

Information and Communications Technologies Go Greener Beyond IOT- Behind Is All the Earth

-Part2-

Prof. Eng. Ph.D. Victor GREU



Abstract

The paper presents a systemic analysis of the context, implementation and consequences of „greener” Information and Communications Technologies (ICT). The presented context reveals the necessity to carefully „observe” the fast and complex processes of ICT development, in order to identify real-time solutions to compensate all their (unwanted) consequences in the future and shows that it is reasonably to suppose that building greener ICT while extending IoT as a network of networks at Earth scale has to go beyond ... energy savings.

The analysis covered the desired consequences of **greener** ICT as coming from two main directions: directly from all processes of production and utilization of ICT (products and services); indirectly from the whole diversity of applications of ICT as imbedded in practically all areas of humankind activity fields.

The analysis focused on identifying the most important directions where energy savings are significant for ICT carbon footprint, but more than this, on ways ICT could generate, for humankind life on Earth and generally for Information society (IS) toward Knowledge Based Society (KBS) evolution, benefic effects that could be also considered „green” or environment friendly for the humankind ecosystem, although they could not be quantified as energy savings.

Based on United Nations definition, the author considered that sustainable processes in social and economic are also green forms of development, extending the environment to the ecosystem of humankind life on Earth.

The analysis presented also the two main directions for the „greener” ICT/IoT implementation, mainly for energy savings, as improvements of technologies, architectures, components, devices, algorithms, methods and protocols. The other side is generated by a diversity of methods to provide a green behaviour of ICT/IoT use. The essential aspect is that the effect of those technologies will be multiplied by the number of expected IoT networks/devices, this way appearing the huge relevance and consequences of greener ICT in the IoT era. The paper also approached some evaluation/measuring aspects referring to the the greener ICT processes.

A special attention, in the second section of the paper, is given to learning from green ICT, as going beyond energy savings, where the main consequence is given by the changes of business models, with sustainable progress for humankind, representing one of the most dramatic non-energy savings consequences of ICT (green) evolution in IS/KBS.

The analysis concluded that Big Data, Cloud and Analytics could be the main vectors of this transformation, but here the point paper analyzed is even further forecasting: how to manage the design and use of those technologies in order to leverage the generation of above mentioned green consequences by ICT/IoT. Last but not least, the analysis pointed that humankind have to beware of ICT exponential development negative consequences as “ICT dependence”, physical/intellectual activity fading and excessive resources consumption.

Keywords: energy saving, sustainable development, green communications and information technologies, changes of business models, software defined, Internet of things, Big Data, information society, knowledge based society.

Jel Classification: L63; L86; M15; O13; O31; O33

1. Building greener ICT while extending IoT as a network of networks at Earth scale

We spoke sometimes about *icebergs*, in the huge „sea” of Information and Communications Technologies (ICT) exponential evolution, which is the driving „engine” of the evolution of the Information society (IS) toward Knowledge Based Society (KBS).

Most recently [4] [7], we have observed and presented the literature confirmations of the fact that Internet of Things (IoT) has the potential to be the first revolution of Internet and more than this, many authors agreed that this IoT/ICT *iceberg* will eventually represent the 4-th Industrial Revolution for humankind.

In fact, speaking about green ICT/IoT we meet again a similar situation (*iceberg*), which seems to be fairly expressed by Daniel Burrus when speaking about IoT[3]:

„When people talk about „the next big thing” they’re never thinking big enough. It’s not a lack of imagination; it’s a lack of observation... the future is always within sight, and you don’t need to imagine what’s already there”.

This way we have added not only a brilliant confirmation of the above mentioned literature on IoT, but also of the main approach for the paper actual section and beyond.

With other words, it is worth to consider that, when we repeatedly have spoken about „big” trends of ICT, usually the reality were even „bigger” – and IoT is by far the case.

Now it is logical to conclude that the complex processes which will be associated with a „**greener ICT/IoT**” have to be carefully analized, in order to express a „big enough” picture.

In a simpler approach, we have to deeply analyze the limits where a greener ICT/IoT have to be extended.

More than all these, the above quotation from [3] recalls (confirms) another idea we have repeatedly presented [10][13]: the necessity to carefully „**observe**” (analyze) the fast and complex processes of ICT development, in order to identify real-time solutions to compensate *all* their consequences (*beyond energy saving*) in the future.

Still, we have a slightly different point of view versus the quotation, as imagination has an essential role in people’s creation, but we fully agree that the main approach of a sustainable ICT/IS/KBS development is to very carefully „observe” (analyze) every step and this way we have the chance to find, in a methaphoric way, that ***the future is always within sight.***

So, considering the above observations, we can pertinently conclude that it is reasonably to suppose that **building greener ICT while extending IoT as a network of networks at Earth scale has to go beyond ... energy savings.**

Of course, in the paper/section next (limited) space we have to further analyze and illustrate this important assumption.

First of all, the desired consequences of **greener** ICT stem from two main directions, as **directly** from all processes of production and utilization of ICT (products and services), but **indirectly** from the whole diversity of applications of ICT as imbedded in practically all areas of humankind activity fields. These two huge sources of benefit are sometimes called *green ICT* and respectively, *green by ICT*.

An example could perhaps better illustrate the big picture, if we would consider the smartphones and the cars, sure the most relevant as *numbers at Earth scale*.

Without entering (here) into details, it is obvious the huge amount of *direct* energy savings which could be obtained with each (little) reduction of energy imbedded in any of the phases of smartphone production or use.

In a similar approach we could consider the cars production or use, in any phase when ICT components apply to *indirectly* reduce the energy consumption.

As a consequence of the fact that these two relevant examples still represent, considering Earth scale and diversity, just the tips of icebergs, *green by ICT* direction will be mainly analyzed in the next section of the paper.

Focussing just on *green ICT (direct)* consequences, theoretically we should analyze separately the IT and Communications technology ways to be greener, in a systematic manner, but such approach, although never exhaustive, would be subject for a book [2].

Anyway, the green directions are spread in an impressive diversity, especially for IT side, as from going from power minimization (servers, storage, cooling, data centres, components technology, virtualization, data de-duplication etc.), software, algorithms, coding/analytics, to paperless office, working behaviour and materials recycling.

Communications have too a wide area of green directions, including networks architectures, components technology, equipments, protocols, algorithms, coding, management etc.

More important than observing these (obviously not orthogonal) *two sets* of elements, we have to recall the main issue in ICT [10]: *IT* and *communications* mature convergence and integration.

The consequences of these green directions on environment are also difficult to separate, mainly because of their integration and proliferation (billions) on Earth.

This way we may conclude that the complexity of green ITC directions and consequences implies rather a systemic approach than a systematic one.

In a realistic and systemic approach, we intend to identify, also mainly by analyzing some relevant examples, the most important directions where energy savings are significant for ICT carbon footprint, but more than this to find the subtle ways ICT could generate, for humankind life on Earth and generally for IS/KBS evolution, benefic effects that could be also considered „*green*” or environment friendly for the humankind ecosystem, although they could not be quantified as energy savings.

Splitting into energy and non-energy fields is again a difficult job and the „*green*” definition in literature reflects it, but opinions diversity is, by our opinion, a positive factor for covering the reality and for a better understanding and management of the above mentioned complexity.

Some authors [8][2] consider that “*green is used in everyday language to refer to environmentally sustainable activities*”.

On the other hand, the United Nations reports consider [2] that “*the three dimensions of sustainable development, which are the social, economic and environmental dimensions ... Being green would correspond to the environmental dimension*”.

Still, everybody could observe, again, that those 3 dimensions are not always orthogonal, but represent a good reference.

We consider also a very useful reference, perhaps the ***best expressed for our analysis***, the United Nations (UN) report “Our Common Future” where processes are ***sustainable*** if they

“meet the needs of the present without compromising the ability of future generations to meet their own needs” [15] [2].

On one hand, this clear definition confirms the opportunity of our precedent analyses [13][10] focused on ICT general development and its optimization criteria, which have to be done considering the long term consequences of such exponential evolution with dramatic influence on all humankind activity and Earth processes, as the time for analysing this influence and refining knowledge are severely reduced.

On the other hand, UN definition reveals the main stream of developing greener ICT and generally ICT for IS evolution towards KBS. This way we may recall the crucial idea [13] that ICT development, including the actual “greener” trend, has to be optimized considering the humankind life and Earth long term evolution and taking into account prominent challenges as the climate changes and Earth resources fading.

As a concrete conclusion of the above premises, based on UN definition, we may consider that **sustainable** processes in social and economic areas are also **green forms of development**, as we extend the **environment** to **the ecosystem of humankind life on Earth**.

Our approach of **green forms of development** makes sense also because it is logical to suppose that **the direct greener ICT development (mainly by energy and resources savings) will generate a larger volume of non-energy benefits for humankind life and Earth on long term, using less from the already fading Earth resources**.

More than these, we have pointed that the ICT exponential pace has to be adjusted in the area of production, just to save the Earth limited resources.

Here it is worth to mention that a similar analysis[2] considered green ICT main global purpose as “conserving energy and other resources such as paper and rare elements”.

A relevant example could better express the significance of the mentioned “rare elements”.

Often we use to show to the students a smartphone saying: It includes most of the humankind science and technologies, but also a diversity of precious and even rare materials! Of course, here is just another iceberg tip, as recycling (for example) is a twofold challenge in the next IoT/ICT era because we need to protect the environment and in the same time to recover useful materials, but it is a good picture of how “green” is extending beyond energy saving.

After fixing the general frame of *green* ICT, some relevant examples could give a realistic dimension of this complex trend and point the priorities.

Among the most important and active factors for planning strategies and developing green ICT, the Green Touch research consortium[6] includes experts of 48 ICT companies, besides academia and non-governmental organizations, as Bell Labs/Alcatel-Lucent, China Mobile, Huawei, Orange, Politecnico di Milano, Swisscom, University of Leeds and University of Melbourne.

Green Touch strategy includes to increase the efficiency of communications networks by 1000 until the year 2020, referring to the levels of 2010 (year when the consortium started work), but considering the expected traffic and performance.

The strategy pointed the green ICT main directions followed by Green Touch, as *technologies, architectures, components, devices, algorithms and protocols*. This way, the net

effect of energy savings would be in 2020 equivalent with *greenhouse gas emissions of 5.8 million cars* [6].

The main technologies Green Touch proposed [6] for providing the energy savings in communications include small cells for networks, which will naturally use lower power base stations and will improve coverage and spectrum efficiency too. Other prominent green technologies are focussed on virtual gateways for residential access networks, optical interconnections for routers, voltage/frequency scaling etc.

As could be observed from above, these directions and technologies are largely promoted, but another prominent direction is emerging from all players in the field [2] [6]: *green behaviour* of ICT use.

Although *green behaviour* of ICT use refers to the energy savings provided by management ways, like *automatic sleep* design and operation of ICT (like wireless access points, routers etc.), the term could be easily extended beyond energy field when benefits could focus on material savings (like paperless office, as we above have mentioned).

If we only imagine only these prominent examples multiplied by the number of expected IoT devices, we could better understand the huge relevance and consequences of *greener* ICT in the IoT era: “*The Internet of objects would encode 50 to 100 trillion objects, and be able to follow the movement of those objects. Human beings in surveyed urban environments are each surrounded by 1000 to 5000 trackable objects*” [3].

After such *big* examples, it seems that nothing could impress or bring something surprising, but let’s just fast mention some actual *green* issues, also covering the energy field.

The exponential proliferation of mobile ICT/IoT devices (without speaking of electric cars), in a greener perspective, ask for a revolutionary battery, but this goal is still far enough, inspite of latest improvement including nanotechnology-battery powered from moving energy [7]. In fact, from Sony revolutionary Li-ion technology nothing similar happened and the expectations are for something really “big” [14].

Solar powered base stations represent another significant technological challenge in the context of IoT/ICT expansion and it is a very promising technology for greener ICT as the future base stations tend to transmit lower power in smaller cells [12].

Again closely linked with IoT exponential development, the smart home field will be a huge area which is expected to have benefits from a new green technology based on the *software defined* concept by integrating a diversity of devices whenever necessary, but more of this offering open design flexible features. It is obvious that these features could optimize almost everything in ICT.

In the particular case of *software defined* smart home, the main advantage is the IoT-oriented structure design, which will provide a huge benefit as IoT will be deployed at Earth scale [1].

It is sure that *software defined* is one of the ICT directions that will extend their *greener* benefits beyond energy savings, but not the only one, as the next section will present.

2. Learning from green ICT beyond energy savings and getting more benefit ... when “greener by ICT”

Before looking for other consequences of green ICT, a realistic approach must include the answer to a natural question: how can we measure “green” ICT?

Indeed, as the research, investments and expectations are so high, the *greener* ICT have to appear in measurable ways.

At least for metering green ICT energy savings, as the main goal, many approaches have been proposed [2][6].

In such complex and diverse area of greener ICT directions, implementations and consequences (we above presented), it is very difficult to find clear, simple and precise metering methods, algorithms and instruments.

Many analyses rather considered relevant to present first some criteria of classifying the greener ICT consequences and this is our opinion too, at least in this paper space.

In fact it is important to add that this classification is mandatory when speaking about prominent categories consequences of *greener* ICT, as energy savings, non-energy savings and the huge area of *greener by* ICT. Notice that *greener by* ICT is a common expression referring to all the green consequences *indirectly* generated *by* ICT in other humankind activity fields – for example any optimization of cars fuel consumption provided by electronic devices and generally by ICT. Also we can observe that both direct and indirect green ICT consequences could be energy or non-energy savings – as it will be further presented.

With other words, the priority and a good result is to have criteria and methods at least to identify the appropriate category where consequences of a certain green ICT implementation in fact lay.

This way we have just arrived to this section point and its link with metering is now clear, as for energy savings some ways of metering or estimate have been established, while for the other 2 categories it is important to identify their appearance rate and then add it in statistic which could be a first step for estimation, instead of a precise metering.

Again some relevant examples will make the above principles more clear and useful in practice.

The case of smartphones and cars, we have mentioned above, is also considered very relevant by [9], where a “metric” for embedded energy (indirectly pointing the relevance of savings) is investigated step by step.

Apparently there is no comparison between embedded energy in a smartphone of 140 grams and in a car of 1.4 tones.

Still, if we consider the number of main mobil devices [9], in 2015 the global sales of mobile phones reached 1.9 billion, for laptops 60 million and for tablets 230 million. The average embedded energy in these devices was of about 1 exaJoule (10^{18} J), while the production of vehicles in 2015, reaching 72 million units, required 7 exaJoule.

The surprising results could be even more relevant if we recall the fact that these mobile devices are usually changed after only 2 years, while a car after 10 years.

Hence a simple correction of (1/5) leads to a ratio of only (5/7) between embedded energy for these main “loved companions” of people, in a decade.

Now we can easily understand the significance of energy savings by green ICT, although the last example reflects just part of the picture, as the communications and information networks used 2.2 % of all generation energy in 2012 and the estimation for 2020 is of 10%[9].

Speaking of mobile devices and cars energy savings has also opened the way to the other two categories, non-energy savings and *greener by ICT*.

First let's see how mobile devices and generally greener ICT could bring non-energy savings for humankind and IS/KBS.

From the beginning we have to notice that those 3 categories are not completely independent as it is obvious, for example if we consider money savings versus energy savings.

In fact we just exemplified one of the main links (money) which produce the "dependence", because, for short time, money and energy could be converted.

More than this, when saving money by greener ICT, they could be converted in other benefits for humankind, as education, health etc.

The question is which are the greener ICT (*subtle*) ways to generate money savings and other non-energy savings, beyond indirectly by energy savings.

As we already mentioned, although often subtle, non-energy savings represent a huge area of benefits/consequences of greener ICT, which could be generated either directly or indirectly. Recalling the car fuel consumption example, we can observe that here other ICT benefits could lay in the passengers environment/security/comfort/health areas, which are obviously non-energy.

Again adopting a systemic approach versus systematically when analyzing the entire diversity of cases, we consider that ***changes of business models***, with ***sustainable*** progress for humankind, represent ***one of the most dramatic non-energy savings consequences of ICT/IoT (green) evolution in IS/KBS***.

One example could show that this opinion is not only largely shared, but more than one could also reveal the phenomenon dimensions.

This time the example is even more relevant for our paper title, as IoT is the main factor of ICT considered by [11], which observes that the diversity of IoT devices offers, among other features, benefits for consumers, i.e. people could have larger options to communicate or use ICT services, when, if necessary, avoiding the main operators, because many other gadgets than smartphones provide ICT features (like tablets, watches etc).

The phenomenon (***changes of business models***) dimensions are also pointed by [3]: "*When we start making things intelligent, it's going to be a major engine for creating new products and new services*".

As a consequence, such huge development processes will be leveraged by ICT/IoT exponential evolution and eventually, as we have above mentioned, they could generate *green by ICT* (non-energy) ***sustainable*** effects (we have called ***green forms of development***).

It is interesting to observe that in these complex areas, we can speak about the capacity of ***sustainable*** effects (***green forms of development***) to "*colour in green*" the ICT/IoT which generated them.

This way we have estimated a subtle way ICT/IoT could be designed "*greener*" for inducing (non-energy) ***sustainable*** effects in ***the ecosystem of humankind life on Earth***.

We have already repeatedly presented the same idea [7][13], but now IoT emergence became, by its multiplying factor, a dramatic leveraging factor for it.

Here is the point where we have to observe that the multiplying factor must make us even more aware of the huge responsibilities of carefully designing ICT/IoT development in order to produce **only sustainable** effects, as any errors could be also dramatically multiplied.

These responsibilities and IoT extended benefic consequences are also clearly confirmed by EU [5]:

„Adopting a proactive approach, Europe could play a leading role in shaping how IoT works and reap the associated benefits in terms of economic growth and individual well-being, thus making the Internet of things an Internet of things for people”.

In order to leverage this reaping, concrete procedures and instruments for monitoring the evolution of IoT were initiated by EU [5].

The concrete ways to provide these benefits could be shortly presented by recalling the main areas where IoT proliferation will be the most visible [3][7][17], but here the selection criteria is given by their potential to generate **green consequences** (**sustainable** effects - **green forms of development**).

A general agreed opinion is that IoT will be developed at Earth scale mainly by a huge diversity of sensors networks, covering most of applications areas [3]: *“The ability to network embedded devices with limited CPU, memory and power resources means that IoT finds applications in nearly every field”.*

It is important to observe that the *greener* IoT/ICT trend will be provided by devices with *limited resources*, but globally the amount of power has to be considered as we have mentioned in the first section of the paper.

Environment monitoring will be the largest area of IoT applications, with huge benefits, as it could cover, without being limited at [3][7] [18][19]: air/water/soil parameters, vegetation, fauna, earthquakes, radiations etc.

The areas list must also include human body health networks, people's movement/behaviour, objects identifiers/inventory control, end-user experience, legal conformity/copyright, digital security/rights etc.

Special “greener” significance and consequences will have the recycling services covered by IoT: *„able to precisely identify objects during the recycling process is an advantage and tagged objects could therefore be recycled more efficiently by being retrieved from normal bulk waste disposal”* [5].

Also a human friendly “greener” impact will have the low radiation of IoT devices: *„operate with very low power, unlikely to produce significant levels of exposure to EMF”* [5].

It is important to add that the same trend will be implemented generally in “greener” cellular communications networks, as we have mentioned in the paper first section, by reducing cell radius and then the necessary radiated power in both base stations and mobile devices. As a human friendly “greener” consequence, the level of EMF (electromagnetic field) to which human body will be daily exposed will be also reduced.

As we already presented [16], context-aware communications will enable a huge area of IoT/ICT services, oriented on industrial, commercial, social, educational applications.

Sometimes, following this fantastic world of ICT/IoT could induce a sensation of wondering/fear: Where all these end? There is a bottleneck?

Moore Law is one of the most discussed “bottlenecks”, referring to an eventual slowing of ICT exponential pace and we also have analyzed this challenge [10].

Here, still we are referring to a systemic challenge which could affect exactly the main goal of ICT/IoT the paper presents: a greener (**sustainable** or least efficient) development of ICT/IoT.

Of course, there is a general warning in the paper title “**behind is all the Earth**”, but on the other hand we have already presented [10] [7] the importance of Big Data, Cloud and Analytics.

In fact, **we have to learn to design and use IoT** in order to generate **green consequences**, i.e. be sure that the investment in the billions of IoT devices and networks will be efficient, because **the most complicate challenge will be to optimally manage the huge amount of data generated every second by these IoT devices**.

We already analyzed the prominent role of Big Data in IS/KBS (sometimes called Exa Data) [10] but the emergent context of ICT/IoT enables a more complex and dramatic role.

This opinion is also generally confirmed by [3]:

“Data is the key derivative of device interconnectivity, whilst being pivotal in allowing clearer accuracy in targeting. The Internet of Things therefore transforms the media industry, companies and even governments, opening up a new era of economic growth and competitiveness”.

More than this, we consider that Big Data, Cloud and Analytics could be the main vectors of this transformation, but here the point we want to analyze is even further forecasting: how to manage the design and use of those technologies in order to leverage the generation of above mentioned **green consequences by ICT/IoT**.

The challenge is very complex, as the optimization of **green consequences** of ICT/IoT for IS toward KBS is a multicriterial set of processes.

A first enabling process is the contribution of these technologies to the efficient and greener development of IoT.

For example, Cloud will be used for most IoT applications, as the devices will have, as we have mentioned, minimal memory.

The importance of Cloud, as a ubiquitous support for IoT World wide applications is also confirmed by [3]:

“Cloud-based applications are the key to using leveraged data. The Internet of Things doesn’t function without cloud-based applications to interpret and transmit the data coming from all these sensors”.

Another large applications area will ease the implementation of IoT as “network of networks” with minimal network resources, using, as we have mentioned in the first paper section, *virtual gateways for residential access networks*.

Naturally, the most complex and complicate problems will consist in designing and implementing new performant algorithms and soft applications capable to handle the huge amount of data (Big Data) and whilst, in real time, provide the best results, assistance and decisions for optimizing the IoT applications concrete processes.

In our paper goal, all these greener ICT/IoT results have to be highly exploited for the IS **sustainable** development to KBS.

In fact, as we have already generally approached for ICT [13], the great investments, of intelligence first, in the exponential development of ICT/IoT, must come back as

models/lessons learned, or refined knowledge for humankind in all activities, but especially in education and creation/innovation processes.

For example, context aware communications, resources monitoring and refining/updating knowledge are only some of the models people have to lend from ICT, in order to obtain, on long term, better efficiency and progress with minimal resources.

In the same time, ***humankind has to beware of ICT exponential development negative consequences as “ICT dependence”, physical/intellectual activity fading and ... excessive resources consumption.***

Our opinion is that, beyond “beware of”, we have to “learn” from ICT also by refining knowledge with responsible and rigorous analysis/reaction, especially when the essence of humankind is influenced.

Last but not least, we have to remember that, as the system complexity and number of elements are increasing, its reliability tends to decrease, so just ***imagine what failures could bring in an IoT World, where almost all our lives segments will depend on ICT/IoT (hazard)!***

Speaking of “ICT dependence” seems not a very important negative consequence, but it is sufficient to recall the first “signs” of this “disease”: dependence of watching TV, computer, games, mobile phones and ... What will be next?

Here the essence is not only the “disease” issues, or time losing, but a ***kind of alienation from the natural humankind behaviour.***

Without approaching psychological issues, we have to point that in the actual stage of IS/KBS “***the natural humankind behaviour***” means human kind basic features preservation and ... focussing our physical/intellectual activity for humankind life progress and Earth survival.

All these “features” suppose mature thinking and higher innovation/creation potential, which unfortunately are fading as more and more of “thinking” is transferred to ... ICT “machines” and the time is ... wasted.

Of course, the challenges are even more complex, but it is clear that the emergent “greener” ICT/IoT have to contribute to a ***“greener” (younger) human potential***, but for this ***... all these must be further analyzed!***

3. Conclusions

The paper is a the systemic analysis of the context, implementation and consequences of „greener” ICT.

The analysis presented the necessity to carefully „***observe***” the fast and complex processes of ICT development, in order to identify real-time solutions to compensate all their (unwanted) consequences in the future and shows that it is reasonably to suppose that ***building greener ICT while extending IoT as a network of networks at Earth scale has to go beyond ... energy savings.***

The desired consequences of ***greener*** ICT stem from two main directions, as ***directly*** from all processes of production and utilization of ICT (products and services), but ***indirectly*** from the whole diversity of applications of ICT as imbedded in practically all areas of humankind activity fields.

The analysis approached the ways to identify the most important directions where energy savings are significant for ICT carbon footprint, but more than this, some subtle ways ICT could generate, for humankind life on Earth and generally for IS/KBS evolution, benefic effects that could be also considered „green” or environment friendly for the humankind ecosystem, although they could not be quantified as energy savings.

As a concrete way to identify such benefic effects, based on UN definition, we considered that **sustainable** processes in social and economic are also **green forms of development**, as we extend the **environment** to **the ecosystem of humankind life on Earth**.

The „greener” ICT/IoT implementation is a two fold complex process, using, mainly for energy savings, improvements of technologies, architectures, components, devices, algorithms, methods and protocols. The other side of process is generated by a diversity of methods to provide a *green behaviour* of ICT/IoT use.

The most prominent „greener” technologies include small cells for networks, which will naturally use lower power base stations and will improve coverage and spectrum efficiency too. Other prominent green technologies are focussed on virtual gateway for residential access networks, optical interconnections for routers, voltage/frequency scaling etc.

The essential aspect is that the effect of those technologies will be multiplied by the number of expected IoT networks/devices, this way appearing the huge relevance and consequences of *greener* ICT in the IoT era.

Considering that the research, investments and expectations are so high, the *greener* ICT have to appear in measurable forms, this issue being also analyzed.

Learning from green ICT, as going beyond energy savings we consider that **changes of business models**, with **sustainable** progress for humankind, represent **one of the most dramatic non-energy savings consequences of ICT (green) evolution in IS/KBS**.

The analysis concluded that Big Data, Cloud and Analytics could be the main vectors of this transformation, but here the point we detailed is even further forecasting: how to manage the design and use of those technologies in order to leverage the generation of above mentioned **green consequences by** ICT/IoT.

Last but not least, the analysis pointed that humankind have to beware of ICT exponential development negative consequences as “ICT dependence”, physical/intellectual activity fading and ... excessive resources consumption.

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