Asian Journal of Energy Transformation and Conservation
2014 Vol. 1, No. 1, pp. 1-18
ISSN(e): 2409-4293
ISSN(p): 2412-3390
DOI: 10.18488/journal.81/2014.1.1/81.1.1.18

ENERGY EDUCATION AS A NECESSARY CONDITION TO TRANSITION TO A ROBUST FUTURE ENERGY SECURITY IN SURINAME

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ABSTRACT

There is significant uncertainty when it concerns future energy security. One way to deal with this is the so-called Scenario Planning methodology. Energy scenarios for Suriname have been made which indicate that climate change will have the greatest impact on the energy sector, thereby threatening energy security. The exact nature of this impact is however too uncertain to determine. To overcome this uncertainty there is a growing consensus with respect to the main ingredients for a sustainable energy system that can deal with this uncertain impact. However, current developments stray away from this system and rather lock Suriname in centralized, large-scale thermal and hydro power systems. The reasons behind this must be found in the Government's lack of capacity of making energy policy and the influence of public companies, EBS and the State Oil Company, who are heavily vested into the existing energy system. It is therefore of paramount importance to address and intensify education in the field of energy engineering, policy, scenarios, networks, strategy, etc. This impacts the likelihood of transition pathways actually occurring. This notion might be applicable to other (small) (developing) countries, and adds to the growing literature on the difference in transitions across geographical regions.

Keywords: Climate change, Energy systems, Energy transition, Energy education, Suriname, Scenarios

Contribution/ Originality

This study is one of very few studies which have investigated how education in the field of sustainable energy systems (transitions) can turnaround the momentum given to the proliferation of an energy system which is doomed to crack energy security is all future energy scenarios for Suriname.

1. INTRODUCTION

Climate change is arguably the most significant challenge of our contemporary world. In this regard, by far the largest contributor to this phenomenon is global warming, about which there is a strong global scientific consensus that it has anthropomorphous origins, namely the emission of greenhouse gases. Fossil fuel-based electricity production systems and the fossil fuel-based transportation sector are globally the main emitters. Consequently, this mandates a transition towards sustainable electricity production and transportation systems.

When it concerns electricity production, many nations are fortunate to have significant amounts of electricity produced by means of non-emitting production systems – so-called renewable energy systems – and are seemingly in a comfortable spot when it concerns energy security, since they are less dependant on (often foreign) finite fossil fuel resources which are subject to highly volatile prices. However, there are strong indications that these nations (with large renewable energy production capacity) will still be forced to transform their energy system in order to safeguard energy security in the wake of uncertainty. This paper explores this theme and has relevance for safeguarding energy security, even for those countries that seemingly enjoy so-called "renewables" constituting a major portion of their energy supply. Especially this latter topic has barely been addressed in literature, and this paper attempts to highlight this issue, and to suggest possible solutions to avert any serious future threats to energy security in such countries.

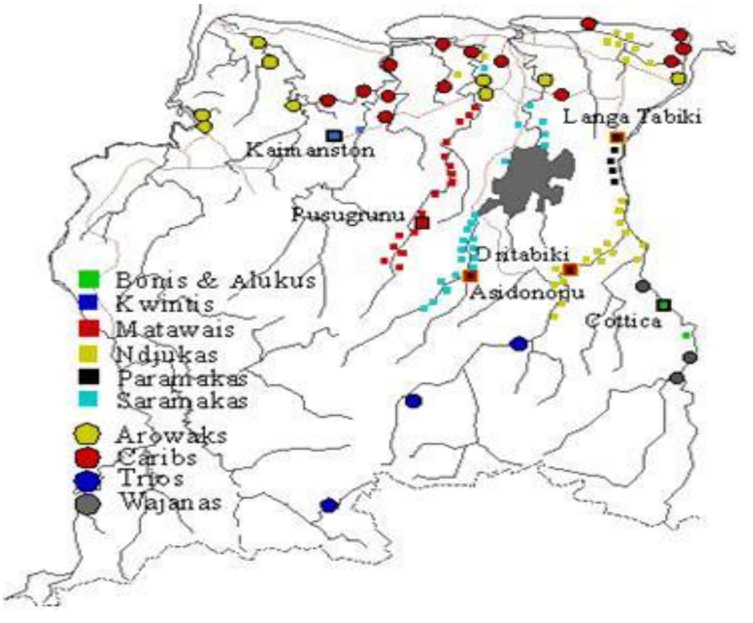
This paper will discuss this transition in the case of Suriname (a country in the northwestern part of South-America). The following section will briefly shed some light on the energy sector in Suriname. The section thereafter will exhibit the most significant uncertainty outside the energy sector and the impact it could have on energy security. The fourth section will highlight one important characteristic of the Surinamese energy sector which jeopardizes energy security in the face of looming uncertainties. The fifth section discusses how the energy system could be hedged against uncertainties by redesigning / altering the system itself. The sixth section one particular condition necessary to achieve such a transformation. The last section provides conclusions and recommendations.

2. BRIEF ON THE POWER SECTOR IN SURINAME

Suriname is a relative small country (a little under 500,000 inhabitants) in the northeastern part of Latin-America. The majority of the energy supplied in this country comes in the form of electricity, propane (used for cooking) and transportation fuels, such as diesel, gasoline and kerosene [1] . The country is rich in natural resources which with current available technology can be converted into energy, such as uranium, hydrocarbons such as oil and gas, sunlight, hydro energy, biomass etc. With regard to hydro energy, though the country's geography differs relatively little in height, studies have shown that many possibilities exist to create hydro reservoirs through the construction of dams; the potential amount of hydro energy that could be generated relatively easy in Suriname is estimated at approximately 2419 MW [1] (the total amount has been estimated to be around 4000 MW). This includes both bulk hydro power and small scale – also called micro – hydro power.

Most inhabitants live in Suriname's coastal area, with a large amount of people living in and around Paramaribo. In the interior, there are numerous maroon and indigenous villages, some of which are being supplied with electricity. Because of this wide dispersion of people, Suriname has a number of independent power systems (some of these are interconnected) [2]: EPAR (82 MW, owned by EBS and centers on Paramaribo and its surroundings), ENIC (15.9 MW, also owned by EBS and covers Nieuw Nickerie and its surrounding areas), Rosebel Gold Mines (private company), the Rural District Power Systems (around 18 MW, owned by EBS), and the Brokopondo Distribution System. Apart from the relative large power systems depicted above which are concentrated along the coastline, 111 villages in the interior are equipped with diesel-fueled electricity generators [3] ranging in capacity from 15 – 149 kW [1], see figure 1.

Figure-1. An overview of the location of villages in the interior. The colors correspond to tribes and the shapes correspond to maroons (squares) and indigenous people (circles)



The main suppliers of electricity are Suralco L.L.C. (a private-owned company with 189 MW), N.V. Energiebedrijven Suriname (N.V. EBS), Staatsolie Power Company Suriname (15 MW) and Dienst Electriciteitsvoorziening (DEV). Of these, Suralco's Afobaka hydroplant is by far the largest and delivers the majority of the electricity consumed. This electricity is sold to the Government (at a cost that is partly dependent on oil prices), and being distributed further by the N.V. EBS [1]. The total electricity generation capacity is currently an approximate 210 MW.

Apart from the Afobaka dam, there are a handful of locations that have equipment to generate electricity from alternative energy and few companies involved in micro-scale applications of solar and hydro power.

Suriname has a relative high consumption of energy on a per capita basis when compared to other developing countries and its coverage is 79 % [3]. The provision of electricity to villages in the interior is expensive in nature because of low efficiencies of the generating units and high transportation costs. Nevertheless, the villagers receive the electricity free of charge [3]. The main reasons to maintain inadequate tariffs (and consequently a financially malfunctioning utility company), and free electricity for villagers in the interior, are based on political decisions [3].

The costs of electricity supplied by EBS (approximately US$ 0.06/kWh) consists for 39% of fixed costs and 61% of variable costs, such as the purchase of hydro-electricity from Suralco (with the government acting as an intermediary), fuel and lubricants to run generators, etc. However, the electricity tariffs (determined by the Government) cover approximately 60% of the costs involved, and are approximately 39% of the Caricom average [1]. This is the main reason why the financial performance of the EBS is significantly below generally accepted standards [3]. Also, due to the fact that the EBS operates below its break-even point and the fact that power system capacity is capital intensive, the electricity sector has been forced to be directly or indirectly dependent on development aid, and necessary investments are postponed, dismissed or scaled down, resulting in a backlog of maintenance activities, an increasing inability to keep up with the growing demand for electricity and below standard efficiencies. Estimates show that energy consumption in Suriname will double within 12 years and to keep up with this increase investments worth US $ 1 billion will be required [2].

The Surinamese electricity sector is governed by the Ministry of Natural Resources, the state-owned EBS, and (when taking into account the amount of supply) Suralco. Little other actions have been undertaken to build / strengthen institutional capacity in the sector, though the call for an Energy Authority and Electricity Act becomes louder

Various studies have been conducted, resulting in a number of plans to strengthen the electricity sector in order to achieve higher efficiencies, keep up with growth in energy demand, improve resilience against foreign influences such as oil price increase, and increase energy generation (both conventional and alternative) and transmission: there are plans to build the Kabalebo Project in the west (up to 865 MW), whereas the Tapajai Hydro Project (a complex of projects which generate energy and simultaneously divert water into the Afobaka reservoir; at their maximum development, the diversion projects have a capacity of around 300 MW and an additional 116 MW could be generated via the existing infrastructure at Afobaka) has been canceled. Instead, the focus will be on thermal electricity generation.

Currently, there is an experiment with the cultivation of jatropha as feedstock for biofuels in the interior, but strong results still need to be achieved. Furthermore, Staatsolie Maatschappij Suriname N.V. is readying itself to start the production of ethanol from sugarcane at the former rice production facility in Wageningen (in the West of Suriname), and is intensifying research in other energy sources, such as algae oil [4].

Though an earlier study has indicated that operational and maintenance practices are up to standard [3], reality suggests otherwise, as evidenced by premature failures in the generation, transmission and distribution part of the infrastructure. These failures are the result of [5]:

- improper and / or outdated practices;
- reactive / corrective maintenance philosophy;
- insufficient funds to execute preventive or predictive (proactive) maintenance, and;
- management acceptance of deviations from engineering and maintenance standards.

These outcomes have resulted in electricity frequency and voltage fluctuations, (planned and unplanned) blackouts, financial losses due to claims from customers, and lost / broken equipment.

3. SCENARIO PLANNING AND THE UNCERTAINTY OF (THE IMPACT OF) CLIMATE CHANGE

In the past, governmental and corporate planning was conducted based solely on the available budget. This was succeeded by the practice of estimating future characteristics by examining past trends. However, in the 1970s there was a growing opinion that this form of planning was ineffective when confronted with sudden events and deviations from trends. Nowadays, this notion has become ever more important because of globalization with increasingly intertwined relationships, emergence of disruptive technologies (e.g. ICT and cognitive intelligence) which alter the social landscape, stronger economic competition (in particular with rising developing countries), shortening product life cycles, developments that succeed each other at a steadily faster rate, etc.

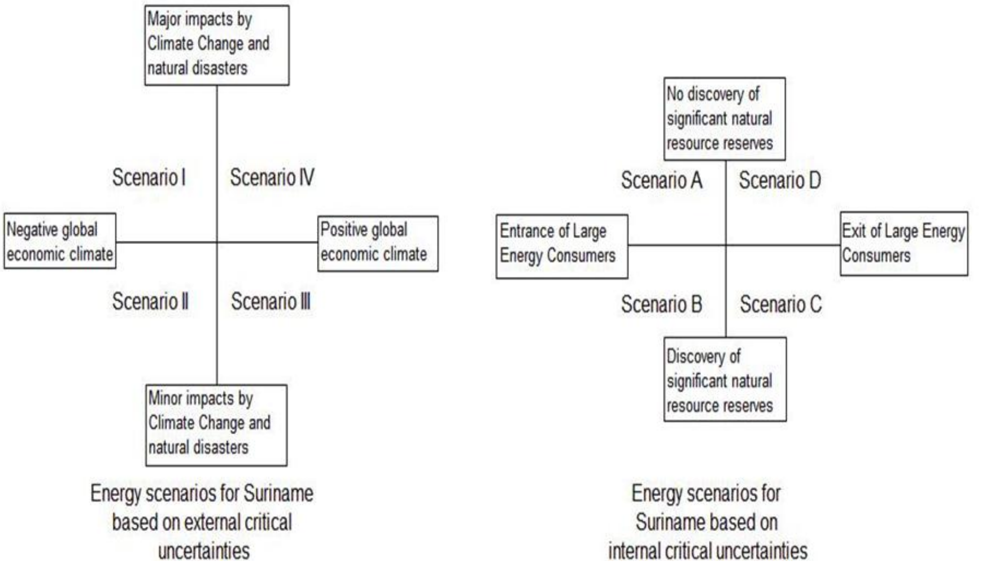
Some recent examples that embody this uncertainty are the (unforeseen) bankruptcies at the end of 2008 which led to the global financial crisis, and the terrorist attacks on 11 September. Also in the energy sector this aspect of uncertainty clearly exists, as evidenced by the unexpected and fast emergence of hydraulic fracturing technologies leading to a steep incline in natural gas production, Enron's bankruptcy, and the accident at the Fukushima nuclear facility. Naturally, the longer the timeframe that needs to be planned for, the more of these uncertainties can be expected.

Over the years many methodologies have been developed to take this aspect of uncertainty into account when performing the planning function. One of the better known approaches in this regard is Scenario Planning, a methodology that aims to create scenarios which as a set convey the range of possible futures against which the impact – whether favorable or not – of decisions can be assessed [6, 7]. Scenario Planning enables an organization to anticipate unexpected developments, be more perceptive of the environment, rehearse actions under different circumstances, be more flexible, etc. [7, 8]. The merit of this methodology has been proven given the fact that an estimated 50% of the Fortune 500 companies, notable organizations – such as the Intergovernmental Panel on Climate Change and Chatham House [9-13] and countries utilize this methodology [14]. Also in the field of energy, this methodology is frequently used, resulting in the creation of various energy scenarios which are used to inform long term energy strategy and policy [14-18].

The Scenario Planning methodology has been applied to Suriname [19] and updated [4]; figure 2 shows the results of that exercise. From this figure it can be deducted that climate change is one of the biggest uncertainties that have a critical impact on the course of the future and in particular future energy security. It is noteworthy to mention that this critical uncertainty also ranked as one of the highest uncertainties for Panama in a similar exercise [20] and it is likely to assume that this will be the case for many other countries [21, 22]. This critical uncertainty conveys the notion that the type and timing of the repercussions of climate change are relatively unknown. To be more specific, the changing climate can affect the energy system on a massive scale in several ways:

- potential for hydropower is severely impacted in the wake of increasing precipitation, continuing desertification, or increased evaporation because of higher ambient temperatures;
- management of hydropower systems becomes more troublesome because of weather patterns with greater characteristic fluctuations at greater frequencies;
- changing weather patterns can significantly impact yield of bio-fuel crops;
- elevated ambient temperatures can negatively influence the thermal efficiencies of conventional power plants;
- rising sea levels can impact energy infrastructure;
- increased frequency of extreme weather events, such as tornados, floods, and blizzards, can impact the energy system resulting in black-outs.

Figure-2. Internal and external energy scenarios for Suriname [23].



4. BIASES IN SURINAME THREATENING THE ENERGY SECURITY

4.1. Energy Reliability at the Short End of the Stick

In Suriname electricity production was initially provided through the N.V. Energie Bedrijven Suriname (EBS), a public company with power generation in relative dense populated establishments in the coastal zone. This changed when Alcoa invested halfway through the last century in an integrated alumina refinery and alumina smelter. The latter part of their investment would require huge amounts of electricity and to this end the Afobaka hydropower station was built (utilizing the van Blommenstijn reservoir) prior to the realization of the refinery and smelter. Some excess power was sold to the Government (to the EBS transmission and distribution system). However, the situation changed radically toward the end of the last century when Alcoa closed the smelter which implied that enormous electricity generation capacity became available. Therefore, in a deal with the Government it was agreed that this surplus of electricity would be dispatched to the EBS network, which feeds the capital Paramaribo (the EPAR system), see figure 3. The different systems and their relative sizes are displayed in figure 4.

Figure-3. EBS purchases from Suralco [2]

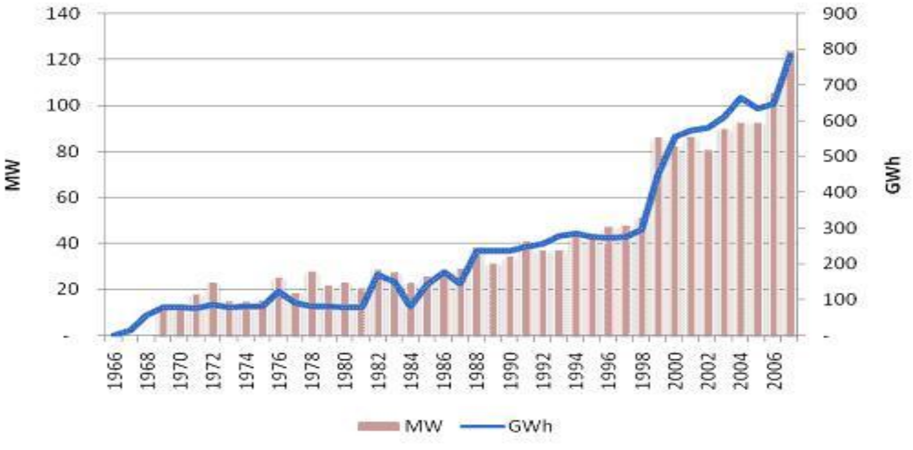
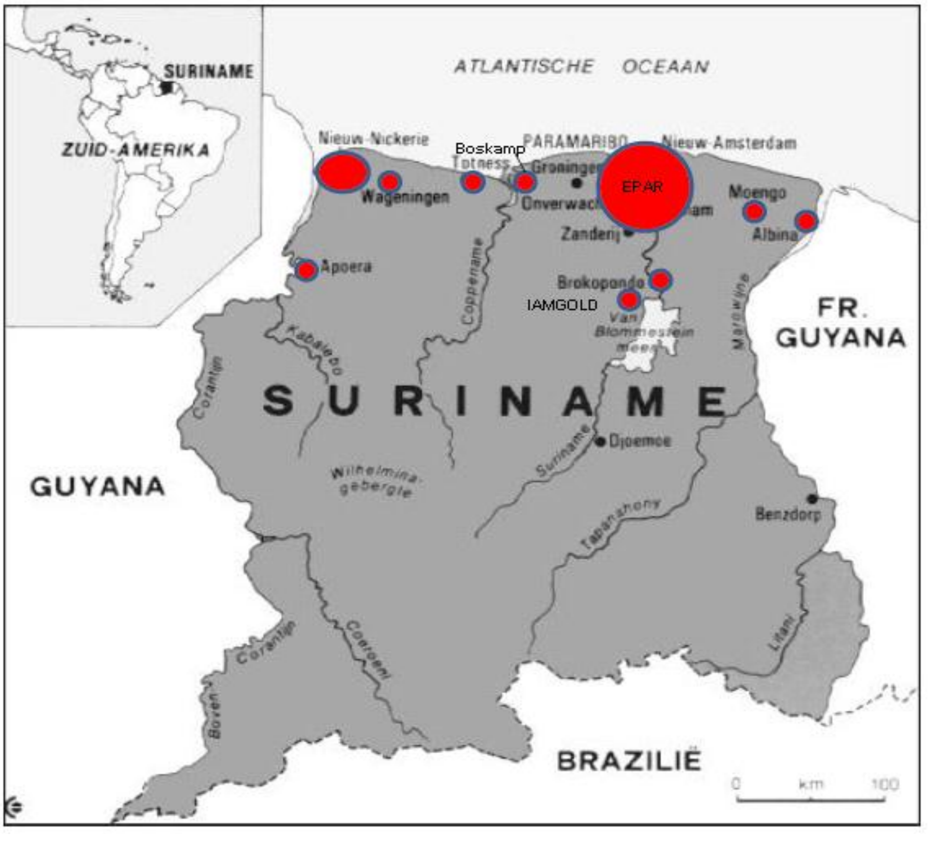


Figure-4. The largest power systems in Suriname [2]



The country had “suddenly” control over an abundance of electrical energy. Drawing parallels with the concept of the “Resource Curse”, i.e. that entities with huge financial inflows, in the absence of sound rule and regulations how to deal with this wealth, spent the earnings inefficient and ineffective, the Government of Suriname (and of course the EBS) had little incentive to think, strategize, and plan for the electricity sector: their was enough electricity for everyone. However, the new millennium was characterized for Suriname by unprecedented economic growth and major investments in the mining (oil and gold), tourism, and commercial sector. On top of this, the population as a whole increased its standard of living (for instance, the use of domestic air conditioning systems turned from a luxurious item into normal practice).

Thus, despite the fact that Suriname had the possession of a surplus of electrical energy (from the hydro power station), this benefit was nullified by an increasing energy intensity because of the growing demand for electrical energy, see figure 5 and 6. However, the real damage was done years before demand actually outstripped supply, namely when the hydropower from the Afobaka generation plant was made available to the population: this relative abundant amount of energy rendered policy makers and decision takers insensitive / unaware of the need for future power sector planning, and therefore the alarm bell was raised when little spare electricity generation capacity was left and thus load shedding (and unplanned black outs) became common practice.

Figure-5. EBS purchases from Suralco [2].

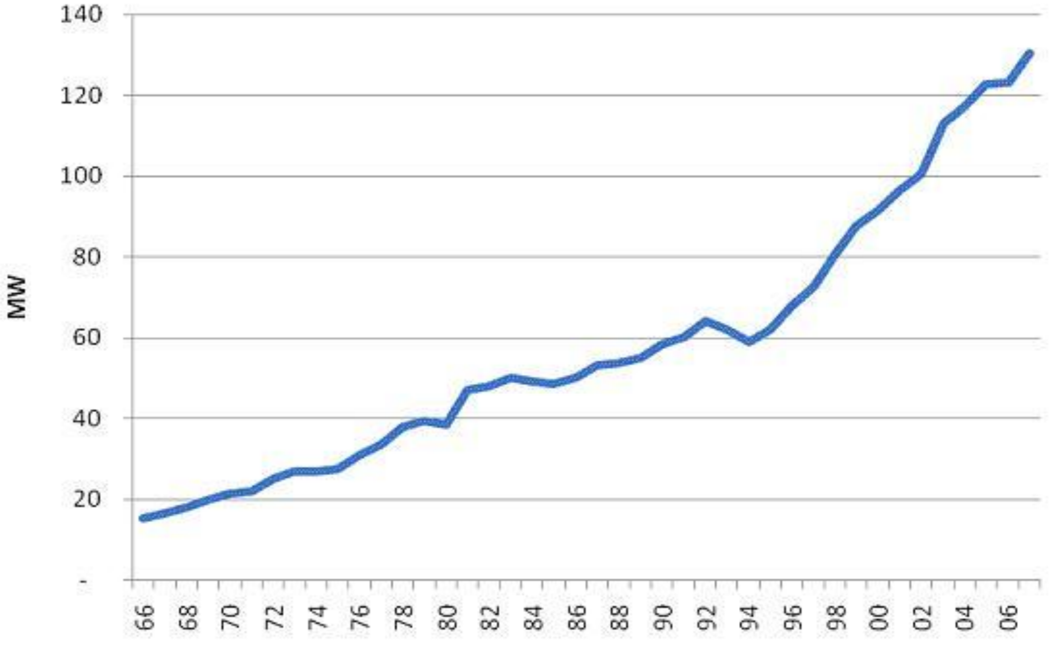
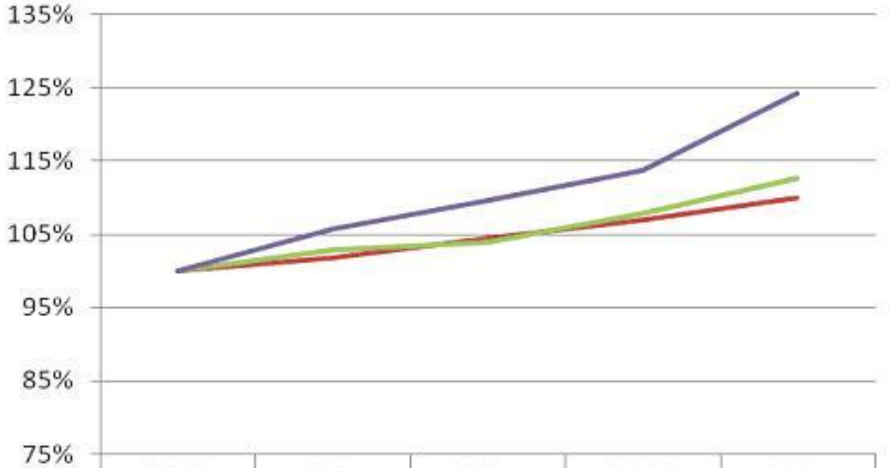


Figure-6. EBS customer growth levels (KEMA 2008a)



	2003	2004	2005	2006	2007
Domestic	100%	102%	104%	107%	110%
Commercial	100%	103%	104%	108%	113%
Industrial	100%	106%	110%	114%	124%

This led to a situation where policy makers and the utility company (EBS) were essentially solely focused on the ability to meet demand, and thus energy availability became the highest priority. Expansion of the power sector didn't occur by design (for instance, there is still no energy act, energy authority and energy institute), but was expanded in a piecemeal nature since policy makers and the utility company were pressed because of electricity demand outstripping supply. However energy security consists of the following interrelated components:

1. Energy Availability: this concept relates to the energy available for use by the consumer. This energy can be available in various forms depending on the user demand, such as electricity, automotive fuel, heat, etc.;
2. Energy Affordability: the degree to which energy supply services are within reach of (industrial, commercial and household) consumers;
3. Energy Reliability: the extent to which the delivered form of energy meets requirements set by the user, e.g. chemical composition of transportation fuels, frequency of (unexpected) electricity black outs and (unexpected) fluctuations in electricity voltage levels. Energy reliability also relates to the guarantee regarding timely delivery of energy (e.g. on time arrival of automotive fuel shipments).

Lately, there is a growing consensus that these three components should be complemented by the concepts of "Social Acceptability" and "Sustainability". In Suriname, energy affordability is addressed through subsidies that the Government hands out to the EBS in order to keep electricity tariffs artificially low for the population. This implies, that the three other components energy, in particular energy reliability, are neglected.

4.2. Other Biases Regarding the Energy Sector in Suriname

Apart from the focus on energy availability en energy affordability, there are also other biases that effectively shield off alternatives. One of these is the focus on thermal and hydro power when considering capacity expansions. The basis for this can be found in the fact that Suriname has considerable hydro power resources (around 4000 MW) combined with the success and impact of the Afobaka hydro power station, and the fact that EBS already was familiar with thermal power systems. The momentum for thermal and hydro power systems is further increased because the public companies EBS and Staatolie (the State Oil Company of Suriname) oftentimes advice directly or indirectly the Government on energy affairs. Effectively, their solutions or directions point in the direction most aligned with their interests or at least with the technology they are most familiar with, namely thermal and hydro power.

Another bias consists of the neglect of micro-scale grids for urban applications; power systems for the coastal zone generally tend to be designed in the MW-order of scale. This is aligned with thermal and hydro power systems since these are deployed on this scale, and therefore effectively shields out power technologies such as small scale wind, solar, and hydro, which are interconnected by means of micro-grids. For example, as mentioned earlier, Suriname has a hydro power potential of around 4000 MW. This resource is scattered all over the country, but two projects usually come to the foreground: the Tapajai and the Kabalebo hydro power projects. The former aims to increase the inflow into the existing van Blommenstijn lake (used by the Afobaka hydro power station). This will generate an extra 421 MW. The second project is located in the Western part of Suriname and should be able to create a capacity of 850 MW hydro power. These two projects thus illustrate this bias towards the construction of large power systems.

5. HEDGING AGAINST CLIMATE CHANGE IMPACT

There is a growing consensus that an energy system, that is able to deal with (the uncertainty associated with) the impacts of climate change, should have at least the following (interrelated) characteristics to a certain degree [24-27]:

- Maximized energy technology diversification: this notion relates to the idea that the widest possible range of electricity generation technologies (with a strong focus on renewables) needs to be included in the energy system. Climate change is already happening and will accelerate, but the actual impact on energy technologies can vary in type (e.g. the uncertainty associated with the future of a particular region pointing in the direction of desertification or increased precipitation, which would be necessary information for hydro power systems) and in degree (e.g. the frequency and severity of extreme weather events). With the inclusion of as many as possible energy technologies risk can be spread as opposed to betting the farm on a single technology which will suffer from yield or reliability loss because of climate change impact;
- Decentralized energy systems: this concept refers to a system which is composed of many (small) electricity generators instead of one big central generator from which all

dispatch occurs. The advantage of decentralized energy systems is its back-up functionality when a portion of the energy network can't function. This loss of functionality can occur because of planned (intrusive) maintenance, unexpected break downs, or, in particular, system breakdowns because of the effects of climate change, e.g. extreme weather events such as hurricanes or tornados. In a decentralized energy system other parts of the system can cover the area of that part of the system that has lost its functionality, i.e. the still active parts – the other generators – of the system will dispatch electricity to the affected area. This is in stark contrast with a centralized system where a system breakdown results in a black out on a much larger scale.

A second advantage of decentralized systems is that they don't require back-up systems to the degree as centralized systems do. Due to the large nature of the generators in centralized systems they require significant back ups (easily surpassing 60% of their nominal generating capacity) in order to ensure energy availability in situations where planned maintenance (e.g. large overhauls) are required or unexpected failures have occurred. In the case of decentralize systems, the generators are able to provide back up capacity to each other. An striking example of a centralized power system is the Afobaka hydro plant is Suriname which provides the majority of the electricity supply to the EPAR network which feeds the capital Paramaribo and its surroundings. When the generation at the hydro plant or the transmission to the EPAR network has failed, practically the entire capital and its surrounding are left in the dark.

A third advantage is that decentralized systems fit well with the nature of renewable energy systems since these tend to be scattered (e.g. hydro power). Another advantage of a decentralized energy system is the fact that transmission and distribution losses are less since generators are relative close to the customers;

- Interconnectedness: this relates to the connection of all separate network and generators. It is has parallels with the concept of decentralized energy systems but on a higher level: whereas the possibility exists that there are several decentralized energy system "islands", interconnectedness implies that even these islands are connected. The concept of interconnectedness is frequently used to refer to connection between energy networks of different countries;
- Energy Saving & Efficiency: saving refers to energy that doesn't have to be used by performing a particular function in a different manner (e.g. opting to drive a bicycle instead of a car). Efficiency relate to that portion of energy involved in performing a particular function that can be left out of the equation without sacrificing the functionality in any way, in other words "doing more with less". This is usually associated with consumers but is also inherent present as one of the advantages of decentralized energy systems;
- Generation (and Transmission & Distribution) Excellence: this term – sometimes more commonly known as simply Production Excellence – conveys the idea of producing and transporting (in this case electricity) in the most efficient and effective way possible. This

included optimizing inventory, maintenance, manpower, supply chain, engineering and production management in such a way in order to produce reliable (on time, with the right quality without excessive process interruptions or fluctuations) at the lowest possible cost [5].

Suriname lends itself quite well for such a system which is described by the points mentioned above: it is rich in renewable energy sources (more than 90% of the country is covered with forest, which makes it suitable for bio-fuels, it has a large coastline with multiple possibilities for offshore energy systems, it has solar and small wind potential, and it has an abundance of hydro power potential) which makes the wide diversification of energy resources possible. This wide diversification combined with the interconnections and decentralized grids could also counter the urbanization trend which overcrowds the coastal areas.

Unfortunately, the bias that exists in Suriname in conjunction with the reliance on centralized thermal and hydro power systems actually render the current energy system not rigid enough to deal with climate change. To make matters worse, due to this bias, the momentum for large centralized thermal and power system (as evidenced by the push for the Tapajai and the Kabalebo projects and the current construction of two thermal plants, 84 and 15 MW by respectively EBS and State Oil Company) indicates that the current course strays away from the more rigid system described above, and actually increases the amount of "lock-in" in the existing system [28]. Thus, the problem at hand is not so much a technical one, but more social in nature [29]. It is likely that, even though Suriname is addressing energy availability by means of expansions and affordability by means of subsidies, energy security will become more fragile since the energy system won't be able to cope with the repercussions of increasing climate change. A transition (and the awareness for this transition) towards a sustainable energy system guaranteeing a desirable level of energy security is therefore of imminent importance [30].

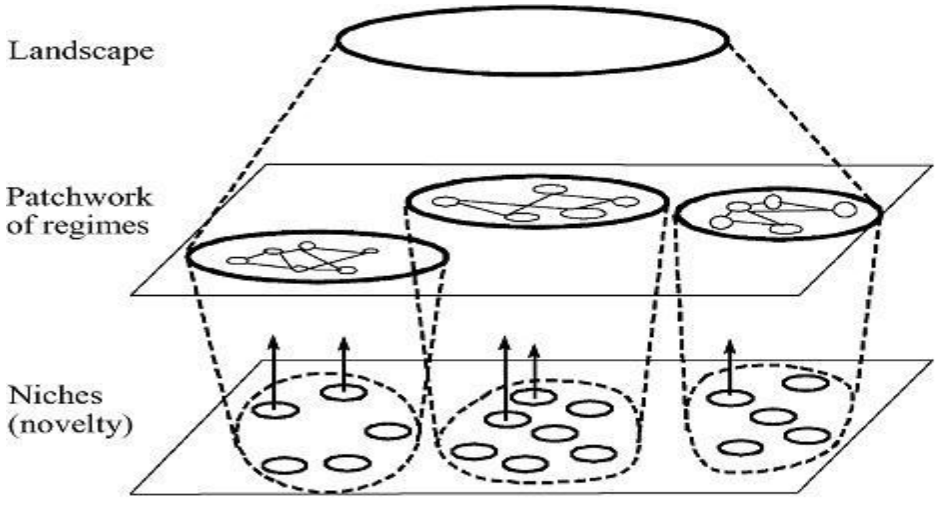
6. DISCUSSION: EDUCATION > ENERGY TRANSITION > ENERGY SECURITY

As mentioned earlier, the EBS and State Oil Company (both public companies) have a strong role in advising the Government. The reason behind this can be found in the fact that it is not out of the ordinary to select people for top functions in these companies based on their political ties (in particular in favor the reigning party) who are able to influence policy (e.g. the former EBS director was also the advisor for the President on energy affairs), sometimes even in informal ways. Another reason is the lack of energy-related policy making capacity; since the Government doesn't pay as well as the public companies, graduates with a degree in (energy) engineering, energy policy & strategy (their is no specific study for this field, but students are able to specialize in this matter in the later phases of their study), etc. usually don't end up in Governmental bodies. Therefore, the Government often requests the public companies (or the privately-owned Suralco, who still delivers the majority of the electricity) the assist / help with policy making affairs (for instance, the State Oil Company currently funds an endeavor to conceive an Electricity Act). A third important reason is simply the fact that – because of the very small nature of Suriname with only about 500,000 inhabitant – there are only literally a handful of people in the entire country who are actually doing research on energy security, scenarios, transitions, policy and strategy.

With this description, the dominance of thermal and hydro power-based centralized systems (as backed up by the Government and the EBS and the State Oil Company) in the energy sector of Suriname can be described using the Multi-Level Perspective (MLP). The MLP is conceptualizes a pattern of long-term change that a macro, meso and micro level, respectively landscape factors, regimes and niches [23, 31, 32], see figure 7:

- Landscape level: the whole set of impacts outside the level of niches and regimes (like autonomous trends and global events) which are able to influences these very same niches and regimes (though niches and regimes can barely influence the landscape;
- Regimes level: this refers to the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artifacts and persons, ways of defining problems; all of them embedded in institutions and infrastructures. The regime consists of three interlinked elements: (1) a network of actors and social groups, which develops over time; (2) the set of formal and informal rules that guide the activities of actors who reproduce and maintain the elements of the socio-technical system and (3) the material and technical elements [33];
- Niche level: spaces where innovative activity takes place and where time-limited protection is offered against dominant selection rules. Niches compete with regimes – and thus the rule-set – and might even replace the incumbent regime. Niches differ from regimes since they tend to be more flexible and less bound by rules [34];

Figure-7. Representation of the multi-level perspective [32]



According to the MLP, transitions occur as a result of dynamics at the different levels which reinforce each other creating a “window of opportunity”: landscape factors destabilize regimes (actors diverge and start to disagree) while niches, developed in protective spaces, gather momentum to take center stage within the system [35, 36].

In the case of Suriname, the regime level is made up of the Government, the EBS and the State Oil Company with a focus on energy availability through thermal and hydro power (and energy affordability through subsidies). At the niche level, various concepts (as discussed in section 5) forming the main ingredients of a sustainable energy system can be found, such as the decentralized energy systems, (a wide range of) renewable energy technologies (save large scale hydro power), and energy savings and efficiency. At the landscape level, the most notable aspect with respect to this paper is climate change.

As explained only a handful of researchers are actively busy in this field, but they have little influence on policy making; the Surinamese Government doesn't always look at the country's research base for advice, rather – in the case of energy-related matter – all attention is given to the public companies. Therefore, since the concepts underlying a sustainable energy system are unknown in Suriname (only a few scholars are involved in this subject), momentum towards a sustainability transition can structurally be built through increasing and intensifying education on energy-related matters, or such a transition will start to gain foothold when a change agent, highly influential in policy making, appears. Since the latter option is strongly dependent on chance and thus far from attractive, a strong emphasis must be laid on education in the field of energy engineering, scenarios, policy, strategy, systems, etc. Such a focus will slowly (or maybe fast considering Suriname's small nature), but surely create the awareness in the Government, the EBS and the State Oil Company, media, political parties, and at the public in general regarding the required transition, which will create momentum towards a belief in and, eventually, the actual ignition of such a transition. As mentioned earlier, the problem at hand is not technical in nature and can't be solved with the erection of infrastructure and systems throughout the country [37], but has its root in the thought processes, paradigms, knowledge base and viewpoints that underlie the selection and development of concepts which need to be realized into physical objects and behavioral aspects in reality.

Transitions can occur along a number of pathways, a typology of which has been provided by [38]. With the earlier mentioned notions regarding the drivers for transitions in Suriname, the following can be stated regarding these pathways:

- Reproduction process: this pathway relates to the absence of landscape pressures which keep the regime dynamically stable, and eventually the regime will reproduce itself. This pathway will guide the transition if the effects of climate change on the energy sector won't surface, and intensified energy education has increased awareness regarding sustainable energy systems with spillovers to the Government and the public companies;
- Transformation path: moderate landscape pressure at a moment when niches have not yet been sufficiently developed, trigger regimes to react by modifying the direction of development paths and innovation activities. This pattern follows the same trend as with the Reproduction process, with the notable exception that the effects of climate change on energy security do become more apparent which in turn pressure the Government

and the public companies (now made aware – through energy education spillovers – of the required transition towards a sustainable energy system);

- De-alignment and re-alignment path: landscape changes are divergent, large and sudden (i.e. the effects of climate change are occurring more frequent and becoming more severe) thereby increasing regime problems (i.e. eroding energy security), which destabilizes the regime, leading to de-alignment. In the absence of sufficiently developed niches, emerging niches (companies or new Government officials with the benefits from intensified energy education) will compete to take center stage. Eventually, one niche becomes dominant, forming the core for re-alignment of a new regime;
- Technological substitution: significant landscape pressure (reducing energy security due to the impacts of climate change on the energy sector) in combination with sufficiently developed niches (same as above) leads to dethroning of regimes (same as above) by niches;
- Reconfiguration pathway: Symbiotic innovations, which developed in niches (same as above), are initially adopted in the regime (same as above) to solve local problems. They subsequently trigger further adjustments in the basic architecture of the regime.

As can be seen from the pathway description above, some pathways are more likely to occur in Suriname than others. This relates to the notion that transitions are likely to differ across geographical regions [39-45], and hence the pathways (and their likelihood) are heavily influenced by the driving factor composed of the focus on education.

7. CONCLUDING REMARKS AND IMPLICATIONS FOR ENERGY POLICY IN SURINAME

An important recommendation for further research relates to the extent energy education lies at the root of countries not developing towards sustainable energy systems. Scrutiny in this regard must especially be applied to (small) developing states. This will simultaneously provide further knowledge about the differences in transition (pathways) across geographical regions.

Currently, the energy sector in Suriname is developed in such a manner that it gets more locked into centralized thermal and hydro power systems. As discussed extensively in the previous section, energy education gives the greatest momentum to stray away from this course which is not robust in the face of the earlier discussed scenarios for Suriname. Fortunately, lately it seems that the first signs are emerging in Suriname regarding intensifying energy education with a focus on sustainable energy systems: several students are sent abroad for Master of Science and PhD scholarships in energy-related matters, the Anton de Kom University of Suriname (ADKUS) has a Sustainable Management of Natural Resources which also discusses the climate change / energy security threats, there is an increasing number of scholars interested in setting up businesses in the energy sector, there is increasing dialogue between the Government, EBS and the State Oil Company on one hand and ADEKUS on the other hand, in 2014 a new Master's program in Renewable Energy will be initiated, the EBS is experimenting with energy efficiency and savings measures, the State Oil Company is starting to look at non-conventional renewable energy technologies, the Government is working on a Electricity Act, Energy Authority and Energy Efficiency and Savings policy, there is more participation of international seminars, and in 2014 the first scholar from ADEKUS will receive his PhD in energy system transition management. Therefore, the future is indeed challenging, but intensifying energy education in Suriname seem to have started to turn the wheels on the road toward the guarantee of Suriname' energy security.

However, this is exactly where the necessity for sound policy enters the picture: in order to increase and capitalize on this momentum, it is of the utmost importance that the Government conceives an energy policy that recognizes the relationship between energy security and climate change which demands a transition towards a sustainable energy system. Simultaneously, Suriname's energy policy must take account of the fact that this transition concerns a "socio-technical" system, in the sense that the energy system conveys technological, political, social, behavioral, etc. aspects; this implies that energy policy must also in a positive sense affect the most effective way to engage the energy transition (and to tackle bias and regimes) which is at the root of many solutions: energy education.

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