Available online at www.sciencedirect.com

ScienceDirect

Procedia - Social and Behavioral Sciences 238 (2018) 432 – 441

Procedia
Social and Behavioral Sciences

SIM 2017 / 14th International Symposium in Management

Change Management Aspects in Solar Energy Implementation

Lorand KACSO-VIDREAN[1], Jörg NIEMANN[2], Raluca BAIDOC[1], Adrian PISLA[1]

[1]*Technical University in Cluj-Napoca, Department of Design Engineering& Robotics, C. Daicoviciu,Cluj-Napoca, RO-400114, Romania, Tel.Fax.:+40401638, Adrian.pisla@muri.utcluj.ro*

[2] *Hochschule Düsseldorf, Geschäftsführender Vorstand FMDauto, FLiX Forschungsstelle Life Cycle Excellence, Gebäude 05, Ebene 3, Raum 020, Münsterstraße 156, Düsseldorf, D-40476, Germany*

Abstract

As presenting a part of a larger study, the aim of this paper is to present how the change management is considered from the first steps in the implementation of a solar energy generator as a need in the complex change process from totally fossil to a hybrid system (that may reach 100% solar), in the presence of technological and economic change triggering factors (CTF).

The need of change management (CM) in the implementation of solar energy generation begins from the very moment and first discussion between the service provider (facilitator, consultant, research team, etc.) and the decisional factors (end-users), due to different approaches, in this new and non-standardized activity, and the capacity to understand the implications on medium and long terms of different decisions made by the involved players. .

When solar generation facility is designed it starts with an investigation of the design data identification. Usually the end-user must provide these data but, also usually, it is not capable to do that and therefore the transition process is affected by incoherent, inconsistent or even false data.

It is totally different to follow the conformity or to run for process lifecycle management (PLM) applying the benefits of change management theory. Those made more complicate the problem, adding new considerations like changes in safety regulations, adapted cleaning necessities and possibilities, continuous development of new materials, sensors requirements, extra data flows, modifications in the intervention resources, and the appearance of different staff profile or staff training.

The global change management activities encompass all the 4 mentioned aspects, reiterating that the staff training and acceptance make no part of the mentioned study.

One of the goals of the mentioned research is to identify a proper problem modeling and digitization in order to raise the right funding that may contribute to better results. As simple as it seems, the mathematical models evolve to more complex scenarios but having a better implementation certainty.

Peer-review under responsibility of SIM 2017 / 14th International Symposium in Management.

Keywords: change management, project management, solar energy.

Peer-review under responsibility of SIM 2017 / 14th International Symposium in Management.
doi:10.1016/j.sbspro.2018.04.021

1 The Solar Energy

They say that with no past exists no future and therefore the research activity, regarding the lifecycle management in implementation and maintenance of green energy infrastructures started by consulting literature and people dealing with green energy generation industry, finding out that the most "scientific" works are based on inherited slightly demonstrated customs and habits from other areas.

Comparing the results from the developed researches with the others results it was confirmed that the most convenient form of green energy source in the area of Cluj County is the solar one. Within the data gathering process, it was no real "big surprise" to find out that like in football (soccer), or politics, where as many experts claiming that they know how to fix their favorite team, as if their opinion is grounded in proven fact), solar energy generation seems to be a subject where everybody is an expert.

But, if in football we may not bother to argue against "experts claim", since they are drunk on their stubborn outlook and will reject any counterargument, we may not have a similar reaction in the case of some strategic managers. Gained experience shows the good part, after a time when the local managers state the "evidence" that is no need to consultancy or other experts opinion because any expertise is futile for such a "simple" applications, they stuck or get in large investments problem. The stucking point is the start point for the change management, when the local managers came back, asking for real detailed solution with technical arguments, economic business plan and risk management. But as mentioned that is after a time when solutions, activities and solutions implementations must be rescheduled with just a fraction from the initial budget, or with a much larger one.

In any case, concerning the implementation of solar electric generators, the most common first questions are:

It is rely necessary this change? It is not better to go in the cozy old fashion way?

Obviously there is no middle answer, people are strongly divided in extreme positions between an absolutely YES (being "convinced" that the solar solution is the most convenient one) and an absolutely NO (as an unreliable and expensive solution, not capable to cover the actual necessities and to constitute a viable alternative).

As presenting a part of a larger study, the aim of this paper is to present how the change management is considered from the first steps in the implementation of a solar energy generator as a need in the complex change process from totally fossil to a hybrid system (that may reach 100% solar) in the presence of economic change triggering factors (CTF). The need of change management (CM) in the implementation of solar energy generation begins from the very moment and first discussion between the service provider (facilitator, consultant, research team, etc.) and the decisional factors (end-users).

The change management process starts with the identification of the startup information flow between: the End-users request (EUQ) and the Service provider offers (SPO). That implies that between the two partners is an optimization agreement (a compromise), the best results provided by the Service provider are possible only if the End-user will open the access to the internal (real, consistent and updated) information. As Kotter mention (Kotter, 2013), communication is crucial in building consensus and for that the End-user decisional level must be completely involved.

In the solar energy "business" we are dealing (mainly) with the following players: the End –users, the Components providers, the Energy transporters, the Certifications facilitators, the Energy brokers and the Consultancy specialists.

The plural is used to introduce competitive aspects in the research, to confirm some technological implementations and to model customized solutions.

The ongoing research looks in a large spectrum of details regarding the solar domain including trends, the consumer profile, technological developments and characteristics, maintenance tasks and facilities, the exploitation available forms and the capacity to robotize the process from transport, manufacturing or construction, up to the maintenance, exploitation and marketing facilities.

In this way the tradition is a background or a backcloth, while innovation is the construction of each moment on time axes, to harmonize the backcloth with the infinity of situational factors. The capacity to impose a change management involves all means up to the limits that Lucian Blaga defines as the conceptual "transcendental censor", (Abrudan, 2017). A mandatory role plays the "technological culture" that offers the support for dialog and communication on a defined ideological level.

2 Up and broad

In this matter, like in any matter, the change management is not really capable to change Hell to Heaven. If the Heaven is where the Police are British (PB); the Cooks are French (CF); the Mechanics are Germans (MG); the Lovers are Italians (LI); and all is organized, the Managers are Swiss (MS) and this is the solution that everybody is looking for by applying the change management. But when we start from Hell where the Police are Germans (PG); the Cooks are British (CB); the Mechanics are French (MF); the Lovers are Swiss (LS) and everything is Managed by the Italians (MI). Based on the allocated resources, the change management looks for the tasks reallocation, after the identification and primary organization of the human tasks force. In real cases we are facing the situation of an X,Y,Z,U,W situation:

Heaven	Hell	Reality
PB	PG	PX
CF	CB	CY
MG	MF	MZ
LI	LS	LU
MS	MI	MW

The **electric (digital)** technology for solar energy generation shows some important characteristics to be used when the change management is applied:

- may be applied on horizontal surfaces, sloping surfaces and even on vertical surfaces. Usually the used surfaces have no other potential destination in order to maximize the land exploitation efficiency;
- all the parts, necessary to create an electric generation facility, can reach a mass production fabrication;
- the production process may be automatized and robotized;
- powerful economies heavily invest in new materials development for solar panels.

2.1 Solar electric consumption

The idea to manage the energy consumption provides the demand for alternate financial and/or technological regional solutions for energy providers. In any case the solar generation design starts with an explicit, detailed, investigation of the design data identification. Usually the End-user must provide these data but, also usually, it is not capable to do that. In the change management data list enters: the change from the existing instant power of the application to a more economic technological solutions; the estimated average energy on intervals (days, weeks, month, year) to a more efficient distribution of the average consumption; the need for instant emergency energy consumption and the possibility to modify this need; the existing energy storage components are not confronted only with different storage solutions but also the transfer process specifications are required; the identification of the real End-user may change an entire list of demands and specifications; electricity is known as an energy easy to use at any distance but how far is the actual consumption from the electricity distribution network became essential once the consumption diversification is an intense process; as long as the solar power energy is far from a constant generation the real actual consumption profile and the design capabilities to the resources provision for alternate versions, is crucial in solar electric consumption and therefore in the change management of the transition.

Logically defined is a hierarchical Holonic approach (Holarchy – fitted hierarchy) required in defining the End-user, to respect some flexible control rules that enables a decentralized process but with co-operant autonomous agents. In this case the change management extends from the first implementation to the next, until one of the three versions is fully covered, the most advanced being considered the hybrid end–user version:

- the solar energy ***electricity provider*** may be also the ***electricity consumer*** that is an ***off-grid end-user***;
- the solar energy ***electricity provider*** and the ***electricity consumer*** are ***two different entities*** then is an ***on-grid end-user***. In this case the electricity consumer may be direct connected to the electricity provider but the energy may be also be pumped in the national electric distribution grid, case in which a new player is considered: the ***electricity distributor***;
- beside the off-grid and on grid consumption profile, exists also the ***hybrid end–user version***. Thy hybrid may be seen in two ways: as an on-grid end user with a backup, reserve if the grid fails; or as a grid supplier if its consumption is under the electricity generation capacity.

2.2 Solar electric generation

In the conducted research activity are considered only the photovoltaic solar panels, as direct electric energy suppliers, so the technological decisions within the change management process are drastically reduced once a specific technology is motivated selected. Even so, the location or relocation management are considering the engineering holistic approach combined with the more deeply considered environmental parameters, the acces to new materials, the available acquisition and distribution of the solar cells and solar panels.

The determined deviations from the initial plans are guiding to redesign different framing solutions where the mechanical, electrical (tension, current, energy, efficiency) and financial parameters are combined with the new installed functioning conditions, connections possibilities, storing necessities, automation, maintenance and service facilities (and/or necessities). All this aspects are converted in also so many data flows that are used in the change management administration for characteristics like: process function, regulations implementations, political "trends" considerations, competitors actions, legislation change, together with the identification of the most adequate modeling and graphical interfacing for definition, implementation, exploitation, maintenance and personnel training.

A new aspect of the change management, within the new lifecycle of the electricity solar generator, is the Project. A - Project - represents independent modules or a combination (integration) of the End-user needs and/or demands. The main defined Projects are: End-user Identification (E_ID) (location, demands, capacities, restrictions); End-user consumption Profile (E_CP), energy interconnection, evolution ramp, competitors development, etc.; Concurrential Technological Models (E_CTM), mix sequential and concurrent computation, to put into evidence properties and dependencies in the process control; Planning (E_PL); Acquisition (E_AC); Construction (E_CO); Testing (E_TE); Validation (E_VA); Maintenance (E_MA); and Exploitation (E_EX).

If some change management aspects concerns only an homogenous approach of well established theories and practices the other aspect have a novelty character introducing modeling elements that are practically unknown or ignored in the everyday implementations like: a complete end-user profile, modeling mathematical methods, validation, maintenance, or in some cases the efficient exploitation model that together (based on a preliminary estimation) may increase the efficiency of the exploitation lifecycle with 70%-80%. This important figures explain the role and the necessity of the started research.

It is totally different to follow conformity or to go for and run a process lifecycle management (PLM) applying the benefits of change management, even if that made more complicate the problem adding new considerations like safety regulations, adapted cleaning necessities and possibilities, continuous development of new materials, sensors requirements, extra data flows, modifications in the intervention resources, and the appearance of different staff profile or staff training.

3 Digitalization process

In the digitalization era, the entire change management process is based on digital data and digital monitoring and managerial IT platforms. It is no wonder that all the physical process parameters are digitalized from the components characterization to the decision representations. Within the defined - Projects - there are some cross project elements that benefit in the first place from digitalization by making compatible in between (through the input/output interfaces) all the – Projects - and all the components. In this paper chapter is very briefly described the modeling approach, regarding the four major aspects constellation.

As first element is the adequate ***infrastructure topology***. The studies starts from reconsider the location analyze from the initial data to the potential determination for alternate technologies, customized to the End-user consumption, behavior and investments possibilities.

A second aspects is the ***logistic and change management for the implementation*** to adapt the transition from the actual situation the desired one (designed or/and planned) in accordance with unknown situations that may occur.

Next is the ***planning and management of the maintenance activity*** for the implementation and post implementation activity and in the end, the ***exploitation management*** that may impose in time some changes in all the other aspects.

The global Change Management activities encompass all the 4 mentioned aspects reiterating that the staff training and acceptance make no part of the mentioned study.

3.1 Theoretical model destined to the service provider

The change management must be based on the actual conditions and the most restrictive is the available location, therefore is considering a topographical approach over the localization representation and modeling. From the two major situations (landscape – broadness and construction - highness) in the actual article only the landscape version is detailed, considering the activity as a "tool generator" that makes comparable any location at national level.

By contacting different solar energy service providers was identified, in all cases, similar approach in creating an easy data base containing some of the End-user characteristics and, based only on their expertise (or simply on actual available components), offers a billable solution.

The acceptance of a solution that may respond to the requirements only in the initial stage is a decision totally on the End-user shoulders. Both the identification of needs and profile cannot be guaranteed, the correspondence with the reality being based only on the End–user given data. As consequence, the results cannot be adequate and in the end the solar technologies are to be blamed not filling the expectations.

Therefore, in the mentioned research activity, the start is from the actual situation and a new decision making model will be developed with the aim to offer an optimal solution for an identified situation. The connection with change management is that the solution is designed flexible enough to be adaptable to the changes occurred during the implementation and later in the exploitation stage.

The process will run in the following way:

1. Placement. The available placement for the photovoltaic solar panel is identified (on the roof or on the ground);
    - the "automatic" assumption is an on-grid end-user with the photovoltaic solar panel placed on the roof;
        - to avoid an embarrassing situation is checked if the location have any physical connection to the national grid (if the case an off-grid end-user will be defined);
2. Power. How many potential kW will be generated?
    - This is a question that frequently receives no answer from the end user. The service supplier will analyze the bill history (at least on the last 8 month, if available) and decide about the maximum energy request and the presumed maximum power installed for the end-user;
    - In some situation is consider the end-user benefice and is calculated the average consumption and the average installed power.
        - of course both cases are valid only for the on-grid end-users;
    - In case that no data are available, an investigation is run, to identify the potential installed power, that is connected with the future electric solar energy generator (ESE);
3. Generator surface. The available surface is determined;
    - this topic is correlated with the dimension of the panels promoted by the service supplier and compared with the required power;
    - the ideal case is adjusted with the surface slope and the surface orientation;
    - the final result consist in the identification of the solar generator surface and the need for auxiliary structural constructions that determine a direct south exposure.
        - In some cases interactive orientation is considered with adequate automation system;
    - if different models of solar panels are available the surface, power and cost decisional triad justifies the solar panels selection;
    - once selected: the solar panels model, the potential power and the end-user type, the decision over the support structure is made;
4. Inverters. Decided by the end-user, but not as the result of a decisional algorithm.
    - the next decisional step is over the inverters: we may have several situations:
        - the on-grid inverter as self consumer (A);
        - on-grid inverter as grid supplier (B);
        - off-grid inverter auto-consumer (C) + storage batteries with charging controller;
        - totally off-grid consumer (D) + batteries, charging controller and backup generator

3.2 Digitalization of the Location Structure

The change management considers the solar panel dimensions, the number and the orientation depending on the initial location and the location characteristics change. Unsatisfied with the potential drawbacks, the running research project is dealing with a better and deeper “digitalized location analyze” divided in two components: the location structure and the location potential.

The location structure (LS) considers the real solution for the location digitalization as an unchained location, from the neighborhood environmental elements. Having the location structure the influence of the neighborhood environmental elements (NEE) are digitalized and introduced over the LS.

For the location, there are two distinctive cases: an outdoor surface (horizontal or with natural slopes), or a construction with horizontal surface and constructed slopes; the second case is with vertical surfaces. In the paper is considered only the first case, the second case being the subject of another part of the research.

The model that will sustain the change management process will be described in the following part of the paper. A surface (land) location is defined by latitude and longitude. The global latitude and longitude are adjusted by a stereographic representation that transpose the position in X,Y coordinates based on the Krasovski ellipsoid, adopted in Romania by the Decree in 305 in 1970 (named STERO70), and the altitude (Z) was established in respect with the Black Sea reference level in 1975. Since then stereographic projection is official on the Romanian territory for every map at normed scales 1:2 000, 1:5 000, 1:10 000, and 1:50 000.

The Projection Pole Q0 (called also projection center) is defined for Romania at latitude B0 = 46^{o} N, and longitude L0 = 25^{o} E Greenwich, located north from Făgăraş city as is depicted in Figure 1.

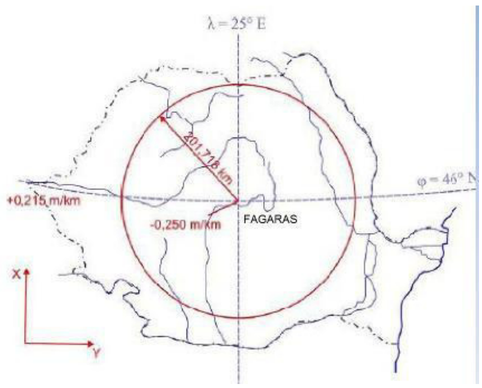

Fig. 1 The Stereo70 Projection Pole for Romania [Credit: Cadastral expert website]

Fig. 2 Romania, landmark for the reference level ±0.00, Black Sea [Credit: 3xforum topographer]

I respect with the Projection pole, the entire country is represented in a single projection plane with a zero deformation circle, having a radius of ρ0 = 201,718 m, that correspond to a secant system with positive and negative values (with a maximum of -25cm/km, in the central point). Therefore the center is modified from (0;0) to +500.000; +500.00). The south west translation made that all the coordinates to be in the positive domain.

For the altitude the last rectification was made in 1990. In Figure 2 can be seen the Black Sea reference level, the place being at about 53 km from Constanţa.

With this data was developed a study case for a real existing area in Transylvania, at about 35 km from Cluj-Napoca, with the purpose to define the unique reference points for a specified area and then to identify the topographic ambit, the topographic placement plan and area identification.

The buildings and the access roads are complete represented in place, together with the adjacent areas. A digital representation of this data helps to compare the selected area with any other are on the Romanian territory. The purpose of the extended comparable date generation is that in accordance with the area orientation to make a selection software module for the solar technology that enables the maximization of the energy production on the available location.

The inflection points, placed on the contour and the grid point placed in the area are determined with GPS/GPRS technology, and can be captured in a tabular form to be processed for the entire application. Very useful is that for the solar applications the desired N-S grid orientation is parallel with the stereographic representation and any desired increment may be applied to identify the intersections between the grid parallel lines and the contour. The result is presented in Figure 3a and adding also the points elevation the 3D surface representation is obtained, Figure 3b.

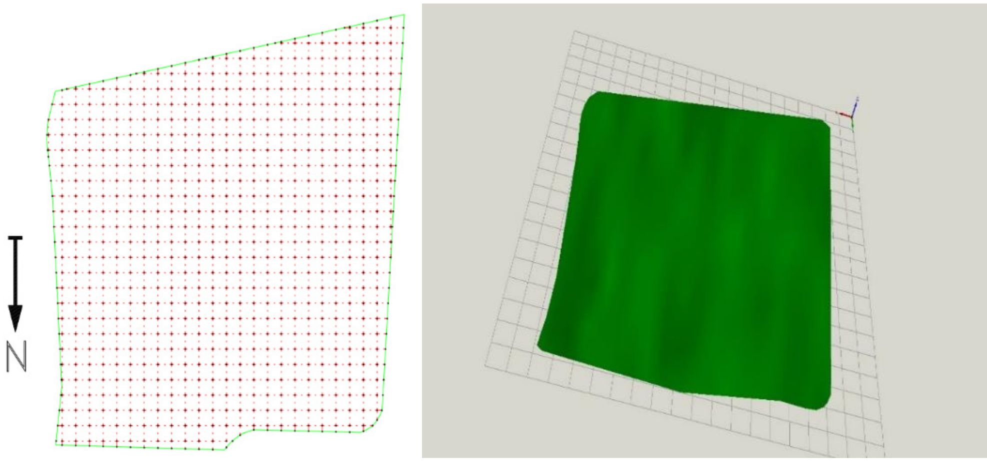

Fig. 3 a) the resulted grid points, b) the 3D model of the surface

3.3 Digitalization of the Location Potential

The change management process needs the adequate tools and techniques that beside the organizational tools helps in the transition. In the solar energy generators such a tool, destined to estimate and update the location potential may be offered by developing a softer module, based on the mathematical modeling in solar applications that creates the capacity of having a profitable public/private partnership, accepted by all the implementation players. The effort to maximize the efficiency of a location considers elements that can be partially predict and controlled.

Within such a tool, the global positioning, the climate change and the location environment are connected with the solar horizon according to the time of the year. The module efficiency combined with economic opportunity and the friendly user character of the software is to be demonstrated for different technological solutions as a critical success factor in electric solar generator implementations.

Through quantitative analysis, made for a specific technique, the software tool became a crucial component for the: solar technology selection, time planning and investment dimensioning, once the extensive practical experience will be gathered.

Solarization depends, in the first instance, on the circadian and seasonal behavior. This behavior may be transpose in two angular variations that generates reference curves. The connection with the curves depends on the area position and orientation. The position is defined by geographic coordinates the latitude (parallel), coordinate φ, and the longitude (meridian), coordinate λ.

The day angle y, may be easy calculated: $y = 360°\frac{n}{365}$, where n is the day number.

This is a linear correlation for the mentioned application being of most important the extreme references March 20, June 21, September 22 and December 21, the equinox and solstice days. The results are:

Day 79 $y = 360°\frac{79}{365} = 77°91'78''$

Day 172 $y = 360°\frac{172}{365} = 169°64'38''$

Day 265 $y = 360°\frac{265}{365} = 261°36'98''$

Day 355 $y = 360°\frac{355}{365} = 350°13'70''$

The angle between the Sun rays and the Equator plane, δ, is the declination angle, and depends on the day angle y, using the function:

$$\delta(y) = 0.3948 - 23.25559\cdot\cos(y + 9.1°) - 0.3915\cdot\cos(2y + 5.4°) - 0.1764\cdot\cos(3y + 105.2°)$$

Considering the same specific days, results:

Day 79 $y = 360°\frac{79}{365} = 77°91'78''$ δ(y) = -13,1529

Day 172 $y = 360°\frac{172}{365} = 169°64'38''$ δ(y) = 22,1801

Day 265 $y = 360°\frac{265}{365} = 261°36'98''$ δ(y) = -22,0665

Day 355 $y = 360°\frac{355}{365} = 350°13'70''$ δ(y) = -10,2562

At these two angles is added also the EQT, the time equation that register the difference between the "solar time" and the "horologic time", max ±15 min.

$$EQT(y) = 0.0066 + 7.3525\cdot\cos(y + 85.9°) + 9.9359\cdot\cos(2y + 108.9°) + 0.3387\cdot\cos(3y + 105.2°)$$

Considering the same specific days, results:

Day 79 $y = 360°\frac{79}{365} = 77°91'78''$ δ(y) = -13,1529 EQT = 14,1726

Day 172 $y = 360°\frac{172}{365} = 169°64'38''$ δ(y) = 22,1801 EQT= -8,3989

Day 265 $y = 360°\frac{265}{365} = 261°36'98''$ δ(y) = -22,0665 EQT = -11,649

Day 355 $y = 360°\frac{355}{365} = 350°13'70''$ δ(y) = -10,2562 EQT = -2,8828

Using an accurate model, the MLT (Mean Local Time) [min], the ST (Solar Time) [h], horary Sun angle ω [°] (the angle between Sun direction and a plane defined by the Earth axes and the Zenith direction), becomes important.

The MLT depends on LT (Local Time), TZ (time zone) and longitude λ and the Sun angular velocity 4°/min.

For Romania LT=12, TZ=+2, and longitude is λ = 23,4710

$$MLT = LT - TZ + \lambda \cdot 4\ min/° \ [min]$$

$$MLT=12-2+23{,}4710*4= 103{,}8840\ min$$

$$ST = \frac{MLT + EQT}{60}$$

$$\omega = (12 - ST)\cdot 15°/h$$

The angle of the solar altitude γS [°] and the angle of solar azimuth αS [°], represents the polar coordinates that define the Sun position in respect with a point on earth (the considered area landmark). The two angles are depicted in figure 4.

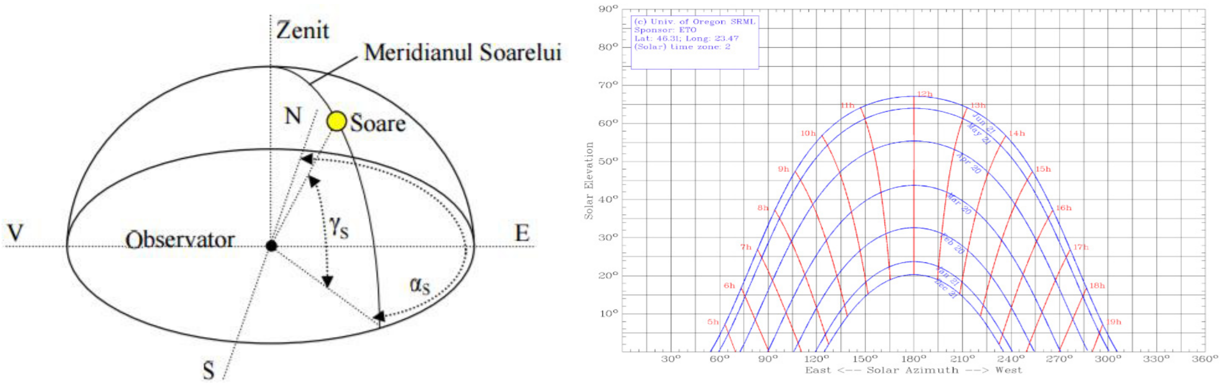

Fig. 4 a) The angle of the solar altitude [Credit: Efficient Nucleus Energy blog spot] b) The angle of solar azimuth [Credit: Oregon University]

The functions that express the two angels are the following:

$$\gamma S = \arcsin(\cos(\omega)\cdot\cos(\varphi)\cdot\cos(\delta) + \sin(\varphi)\cdot\sin(\delta))$$

$$\alpha S = 180° \pm \arccos((\sin(\gamma S)\cdot\sin(\varphi) - \sin(\delta))/(\cos(\gamma S)\cdot\cos(\varphi)))$$

± = "+" IF ST > 12:00 AND "-" IF ST < 12:00

Considering the same specific days, results:

Day 79 EQT = 14,1726, ST=1,97, ω =150,4859, γS = -1,2442, αS = 180,9164

Day 172 EQT= -8,3989, ST=1,59, ω =156,1287, γS = 0,2588, αS =182,1678

Day 265 EQT = -11,6495, ST=1,54, ω =156,9414, γS = 0,8238, αS = 182,9380

Day 355 EQT = -2,8828, ST=1,68, ω =154,7497, γS = 0,2195, αS = 180,5245

4 Conclusions

The change management and success criteria, performance measurement will be more accurate and the implementation progress much reliable.

Each stage is considered in a Project form, the application of the digitalization facilities for modeling and Project evolution monitoring became implementation tasks within the research activity.

At this point the research activity is at PhD stage level. One of the goals is to identify a proper funding that contributes to better results. As simple as it seems, the mathematical models evolve to more complex scenarios but having a better implementation certainty.

The obtained results offer the chance for the implementation parameters optimization and the capability to guide decision over technology selection, based on the lifecycle management generation.

References

Abrudan I., (2017) *Tradition and Innovation in Management*, Review of Management and Economic Engineering, Vol. 16, No 2(64), Todesco Publishing House, Cluj-Napoca, ISSN 1583-624X.

Ashkenas R., (2013) *Change Management Needs to Change*, Harvard Business Review.

Gilbert F., Lorthois L., & Vas A., (2016) *Demystifying Change Management*, Deloitte internal report.

Kacso-Vidrean L., Pîslă A, (2017) *Service Robots*, Report No1, Internal PhD studies, Technical University in Cluj-Napoca.

Kotter J.,(2013), *The 8-Step Process For Leading Change - Dr. Kotter's Methodology Of Change Leadership, RBSGROUP, Change Management*, P.1-5,

Niemann I., (2005). *Strategic Integrated Communication Implementation: Towards A South African Conceptual Model*, Phd., University Of Pretoria Etd.

Niemann J., Tichkiewitch S., Westkämper E., (2009)., *Design of Sustainable Product Life Cycles*, Springer, ISBN 978-3-540-79083-9.

Europages FR, http://www.europages.fr/entreprises/pg-2/presses%20%C3%A0%20d%C3%A9couper.html

FIL 2016, http://www.iff.fraunhofer.de/en/business-units/robotic-systems/facade-cleaning-filius.html

SER 2016, http://www.ifr.org/service-robots/statistics/

SIR 2016, http://www.iff.fraunhofer.de/en/business-units/robotic-systems/facade-cleaning-sirius.html

Solar data, http://solardat.uoregon.edu/SunChartProgram.html

TES 2013, http://www.livescience.com/51791-tesla-electric-car-robot-charger.html

VWE 2015, http://evobsession.com/robotic-electric-car-charging-station-from-volkswagen/

World energy statistics databases, forecasts and analyses, www.enerdata.fr/enerdatauk/