fatigued as a result. All factors that as we have noted previously, have the potential to increase the risk of human error, and a major disaster.

This example is only one of many that can come from taking the time to speak with all involved in the production process, and specifically the humans who are tasked not only with creating the technology but also with operating it. It helps to fully understand every aspect that goes into running an efficient and smooth process with the aim of minimizing potential risks that could lead to a major disaster. With the rapid advances today outpacing our ability to keep up, this is becoming even more critical. Taking a step back, gathering the information, and coming up with a plan is the best start point. Unfortunately there are many situations where this is seen as wasting time because it is assumed that technology will be able to handle everything. Or will it?

When industry is able to realize the importance of putting the human back into the equation, they find that many issues can be identified and solved early on. Not only can it solve production challenges, but it can also help with other challenges that can directly impact both output and bottom line. When presented in terms of impact on financials, management has a clearer view of the priorities as well as the requirements to maximize efficiency. This then becomes a win-win situation from the human factor standpoint as well because the operator environment is improved, production and safety are improved and there is the chance that major impact on the environment can be mitigated as a direct result of proper planning. Technology may be able to solve some of the challenges, but no matter how quickly it develops, it will never be able to fully consider the human aspects that are as impactful on the environment as the technology itself.

8. Conclusion

In looking at the major disasters that have occurred in the past, all of which have had a direct impact on the environment, it is evident that there are recurring elements that are still of concern today. Fatigue, lack of communication, stress, outdated infrastructure, cost cutting measures, lack of training, underestimated understanding of technology all can be related directly back to the impact on operators in industrial environment. Coupled with increased pressure to produce more which is leading to cutting corners to maximize output and income in an attempt to stay ahead of technology or at least maintain the ability to keep up. At the same time, to produce more, technology needs to become more advanced. Advanced technology then leads to the inability to keep up with the changes. The result? Both human factors and human error can be directly related to environmental impact. It is time to take a step back and put the human back into focus. Humans are the ones who are creating the technology that is driving us to a more automated industrial process. The reality is that in many control room situations the number of alarms and the speed with which they occur is such that no human operator can keep up. In such circumstances artificial intelligence (AI) can potentially help especially with key factors. Here intelligent design can potentially help the human operator with the challenges that rapid technological change brings. However, in order to do so, the human must be consulted. But at the same time, what is being lost in the rapid changes we are facing in this newest phase of the industrial revolution, is the impact of the environment on the human and the resulting impact of the human on the environment. It is time to make a change in the way we currently think before another major disaster occurs that might change the world as we know it.

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