FRAMEWORK FOR A SMART ENERGY PATH

A GUIDE TO SOUND ENERGY DECISIONS





HELIO International

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INTRODUCTION

Modern energy planning must take into account a number of interconnected social, economic, ethical and environmental issues. The primary function of the energy system is to help to meet needs in accordance with development priorities, thereby improving the quality of life for everyone. To achieve this, the need for energy services must be met in a manner that is technically efficient and that preserves healthy ecosystems while adapting to climate variations, such variations themselves being largely the result of former harmful practices within the energy system. Lastly, energy planning must also be in line with principles of social justice and of participatory governance, since it is unlikely that an energy system will prove efficient if it is designed and implemented without the participation and full commitment of those whose lives it will affect.

In the past, energy planning focused almost exclusively on the supply side of commercial fuels and electricity. The ways in which fuels and electricity were actually used was the object of scant thinking and attention, rarely going beyond what was necessary to increase supply. Things have changed in recent years as it has become increasingly evident that a traditional top-down approach leads to an outlook for the supply of fuels and electricity that is economically and environmentally non-viable and that has not only failed to constitute an effective way of achieving the goals of human and economic development, but looks largely set to compromise them.

With the threat of climate change the requirement for energy strategies able to meet the aspirations of economic and human development while limiting environmental stress and pollution, as well as minimising the energy system's own vulnerability to climate change, has become more and more pressing. Severe pressures can appear, especially in economies with an unmet demand for electricity and fuels, and can place excessive stress on ecosystems and short-circuit participatory governance by favouring short-term interests.

Energy projects are known throughout the world as being one of the major sources of environmental stress. In the 20th century, development of mining, refining and consumption of non-renewable resources caused massive damage, notably pollution of the seas as a result of hydrocarbon spills, atmospheric pollution from combustion of coal and oil, water pollution from the extraction of uranium and other ores, soil contamination from nuclear accidents and, ultimately, global warming. In the developing countries, households' dependence on biomass and charcoal for cooking and heating has sometimes led to deforestation, to human suffering and to loss of habitat. This situation necessitates a more sophisticated modern response to minimise harm to the environment and to society: a smart energy path.

In summary, a smart energy path (**SEP**) aims to provide energy services that make it possible to achieve economic and social goals for a population within a given perimeter (local, national, regional) in a manner that is compatible with environmental sustainability and within a framework of participatory governance. It is therefore a *"demand based"* or more accurately a *"needs based"* approach relying on the use of soft energy technologies that

1. use renewable energy flows;
2. are diversified and rely on numerous small individual contributions designed for maximum efficiency in a given context;
3. are flexible and technologically accessible;
4. are appropriate to end users' needs in terms of quantity, quality and geographical distribution.

It is important to point out that *"energy planning"* is merely one component of economic and social planning. Of course the energy options selected greatly affect people's living and working conditions and the natural environment, and subsequently the possibility of attaining the Millennium Development Goals (**MDG**) (even though these do not mention energy specifically) and their successors the Sustainable Development Goals (**SDG**) currently being defined. Moreover, the very basis of **SEP** is directly in line with the will to obtain universal access to energy that will be viable in the long term.

CHAPTER 1

BASIC ELEMENTS OF A SMART ENERGY PATH

DEFINITION AND ORIGIN

The smart energy path (**SEP**) aims to respond to the needs of energy services of the whole population through the use of sustainably managed renewable resources – sun, wind, water cycles and biofuels – for long-term provision of energy that is environmentally benign. Smart energy paths use technologies that guarantee high energy performance for end uses, thereby optimising consumption of each unit of energy and reducing the amount of energy produced in the first place, meaning less environmental stress.

"It may then be claimed that renewable energy technologies will stimulate a decentralised development, leaving more room for regional optimization of living conditions and democratic participation, as compared with the large scale technology, which has a tendancy to become the "property" of an elite, such that it might promote a further stratification of regions and societies with respect to the levels of material standard of living." (*Bent Sørensen*)

In this guide, we employ the expression *"smart energy path"* to mean an energy planning approach that starts with the question: *"what kind of future do we want in terms of social and economic development?"* and answers the question *"how can we obtain the energy services and the adapted energy chains required for such a future and satisfy people's aspirations and needs in a way that is compatible with environmental sustainability and participatory governance?"*.

It is inspired from the *"soft energy path"* coined by Amory Lovins in 1976 in a ground-breaking article that appeared in the Foreign Affairs magazine and which defined a new paradigm for the way we consider energy. The ideas propounded by Lovins are closely related to the work of Bent Sørensen in Denmark[2] and of Amulya Reddy in India[3], with the concept of *"energy for development"*.

2. *Amory Lovins. Energy Strategy: The Road Not Taken », Foreign Affairs. Autumn 1976.*
3. *Bent Sørensen. Renewable Energy Planning for Denmark and Other Countrie. Energy: The International Journal, 6:293-303, 1981.*

In contrast to this *"soft"* energy path[4], pursuing the energy planning paradigm prevalent at the time was described by Lovins as the *"hard"* path, characterised by increase in supply of fossil fuels and greater use of centralised and ever more costly energy supply technologies exerting increasing pressure on the environment and resulting in an inflexible, inequitable, vulnerable and ultimately unsustainable energy system.

Smart energy paths are characterised by a focus on the response to the populations needs for modern energy services and optimization of final energy demand. Collective (for example health, education) and productive needs for modern energy services are at the heart of SEP. They use free, natural energy flows that are easy to use and locally accessible. SEP are not only fully compatible with environmental sustainability and with economic self-determination (attributes which are essential elements of ecodevelopment) but also favour economic emergence and long-term viability (*Figure 1*).[5]

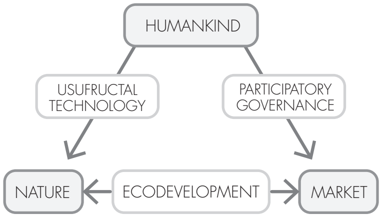

FIGURE 1: **Ecodevelopment**

Humans, utilizing usufructal technologies use natural resources; trough participatory governance, markets are controlled and regulated. It is trough these processes and nteractions that ecodevelopment is achieved. (Source: Helio International)

RELEVANT TO AFRICA?

In the industrial economies access to fossil fuel and electricity is universal and both rural and urban local authorities have the benefit of modern energy services with levels of reliability that are more or less equivalent. In the developing world, and especially in sub-Saharan Africa, access to commercial energy is very limited, per capita consumption of fuels and electricity is very low. Many small and rural communities are almost totally dependent on biomass which is often collected unsustainably, contributing to deforestation and adverse environmental effects. There is a high unsatisfied demand for energy services referred to as *"suppressed demand"*, that is to say an unmet demand that must be taken into account when defining future needs. Meeting suppressed

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4. Amulya K.N. Reddy. Energy Options for the Third World. The Bulletin of Atomic Scientists, vol. 34, no 5, May 1978, pp. 28–33. See also http://amulya-reddy.org.en/.

5. Hélène Connor-Lajambe, Conducting Sustainability Assesssments — ISBN-978-92-64-04725-9 ©OCDE 2008, «Assessing the Energy Contributions to Sustainability», ch. 8, page 109.

demand effectively requires a *"demand side"* approach with a focus on meeting social, communal and productive service needs, combined with progressive enhancement of infrastructure and development of local and national energy resources. In the industrialised economies the amounts of animate (human and animal) energy used are tiny compared to the quantities of energy from electricity and fossil fuels; similarly, biomass is a marginal contributor to the energy mix in most industrialised countries. The opposite tends to be true in the developing world, where animate power is an important energy source in rural areas.

There is no doubt that the current conditions in developing countries are quite different from those that prevailed in industrialised countries when the **SEP** concept was developed (1975–80). However, the basic principles of **SEP** are fundamental, especially in terms of the focus on the services provided by energy: cooking, lighting, mobility, water, motive power (water pumping, processing of foodstuffs), heating, refrigeration, communications and others. It can even be argued that the **SEP** approach, fostering efficient and clean supply of such services (and therefore addressing essential aspects), is particularly relevant to developing countries, for which it represents an unparalleled strategy to future structural development. A similar approach has been developed by Amulya Reddy in the context of the developing world.

EXTRACT

Poverty and energy

In the face of inadequate inanimate energy and of a lack of access to efficient technologies of energy use, the poor are forced to depend on their own labour, on animal power and biomass energy resources to meet their survival needs. If poverty reduction and improved living standards are to be achieved, energy services must be dramatically augmented to improve the level of satisfaction of basic human needs. This is the challenge, a challenge that is aggravated by growing populations already facing shortages of inanimate energy –failure will play a significant role in the perpetuation of poverty, and success can lead to the achievement of equitable, ecologically sound and sustainable development.

Srilatha Batliwala and Amulya K.N. Reddy "Energy as an Obstacle to the Improvement of Living Standards", undated.

A SERVICES ORIENTATION

Why do we need energy? After all, it is not the armful of fuelwood itself that we want, or the container of kerosene, and nobody wants a kilowatt-hour of electricity in their hand! We value fuels and electricity not for their own sake but for the role they play in providing us with the things we really do value directly: heat for cooking, the ability to move ourselves and our produce and other goods from one place to another, light for reading, refrigeration to store foods and medicines, motive power to ease the burden of human labour, and of course all the devices for communication and entertainment that run on electricity. It is these services that have value and that improve the quality of life and, while it may seem obvious, this focus on energy services constitutes a way of looking at our energy system that is profoundly different from viewing it simply in terms of production and consumption of aggregate quantities of fuel and electricity.

A SYSTEM ORIENTATED VIEW

In an SEP approach, understanding the level of energy services and their characteristics is as important as an understanding of these same levels and characteristics relative to fuel and electricity supply. Where energy is concerned, this approach implies taking a system orientated view with human needs and economic development objectives being underpinned by an energy system with as much concern for demand technologies as for energy supply.

Figure 2 illustrates this system orientated view. Operation and overall evolution of the system are driven by the size of the population, numbers of households, settlement patterns, standard of living and economic activities. A smart energy path refers to an energy system in which energy services are provided in ways that are environmentally sustainable and foster participatory governance. Within the overall energy system, energy services are provided via a set of energy chains, in the form of series of technical steps characterised by specific technologies and actors and which link together to provide an energy service to a given population. This encompasses the exploitation of a primary energy resource (crude oil, solar energy, hydropower, etc.) to delivery of an energy service (lighting, motive power, cooking, etc.).

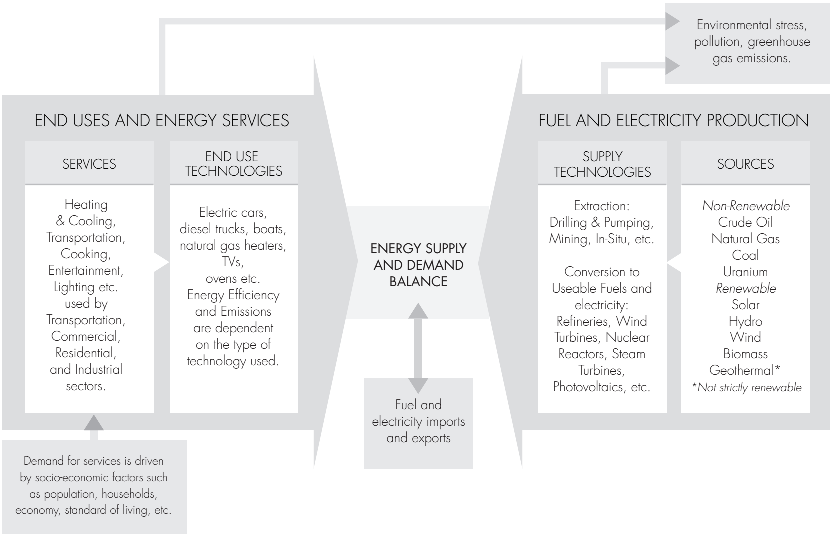


FIGURE 2: **Energy System Schematic**

(Source: From Torrie et. al., "An Inventory of Low-Carbon Energy for Canada", Trottier Energy Futures Project, March 2013. www.trottierenergyfutures.ca. (Based on a diagram developed by ISEEE, University of Calgary, and inspired by Sanborn Scott's five-link architecture of an energy system.)

NOTA BENE

Energy services are essential for development – the example of electricity in sub-Saharan Africa

Avoiding confusion between energy services and energy access

In most sub-Saharan African countries it is not only final energy that is missing, it is above all energy services that are lacking. A paradoxical situation pertains: electricity supply grids are built in rural areas; to achieve this, governments, electricity companies, rural electrification agencies (when these exist), international development partners, etc. finance at great cost grids that "cover" significant parts of national territories. But the goal is not attained because the rural households cannot afford to pay for connection to the grid and cannot afford a monthly bill. Only the wealthy profit from this "windfall", benefiting from public subsidies given to the electricity sector. This is the result of a "supply side" approach: no thought is given to the inability of the majority of people to invest in the appliances that provide electricity services (lighting, refrigeration, ventilation, etc.).

Using energy access to eradicate poverty

Today, access to electricity is often considered as a luxury rather than as a component of development. It is reserved for the wealthiest fringe of society while the majority have no access to modern services. In fact, communal infrastructure and amenities should be provided with modern energy services: health centres; schools; administrative centres; social centres; drinking water wells and all facilities contributing to economic and social development; agricultural, artisanal, or commercial enterprises; markets; etc. Providing these areas with energy services improves their efficiency in delivering services and thereby contributes to achieving the MDG and associated targets (see annex 3) aimed at the population living below the poverty line: specifically levels of school attendance and success, infant/juvenile and maternal mortality, access to drinking water, etc.

The access to energy services approach is therefore a "demand side" one: people's energy service needs are addressed and the optimum energy systems are designed at the relevant territorial scale. The notion of an "energy territory" is introduced, it can be a municipal area, or a part of this, within which a sole controlling authority will ensure availability of energy services to social infrastructure (health, education, water, municipal departments), productive facilities (agricultural, artisanal, service providers) and to households.

SOFT ENERGY TECHNOLOGIES

Smart energy paths use soft energy technologies. As defined originally by Lovins[6], these are technologies with the following five characteristics:

1. They rely on renewable energy flows such as sun, wind and vegetation that are always there whether they are used or not: this means that energy income is being used, not depletable energy capital[7].

2. They are diverse and rely on many individually modest contributions, like a national treasury that relies on many small tax contributions, with each energy contribution being designed for maximum efficiency in particular circumstances.

3. They are flexible and relatively low technology, which does not mean unsophisticated but rather that exceptional skills are not required to understand the operating principles, in other words they are accessible rather than arcane.

4. They are matched in scale and in geographic distribution to end users' needs, taking advantage of the free distribution of most natural energy flows. While power stations and fossil fuel extraction often produce energy at rates in the hundreds or even thousands of megawatts (MW), individual human needs for fuel and electric-

6. Amory Lovins, Soft Energy Paths: Toward a Durable Peace, Ballinger, Cambridge, 1977. pp. 38-39.

7. This is also called "usufructuary use" ity are typically only a few kilowatts (kW), with even the largest industrial facilities rarely requiring as much as 100 MW. This mismatch in the scale of supply and the scale of demand creates inefficiencies and losses associated with the inevitable wide extent of distribution grids.

5. They are matched, in energy quality terms, to end users' needs. Energy by itself is not of great value. Its value derives solely from its capacity to meet needs and, in this regard, some forms of energy are more advantageous than others because they are more versatile and have more relevant attributes than others. For example, one Joule provided in the form of electricity can be used for many more applications than a Joule from low temperature heat, which is why electricity can command unit-of-energy prices that are much higher than those for other forms of energy. Liquid fuels with high energy densities that can be stored on vehicles (e.g. gasoline, diesel fuel) command a high price compared to the same amount of energy in the form of coal.

NOTA BENE:

Optimising economic efficiency of the energy chain

The cost of an energy service is the sum of the costs of each of the links in the energy chain: primary energy, conversion to secondary and then final energy, transport to the consumer, and equipment converting the final energy into an "energy service". Optimising the energy chain means designing and sizing the different links so that the overall cost of the energy service (including externalities) is as low as possible. With a supply side approach, the final energy supplier optimises the upstream part of the chain without really considering the need that is to be met or the choice of appliance converting the final energy into a service. For a given energy service, the investment cost for the equipment providing the service increases with its efficiency of conversion but energy consumption and cost may decrease. For instance, a low-energy light bulb costs more than an incandescent one but requires far less electricity. Economic optimum is achieved when the additional investment cost of avoiding consumption of a certain amount of energy is equal to the cost to provide the energy. Virtually all energy systems are a long way from operating at optimum and the final converting elements (buildings, lamps, industrial processes, vehicles, etc.) could perform far better; the potential for realisable energy efficiency is high. In other words, for identical service, the amount of energy consumed and overall cost of the energy chain could be much lower.

It is possible to envisage and put in place an institutional set-up leading to an optimised energy chain if the controlling authority manages both the upstream and downstream parts of the energy chains. An energy service operator can be brought in within a delegated-service remit and can thereby control all of the energy chain so as to make best use of local resources to give full meaning to energy efficiency. This is also the approach that will allow leap-frogging to accede directly to the best technologies.

SCENARIOS AND BACKCASTING:
GOAL-ORIENTATED ENERGY PLANNING

In SEP planning, wthe energy system is seen as serving human needs and aspirations, which is why the energy service focus is paramount. Future supplies of fuels and electricity are not forecast or predicted but are *"back-cast"* from a point in the future for which targets, used as key indicators, have been defined by consensus.

Backcasting consists in imagining a future and then planning the way to get there. The word itself may be unfamiliar but it actually refers to a commonplace activity. We all use the method, even in such everyday activities as crossing a busy street. If we simply forecast our arrival at the other side by projecting our speed and direction we run the risk of being totally surprised by the traffic. In fact, we look both ways and collect all available information on the presence and speeds of different vehicles and use this information to run different scenarios and assumptions. How much time will it take to cross? Am I in a hurry? If I fall, will I have the time to get up and finish crossing before the approaching truck gets there? Will the truck driver have enough time to stop? Would it be safer to wait until there is no more traffic? After comparing the different scenarios (wait? walk? run?), we make a decision. Of course such decisions are made so automatically that we are rarely aware of the process going on in the background but this is, nonetheless, backcasting. In SEP, backcasting is applied systematically and voluntarily as a tool for comparing different ways of reaching a desired result.

SMART ENERGY PATHS AND TIPEE INDICATORS

HELIO International has developed the TIPEE©[8] indicators enabling measurement of progress resulting from implementation of energy policies integrating the principles of ecodevelopment. The table below provides a summary of the indicators and indicates their compatibility with the SEP approach.

8. *HELIO International, «Processing Information for Energy Policies Conducive to Ecodevelopment (TIPEE)», HELIO, Paris, 2011. http://www.helio-international.org/toolkit/tipee.*

EXTRACT

Backcasting

Backcasting analyses are concerned not with what energy futures are likely to happen, but with how desirable futures can be obtained. They involve "working backwards" from a particular chosen future end-point to the present in order to determine what policy measures would be required to reach that future. The difference between forecasting and backcasting is thus as much one of approach as of methods. Both techniques must incorporate policy changes; both must also make use of some predictions; both can be highly quantitative. The value of backcasting, which, in contrast to forecasting, increases as the time horizon of the study is extended, is that it makes possible the exploration of the feasibility and viability of a wide range of possible energy futures.

David B. Brooks, John B. Robinson and Ralph D. Torrie, 2025: Soft Energy Futures for Canada, Friends of the Earth Canada for Energy Mines and Resources Canada, Ottawa, February 1983.

TABLE 1. **TIPEE indicators and the SEP approach**

INDICATORS	RELEVANT PARAMETERS	LINK WITH SEP APPROACH
ENVIRONMENT		
1.Greenhouse gas emissions	Greenhouse gas emissions (CO_2) from the energy sector	Focus on energy efficiency and renewables.
2. Major local energy pollutant	Concentration or emission level of a significant energy-related local pollutant (CO, NOx, SOx, particulates) per capita	Inclusion of energy system impacts on atmosphere and health. Focus on energy efficiency and renewables, including for end use. Fostering of access to clean cooking to improve indoor air quality.
3. Deforestation	Number of hectares of deforestation or loss of forest vegetation (biodiversity) used for energy purposes	Consideration from source to end use. Lowering of pressure from obtaining fuelwood supplies.
SOCIETY		
4. Electricity access	Number of households with access to electricity	Priority given to energy services, especially those intended for social infrastructure, communal or productive uses. Focus on matching of supply to end uses. Off-grid solutions can accelerate access to electricity.
5. Household energy burden	Proportion of household income spent on energy services	Focus on appropriate energy services with, for example, efficient cooking stoves or solar water heaters that can reduce household energy bills.
ECONOMY		
6. Fossil fuel imports	External energy dependence	Reinforcement of energy independence and reduction of external debt by fostering energy efficiency and renewables.
7. Non-renewable energy reserves	Number of days of stock of non-renewable energy supplies	Reinforcement of energy security.
TECHNOLOGY		
8. Renewable energy	Deployment of modern, local renewable energy	Encouragement of diversified renewables and, in this sense, energy services.

9. Energy efficiency	Energy intensity of industry; GHG emissions per unit of production; or energy intensity of the economy	Fostering of energy efficiency along the energy supply chain, from source to end use.
10. Quality of electricity supply	Length and recurrence of power cuts and variations in voltage	Improvement in service quality and reliability, focusing on energy efficiency and renewables, diversified and decentralised sources and matching of source quality and quantity with end use.
GOVERNANCE		
11. Income control	Reduction in the share of energy revenues that escape taxation	Encouragement of use of local energy resources to facilitate control and redistribution of income. For example, controlled rural markets for biomass from forests in West Africa raise taxes to be used by local authorities.
12. Informed consultation	Public hearings and consultations on the impact assessments of proposed energy projects	Encouragement of participation and upstream public information to facilitate uptake of solutions acceptable to everyone.
13. Women participation	Active participation of women in the governance of the energy sector	Affording of an official position to women in places where energy sector decisions are made, given their active role in obtaining energy supplies and access to energy services.
14. Balanced governance	Balanced representation of energy demand and supply stakeholders as well as transparency in the decision-making process	Guaranteeing of balanced representation of all stakeholders concerned by energy decisions, to encourage transparency of decision making processes and active participation of all actors involved.
VULNERABILITY		
15. Vulnerability of thermal power supply	Vulnerability of power plants (and refineries if applicable) to flooding	Diversification of production sources, focus on energy efficiency, avoid siting power plants in risk areas (flooding, loss of production capacity due to low levels in water courses used for cooling, etc.).
16. Vulnerability of renewable power systems	Vulnerability of renewable energy systems to climatic variations	Diversification of production sources, focus on energy efficiency, reduced dependence on biomass.
17. Vulnerability of transmission lines	Length of transmission lines/ distribution networks threatened by extreme weather events	Encouragement of varied and distributed sources, development of a meshed grid.
RESILIENCE		
18. Investment assets	Rate of domestic savings/GDP	Starting with investment with local savings, encourage soft energy technologies without climate impacts able to benefit from international cooperation and "Finance Climat" financing mechanisms.
19. Mobilisation of renewable energy potential	Proportion of national investment earmarked for renewable energy and energy efficiency	Fostering of clean investment in energy efficiency and renewables.
20. Local technical capacity	Annual number of science and engineering graduates per total population	Building of local strategic and technical capacities, offer local centres for study and skill development, encouraging local employment.
21. Scientific information	Availability of risk maps (flooding, desertification, contamination)	Facilitating of access to reliable information, published and commonly known.
22. Siting guidelines	Climate-proofing guidelines for power plant siting and construction	Planning of introduction of facilities that are not vulnerable to climate change.
23. Crisis management	Emergency plans for power plants	Provision of clear instructions to increase energy system resilience.
24. Insurance	Availability of domestic insurance policies that account for climate change-related damages	Proposal of adaptation solutions to enterprises, farmers and household to cope with hazards.

CHAPTER 2

FRAMEWORK FOR PLANNING A SMART ENERGY PATH

Soft energy planning requires two types of activities that are complementary and are necessary to maintaining the balance between the economic, environmental and social criteria for ecodevelopment:

- An economic and technological analysis coupled with a backcasting exercise reconciling energy demand with available supply.
- A participation protocol supporting all aspects of the SEP approach.

This chapter covers the technical-economic analysis and backcasting that are at the core of SEP planning. The following chapter looks at the issues of participation and governance.

TECHNOLOGICAL AND ECONOMIC ANALYSIS AND BACKCASTING

The method for conducting an economic and technological analysis for a soft energy planning exercise is determined by the practical orientation (meeting demand) of the latter and by application of a backcasting approach with the aim of exploring different pathways to achieve a desired result (in this case, an energy system compatible with ecodevelopment).

The essential elements of SEP planning are shown in *Figure 3* in the form of a seven-step process. Each step includes a participation component that is described in the Backgrounder *"Successful Stakeholder Engagement"* [9].

9. *http://www.helio-international.org/toolkit/sep*

The individual steps are described in more detail later in this chapter, but there are some characteristics of the overall method that are important to note at the outset.

- Although SEP planning requires more specific information as to how energy is used than traditional supply orientated planning based on forecasts, it can be developed gradually and does not necessarily need to be perfect or exhaustive before being undertaken and implemented. In fact, the SEP planning exercise will identify the information necessary for improvement of the planning in question which is a continuous process of learning and adjustment of programmes and measures in response to both results obtained and new information.

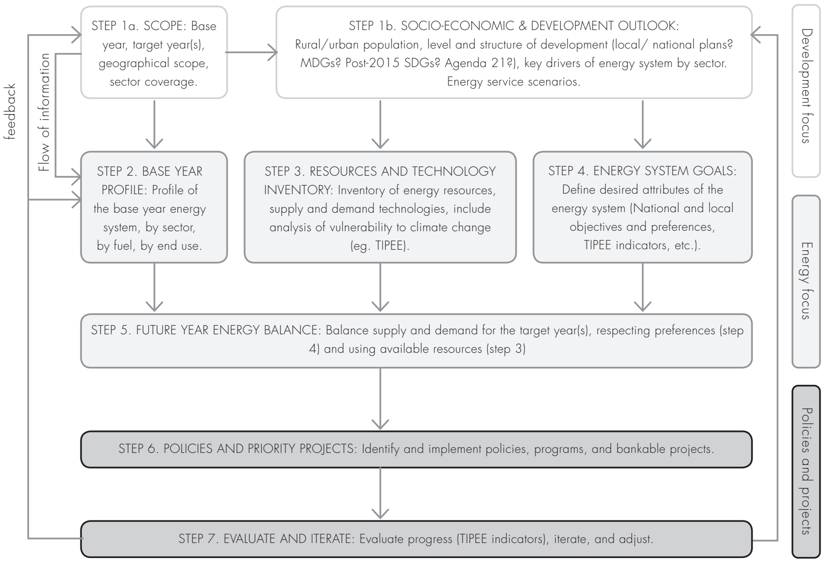
- Although the steps in *Figure 3* are numbered and presented in sequence, planning work can and should proceed simultaneously for most of the steps, especially in the research and information gathering steps: development of the base year profile (step 3); cataloguing of technologies enabling energy efficiency and of the possibilities in this area (step 4); and identification of policies and programmes to be included in the plan (step 6).

- The characteristic SEP planning approach is not to *"forecast"* the future but to *"backcast"* the measures to be taken to establish the future energy system, thereby facilitating identification of the priority policies and projects best suited to achieving progress towards ecodevelopment.

- SEP planning is possible even in situations where available information is limited or is poor. The scenario based approach can be applied not only to the future but also to filling any information gaps when establishing the base year profile. For instance, the analyst may obtain relatively reliable information on total diesel consumption for transport from the national energy balance but only fragments of end-use information such as types of vehicles, fuel energy efficiency, number of trips by vehicles, length and purpose of trips, etc. Using a scenario based approach, the analyst can combine assumptions with available information (e.g. vehicle registration date, standard information on fuel efficiency, local information and information from observations of vehicle movements, etc.) so as to establish a plausible profile by successive aggregations of diesel consumption for the base year. Total diesel consumption from the national energy balance can be used to *"normalise"* this end-use profile, thereby making it possible to determine priorities for gathering of additional reliable data. Meanwhile, the analyst can pursue work with the other elements of soft energy analysis (reference projection, energy efficiency analysis and fuel substitution measures, etc.) while continuing to improve the base year profile by integrating new information gathered and results from the analysis itself.

Figure 3 presents the seven steps of an SEP analysis; each step is examined in more detail below.

FIGURE 3: **Schematic of smart energy path (SEP)**



STEP 1A: SCOPE

A few decisions are necessary to get the process started.

WHAT IS THE GEOGRAPHICAL SCOPE OF THE ANALYSIS?

The language and examples in this guide are based on the assumption that SEP planning is being developed at national level, but smart energy paths can and have been developed for regions, states, municipalities and even villages. In fact, the SEP process can prove to be very effective when applied at the local level, given its emphasis on achieving an efficient match between local demands and local energy resources, the importance of participation by the public and by local stakeholders, and the importance of information from the field.

For instance, it can be seen from *Table 2* that the energy systems in West Africa are different in rural, periurban and urban communities and that there are clear differences between the needs and opportunities in coastal and inland regions. Information and data availability may also vary from one region to another.

TABLE 2. **Issues in rural, urban and periurban areas**

RURAL AREA	URBAN AREA	PERIURBAN AREA
Home to the majority of the population, up to 70%, proportion tending to diminish as a result of extreme hardship driving exodus of populations to periurban areas. Poverty is extreme in rural areas and all of the Millennium Development Goal indicators are at their lowest level. The "smart energy path" should lead to rapid increase of the indicators.	Urban areas are occupied by a minority of the population. A large majority of people there continue to use biomass based fuels (mainly charcoal); they generally use improved stoves (not three stone hearths) and LPG is developing amongst the middle class. The other aspect of the urban energy problem is electricity: appliances (lighting, motors, A/C, etc.) have very mediocre efficiency; growth in demand is therefore strong and inadequacy of means of generation is recurrent.	It is difficult to define the periurban area in geographical, topographical, economic or sociological terms. Populations are highly diverse. Precariousness of housing and of public infrastructure is a constant. The energy issue is complex, combining characteristics of rural areas (need to strengthen social and community services to combat poverty) and of urban areas (presence of industry, commercial services and transport). The actors are at least as numerous as in rural or urban areas. Above all, it is the uncertainty of land tenure that causes difficulty in making choices as to technology and organisation. The sociological dimension of the different populations involved must be analysed carefully.

It may therefore be worth considering an analysis with infra-national scope. While the content of this guide implicitly assumes the analysis will be national in scope, the methods it presents for conducting an SEP study are applicable on a smaller scale. Therefore, establishing a perimeter or *"energy territory"* to which analysis is applied is the initial concern of the study. The perimeter characterises a physical unit (coherence of infrastructure) and an institutional unit (decision making, coherence with decentralisation of institutions ongoing or already effective in a number of African countries).

WHAT IS THE SECTORAL SCOPE OF THE ANALYSIS?

Regarding sector coverage, the implicit assumption throughout this guide is that soft energy planning covers all energy sources and all energy consuming sectors: households, passenger transportation, freight transportation, commercial and institutional activities (including government), and industrial production. However, as with the geographical scope, SEP analysis techniques can also be applied to individual sectors. Focussing on a single sector (e.g. households) or sub-sector (e.g. urban households or rural households) can be a good way to gain experience with the method or to restrict the scope to an area where data is known to be available. The SEP method is very flexible; it is possible to have different levels of detail for different regions and for different sectors depending on the information that is available and the resources available for the analysis. For example, it is perfectly possible, within the same SEP process, to have an analysis of household energy use that distinguishes between regions or between community types (e.g. urban or rural households) and a national analysis of the commercial and institutional sectors without any disaggregation by region or subsector. Detail can be added over time as information becomes available.

WHAT WILL BE THE BASE YEAR?

Availability of information is the most important attribute of the base year in an SEP analysis or any other energy demand analysis. The most recent year for which national statistics are readily available should be chosen. The statistics may cover all sorts of information on energy supply and demand (e.g. electricity sales from national energy balances) as well as information about the demographic and economic determinants of energy demand (e.g. number of households, urban/rural split of population, GDP by sector of activity, vehicle registrations, numbers of schools, hospitals, and other types of buildings, etc.). While assumptions and estimates can be substituted for hard data in any of these areas, it is nonetheless preferable to have a maximum of solid statistical information. Given that, in general, several years elapse before national statistics agencies finalise data profiles, the base year used in an energy demand analysis is usually not the most recent historical year but rather the most recent historical year for which reasonably complete data are available. For example, the national energy balance is an important input to the analysis.

WHAT IS THE ANALYSIS TIME HORIZON ("TARGET YEAR")?

A target year is chosen in accordance with the timeline for the energy plan. It may be useful to synchronise the analysis target year with the planning horizon of the national economic development plan or Agenda 21. It is also possible to determine a number of years between the start of the analysis and the target year and to set many intermediary milestones. As some measures for improving energy efficiency require capital stock turnover or infrastructure investments that are relatively long term, it seems reasonable to suggest that the target year be at least twenty years in the future. It may be useful to have more than one *"milestone"* year so that both medium term and longer term scenarios can be developed. For example the years 2030 and 2050 could be used for a plan developed in 2014. When analysis is at the local level, a closer horizon is certainly preferable; local development plans usually have horizons of around five years.

STEP 1B: SOCIO-ECONOMIC OUTLOOK

WHICH CURRENT AND FUTURE ECONOMIC AND DEMOGRAPHIC CHARACTERISTICS NEED TO BE CONSIDERED?

Knowledge of the socio-economic situation and expected development for all of the population in the perimeter and by the chosen time horizon is a required foundation for the approach to developing an SEP. The energy system has relevance for all activities contributing to socio-economic development. Socio-economic development is defined by considering values for the base year (reference situation) and for the target year; it includes characterisation of, notably:

- population data (headcount, age, number of households, dwellings);
- economic data, such as activities involving all members of the population (agricultural, crafts, trade), people's income, poverty level;
- social and health data, such as the level of school attendance, infant and maternal mortality rate, number of social and communal amenities (health, education, religion, markets, street lighting, leisure, etc.) either already existing or planned, and with which energy services are associated;
- environmental data such as local emissions of pollutants, deforestation;
- institutional data, such as existence of national or local policies and strategies (e.g. village development plan; and
- desired objectives for all of the above-mentioned elements.

The formulation of hypotheses concerning the population and economic activities that the future energy system will have to support is a prerequisite for consensus development of a vision of what the future energy system should be if it is to correspond to the goals for the target year. The hypotheses may be relatively general (e.g. total population, number and make-up of households, breakdown of households between urban and rural areas, GDP per sector, etc.). The Millennium Development Goals can contribute to choice of hypotheses.

Most SEP studies adopt official figures on future population, household patterns, migration and economic growth. This allows a comparison, all economic and demographic hypotheses being otherwise equal, between conventional energy paths and *"soft"* paths. Holding demographic and economic assumptions constant allows the costs and benefits of adopting the alternative energy path to be clearly related with the attributes of the soft energy technologies.

It may be useful to explore more than one scenario of demographic and economic activity when considering alternative energy strategies and policies. Understanding the sensitivity of the energy system to demographic, migratory and economic variations helps foster development of energy plans that remain relevant in the face of a number of possible futures. Moreover, the exercise can lead to changes in policies in areas such as industrial and economic development that are not necessarily perceived as energy policies but which nevertheless are influential in determining the prospects for sustainable energy and ecodevelopment.

We recommend starting with a single future: the government's official projections for population and economic activity for the target year. Once a smart energy path has been developed for this future date, sensitivity analysis of the results to different starting assumptions about population and economic activity in the target year can be conducted (following the feedback loop between steps 7 and 1 in *Figure 3*). For example, consider the impacts on energy demand from various distribution scenarios for industrial activity between different sectors, for migratory flows between rural and urban areas and for population and economic growth.

STEP 2: BASE YEAR PROFILE
HOW IS ENERGY CURRENTLY BEING USED?

The aim of this step is to establish a quantitative and qualitative description of the way energy is used in the base year, by source, sector, sub-sector and end use. Drawing up this profile – providing a view of the current situation, of the level and pattern of energy services provided and of the gap between the current situation and goals for the future energy system – is one of the most important steps in conducting an SEP analysis. Lack of detailed data must not be seen as an obstacle. First, the initial level of description is qualitative; this is essential to understand the nature of energy service needs and the ways in which they are met in the base year. Second, surveys can be organised if necessary, or proxies can be used for quantification. A field trip planned over a few days can be used to get an *"idea"* for the base year. A few weeks or even months will be necessary for surveys.

The first step is to create the general framework: a list of sectors, subsectors, fuels used, and energy services for each sector. The national energy balance should be used as the starting point plus other standard sources of information on fuel and electricity use that may be readily available, to define sectors and different types of fuels and electricity used. The qualitative aspects of the various energy uses – different heat temperatures for different uses, specific types of electricity, mobility – can then be evaluated.

SUB-SECTORS

The national energy balance will indicate the essential sector definitions: household, commercial/institutional, transportation, agriculture and industry. Subsectors should be differentiated as required on the basis of energy consumption patterns. The residential sector, for example, can be subdivided into rural, periurban and urban households in recognition of the distinct characteristics and source dependencies of these three types of households. This information will allow for a timely account of the likelihood that different policies and programmes may be required for these different types of communities. The industrial sector can be subdivided in terms of activities, particularly if there are one or two industrial subsectors that dominate production and that have unique energy use characteristics. In the case of commercial buildings, there may be no need to further divide into sub-categories (e.g. offices, shops, schools, hospitals, etc.) and, even when division is desirable, the data necessary to make it relevant to the analysis may not be available. It is possible to select two sub-sectors corresponding to one or two types of buildings of particular interest and worthy of separate analysis, the other buildings being integrated into a single *"other buildings"* sub-sector. The transport sector must, at a minimum, be subdivided into personal and freight transportation, with additional disaggregation by vehicle type or by trip type as required, and as permitted by the available data.

ENERGY SOURCES

For each sector, a list should be made of energy sources used or likely to be used in the future. Human and animal power should be included where they are known to be significant.

END USES AND ENERGY SERVICES

A SEP analysis requires a breakdown of final energy use and of energy services. It does not matter if the list includes energy services for which the analysts know they will not be able to find data; the point of the exercise is to create a framework for understanding the different ways in which fuels and electricity are used. Lists will differ from one part of the world to another and even within a sector there may be significant differences in the way in which energy is used in different circumstances: for example, the end uses in rural households may be somewhat different from the end uses in urban households.

Table 3 describes the different aspects to be considered in an SEP analysis with an African focus, including socio-economic sub-sectors, energy uses and final energy forms.

TABLE 3. **Socio-economic structures, energy uses and final energy forms**

<table>
<tr><th colspan="2">TYPES OF SOCIO-ECONOMIC SECTORS</th></tr>
<tr><td colspan="2">• Social services and infrastructure: health, education, drinking water pumping and supply.
• Community services and amenities: administrative centres, places of worship, markets, multi-purpose venues, street lighting.
• Structuring agricultural: irrigated areas under public or cooperative management (rural).
• Income generating activities: small agricultural (rural), craft or trade facilities.
• Industrial units: agro-food, metallurgical, textile and other industries.
• Passenger and freight transport.
• Households.</td></tr>
<tr><th colspan="2">TYPES OF ENERGY USE</th></tr>
<tr><td colspan="2">• Cooking, water heating, “three-stone” hearth, improved stoves, LPG stoves, solar stoves.
• Motive power (human and animal): carrying, milling, multi-function units, drinking water conveyance and distribution, standalone generators, craft machine tools, welding sets, vehicles and others.
• Lighting and other specific uses: oil lamps, hurricane lamps, bulbs, refrigerators, ventilators, telecommunications, IT devices, electrical appliances, air-conditioners and others.</td></tr>
<tr><th colspan="2">TYPES OF FINAL ENERGY</th></tr>
<tr><th>TRADITIONAL ENERGY</th><th>MODERN ENERGY</th></tr>
<tr><td>• Traditional biomass (collected, charcoal) and waste
• Animate motive power
• Lamp oil
• Electricity from reused vehicle batteries and other batteries
• “Illegal” electrical connections (“non-technical losses” on electricity grids)</td><td>• “Sustainable” biomass and charcoal (controlled forests and rural markets), biogas, sustainable liquid biofuels
• LPG
• Fuel oils
• Electricity from national grid / local grid
• Electricity from solar, wind, hydro, geothermal sources.
• Electricity from rechargeable batteries</td></tr>
</table>

Table 4 illustrates a possible framework for the characterisation of energy demand per sector or sub-sector, fuel and end use, including the activity unit applied for each sector.

TABLE 4. **Example End-use Framework for Smart energy path Analysis**

SECTOR	UNIT OF ACTIVITY	SUB-SECTOR	FUELS	END-USE SERVICES
Residential	No. of households	Rural Peri-urban Urban (apartment, house)	Fuelwood Charcoal Electricity Bottled gas Piped gas	Lighting Cooking Electronics Water pumping Refrigeration Air conditioning Heating
Commercial	Square metres of floor area	Administrative Shops Schools Religious buildings Hospitals Other	Piped gas Electricity Bottled gas Fuel oil	Lighting Electronics Air conditioning Heating Motors and equipment Hot water
Personal transport	Person-km or vehicle-km of travel	Walking Cycling and human-powered vehicles Motorbikes Cars Buses Transit	Gasoline Diesel Biofuel Biodiesel Human power Animal power	Person-km of mobility
Freight transport	Tonne-km or vehicle-km of travel	Human-powered vehicles, carts Small trucks Large trucks	Diesel Biofuel Gasoline Human power Animal power	tonne-km of goods movement
Industry and Agriculture	Dollars or tonnes of output	Cotton Food-processing Coffee Phosphate Palm Products Mixed crop	Piped gas Bottled gas Biomass Electricity Biofuel Diesel Biodiesel Fuel oil	Process Heat Motive Power Stationary power Lighting Information processing and electronics Hot water

ACTIVITY UNIT AND PENETRATION RATE

The activity unit and penetration rate are important concepts in energy demand analysis that need to be defined. They can be used for estimates of energy consumption for a base year when corresponding data are not readily available and for modelling of future energy use scenarios.

With the simple formula below the values of these two parameters can be used to calculate energy consumption for any end use or particular service.

<table>
<tr><th colspan="2">[ENERGY USE] = [ACTIVITY UNIT] X [PENETRATION RATE] X [ENERGY INTENSITY]</th></tr>
<tr><td rowspan="3">WHERE:</td><td>ACTIVITY UNIT is the driver of energy use. The most common choices are:
• households for residential energy services and end uses
• square metres of floor area for commercial buildings
• person-kilometres of travel for personal transportation
• tonne-km or vehicle-km for freight transport
• output or value added (in currency or physical tonnes of output) for the agricultural and industrial activities.</td></tr>
<tr><td>PENETRATION RATE is the percent of the activity to which the energy service in question is applied. So for example, if 25% of households have electric lighting, then the penetration for calculating the energy needed or electric lighting in households is 25%.</td></tr>
<tr><td>ENERGY INTENSITY is the annual energy use per activity unit for the energy service. For example, if houses with electric lighting use 100 kilowatt-hours per household for electric lighting, then the energy intensity of electric lighting is 100 kWh per household.</td></tr>
</table>

This formula is used in energy demand analysis in two important ways.

- First, to establish an energy profile for a base year. It is sometimes the case that there is more reliable information for activity units, penetration rates and energy intensities than for actual energy consumption. In the above example, if the penetration rate and energy intensity for electric lighting are known (or can be reasonably estimated) and there are one million households, then the base year electricity consumption for household electric lighting can be estimated as: 1,000,000 (households) × 25% (penetration rate of electric lighting) × 100 kWh (energy intensity per household) = 25,000,000 kWh.

- Second, the formula can also be used once the energy profile for the base year has been established, to estimate future energy consumption scenarios by varying the three parameters. Continuing with the example above: if the number of households for the target year is expected to reach 1.5 million (as per Step 1 – Scope), the proportion of households with electric lighting is assumed to be 40% and technological progress allows consumption of electricity for this type of service to be reduced by 20%, then electricity consumption for household lighting for the target year can be estimated to be: 1,500,000 (households) × 40% (penetration rate of electric lighting) × 80 kWh (energy intensity per household) = 48,000,000 kWh.

USING MODELS

The approach using estimation of past and future consumption of different energy services can be applied with a wide spectrum of levels of sophistication, from the basic exercise illustrated above through to highly disaggregated schematics based on computer models enabling tracking of stocks and energy consumption flows for several buildings and several consuming load items and simulation of marginal changes in energy efficiency and fuel choices over time. There are many exhaustive energy planning computer models that can be used. However, the analyst may also use spreadsheets to record data and analyse measures envisaged in the planning framework. This method offers the unique advantage that, in designing and finalising spreadsheets, the analyst is faced with the actual problems to be solved and nothing else, since the tool developed will include only the functionalities needed. The analyst's work will be wholly transparent.

FILLING THE FRAMEWORK USING BASE YEAR DATA

Once a framework has been established for disaggregating energy consumption by sector, subsector, source and end use, the next task is to start filling in the data. The national energy balance will usually give totals for fuel and electricity for each sector, and sometimes for subsectors. An energy consumption table can then be built *"from the bottom-up"* using the sector totals by fuel in the energy balance to *"calibrate"* the exercise. As direct data on different energy services is rarely available at the national level, the art of developing an energy consumption profile per energy service consists in using the available data with informed assumptions and deductive reasoning to create a plausible description of how the fuel and electricity use totals in the national energy balance break down by subsector and by energy service.

There are a number of short-cuts and *"tricks of the trade"* that can help build the end-use service profile. Here are a few of them:

- Although there are, in theory, many possible subsector/fuel/energy service combinations within the framework of *Table 2*, many of them are not practically relevant (e.g. charcoal/lighting, fuelwood/air conditioning) and in most situations four or five combinations of this type will cover practically all energy consumption for a given sector. So, while the overall framework may seem daunting, it will usually only be necessary to quantify a small number of subsector/source/energy service combinations.

- In some cases there is a very direct relationship between the energy consumed for a particular sector/source combination (which can be found in the national energy balance) and the energy used for a given end use. For example, gasoline used in the transportation sector is almost always used for transportation by automobile. Similarly, unless there are significant numbers of diesel cars in use, diesel fuel use in the transportation sector can be assumed to be for trucks. Biomass use in the household sector is for cooking and hot water, and kerosene use in the household sector can often be exclusively associated with lighting.

- There are very often surveys or even specific technical studies that shed light on the energy intensities of different end-use services in different sectors. As described above, this type of data can be combined with facts or estimates of activity levels and penetration rates to obtain reasonable estimates for a particular end use. In the industrial sector, there are often a small number of plants (sometimes only one or two) that account for most of the industrial fuel and electricity consumption. With cooperation from these firms, information about their fuel and electricity end uses can go a long way towards determining the details of energy consumption in the industrial sector.

- For any particular end-use service, energy intensities will tend to be fairly uniform or be limited to a small number of values that reflect subsector attributes or variations in local circumstances. For example, the energy use per square metre of office building floor area will generally not be too different from one office building to the next, at least within a particular city. If information about the end use profiles for the office buildings sub-sector or even for one or two *"typical"* buildings can be obtained (there may have been a building energy audit or the utility may have data) and if the total floor area of offices is known or can be estimated, these three items of information can be combined to produce an estimate of the total energy consumption per end use for all of the office buildings.

- When using methods like this it is important to remember that the purpose of the exercise is not to produce the most accurate possible measurement of energy consumption by subsector and by service to end users but to obtain a credible and plausible *"bottom-up"* explanation of how energy is used, while ensuring that sector totals match the national energy balance. It is not necessary to be overly precise, nor is it necessary to count every sub-sector/end-use service combination, or to get the base year profile *"perfect"* before moving on to the other energy planning steps. The profile can be continuously updated and improved as knowledge of energy demand patterns develops.

STEP 3: RESOURCES AND TECHNOLOGIES INVENTORY

WHAT ENERGY RESOURCES AND TECHNOLOGIES ARE AVAILABLE, WITH A FOCUS ON TECHNOLOGIES THAT IMPROVE EFFICIENCY?

This step can commence at the outset and continue in parallel with other activities throughout the planning cycle. It involves identifying candidate energy efficiency and renewable energy supply and demand technologies for inclusion in SEP planning. In this step, the focus is on technologies and techniques that increase the long-term viability, efficiency, resilience and environmental performance of the energy system (for example, replacing kerosene lamps with solar powered lighting). The aim here is not to highlight policy and programme measures to accelerate deployment of the technologies; such policy and programme measures are considered in Step 6.

On the demand side, work involves the systematic assessment of the potential for improved energy efficiency for each sector and each end-use service. For technologies improving energy efficiency, key information includes the marginal reduction in energy intensity that the technology can achieve, and the capital cost associated with this improvement. For new equipment, this means the marginal cost, if any, of the energy-improving technology and the marginal reduction it achieves relative to the status quo. In the case of building retrofits, the relevant data includes the cost of the retrofit and the amount of energy saved relative to the building's consumption prior to the retrofit.

For supply side technologies, the goal should be to produce a comprehensive assessment and mapping of the availability of the various renewable energy resources, including their capital and operating costs. In addition, the vulnerability of the energy source to climate change should also be assessed.

STEP 4: ENERGY SYSTEM GOALS
WHAT IS THE DESIRED FUTURE?

This step involves setting targets for various attributes of the energy system to be achieved by the SEP planning target year. To an extent, these goals are embodied in the nature of ecodevelopment and the smart energy path itself: a reliance on clean renewable energy, decentralised matching of energy sources to demands in terms of quantity and quality, and a commitment to diverse, flexible and *"user-friendly"* technologies that support participatory governance, community self-reliance and environmental sustainability.

In SEP planning, goals for the attributes of the energy system should be explicit and used to guide technological choices in the development of the plan. The goals will depend on local circumstances and the priorities governing the particular planning exercise; the following are some of the attributes of the energy system for which goals could be set:

- Greenhouse gas emissions from the energy sector (TIPEE 1[10]).
- Concentration or emission levels of predominant local pollutant (TIPEE 2).
- Proportion of households with access to clean cooking fuel (EDI[11]).
- Percentage of electricity provided by renewables.
- Hectares of deforestation due to energy uses (TIPEE 3).
- Proportion of households with access to electricity (EDI, TIPEE 4).
- Per capita household electricity consumption (EDI).

10. For reference and numbering of TIPEE indicators see Table 1.

11. EDI: the International Energy Agency's Energy Development Index.

- Proportion of household income spent on energy services (**TIPEE 5**).
- Hours per week per household spent in fuel and water procurement.
- Target for access to modern energy services for health and educational infrastructure, places of worship, water pumping, markets, street lighting, productive activities.
- Improved household penetration.
- Electrical independence (not dependent on national grid) (**TIPEE 6**).
- Weight of expenditure for energy in household budgets (**TIPEE 5**).
- Energy intensity of industrial production (**TIPEE 9**).
- Energy intensity of the economy (**TIPEE 9**).
- Number of recorded cases of illness from energy-related atmospheric pollution.
- Total national investment in clean energy infrastructure and technologies.
- Per capita electricity consumption in the public sector (**EDI**).
- Percentage of total energy use in productive sectors (**EDI**).
- Local renewable energy supplies (**TIPEE 8**).
- Duration and frequency of power cuts (**TIPEE 10**).
- Percentage of energy revenue escaping income tax (**TIPEE 11**).
- Proportion of national investment in renewable energy (**TIPEE 19**).
- Number of science and engineering graduates in the population (**TIPEE 20**).
- Length of transmission lines threatened by extreme weather conditions (**TIPEE 17**).
- Number of citizens, and particularly of women, involved in energy planning (**TIPEE 13**).
- Balance between demand side and supply side actors in energy planning (**TIPEE 14**).

Some of these lend themselves to the quantitative dimension of energy planning and some do not. Furthermore, this is only a partial and illustrative list. Analysts must ask themselves: what are the most important attributes of the energy system that stakeholders would like to see improved through the implementation of a smart energy path?

SOFT ENERGY AND LEAST COST ENERGY

Several **SEP** studies have used a *"least cost"* criterion to determine the demand and supply options included in the plan. Given that some new (soft) energy options – energy efficiency in particular – are much less expensive than conventional energy, this will usually result in an energy plan that is much *"softer"* than a purely business-as-usual plan. This least cost approach has the advantage of leading to an energy plan that will be demonstrably economical in the narrow sense of the term, bearing in mind, however, that it will not necessarily achieve the levels of efficiency, renewability and resilience required to achieve the goals of sustainable ecodevelopment.

It has been determined that very often dividing the incremental cost represented by investing in an energy efficiency improving technology (when spread over the life of the technology, i.e. annualised) by the annual fuel or electricity savings achieved by the technology gives a *"saved energy cost"* (i.e. a monetary value per Joule or kWh saved) which is lower than the incremental cost of supplying an additional unit of energy. This finding created interest in *"least cost energy planning"* in which the goal was an energy system in which costs were minimised by ensuring that supply and demand alternatives were compared on a *"level playing field"*, using symmetrical methods. Even without including the costs of the environmental externalities, which were one of the main reasons for adopting the smart energy path, least-cost planning would very often favour investments in the soft energy technologies because they could be shown to be cheaper. Smart energy path plans were often produced that were actually more like least-cost energy plans insofar as energy system choices were limited to solutions that could be shown to be less expensive than the conventional *"hard path"* alternatives.

The *"least cost"* objective is a legitimate criterion for guiding energy planning exercises. It will almost always result in a *"softer"* energy path than *"business-as-usual"*. Such a strategy is particularly effective at highlighting the policies and market barriers that have resulted in current energy systems that are not the least costly solutions. When the energy security and environmental objectives of energy policies were more modest than those made necessary by the threat of climate change, by globalisation of toxic and radioactive pollution or by the goals of ecodevelopment, a least-cost approach was sufficient to point out the significant saving potential from energy efficiency, as much as 30% or more, compared to business-as-usual. However, SEP planning goes beyond the least-cost approach. This does not mean it results in a more expensive energy system! On the contrary, it is the soft path approach, with its emphasis on efficiency and renewable energy, which offers the greatest promise for avoiding the incalculable costs of perpetual poverty, ecosystem collapse and climate change.

STEP 5: BALANCING ENERGY SUPPLY AND DEMAND FOR THE TARGET YEAR

SATISFYING FUTURE DEMANDS WITH AVAILABLE RESOURCES AND TECHNOLOGIES

This is where all the work done in the previous steps comes together in an energy supply and demand scenario for the target year. The scenario can be built with different levels of complexity, ranging from a simple spreadsheet balance to a large and data-intensive computer modelling exercise. The central objective is the same in each case: to combine the supply and demand resources identified above in Step 4 with the demographic and economic future identified in Step 1 to achieve an energy balance meeting the goals for the energy system defined in Step 2.

The simple formula described in Step 2 can form the basis for developing future scenarios. The product of future activity levels (e.g. households, floor areas of commercial buildings, personal and freight transportation, industrial and agricultural output), penetration rates, and energy intensities (from the Step 3 research) gives energy use in the target year at the level of disaggregation by subsector and end use applied in the research and data collection.

THE "OPTIONAL REFERENCE" PROJECTION

Usual practice in SEP analysis is to generate a *"reference projection"*, that is to say a purely business-as-usual energy-use future based on extrapolation of current levels, trends and policies. The reference projection is not a forecast, or does not need to be. Its purpose is to provide a point of reference for the analysis of measures, and to clarify the relationship between projected population, economic activity and the corresponding levels and patterns of energy-use services. It then serves as a starting point for an analysis that aims to reduce the intensity of fuel and electricity consumption, increase energy efficiency, and switch to carbon-free energy sources. It can be generated from a computer model and highly sophisticated treatment of the evolution of the contribution of each source and of its energy efficiency within a detailed stock-and-flow representation of energy-using equipment, or it can be generated very simply with a spreadsheet and broad-brush assumptions.

STEP 6: POLICIES AND PRIORITY PROJECTS

WHICH POLICIES AND MEASURES WILL SUPPORT DEPLOYMENT OF THE DESIRED AND NECESSARY TECHNOLOGIES?

Once a scenario of the future energy balance has been obtained for the target and selected intermediate years, the next step is to identify the policy measures that would be required to deploy the technologies in the backcasting scenario at a rate that will ensure they are in place by the target year.

Within the energy system, there are well developed policy strategies for accelerating the deployment of new technologies on the supply and demand side, notably financial incentives, regulations, direct public investment, information and training programmes, etc.

National SEP managers have identified a wide range of tools for short, mid and long term use. HELIO International's Guide for Decision Makers[12] presents 36 examples of possible instruments.

WHAT ARE THE PRIORITY PROJECTS?

In addition to developing a set of policies for implementing the SEP scenario, it is also useful at this stage to identify certain specific priority projects. The target-driven nature of the SEP approach lends itself to the identification of focused campaigns, e.g. achieving 50% penetration of household electricity access or building a specified number of village-based photovoltaic power systems, etc. Criteria for identifying and prioritizing projects should be developed and should also include emphasis on their attractiveness to outside investors.

WHAT ARE THE SOURCES OF FINANCING?

Energy projects designed with the SEP approach are in line with the principles of ecodevelopment and, notably, make use of encouraged alternative practices. Insofar as they help to combat climate change, they are eligible for financing made available specifically for that purpose. This financing comes under industrial countries' public development aid (PDA) programmes (bilateral or multilateral agreements). Developing countries also have access to financing directed more specifically at preventing climate change. A deeper analysis in the light of policies and priority projects will enable development of a *"roadmap"* to establish

12. http://www.helio-international.org/project/eera contact with national and international institutions to establish conditions of access to financing.

STEP 7: EVALUATE PROGRESS, ITERATE, MAKE JUDGEMENTS

SEP planning is a process of continuous adaptation in which results are compared with the target attributes of the energy system (Step 3), followed by a repeat of the exercise from Step 1 through Step 7 (with the exception of Step 2, the base year profile, which does not need to be repeated).

CHAPTER 3

STAKEHOLDER AND PUBLIC INVOLVEMENT THE KEY TO SUCCESS

AN EXPERT MANAGEMENT TEAM WITH VARYING BACKGROUNDS

The **SEP** approach requires a mix of technical expertise and inter-personal skills to ensure full stakeholder participation. On the technical side, it requires the ability to research and evaluate technology options, analyse their respective costs and benefits, and conduct integrated, quantitative analysis. In this context, availability of data is always an issue, and an innovative, flexible and pragmatic approach to the problem is required. The *"participation"* component of **SEP**, for its part, requires good facilitation skills, an ability to understand and empathise with stakeholder objectives, and to work closely with the technical team to ensure that stakeholders' requirements and the information they provide are actually taken into account in the technical analysis and scenario development.

In the early stages, the participants, i.e. the project initiators, are often civil servants and politicians, possibly with the assistance of experts (consultants, NGOs, universities). They may form a key technical group responsible for technical analysis and stakeholder mobilisation.

Indeed, almost all ministries and government agencies need to be involved via their representatives if **SEP** planning is to be successful: finance, science and technology, skills development and education, environment, health, energy planning, agriculture, housing, infrastructure, economics and industry. In this context, each agency and ministry must grasp the usefulness of the **SEP** process in attaining important objectives that are of direct relevance to them. Not-for-profit organisations, universities and funding agencies may also be involved.

All of these stakeholders – who can be grouped in seven categories, are directly or potentially concerned by the development of energy policies and strategies (*Figure 4*) – can participate in a liaison committee supporting and monitoring the overall approach (*Figure 5*).

FIGURE 4. **The seven categories of stakeholders concerned by energy policy and implementation of energy programmes**

PUBLIC BODIES	PROVIDERS OF GOODS AND SERVICES	PROVIDERS OF GOODS AND SERVICES
Public institutions develop and implement energy policies and sectoral policies, regulations and monitoring; they also instigate policy. There are several levels of organisation: • Supranational: economic communities, energy pools; • Centralised national: all ministries, government agencies, centralised and devolved departments, regulatory commissions, etc. including sectoral departments (health, education, agriculture, industry, spatial planning, etc.); • Decentralised national: all local authorities, appointed or elected (regional, municipal).	Involved in energy delivery. Firms and NGOs providing services such as design, management, legal advice, economic studies, energy service operation, transport, etc., procurement of energy producing equipment when this is not provided by the energy operator. For example, design engineering firm, system installer, private individual generating electricity sold to an energy operator, energy service operator.	Public or private companies supplying final energy: electricity companies, oil companies, energy distributors, cooperatives of charcoal producers or carriers, etc.

USERS AND BENEFICIARIES (INDUSTRIES, HOUSEHOLDS, FARMS)	FINANCIAL SERVICES	FACILITATORS	INTERNATIONAL FINANCING INSTITUTIONS
People and legal entities using energy services. These are customers of energy operators and energy services. They may also be energy producers.	Banks and loan and micro-credit establishments providing local financial support to project owners, operators, firms and households.	Any actor concerned indirectly by the service to be provided, notably members of civil society playing a catalysing role: research and standards organisations, universities, NGOs, consumer groups, journalists, trade unions, etc.	The IFIs are involved directly in setting up energy programmes aimed specifically at poverty alleviation. They are multi-lateral and bilateral funding agencies.

The example of multi-sectoral committees can also provide a basis for mobilisation of stakeholders.

FIGURE 5. **Two teams at two levels of intervention.**

TECHNICAL TEAM	LIAISON COMMITTEE
MAIN RESPONSIBILITY Research and analysis of the country's current and future energy situation.	MAIN RESPONSIBILITY Interface between the technical team and main decision makers.
SPECIFIC RESPONSIBILITIES Evaluation of national resources to meet present and future energy service needs by study of demand and supply. Use of these results to design an SEP within an ecodevelopment framework actively involving all of the country's energy sector stakeholders. Collect and share lessons learned and experience gained in the country in terms of decision making processes and prospective studies in the area of energy.	SPECIFIC RESPONSIBILITIES Ensuring that the principles of an SEP in line with ecodevelopment criteria are shared by the stakeholders and, notably, by decision makers. Examination of the position of energy services in regional, national or local projects, programmes and policies (fighting poverty, energy, economic development, etc.) and recommending of corresponding legal and institutional measures to competent authorities.
TYPICAL MEMBERSHIP Small number of people (5–6) available to work on data collection and analysis and mobilisation of stakeholders, expert energy analysis, climate change, environment, ability to think beyond conventional energy indicators. Ideally: Experts from ministries in charge of energy, environment and from civil society.	TYPICAL MEMBERSHIP Members are from the main bodies involved directly and indirectly with energy and ecodevelopment issues. Some participants may also represent social or productive sectors such as health, education, water, rural development, etc. from specialist ministries and agencies or NGOs sensitive to the advantages of developing energy services in their sector of activity.

NATIONAL SEP APPROACH
(UNDER THE MINISTRY OF ENERGY OR DEVELOPMENT)

CASE STUDY:

National Multi-sectoral Energy Committees in Africa

Born at the start of the 21st century, the multi-sectoral approach had high ambitions. "Multi-sectoral energy groups" have been created in most African countries by and within the ministries responsible for energy. They include representatives from the sectoral ministries (health, education, etc.), cross-cutting organisations (ministries for economy, those tasked with decentralisation, in charge of poverty alleviation strategies), and sometimes representatives from civil society, private enterprise, and financial organisations. Creating such groups was a definite success: "clients" (potential users of energy services on the demand side) and suppliers (energy operators) at last had the opportunity for dialogue, to understand one another and undertake joint programmes for better access to energy services.

But the limits to the actions of multi-sectoral energy groups also became evident. Absence of a suitable method to identify and rank energy service needs prevented the groups from acquiring a degree of legitimacy that was essential for their action. In addition, it was necessary to adapt countries' legal and institutional frameworks for energy access programmes to be implemented. The notion of "energy service" is wholly absent from legislation in most countries.

DESIGN OF AN SEP PARTICIPATION PROTOCOL

Participatory governance is the cornerstone of ecodevelopment and the SEP focus on energy services provides a solid and pragmatic justification for participation of the public, local actors and as wide a range as possible of government officials. Such participation is effective proof of the essential nature of SEP for implementation of new technologies that are better distributed on both the demand and supply sides.

The project initiators' initial task is to examine the reason why they need a soft energy plan. An examination of the need must consider alternative ways to meet that need (i.e. other energy planning methods including the consequences of doing nothing – the business as usual or null hypothesis). All parties to the project must feel they have a stake in the success of the SEP planning process and must be aware that, in comparison to other energy planning methods, SEP achieves the most benefits for the greatest number.

Each participant in the SEP process must also understand why they are involved and why the others are involved. This understanding can only be reached if everyone's aspirations are clear to all. A professional facilitator can be helpful to keep all government departments and agencies engaged in seeking common ground wherever it exists and to regularly check back with participants to see that their views are being given proper consideration. To ensure that all government agencies and ministries cooperate to attain mutually favourable results, common objectives must be laid down in writing and diversity of opinion must be respected.

The document *"Backgrounder: Successful Stakeholder Engagement"*[13] illustrates the way in which a participation protocol can contribute to every stage of an SEP.

SEP planning is an iterative process that needs to be refined regularly, every few years or more frequently depending on circumstances. It can be hoped that a country's energy situation will improve as the SEP plan produces tangible results for energy efficiency and self-sufficiency of energy supply.

BENEFITS FOR ALL

In the context of energy, the term *"cobenefits"*, short for *"collateral benefits"* refers to outcomes of the energy plan which are not the direct goals of the plan but that are nevertheless beneficial and that are often important justifications for supporting the plan. A few examples:

- **EMPLOYMENT.** An energy plan that emphasizes energy efficiency will generally create more employment per dollar of investment than an energy plan that emphasizes investments in central power plants.

- **AIR QUALITY.** An energy plan that emphasizes renewables and energy efficiency will have lower emissions of both indoor and outdoor air pollutants.

- **COMPETITIVENESS.** Efforts to improve energy efficiency not only save the direct costs of the saved energy but the focus on the end-use services and processes required to identify the energy efficiency opportunities very often lead to better supply-chain performance, internal operation efficiencies, and increased institutional capacity that enhance overall competitiveness and innovation capacity.

- **BALANCE OF PAYMENTS.** For oil importing economies, energy plans that emphasize efficiency and the development of indigenous supplies of distributed energy can have the significant cobenefit of reducing the foreign exchange earnings needed to pay for imported oil.

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13. http://www.helio-international.org/toolkit/sep

- **SCIENTIFIC AND TECHNOLOGICAL CAPACITY BUILDING.** An energy plan that matches energy end uses and supplies with local resources stimulates indigenous technological know-how and capacity, both in short supply in developing countries.

- **ECONOMIC AND SOCIAL BENEFITS.** Saving energy saves money, and energy plans that give priority to efficiency of energy service provision free up financial resources for other economic development objectives and social programmes, or for accelerated deployment of energy solutions.

- **STRENGTHENED DEMOCRACY.** An energy plan that deliberately engages stakeholders, communities and service providers in the identification of solutions for energy service needs will inevitably lead to strengthened democracies.

- **SELF-RELIANCE.** An energy plan that seeks to match energy end-use service demands with local and indigenous resources leads to a greater level of self-reliance at both the community and the national level.

- **REDUCED DISPARITY BETWEEN RICH AND POOR.** An energy plan that focuses on energy services results in more energy service being delivered per unit of fuel or electricity consumed, and this differentially helps the poor who utilize technologies with the lowest efficiencies and who have the lowest level of energy services.

These are just a few examples and cobenefits often emerge unexpectedly as the energy plan progresses. In fact, the cobenefits of an energy plan are often more highly valued than the direct energy outcomes of the plan, and energy planners who keep this in mind will often find that support for their proposals will depend on the extent to which they are able to demonstrate the cobenefits their plan may deliver.

The SEP protocol starts with an assessment of the demand for energy services and gives priority to the earliest possible involvement of stakeholders in development of the energy plan – stakeholders whose first concern will be *"how can the energy plan help me?"* – the approach to energy planning described in this guide virtually guarantees that cobenefits are an important component.

CHAPTER 4

CONCLUSION

Energy planning is far less problematic in industrialised economies than in developing countries, where there are typically large differences between the current situation and the prospects for improvement, between urban and rural areas and between the rich and the poor. Although it is true that supply-orientated energy strategies based on grid transmission of centrally generated electricity, requiring ever increasing amounts of usually imported fossil fuels, have provided for some industrial growth and met the transportation and modern energy service demands of urban elites, these strategies have also proven a slow and costly path to self-reliant economic development, and barely a trickle of the supply reaches the rural and urban poor.

Poverty is characterised by low levels of energy services, sometimes even inadequate to meet basic human needs. The prime focus of energy policies is often to increase supply of electricity and fossil fuels, disregarding the fact that the infrastructure to guarantee reliable access to this energy is costly and concentrated essentially in urban areas. Even in urban areas, and in rural areas where the grid is available, connection costs and electricity tariffs make access to the grid unaffordable for poor households, which remain reliant for their energy supply on their own labour, gathered fuelwood, and kerosene for lighting.

Conversely, the SEP planning approach outlined in this guide – with its emphasis on energy services and the priority it gives to improved energy efficiency – can make the energy sector a true instrument for sustainable development. An energy plan that starts with an assessment of energy service needs is more likely to identify technologies and solutions that will be effective in promoting self-reliant development than a plan that assumes a *"trickle down"* effect from increased supplies of centralized grid electricity and more imported fossil fuels. This is not to say that there will not be a role for increased electrification and increased use of fossil fuels in developing country energy strategies. But the SEP approach described in this manual, with its focus on access to energy service for all, will point the way to many other strategies for promotion of development, strategies that are often overlooked altogether in the traditional, supply-orientated approach to energy.

Amongst all of the characteristic aspects of the SEP approach, the importance given to improving energy efficiency is capital. Each marginal improvement in the efficiency with which a barrel of oil or a kilowatt of electricity is used frees energy that can be used to supply additional energy service elsewhere.

The focus on energy services also draws attention to the critical role of biomass and human and animal energy, particularly in the less developed countries. Even with a concerted effort on electrification and increased mechanisation of agriculture, human and animal energy will continue to be important in those countries in coming decades. That is why improving the efficiency with which these energy sources are applied will be a particularly effective strategy for supporting ecodevelopment in some places.

The SEP approach provides tools to design an energy plan that is tailored to the unique circumstances and aspirations of each individual situation. Its central focus on the energy efficiency of services provided to end users and its emphasis on participation of everyone concerned by the plan supports the identification of solutions and strategies that are often missed by more *"top down"*, supply-orientated approaches. SEP planning contributes to the emergence of resilient communities that, even in periods of uncertainty, will be able to undertake their own ecodevelopment.

"The challenges facing societies in the third millennium oblige us to reflect on the types of communities that could lead to a higher structure and that could, simultaneously, ensure their present-day survival so as to develop and evolve."

Dolores Garcia-Téllez, in «L'évolution de la noosphère. Nouvel ordre, nouvelle civilisation, nouvelle communautés» page 41, Teilhard aujourd'hui, January 2013.

ANNEX 1
BIBLIOGRAPHY

REFERENCES

Brooks David B., John B. Robinson and Ralph D. Torrie, 1983. 2025: Soft Energy Futures for Canada. Friends of the Earth Canada for Energy Mines and Resources Canada, Ottawa.

Connor-Lajambe, Hélène, L'autonomie énergétique du Québec dans une perspective écologique, Futuribles *"Analyse-Prévision-Prospective"*, June 1981, pp 33-55.

Communauté économique des États de l'Afrique de l'Ouest, 2006. Livre blanc pour une politique régionale. CEDEAO, 64p. http://www.energyaccessafrica.org/index.php/fr/bibliotheque/finish/36-lb/128-cedeao-livre-blanc/0

Guibert C. et J. Debreu, 2013. Africa Express, Livre blanc des énergies durables en Afrique, Guides des bonnes pratiques, MkF éditions, 144p.

Institut Francophone pour le Développement Durable, 2013. La transition énergétique ou les énergies que nous aurons. Liaison-Énergie-Francophonie, Numéro 93, 1er trimestre 2013, 135p. http://www.ifdd.francophonie.org/media/docs/publications/542_LEF93_web.pdf

International Renewable Energy Agency, 2013. L'Afrique et les énergies renouvelables: la voie vers la croissance durable ». IRENA, 36p. http://www.irena.org/DocumentDownloads/Publications/Afrique_%C3%A9nergies_renouvelables.pdf

Lovins A., 2013. Réinventer le feu: des solutions économiques novatrices pour une nouvelle ère énergétique. Rue de l'échiquier, 448p.

Lovins A., 1977. Soft Energy Paths. Towards a durable peace. Penguin Books.

Mutombo E. J. K., T. Bauler et G. Wallenborn, 2007. Méthodes participatives de prospective et de planification pour un développement durable: analyse d'approches et de réalisations. Université Libre de Bruxelles, 166p.
http://www.belspo.be/belspo/organisation/publ/pub_ostc/AP/rAP22_fr.pdf

Robinson J., 2003. Future Subjunctive: Backcasting as Social Learning. Futures 35:8, 839-856.

Robinson J., S. Burch, S. Talwar, M. O'Shea, M. Walsh, 2011. Envisioning sustainability: Recent progress in the use of participatory backcasting approaches for sustainability research, Technological Forecasting and Social Change, Volume 78, Issue 5, 756-768.

Rojey A., 2008. Energie et climat - Réussir la transition énergétique, TECHNIP, 216p.

Salomon T. et M. Jedliczka, 2013. Changeons d'énergies - transition, mode d'emploi, Actes Sud/Colibris/Association négaWatt, 112p.

Salter J., J. Robinson. and A. Wiek, 2010. Participatory methods of integrated assessment—a review. WIREs Clim Change, 1: 697–717.

Sarr S. et J-P Correa, 2005. Liens services énergétiques et développement: Quels impacts potentiels », ENDA, Sénégal, 12p. http://deafrica.net/Country%20Background/S%C3%A9n%C3%A9gal%20background%20paper-French.pdf.

Waldron D., 2006. Quelle méthode pour imaginer le futur énergétique de nos cités? http://www.energy-cities.eu/IMG/pdf/imagine_session5_waldron_fr.pdf

RELEVANT HELIO GUIDES AND REPORTS

HELIO International (2009). Climate-proofing energy systems /Climatiser les systèmes énergétiques. http://helio-international.org/wp-content/uploads/Global-Report.En_.pdf

HELIO International (2012)., Manuel TIPEE: Politique énergétique et écodéveloppement. Manuel d'accompagnement destiné aux planificateurs. http://www.helio-international.org/ManualFinal.pdf

HELIO International (2012). Guide pour les décideurs énergétiques. Choisir l'écodéveloppement. http://helio-international.org/wp-content/uploads/Guide_decision-makers.pdf

HELIO International (2014). Guide pour les décideurs énergétiques, update. http://www.helio-international.org/project/eera

DATA SOURCES

Renewable Energy and Energy Efficiency Partnership.
http://www.reegle.info

International Renewable Energy Agency.
http://www.irena.org

Centre pour les Énergies Renouvelables et l'Efficacité Énergétique de la CEDEAO.
http://www.ecreee.org

Observatoire de la CEDEAO pour les Énergies Renouvelables et l'Efficacité Énergétique.
http://www.ecowrex.org