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FUTURE ENERGY DEMAND IN LAOS

Scenario Alternatives for Development

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1. INTRODUCTION

1.1. Laos as a country: an overview

Laos is a landlocked country (nowadays sometimes called landlinked country) in the South-Eastern Asia having a population of almost 7 million people. It shares borders with China, Thailand, Myanmar, Vietnam and Cambodia. Laos belongs to the Least Developed Countries (LDC) with the average GNI per capita about 1050 USD in 2010 (Atlas method (current US\$), World Bank Database (2012)). Laos is the landlocked former kingdom, but nowadays a country in a fast modernization process (see e.g. Evans 1999). Laos has begun the World Trade Organization accession process, with the intention of joining that organization as soon as possible. Laos is today a single-party socialist republic. The only legal political party is the Lao People's Revolutionary Party (LPRP). The capital city is Vientiane and other large cities include Luang Prabang, Savannakhet and Pakse. Laos is criss-crossed with a myriad of rivers and streams. The largest river is the Mekong River, flowing for 1,898 kilometres from the North to the South, with 919 kilometres of the river forming the major portion of the border with Thailand. Today it is estimated that some 60% of all the water entering the Mekong River system originates from Laos. Rivers and streams provide great potential for hydropower development with 51% of the power potential in the lower Mekong basin contained within Laos (Lao National Tourism Administration 2012).

The Greater Mekong Subregion (GMS) is a natural economic area bound together by the Mekong River. GMS is covering 2.6 million square kilometres and a combined population of around 326 million. The GMS countries are Cambodia, the People's Republic of China (PRC, specifically Yunnan Province and Guangxi Zhuang Autonomous Region), Lao People's Democratic Republic (Lao PDR), Myanmar, Thailand, and Viet Nam. In 1992, with assistance from ADB, the six countries entered into a program of subregional economic cooperation, designed to enhance economic relations among the countries. GMS cooperation in energy primarily aims to establish “a competitive and integrated regional power market that will exploit, in a sustainable manner the rich energy resources of the GMS, improving the subregion’s energy security and enhancing the peoples’ access to modern and affordable energy supplies, thereby helping realize the GMS countries’ poverty reduction and economic development goals.” (see Asian Development Bank 2012a, 2012b, 6). For Laos, GMS cooperation is important element of energy planning framework.

ASEAN Free Trade Area (AFTA) is a trade bloc agreement by the Association of Southeast Asian Nations supporting local manufacturing in all ASEAN countries. The AFTA agreement was signed on 28 January 1992 in Singapore. Laos joined the AFTA agreement in 1997. AFTA now comprises ten countries of ASEAN. Lao PDR was required to sign the AFTA agreement in order to join ASEAN, but was given longer time frames in which to meet AFTA's tariff reduction obligations.

The primary goals of AFTA seek to increase ASEAN's competitive edge as a production base in the world market through the elimination, within ASEAN, of tariffs and non-tariff barriers; and to attract more foreign direct investment to ASEAN. The primary mechanism for achieving these goals is the Common

Effective Preferential Tariff (CEPT) scheme, which established a schedule for phasing out the tariffs. Unlike the EU, AFTA does not apply a common external tariff on imported goods. Each ASEAN member may impose tariffs on goods entering from outside ASEAN based on its national schedules. However, for goods originating within ASEAN, ASEAN members are to apply a tariff rate of zero per cent by the year 2015. (ASEAN 2012)

The government of Laos wants to graduate from the UN Development Programme's list of LDC by 2020 (Lao People's Democratic Republic, Ministry of Planning and Investment 2011, Lao Investors House 2012). The role of hydropower in the development of the country is highlighted in the national poverty reduction efforts. Laos is currently both buying electricity from and providing electricity to its neighbouring countries. The country is planning to accelerate its economy by increasing the electricity production capacity and export of electricity to neighbouring countries with the help of hydropower development and has, thus, been named as "the Battery of Southeast Asia".

The economy of Laos is accelerating rapidly also with the fast international demands for its metals. Some experts call Laos "dynamo of the Mekong River region". The stated official policy objectives of both the Lao government and international donors remain focused toward achieving sustainable economic growth and poverty reduction. Because of heavy dependence on natural resources use and export, Laos is suffering from Dutch disease (Lao People's Democratic Republic, Ministry of Planning and Investment 2011).

GDP growth rate by fiscal year was in Laos as follows (Lao People's Democratic Republic, Ministry of Planning and Investment 2011, 2):

- FY (Fiscal Year) 2005-2006: 8.2%
- FY 2006-2007: 8.0%
- FY 2007-2008: 7.8%
- FY 2008-2009: 7.6%
- FY 2009-2010: 7.8% (estimated rate).

The economic growth has been quite fast in Laos during the last years equalling about 7.5 % real annual growth. Despite high economic growth rate, Laos remains a country with an underdeveloped infrastructure, particularly in rural areas. It has a rudimentary, but improving, road system, and limited external and internal telecommunications. Electricity is available in urban areas and in many rural districts. In the latest 5 Year Plan, the following performance summary was made (Lao People's Democratic Republic, Ministry of Planning and Investment 2011, 4):

"Energy Sector: 97% of the plan projection was implemented, between 2006 and 2009. Construction of Nam Mung 3 Dam, NT2 Dam and Sesad 2 Dam, have been completed, and pilot production has begun. Dams that are still in the process of construction are Sekamarn 3, Nam Ngum 2, Nam Lik 1 and 2, Nam Yon, Nam Ngum 5, Theun-Hinboun (expansion), Tad Salan, and Nam

Song. Their construction is expected to be completed during 2010- 2012. The total electricity production capacity is currently 1,377 MW, and the power generated nationwide reaches 5,950 million kWh per year. Currently, the total length of electricity transmission lines is 19,503 km across the country.”

Subsistence agriculture, which is dominated by rice cultivation in lowland areas, accounts for about 30% of GDP and provides 80% of total employment. Laos has been quite successful in reducing poverty. The official poverty rates have reduced from 46% in 1992 to 26% in 2009. The economy has benefited from high foreign investment in hydropower, mining, and construction. Laos gained Normal Trade Relations status with the US in 2004, and is taking steps required to join the World Trade Organization, such as reforming import licensing. The 7th Socio-Economic Development Plan for 2011-15 is planned to outline efforts to achieve Millennium Development Goals.

In the latest 5 Year Plan, the following performance summaries for mineral production and manufacturing were made (see Lao People’s Democratic Republic, Ministry of Planning and Investment 2011, 4):

“**Mineral production:** The value added in mineral production has increased significantly, by 25% annually, and the share of this sector in the GDP has risen to 9.5% as per the latest data. The total value of mineral production in the past five years between 2006 and 2010 increased 13.9% per year (as per current price) and 19.9% per year (at 2002 prices). The exploration and manufacturing of gold increased from 9.7 tonnes in FY 2005-2006 to 10.08 tonnes in FY 2007-2008 (Plan target for 2010 is 13 tons).”

and

“**Manufacturing industry sector:** The total value of manufacturing production rose at an average rate of 9.4% per year in the period 2006-2010. Manufacturing and processing activities requires less capital investment when compared to other types of industries, but has higher employment potential. Some sectors of manufacturing that have grown significantly are garment production, tailoring, timber and food processing industry.” (Lao People’s Democratic Republic, Ministry of Planning and Investment 2011, 4).

We can expect that mineral sector and manufacturing will be key sectors of energy demand, if current trends are going to continue. Also tourism sector will increase its energy demand in the future. In 5 Year Plan a short summary is reporting that:

“A comparison of tourist arrival between the Sixth Five Year Plan (2006-2010) and the Fifth Five Year Plan (2001-2005) suggests that *tourists to Laos increased 44.45%, and have generated twice the income in Sixth Plan compared to the Fifth Plan.*” (Lao People’s Democratic Republic, Ministry of Planning and Investment 2011, 4-5).

Energy production in Laos is still dominated by traditional fuels. Fuelwood in the main source of energy and most of the energy is consumed at households for cooking. Increase in the number of cars and motorbikes is rapidly increasing the use of imported petroleum products. Electrification is one of the central targets of the Lao government. The electrification rate has increased fast in Laos and in the year 2010 over 70 % households had electricity supply. The target is to have 90 % access to electricity by the year 2020. The World Bank regards the electrification of Lao PDR to be a success story (World Bank 2012).

This paper deals with the present and future energy consumption in Laos. First the historical trends of energy use in different sectors are analysed. The future scenarios are constructed using LaoLinda model. Four different future alternative development paths are analysed using the model results.

The energy use data source for the analysis is from the Ministry of Energy and Mines (MEM) of Lao PDR. Economic and other data is from the Department of Statistics of Lao PDR.

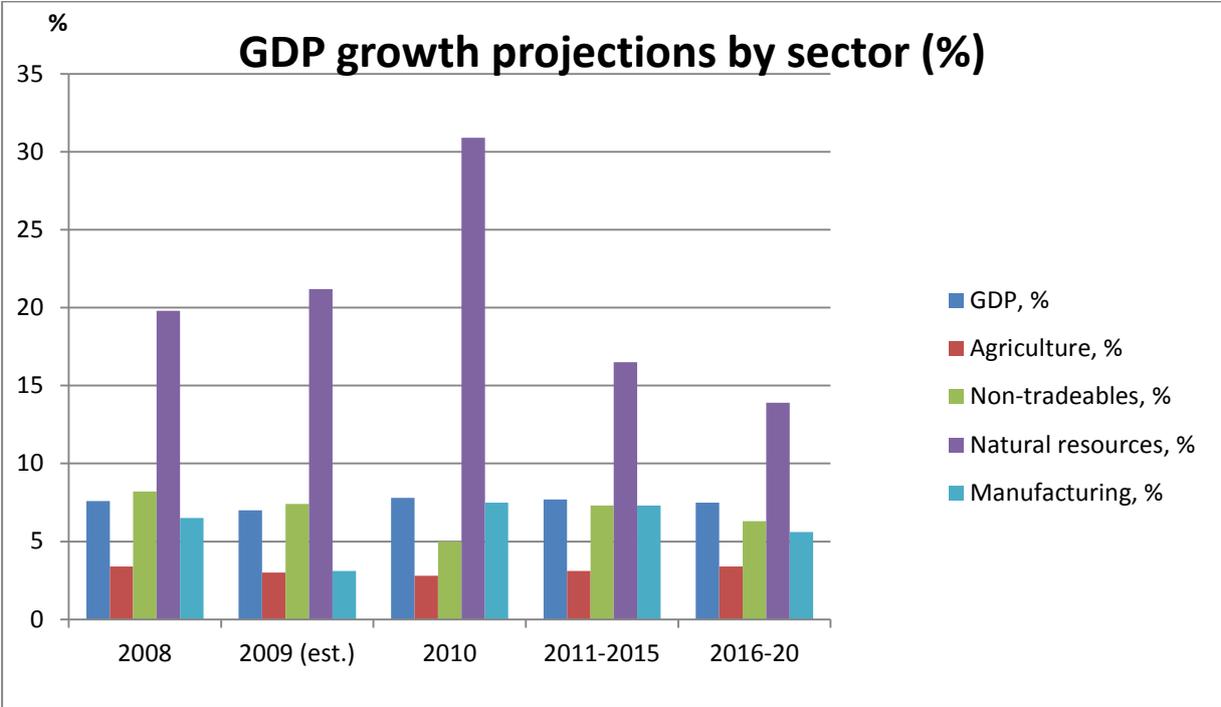


Figure 1. GDP growth projections by sector (%) in Lao PDR (World Bank 2009).

In Fig. 1. GDP growth projections by sector (%) in Lao PDR by the World Bank are presented. According to the World Bank the expected growth is 7.7 percent in 2011-15, and 7,5% in 2016-20,. Economic growth is highest in natural resources sector, mainly in electricity production and minerals (16,5 % in 2011-2015 and 13,9% in 2016-2020) and this dependence in utilization of natural resources is expected to continue also in the future. The second highest growth sector is non-tradables (construction and services) (7,3% in 2011-2015 and 6,3% in 2016-2020). In manufacturing sector growth projection is 7,3% in 2011-2015 and 5,6% in 2016-2020. (World Bank 2009).

1.2. Scenario planning and energy futures

In scenario planning process, a major focus is on how future can evolve from today's point in time to the future that has unfolded in the horizon year. Scenario thinking is focused on the reasoning underpinning our judgements about the future. These judgements are essentially separated into those about key uncertainties and those about key certainties. Key certainties are key trends that are already in the pipeline.

This section of e-book is mostly based on the article of Kaivo-oja (2002), which presented the idea to connect scenario learning to sustainability management.

Scenarios can be used to identify areas of uncertainty and provide some practical advice to local planners and managers about how to manage uncertainty. There are many uncertainties concerning global, national and local sustainability. A key issue in the construction of alternative scenarios is how these scenarios can identify key uncertainties of sustainable development. Scenarios should be written in sets of stories that describe the range of alternative futures most relevant to sustainability problems and challenges. In this article, we focus on the sustainability challenges of the energy sector in the Lao PDR.

When we construct alternative scenarios, we should select the most critical uncertainties. Usually local decision-makers and planners have to have extensive discussion before they can define the critical uncertainties. There are two fundamentally different approaches to determining the basic premises of a small number of scenarios. One method is inductive, the other deductive. Today, many scholars advocate that all organizations, which seek to learn from the future use of a methodology that combines scenario development with the decision-making processes of strategy management. Usually, this process is called scenario learning. Scenario learning can help planning organizations responsible for sustainable spatial development processes understand how to manage its future strategically.

There is not just one right way to design scenarios. Different planning cultures, organizational cultures, different facilitation styles may dictate the use of one or another of the approaches for settling on the basic logic of a few scenarios (Schwartz and Ogilvy 1998). In an assessment of 20 European and global scenario studies and models, the following weaknesses were identified by ICIS research group (Greuw et al 2000):

- Detailed scenario is not the same as comprehensive.
- Integration of study is not merely addressing a variety of scales, sectors and issues. Crucial to integration is analysis of the mutual interplay and trade-offs.
- Using perspectives is no quarantine that all relevant uncertainties are addressed and that all assumptions are transparent. Stringent documentation remains needed.
- The composition of a participatory scenario group should be both heterogeneous as well as balanced.
- Most scenario studies are too technical. They miss the institutional dimension. If they are not desk studies, they miss the variety that they need.
- Methodological underpinnings of scenario studies are crucial. More research should be dedicated toward the methodology of scenarios.

In an ideal situation, models and scenarios are used in a complementary manner. However, this is not always possible in changing spatial contexts. Also specific decision-making situations do have impacts on which scenario planning approaches are suitable for decision-makers.

Scenario learning involves two critical elements: (1) *constructing or developing scenarios* and (2) *integrating the content of scenarios into decision making*. In the identification of potential spatial sustainable processes, these two elements of scenario learning are very important. Both elements are central to what we mean by scenario learning. Neither one alone is sufficient for successful scenario use in spatial strategy formulation (Fahey and Randall 1998).

Today, many scholars prefer scenario learning to the more common term scenario planning for a number of reasons. Firstly, learning, as used in the management literature, is not just a means of generating or acquiring knowledge. Today we have a lot of knowledge concerning serious environmental problems. Today, the role of management is to put knowledge to use. Whether and how environmental knowledge and other pieces of knowledge are acted upon is essential to learning. Scenario learning reinforces the need for scenarios and decision making to be intimately interconnected (Fahey and Randall 1998).

Secondly, scenarios, by definition, challenge the mind-set of managers and planners by developing plausible alternatives. The degree of sustainability of these alternatives varies. For example, some alternatives may help us to "make money" and some other alternatives may "save the world". Thus, we cannot avoid make some ethical value statements in the context of scenario planning. Scenario models are not value-free. Typically the models of the future begin as conceptual and later perceptual (Jeans 1943). They take decision-makers into new substantive terrain. They require them to be willing to suspend their beliefs, assumptions, and preconceptions. Scenario learning not only emphasizes the role of scenarios as a generator of thought and reflection, but also explicitly challenges conventional wisdom, historic ways of thinking and operating systems, and long-held assumptions about important issues (Fahey and Randall 1998).

There are three alternative ways in which scenarios can be used in decision making. **The first approach** is to test the viability of a current ideas and strategies against the plausible futures represented in the scenarios. **The second approach** to utilise the scenarios in a decision process is to evaluate lower-level strategies or decisions. Often, no one strategy performs well against the whole range of constructed scenarios. Thus, it is very important to evaluate strategies in the light of scenarios (see Wright 2001). **The third approach** to utilise the scenarios in decision and planning processes is to monitor historical development in the light of previous scenarios. This evaluation approach allows the possibility scenario learning processes in societies. Scenarios can be utilised in the historical hindsight evaluations (*post event evaluations*), not only in the futuristic foresight evaluations (*ex ante evaluations*).

In this e-book, we provide analyses of various energy demand scenarios of the Lao PDR. These alternative energy demand scenarios give interesting possibilities to evaluate different strategies and future plans of the Lao PDR. Our hope is that we can provide a testing framework of strategies of energy sector against energy demand scenarios. The scenario approach is useful both for energy policy planning and for strategic planning of the energy sector and other linked sectors.

Thirdly, learning implies discussion and dialogue. Managers and others inside and outside the spatial management organization must engage each other in a free-ranging exchange of ideas, perceptions, concerns, alarms and new discoveries. Such communication and exchanges will invariably provoke some degree of tension - between individuals, organizations and functional operations of planning activities. Such tension is the essence of collective learning (Fahey and Randall 1998).

Fourthly, learning suggests that scenarios are a continual input to decision-making and actions, and decisions in turn spawn further reflection and thinking, i.e. further learning, which is an endless process of humankind in an ideal case. Scenarios provide views of the future against which managers can monitor and assess the world as it unfolds around them. For example, they can compare various scenarios with proposed sustainability scenarios (Fahey and Randall 1998).

A learning perspective suggest that the various tools and techniques involved in scenario development and use are a means to an end-aids to understanding how the world might unfold and how that understanding can be incorporated into decision- making. If this objective is to be achieved, scenario methodologies must not and cannot take on a life of their own as they have in some organizations. Scenarios are intended only to serve the purposes of augmenting understanding and informing good decisions.

Scenario learning and futures perspectives in spatial development

Scenarios are usually seen as a means to explain and manage uncertainty. Over the past decades we have learned that forecasts of anything are truly uncertain. In fact, predictions fail frequently. Frechtling (1996) has noted that there are three basic ways to see the future:

- The future is totally predictable (i.e. unalterable), implying sound forecasts are useless.
- The future is totally unpredictable (i.e. random), implying sound forecasts are impossible.
- The future is somewhat predictable and somewhat alterable, implying sound forecasts are useful and feasible.

Conventional wisdom in futures studies is that the third way is the relevant way to think about future events. In some situations forecasts are useful and sound. Figure 2 presents the elements of uncertainty and pre-determined (van der Heijden 1996).

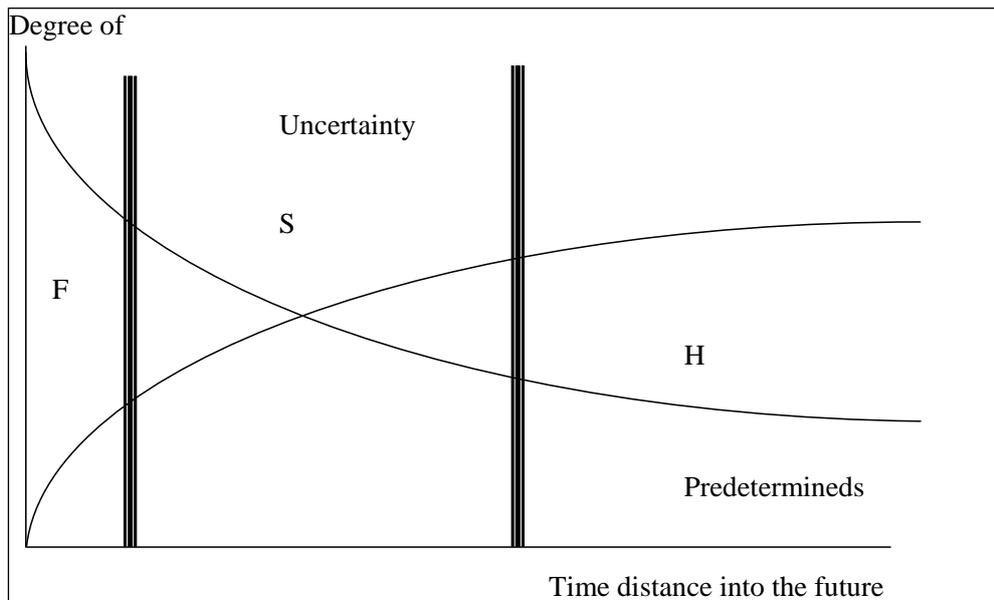


Figure 2. *The balance between predictability and uncertainty (van der Heijden 1996, 92). F = Forecasting, S = Scenarios and simulations, H = Hope connected to commitments and strong visions.*

We see that the degree of uncertainty and predetermined changes in a time horizon. Time distance into the future is a crucial thing, when we try to manage future events. In the short run, we really can use forecasting methods, because predictability is high. In the middle zone, scenarios and simulation models are useful, because there is a considerable level of predictability, but also a considerable amount of uncertainty. In the very long-run, we do not have a very reliable basis to forecast the future, but we have, of course, our hopes, long-run transactions and commitments, because the very distant future provides us very few predetermined, but a lot of uncertainty. It is important to understand that our hopes and commitments can be connected to sustainable development alternatives. In this sense, we should also think of the very long-run effects of our current activities. However, in the very long-term, everything is uncertain and attempts to fix planning and decision-making demonstrate diminishing returns.

In Figure 1, the F-dimension is a short-run opportunistic perspective to the future, the S-dimension is a strategic perspective to the future, and the H-dimension is a visionary perspective to the future. If we think about the management challenges of the long-run sustainability, it seems that we should first learn to manage the F-dimension in order to reach the S-dimension, because if we make very wrong forecasts concerning sustainability issues, there is not going to be a resource base for strategic initiatives. If we learn to reach the S-dimension, then we have possibilities to reach the H-dimension i.e. visionary leadership criteria of sustainable development. Thus, traditional predict-and-control no longer works in the field of sustainability management, although many planning tools of environmental management are still connected to this kind of simplistic thinking.

On the basis of Figure 1, we can note that scenario learning is a crucial issue in middle- and long run futures studies. In short-run analyses, traditional forecasting may be useful and necessary in order to reach strategic level of management. However, we can note that middle- or long run perspectives are the necessary dimensions of management when we discuss sustainability issues in spatial contexts.

On the basis of scenarios, we can understand the environment of spatial systems. The key question in various spatial contexts is: "Is this the right spatial system for these future decision environments described in spatial scenarios?" It is very important to understand that the concept of sustainable development should always be problem-oriented. There is not a universal SD policy toolbox for all possible spatial contexts. Having gone through all relevant scenarios in this thinking mode, a judgement has to be made on whether the answers are positive enough to strengthen confidence in the future relevance of the formula (see Fig. 3).

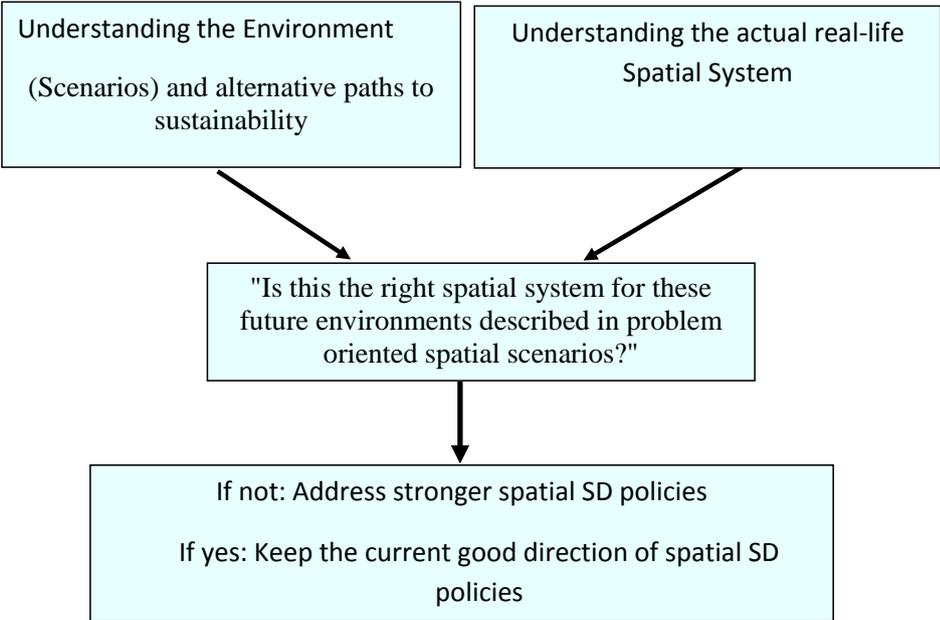


Figure 3. *Fit between the decision environment and the spatial system (van der Heijden 1996, 108) (modified version of van der Heijden 1996).*

The final answer of actual decision-makers may come out positive or negative. Depending on this outcome, scenario learning and the strategy process move in different directions. Also, a vision of spatial systems gets a different content, depending on a strategic conversation of shareholders of a spatial system.

"Bermuda triangle" of vision, strategy and scenarios in spatial contexts

In futures oriented management, one of the key challenges is to find a balance between spatial vision, strategies and scenarios of spatial development. I claim that there is a "Bermuda triangle" of management between these management concepts. If any of the three elements is missing in the spatial planning, there will be some problems in futures oriented management.

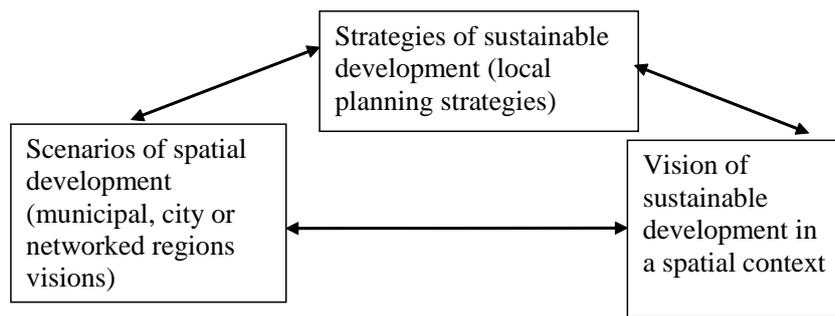


Figure 4. "Bermuda triangle" of vision, strategy and scenarios (Kaivo-oja 2002).

The conventional dictionary definition of a scenario is "an outline of a natural or expected course of events." Thus, scenarios are descriptive narratives of plausible alternative projections of a specific part of the future (Fahey and Randall, 1998). The function of scenarios in the management process is usually to make better strategies and well-argued visions (Wilson 1992; 1993; 1994, 1995; Malaska and Holstius 1999). Scenario learning trains responsible spatial managers and planners to organize what they know and what they can imagine into logical, useful storylines about the future. They can also consider the logical implications of these "future stories for their current and future strategy choices." A benefit of scenario learning is that it prods the imagination, stimulating managers to think more audaciously about what is possible. It encourages managers to make informed, imaginative judgements about what they do not know. Reliable scenario sets of spatial development provide vividly contrasting narrative descriptions of how several uncertain aspects of the future might evolve. The scenarios are projections of a potential future. Some projections may be sustainable and some less sustainable, and some others even unsustainable.

Indeed, it is possible to present scenario framework for sustainable social development on the basis of socio-economic theories. (Kaivo-oja 1999). The problem of spatial planning can be that many cases do not utilize scenario learning methodologies in the formulation of local strategies and local visions. The same problem can be identified in the formulation of global sustainability strategies and visions (Luukkanen and Kaivo-oja 1999). If the scenario learning component is missing when we formulate visions and strategies, the management process tends to be inefficient. In non-scenario learning, risk options that we shall not reach sustainable spatial development process are greater than if we use active scenario learning tools.

In the promotion of sustainable development, we need strategies in order to someday reach our visions concerning global sustainability. The conventional roles of strategic thinking are the following (Mintzberg, Ahlstrand and Lampel 1998):

- Set a direction of change,
- Focus efforts,
- Define responsible organizations, and
- Provide consistency.

In the context of scenario learning of sustainable development management, these issues are important. There are both advantages and disadvantages associated with strong strategies. A typical disadvantage is that strategic direction can also serve as a set of blinders to hide potential dangers. Setting out on a predetermined course in unknown waters is the perfect way to sail into an iceberg. Secondly, group thinking arises when an effort is too carefully focused. There may also be peripheral visions and storylines, which open other possibilities. By scenario learning we may avoid too limited group thinking in spatial management process. Thirdly, in some cases, defining responsible organizations too sharply may also mean defining them too simply, so that the rich complexity of the whole spatial system is totally lost. Scenario learning may help us to see the rich complexity in a better way. Fourthly, creativity thrives on inconsistency by finding new combinations of hitherto separate phenomena. Every strategy, like every theory, is a simplification that necessarily distorts reality. This means that every strategy can have a misrepresenting or distorting effect. That is the price of having a strategy of sustainable development. (Mintzberg, Ahlstrand and Lampel 1998). Strategies provide us future-oriented plans (intended activities), potential patterns positions (realize activities), analytical perspectives and plans, which may help us to reach our visions of sustainable development (Mintzberg, Ahlstrand and Lampel 1998).

We summarise theoretical discussion about scenario approach in the following way. There are four types of models of the future (Loveridge 2009, 31):

- (1) Formal,
- (2) informal,
- (3) accidental and
- (4) intentional.

Two of these models describe how they are created (intentional and accidental) and two of these describe the nature of the model (formal or informal). Foresight activities are creating these models in some form. Without foresight processes we use informal and accidental models of the future (see Loveridge 2009, 31). Scenario approach helps us to create formal and intentional models of the future. That is why they are useful for energy planning and strategy processes.

2. ENERGY USE IN DIFFERENT SECTORS OF ECONOMY

Growth in electricity use is often correlated with a rise in GDP and improvements in the quality of life especially in earlier stages of industrial development. Also in these scenarios of energy demand the growth of GDP is key trend driver. Typically, there is a strong correlation between electricity consumption, income level and status of value-added manufacturing activity. This kind of basic logic is also basis of our energy demand scenario analysis. Scenario planning is a useful approach to design and plan long-term electricity infrastructures to cope with the uncertain future demand for power in Laos. This kind of approach is popular in many countries (Ghanadan & Koomey 2005).

Scenarios describe a hypothetical sequence of events that could develop over a period of time. In this scenario analysis our target is to look at 4 possible energy demand scenarios. In this study we are not analysing probabilities, but scenarios are seen to be feasible as such. Energy scenarios for Lao PDR are constructed in this e-book to represent the range of opportunities and constraints associated with divergent set of technical and policy options. Our aim is to present policy-relevant energy demand scenarios. Scenarios present alternative images of the future. Scenarios are built by examining an internally consistent and rational chain of events and trends that may follow from present actions.

Maintaining growth in Laos will require a continued expansion of the country's electricity generation capacity to satisfy increasing demand for power. The electricity supply should not only satisfy the domestic demand. Also the increasing demand for electricity in neighbouring countries increase the need for new export oriented production capacity in Laos. In this study we shall also analyse this critical issue which will have both resource and environmental implications.

Scenarios provide some 'food for thought' about alternative and possible future developments in Laos. These energy demand scenarios are constructed with the LaoLinda model, which is a macro level model for strategic energy planning purposes. It is important to bridge models and scenarios (Fontela 2000) and link scenario building and strategic thinking (Godet 1987). Our scenario analysis includes a typical BAU-scenario and three alternative scenarios. The BAU scenario represents the energy demand scenario that follows the continuation of current trends by using official state-level forecasts and widely accepted national plans.

The most simple way of producing future scenarios for energy consumption is to calculate the energy intensity of the economy (energy use/GDP) and extrapolate the past trend to the future. This produces so called forecasting scenario. In Fig. 5 the historical dependence between energy consumption and GDP is depicted.

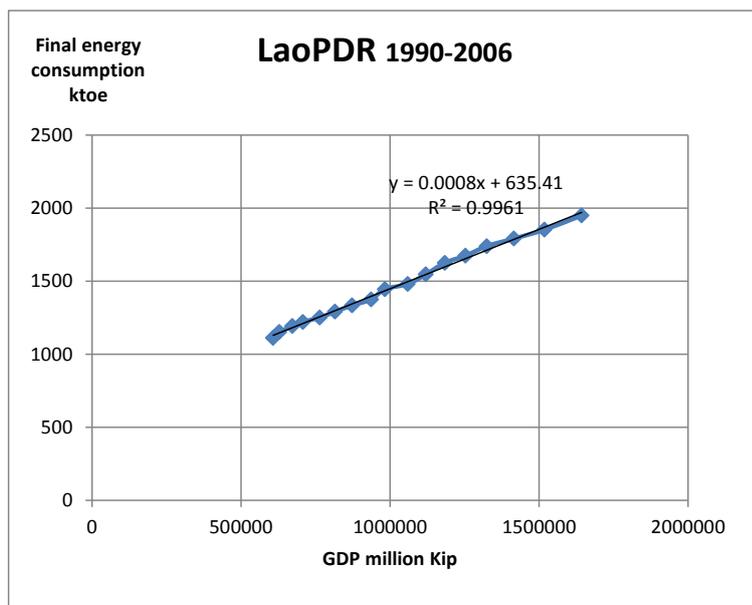


Figure 5. Relationship between final energy consumption and GDP in Lao PDR for 1990-2006.

If the relationship between energy consumption and GDP growth is expected to continue in the future we can create a forecasting scenario, which is shown in Fig. 6.

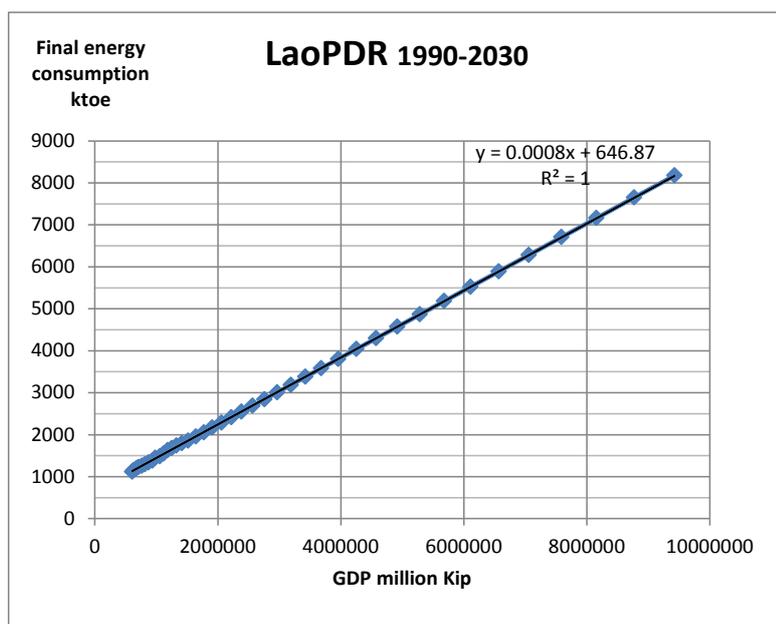


Figure 6. Forecasting scenario for energy consumption and economic development in Lao PDR up to year 2030.

In Fig. 7 we have calculated different forecasting scenarios based on different growth rates for GDP. From the figure it can be deduced that the growth rate of GDP has a considerable impact on the energy demand. These scenarios, which are based on the assumption of constant ratio between GDP growth and energy demand, can be used as a benchmark for model based scenarios. In the model based scenarios the relationship between energy demand and GDP growth is not expected to be constant but is different in the different economic sectors and, in addition, the economic structure is expected to change in the course of

time. The basic assumption of 7.5 % GDP growth rate can be seen as a starting point for scenario building based on the World Bank GDP growth projections (World Bank 2009).

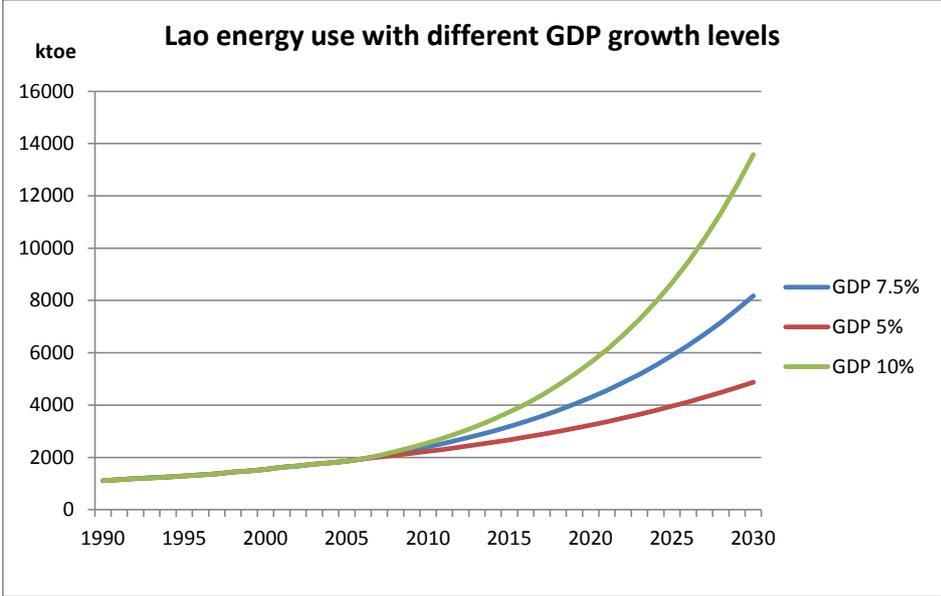


Figure 7. Lao energy use with different GDP growth levels based on constant ratio between energy demand and GDP growth.

The optimistic growth rate of 10 % will lead to 66 % higher energy consumption in 2030 compared to the basic 7.5 % growth level of GDP, if we assume constant energy/GDP ratio. The 5 % growth in GDP would, in turn, lead to 40 % decrease in energy consumption compared to the basic growth path. This comparison clearly indicates the uncertainty related to long term forecasting and the need for constructing several alternative scenarios. The risk related to the inability to build multifaceted scenarios for future can easily result in either over-investment or under-investment in the energy infrastructure. On the one hand, the sunk costs related to over-investments can be considerable because the energy infrastructure investments have typically a long life cycle. On the other hand, the under-investments can result in considerable loss of income and wealth if the demand cannot be satisfied. Consciousness of this dilemma is necessary requirement for good energy planning.

2.1. Sectoral energy use in Laos

Energy use in Lao PDR has been growing considerably in recent years (see Fig. 8). Especially growth in transport energy use and industrial energy use has been rapid. Residential energy use is still, however, dominant in Laos. The energy use data is from Mr. Khamso Kouphokham, the Department of Electricity, Ministry of Energy and Mines, Lao PDR.

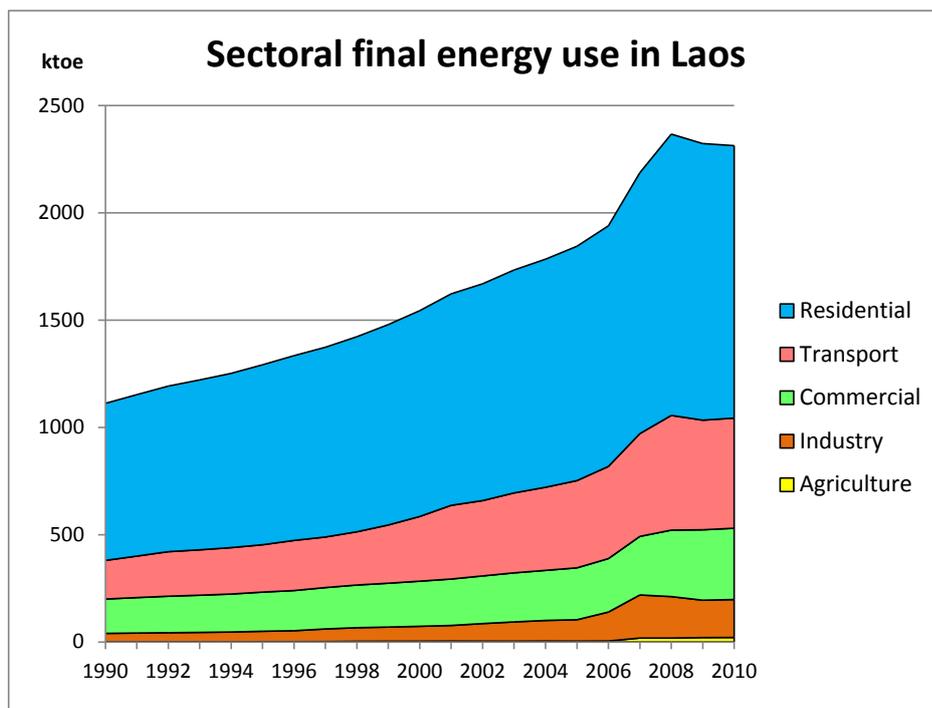


Figure 8. Energy use in different sectors in Laos.

Fuelwood is the main energy source in Laos. It is used mainly for cooking, but also industrial use of Fuelwood is considerable. Charcoal is another important fuel for cooking especially in urban areas. The fuels used in the transport sector, diesel, gasoline and jet fuel, cover over 20 % of the total consumption.

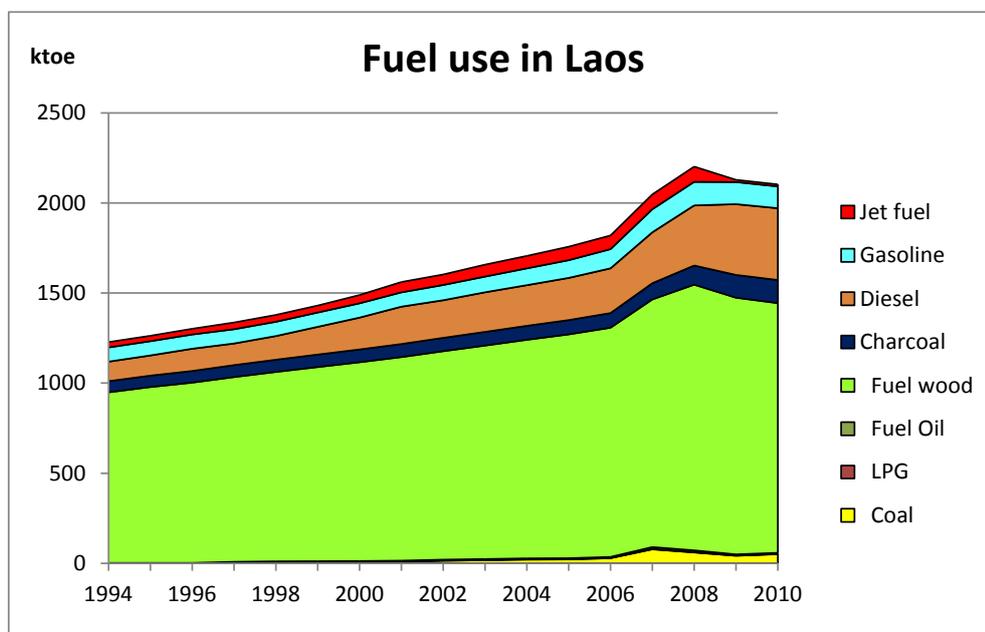


Figure 9. Fuel use in Laos.

2.2. Industry and energy use

In the industrial sector the energy consumption has grown very rapidly, although its share in total energy consumption is still small (see Fig. 10.). Especially coal use for industrial purposes has increased considerably. Also electricity consumption in industry has grown fast. In the future the main question concerning industrial energy use is the establishment of metal industry in Laos. There are a lot of mineral deposits available and if their processing will start in the future the energy consumption will grow considerably. Especially, if aluminium production will be decided to start in Laos, the increase in energy consumption will be high.

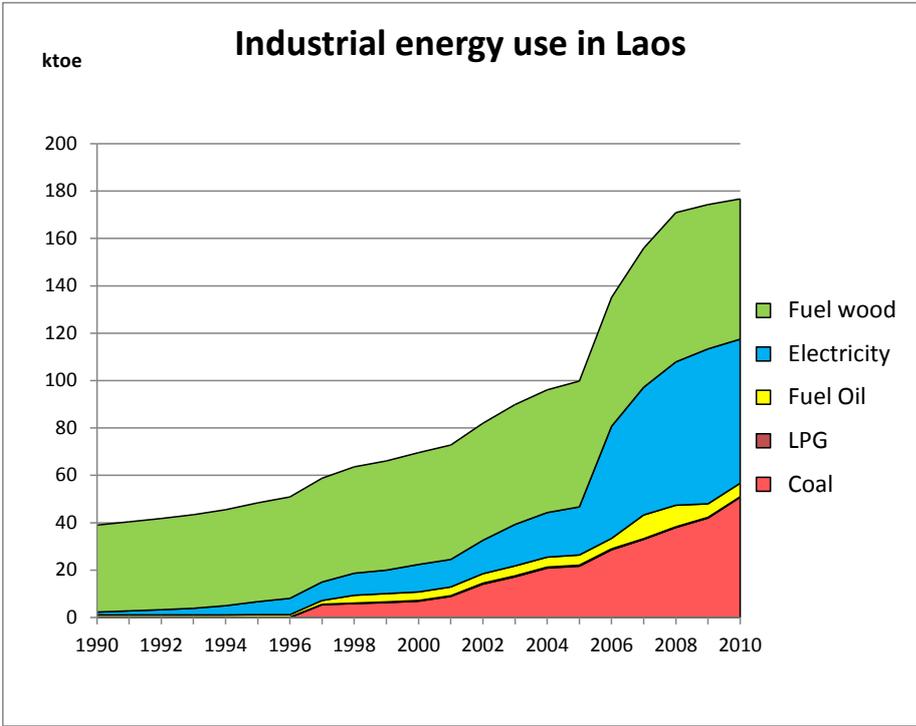


Figure 10. Industrial energy use in Laos.

2.3. Transport energy use

Transport sector has increased its share in energy use rapidly due to the increase in number of cars and motorbikes and the mobility of people. Also the freight transport has increased considerably. Especially the use of diesel oil in transport sector has increased rapidly. Continuous growth in road transport requires investments in infrastructure (roads). Increasing demand in diesel and gasoline and increasing oil price will rapidly increase the cost of imported fuels. This will have an effect on the trade balance. This is one reason why the potential for biofuels in transport sector has gained increasing interest.

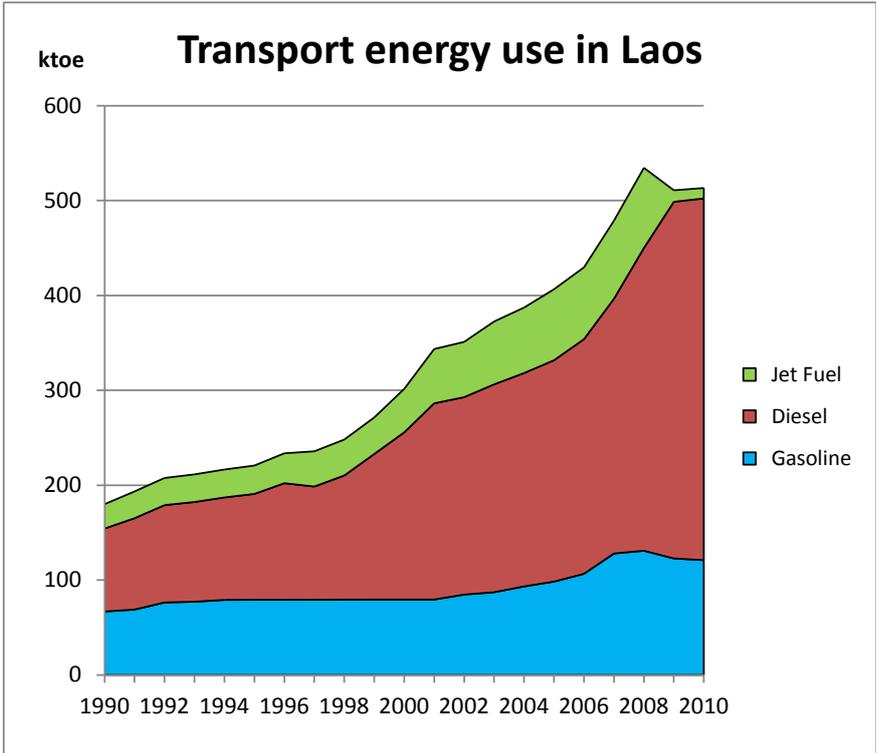


Figure 11. Transport energy use in Laos.

2.4. Commercial sector energy use

Energy use in commercial sector has steadily grown. Increasing tourism will have an effect on the energy use in commercial sector. Especially the electricity use will be growing fast. Fuelwood and charcoal still dominate the energy use in commercial sector. This indicates the importance of cooking as a form of energy use in the sector. The structural change in economy in the long term will increase service sector energy use with the increased share of the commercial sector in producing value added at the national level.

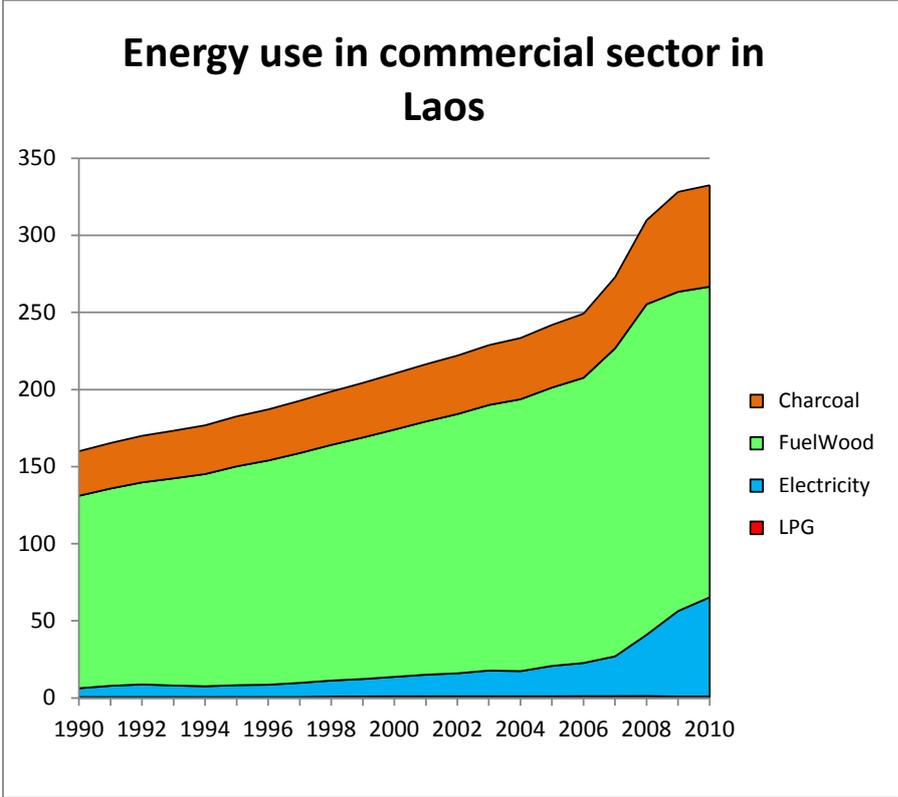


Figure 12. Energy use in the commercial sector in Laos.

2.5. Agricultural energy use

In the agricultural sector the electricity use has increased especially in the late 1990's. This is due to the increased pumping for irrigation and the processing of agricultural products such as rice milling. Increased mechanisation of agriculture will increase energy use, especially diesel consumption. Agricultural residues have a large renewable energy potential, but their use is still very limited. There is large potential for biogas and biofuels production, but the introduction of these technologies requires considerable investments, which are not always available.

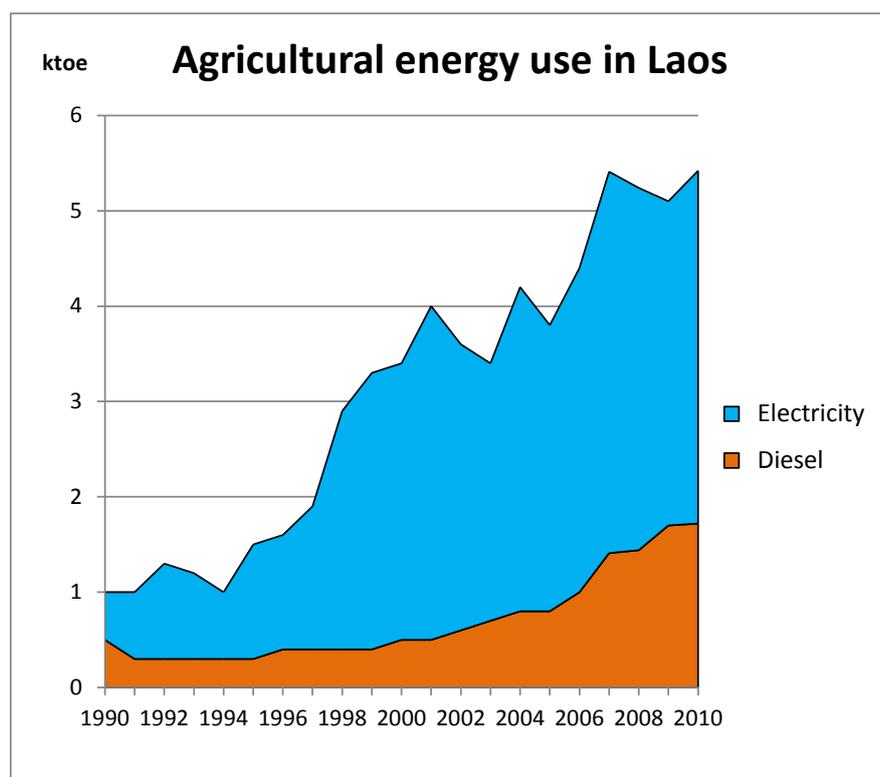


Figure 13. *Agricultural energy use in Laos.*

2.6. Household energy use

Households still constitute the main energy consuming sector in Laos. Household energy use is dominated by fuelwood for cooking. Electricity consumption, which is still very low, will increase with electrification rate and new appliances. The fast population growth and increased urbanisation will increase LPG, charcoal and electricity use in the future while the share of fuelwood will diminish. One important question is what is the potential of forests to supply enough of wood for household energy and industry in the future.

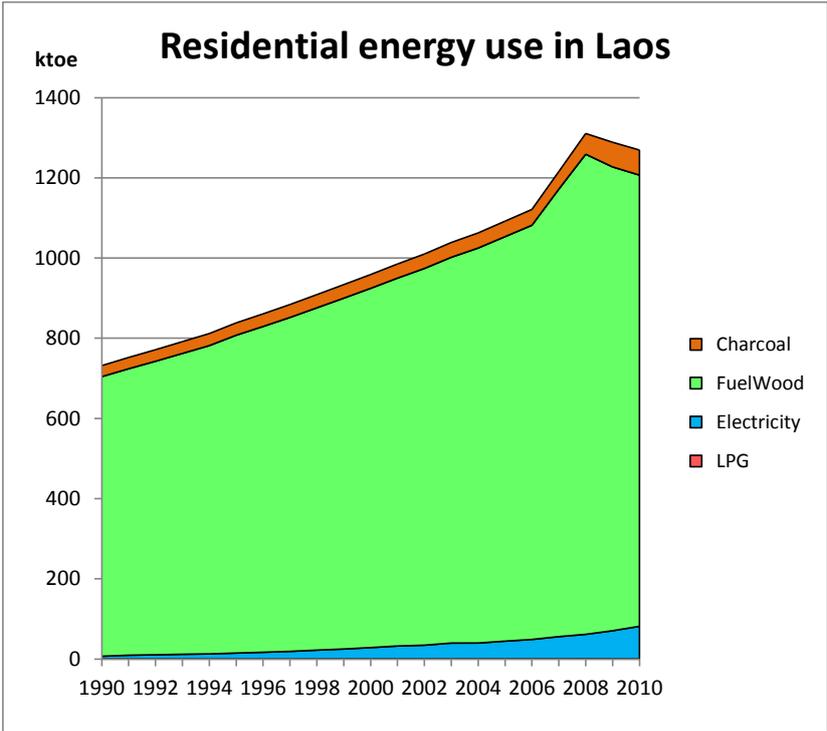


Figure 14. Residential energy use in Laos.

3. SCENARIOS WITH LAOLINDA ENERGY PLANNING MODEL

3.1. LaoLINDA energy planning model

LINDA energy model (Long-range INtegrated Development Analysis) is a scenario building calculation system for integrating different aspects of future development in one tool. LINDA model has been developed for Finland, the Philippines, Cambodia, Cuba and Laos by Dr. J. Luukkanen. The LaoLinda model deals with five sectors of the economy: Agriculture, Industry, Commercial, Transport and Residential sectors. The availability of statistical data in Laos limits the inclusion of more detailed sectoral allocation in the model. The LaoLinda model constructs future scenarios for energy use (different forms of energy) in the different sectors based on the historical data and the user input data on sectoral economic growth levels and future changes in energy intensity (both electricity intensity and fuel intensity). In addition, the user gives an estimation of future changes in residential energy use as well as in transport volume and intensity. The model user can also give input data on future power plant construction figures and change the prefilled data, which is based on the government plans for power plant construction. The user can also change the future load factor data of the power plants.

When we want to analyse the future trends of energy use in Laos, we have to look at different driving forces in the economy. Population growth is an important driver for increasing energy use. From the energy use point of view the population growth shall be linked with migration, especially urbanisation, which will change the energy use profile of households. Another important factor is economic growth. It will also change energy use profile of households due to the purchasing of increased number of electricity consuming devices and increased amount of money to pay for energy.

Industrialisation is an important factor in energy consumption increase. In the process of industrialization the energy intensity of production usually increases due to the larger share of industrial sector in GDP production and the increased share of heavy industry. This can be the case also for Laos in the future since the utilization of the available natural resources (both hydro power and metal minerals) will most probably direct the structural development of the economy in increased basic metal production. Industrialization based on e.g. ITC sector development (which would be less energy intensive) can be another development path in Laos. Some indication for this type of development has been seen recently with the opening of Dominant Semiconductors Lao in October 2011, with the target of employing 1000 workers in 2012 in the manufacturing of LED components.

Increased mobility is one important factor in increasing energy use in Laos. The number of cars and motorbikes is still very low in Laos in international comparison and the transport infrastructure is not well

developed. There is probably going to be a rapid increase in the number of cars due to the high social status of car ownership. Transport policy supporting public transport instead of private transport could affect the future energy growth in this sector.

The following four different scenarios are based on the total economic growth of 7.5 % per year, which is in line with the plans of the Government of Lao PDR. These scenarios are illustrating different types of growth patterns which result similar overall growth, but differ considerably in the structure of growth. This provides us possibilities to analyse the different energy requirements of different growth options.

3.2. Demographic and regional change in Laos: Some scenario analyses

Population changes are important for the energy consumption as was mentioned above. The population scenarios in this report are based on the model developed by Juha Panula-Ontto. The assumptions of the model are given in the Appendix.

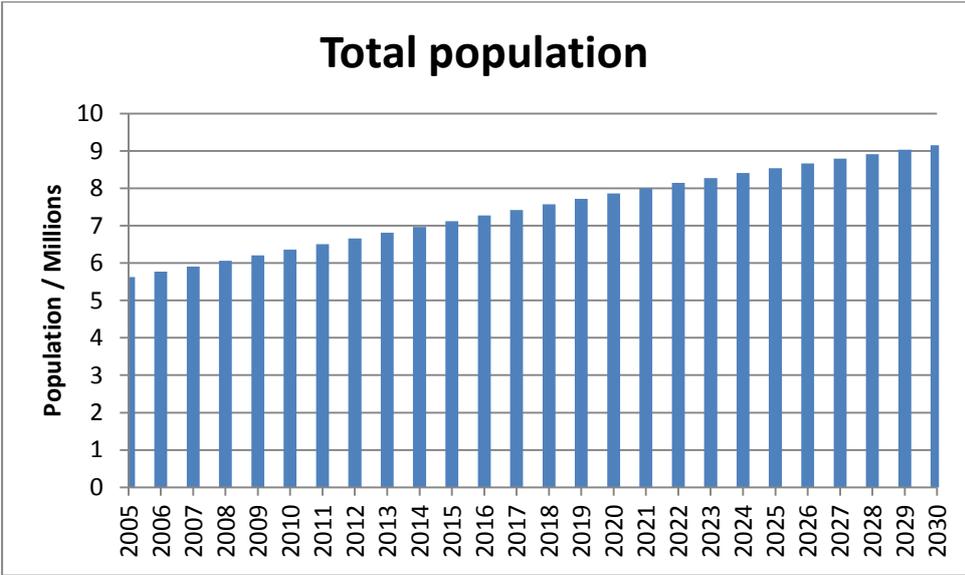
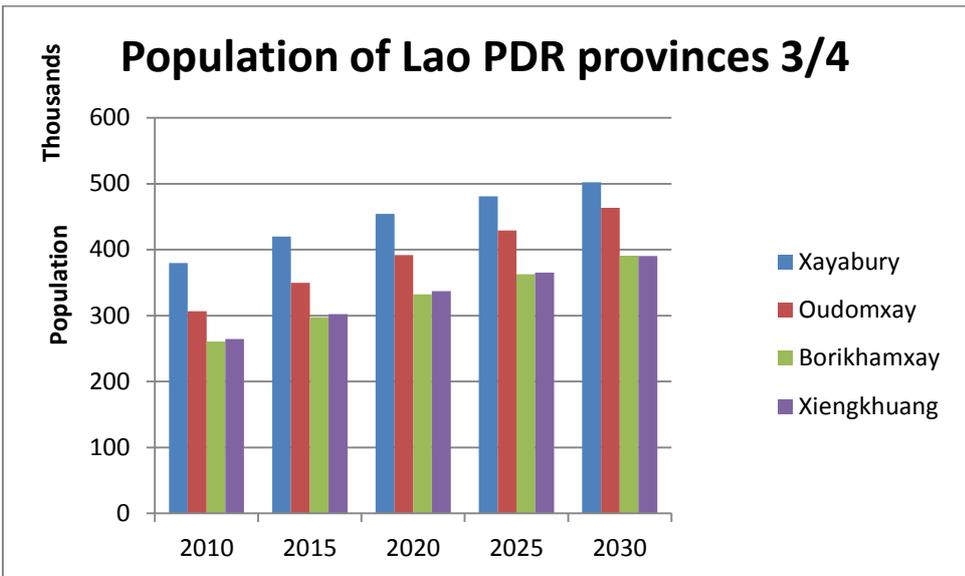
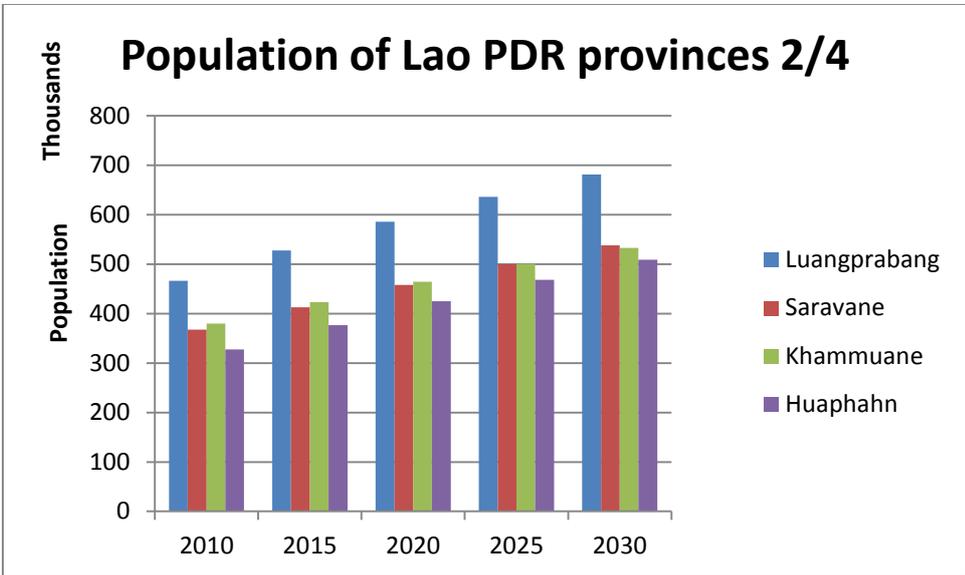
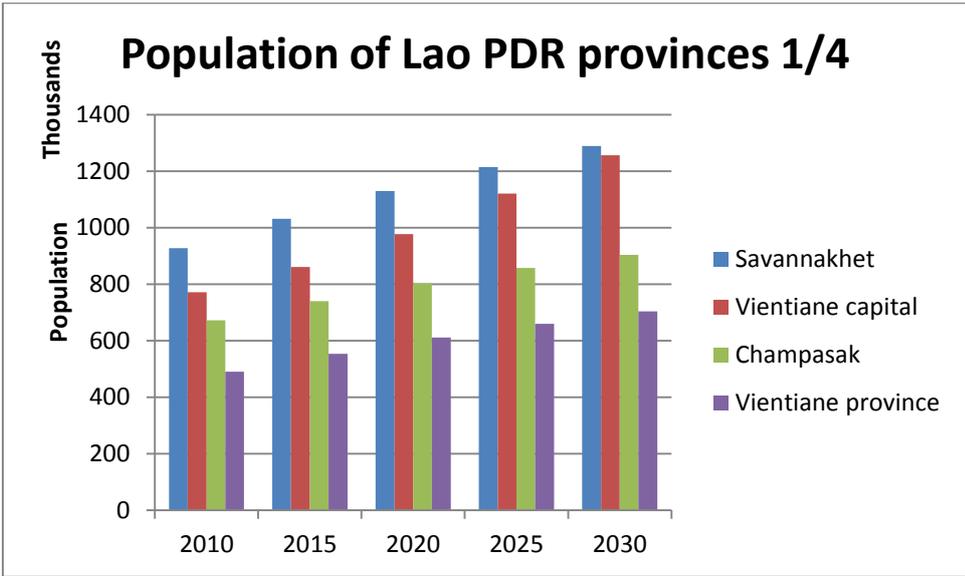
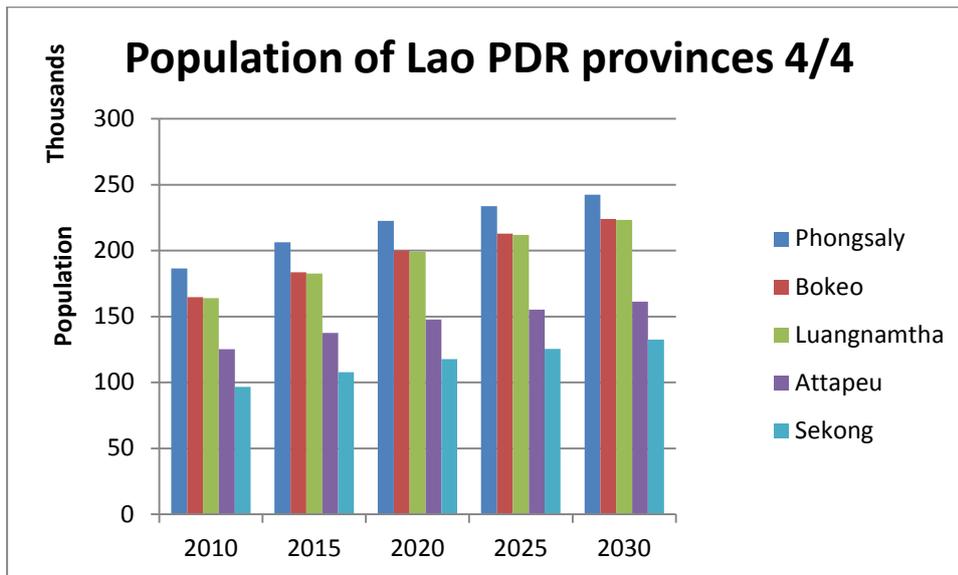


Figure 15. Scenario for Lao PDR population growth.

Projection for the total population of Lao PDR is presented in figure 14. The population growth of Lao PDR is 2,58% annually in 2006 and in this scenario it is projected to drop to about 1,3% annually by the year 2030. The total population in 2030 is 9,15 million people; this is more or less concurrent if United Nations long-range population projections for Lao PDR and International Futures model baseline population projection.





Figures 16a, b, c and d. Population scenarios for different provinces in Lao PDR.

The population projections for the most populous provinces of Lao PDR are presented in figure 15a. According to the scenario Savannakhet remains the most populous of the statistical provinces with 1,3 million inhabitants. Vientiane capital area holds nearly as many inhabitants and the combined population of Vientiane capital and surrounding Vientiane province area is about 1,96 million people, meaning that the population increase in the capital area from 2010 would be nearly 700000 people.

As total fertility rates in the capital area are distinctly lower than other parts of Lao PDR, the increase in population comes largely from migration from rural provinces. In the scenario migration rates from the poorest provinces to Vientiane Capital area come close to 2% annually for the age group 20- to 34-year-old people. As a result of this migration of working-age people, the dependency ratio of Vientiane Capital can be expected to be as low as 38.5 in 2030, while e.g. Huaphahn's dependency ratio is about 82 in 2030 according to the scenario. Vientiane's age profile will be starkly contrasted with other provinces of Lao PDR in 2030.

3.3. Four Scenarios

In the following section four different scenarios for the economics and energy use in Laos is presented. The scenarios are produced with the LaoLinda model and the basic assumptions of each scenario are presented in the tables.

3.3.1 A Business as Usual Scenario for Laos (BAU)

The economic growth of the Business as Usual (BaU) scenario for Laos is presented in Fig. 17 and in Table 1.

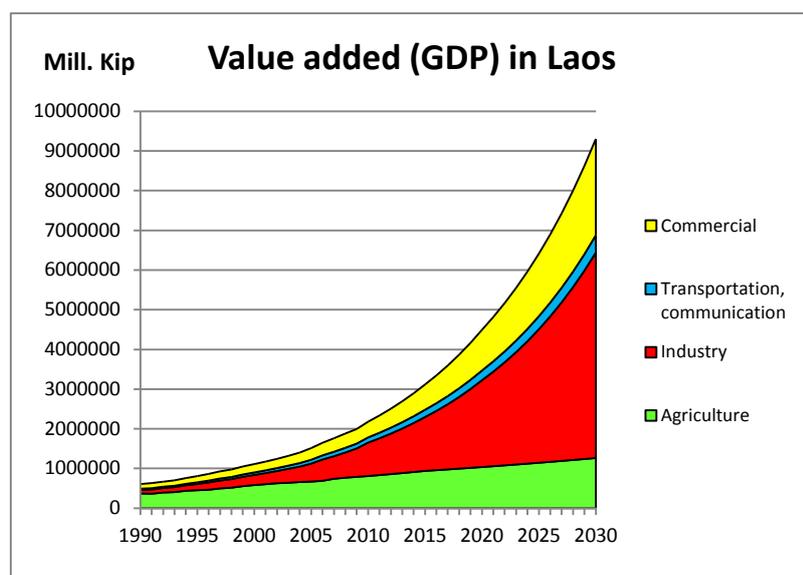


Figure 17. Economic growth in different sectors in Laos according to the Business as Usual scenario.

Table 1. Historical and future annual economic growth in different sectors in Laos.

Annual percentual changes				Fill in the future annual growth rates (%) in the yellow cells				
GDP	1990-95	1995-98	1998-2001	2001-06	2006-10	2010-15	2015-20	2020-30
Agriculture	4.1 %	4.4 %	5.4 %	2.7 %	4.1 %	3.0 %	2.0 %	2.0 %
Industry	12.2 %	11.2 %	9.1 %	13.9 %	11.9 %	10.0 %	10.0 %	9.0 %
Transportation, communication	5.8 %	8.7 %	8.0 %	8.8 %	5.7 %	7.0 %	6.0 %	6.0 %
Commercial	6.0 %	6.4 %	5.4 %	7.5 %	5.7 %	10.0 %	10.0 %	9.0 %
Total	5.9 %	6.4 %	6.8 %	6.8 %	7.2 %	7.4 %	7.6 %	7.6 %

The annual economic growth in the BaU scenario is about 7.5 %. This growth rate is close to the growth target of the government of Lao PDR. In the BaU scenario the industrial growth is the main driving force in the economy. This follows the historical development. The growth in commercial sector is thought to increase in this scenario due to the growing importance of tourism and other services.

Figure 17 shows the changes of the shares of different economic sectors of GDP. During the scenario period Laos is transformed from agricultural society to industrial society. The share of agricultural produc-

tion is decreasing considerably and dropping from 60 % in 1990 to 14 % in 2030 while the industrial share increases from 15 % to 55 %.

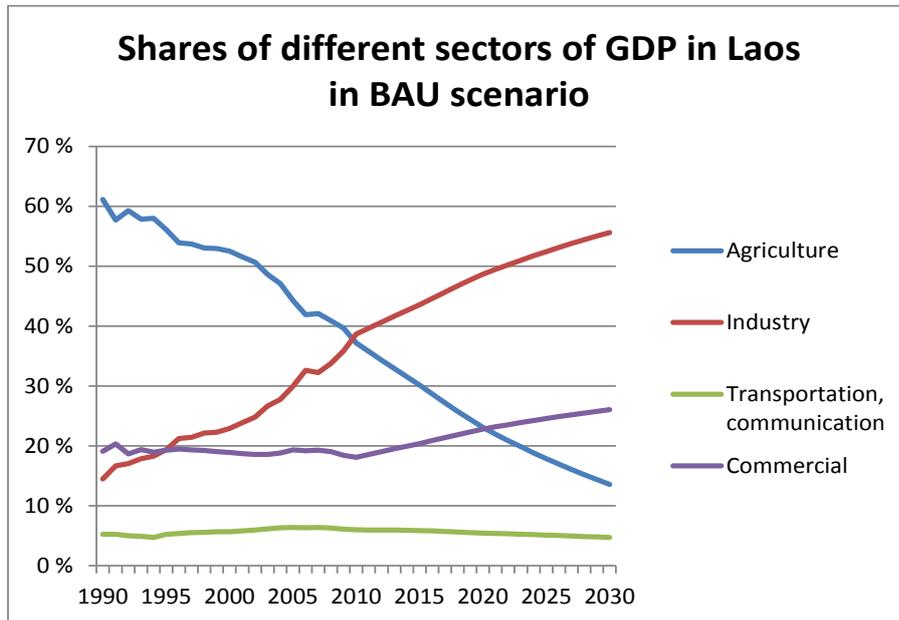


Figure 18. The changes in shares of different economic sectors of GDP in Laos in BAU scenario between 1990 and 2030.

The impacts of the BaU economic growth on the electricity consumption in different sectors is shown in Fig. 19. In this scenario the electricity consumption in industrial sector is considerable due to the high growth in the sector.

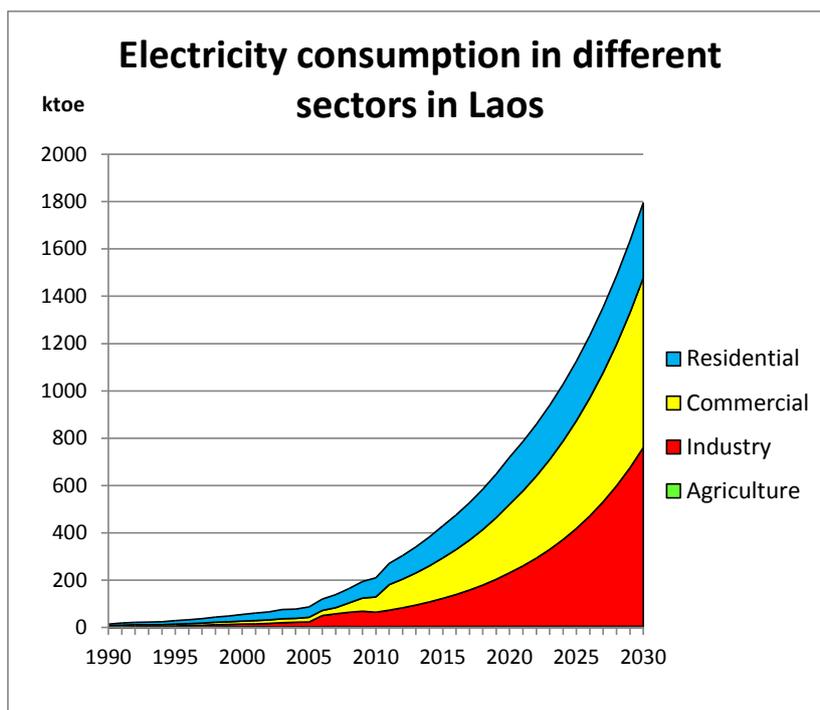


Figure 19. Electricity consumption in different sectors in Laos according to the BaU scenario.

The total electricity consumption together with the exported electricity is shown in Fig. 20. The growth of electricity export is thought to be considerable according to the plans of increased export earnings and the capacity expansion plans.

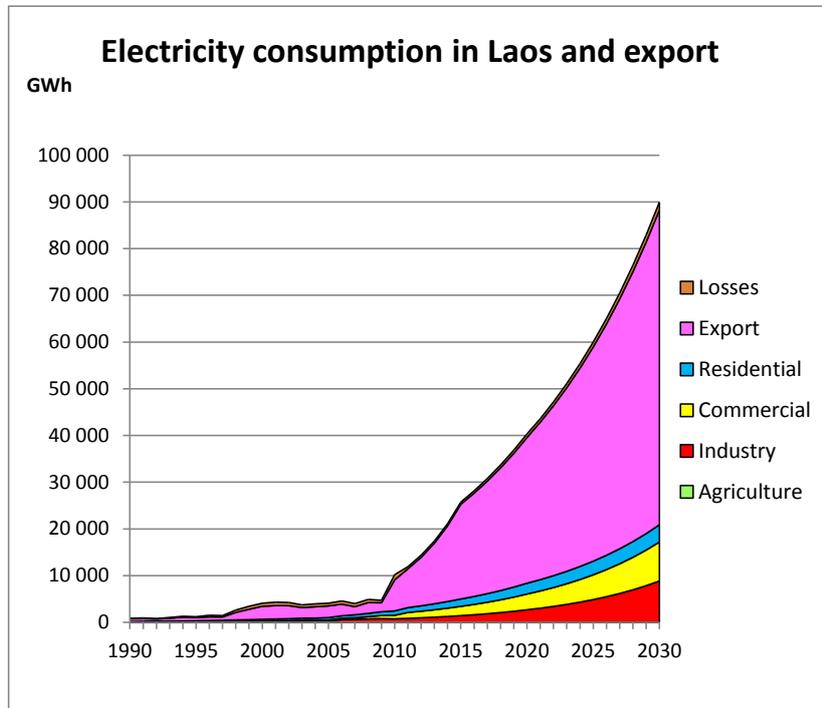


Figure 20. Electricity consumption and export in Laos in the BaU scenario.

The planned and required electricity production capacity in Laos is presented in Fig. 21. In this figure the planned capacity is taken from the existing governmental plans for new production capacity up to the year 2015. The required capacity is calculated with the model. Since the planned capacity is only up to 2015 the production deficit will grow after 2020 according to the model calculation.

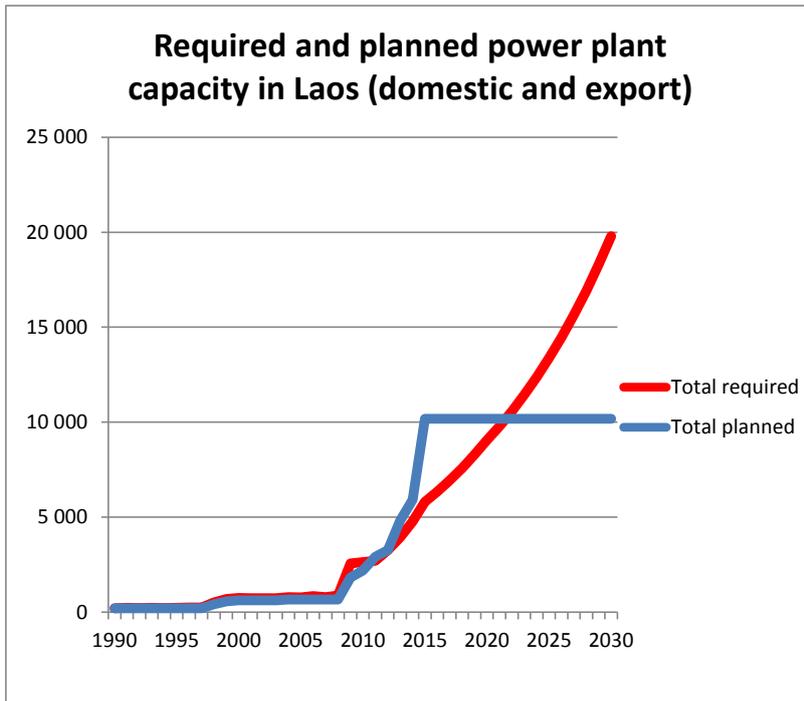


Figure 21. Planned and required power plant capacity in MW in Laos for domestic and export electricity consumption in BaU scenario.

The sectoral final energy use in the BaU scenario is given in Fig 22. The residential energy use has been dominating the energy consumption in the 1990's but the fast growth in transport sector and other production sectors will change the situation considerably in the future according to the BaU scenario.

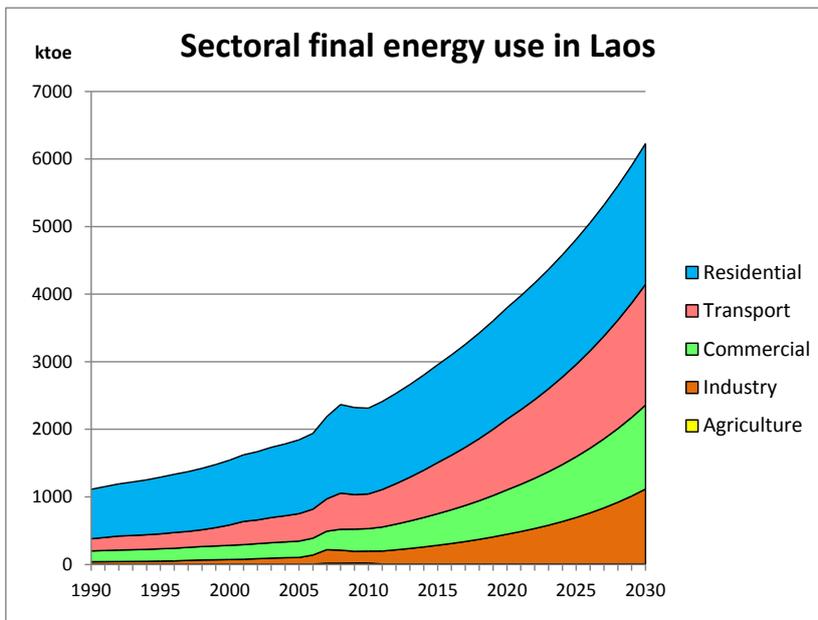


Figure 22. Final energy use in different sectors in Laos according to the BaU scenario.

Figure 23 illustrates the percentage changes in the shares of energy consumption of the different economic sectors. The share of residential sector decreases from 65 % in 1990 to 37 % in 2030 while the shares of other sectors slowly increase.

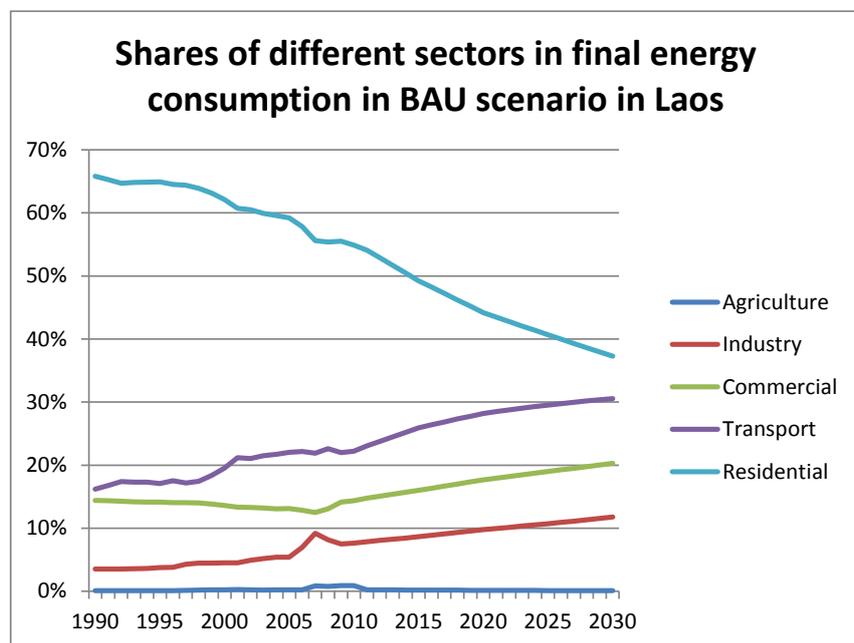


Figure 23. Shares of different sectors in final energy consumption in Laos between 1990 and 2030.

The use of different fuels in the Lao economy in the BaU scenario, are given in Fig. 24. Fuelwood has been dominating the fuel use, but in 2015 the use of coal increases sharply due to the start of the Hongsa Lignite power plant, which will be selling electricity to Thailand. In the BaU scenario there is considerable growth in the transport sector fuel use.

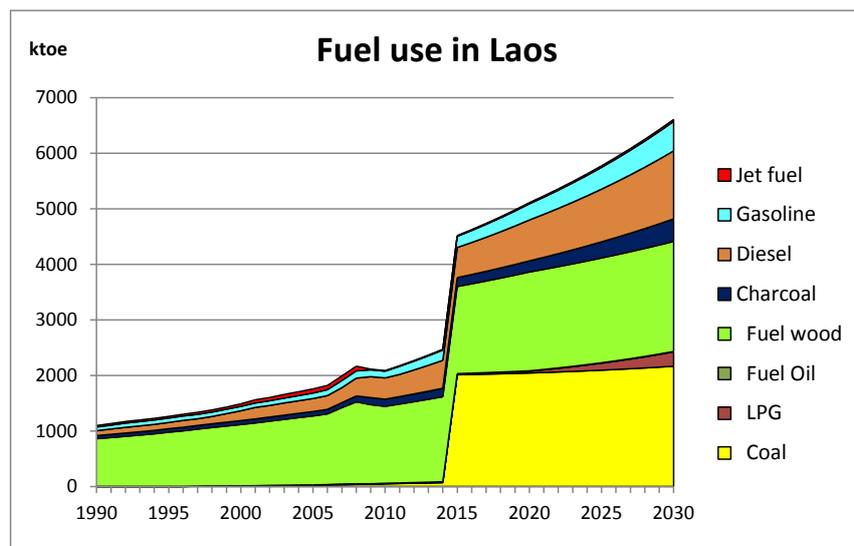


Figure 24. Use of different fuels in Laos according to the BaU scenario.

Industrial energy use in the BaU scenario is depicted in Fig. 25. The considerable increase in electricity consumption and coal use in industrial production are the main features of the development.

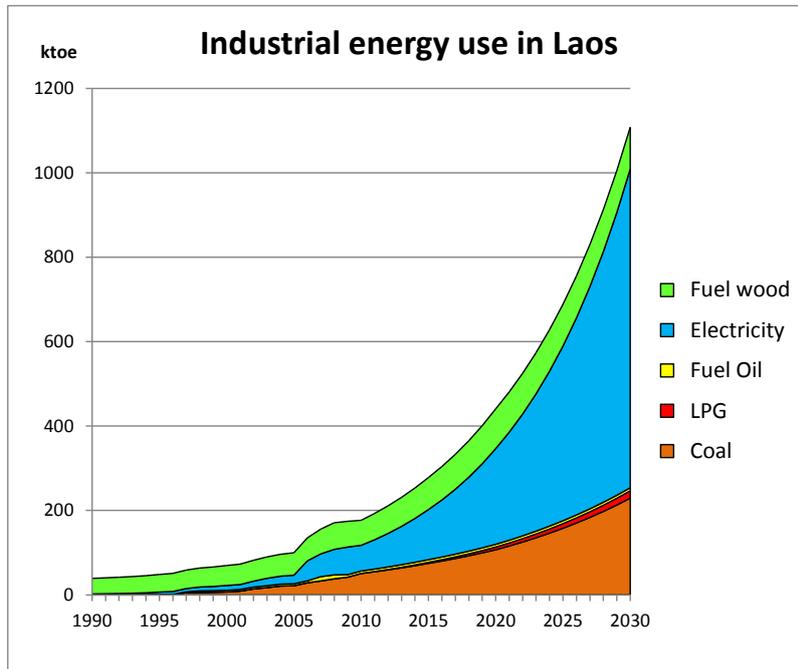


Figure 25. Energy use in industrial sector in Laos according to the BaU scenario.

The transport sector energy use in BaU scenario is given in Fig. 26. In the transport sector the fast growth in the number of private cars as well as mobility and increased freight transport are the main reasons behind the fast growth in diesel consumption.

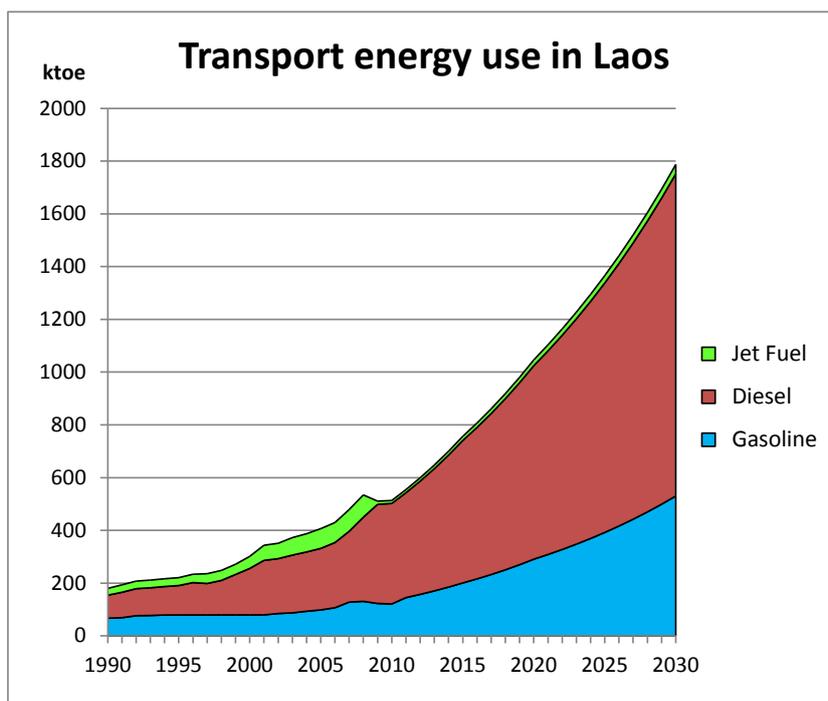


Figure 26. Energy use in the transport sector in Laos according to the BaU scenario.

In the commercial sector fuelwood has been the dominating energy form, but in the BaU scenario the increase in electricity use and LPG use is considerable. The growth of tourism and other related services are main driving factors in this scenario.

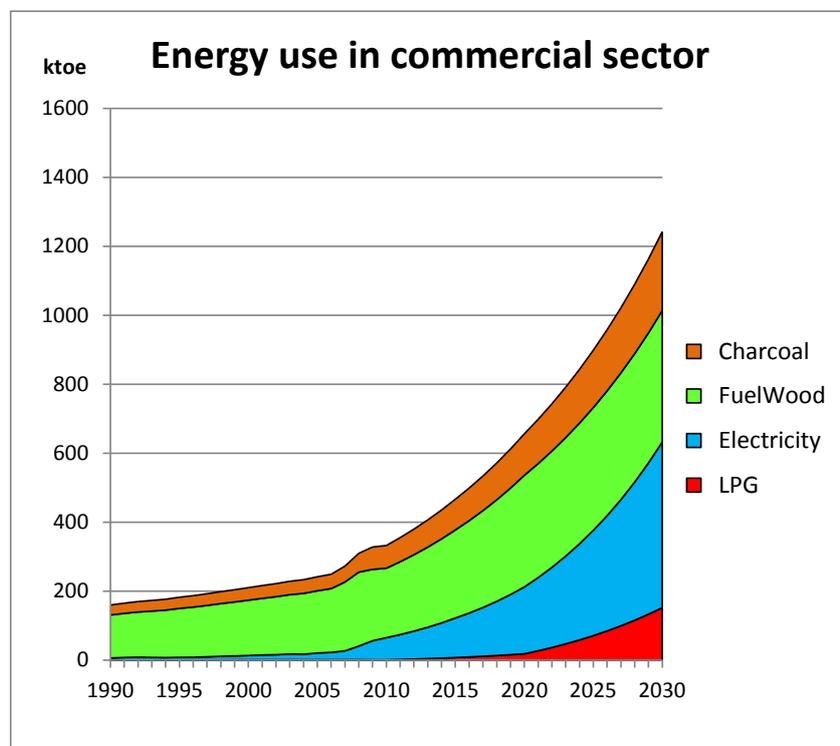


Figure 27. Energy use in the commercial sector in Laos according to the BaU scenario.

Residential energy use in Laos is dominated by fuelwood which is used for cooking (Fig. 28). According to the BaU scenario electricity use will increase considerably due to the increase of households connected to the grid and increased use per household.

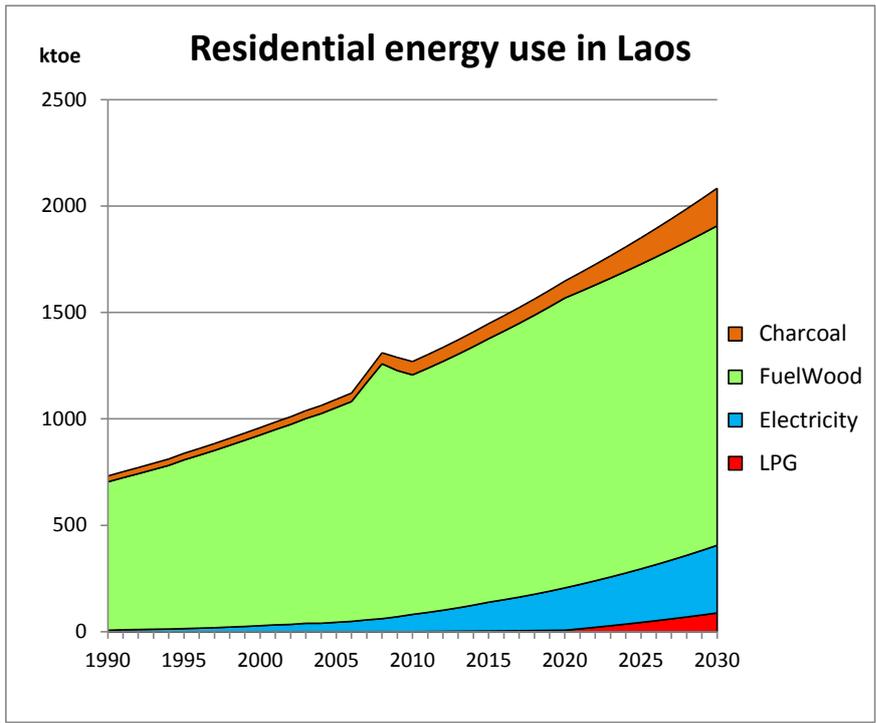


Figure 28. Energy use in the residential sector in Laos according to the BaU scenario.

Agricultural energy is used mainly for pumping irrigation water and for different machines like two wheel tractors and rice mills. In the BaU scenario (Fig. 29) the total energy use in agricultural sector is decreasing due to the low growth of production and improved efficiency of the machinery.

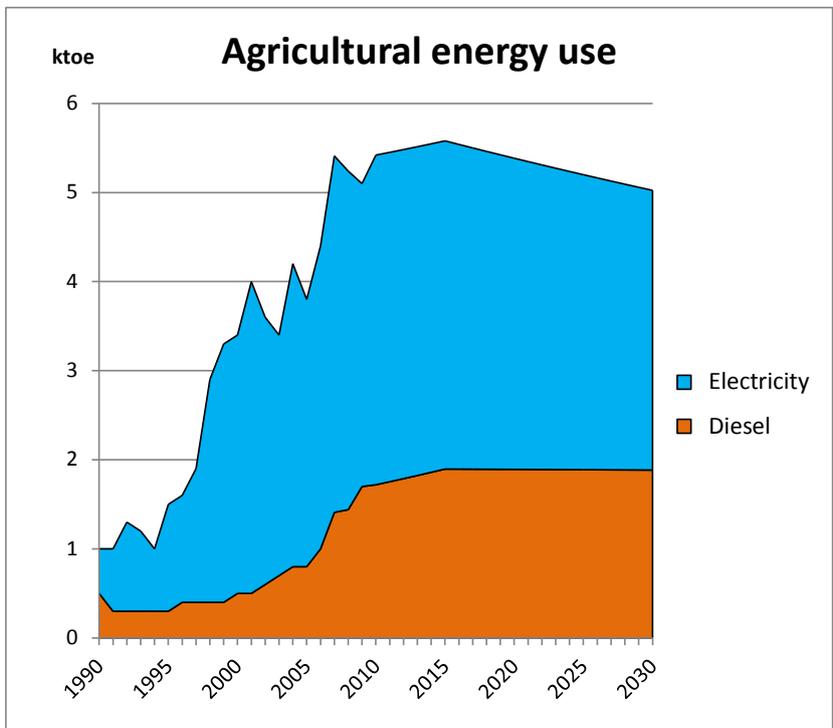


Figure 29. Energy use in the agricultural sector in Laos according to the BaU scenario.

The fossil fuel use in the BaU scenario produces CO₂ emissions according to the Fig. 30. The emissions grow fast mainly due to the introduction of the Hongsa Lignite power plant (which will be selling electricity to Thailand) and the increased use of petroleum products in transportation. However, the total emissions of CO₂ remain at very low level in international comparison equalling less than 0.3 tons of CO₂ per capita in 2010 and 0.65 tons of CO₂ per capita in 2030 compared to the world average of about 4 tons of CO₂ per capita.

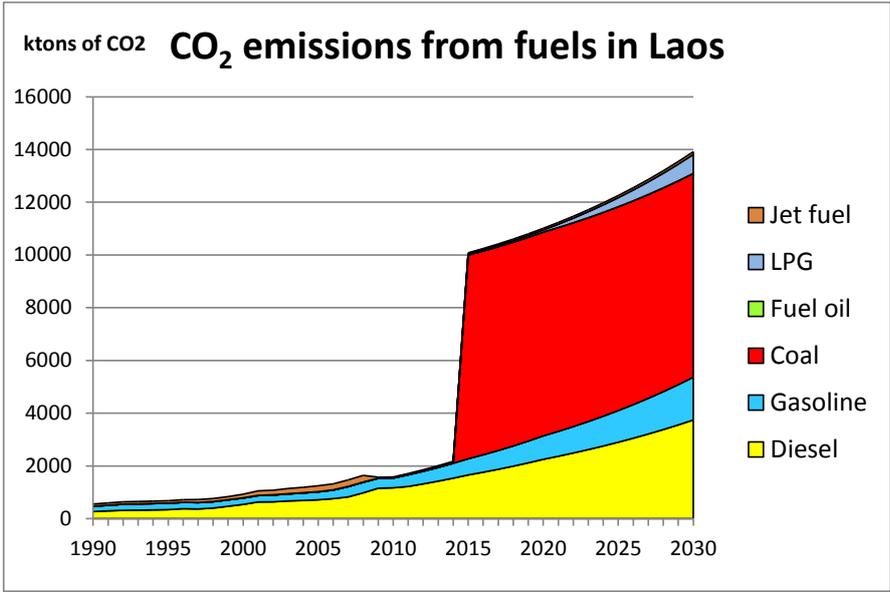


Figure 30. CO₂ emissions from fuel combustion in Laos according to the BaU scenario.

3.3.2 Mobile Laos Scenario

In this scenario the mobility of the people and goods as well as communication in Laos is thought to increase considerably. In this scenario the value added of the transportation and communication is thought to increase while the growth in other sectors is not as high as in BaU scenario. The total growth of GDP in the 'Mobile Laos' scenario is about as high as in the BaU scenario.

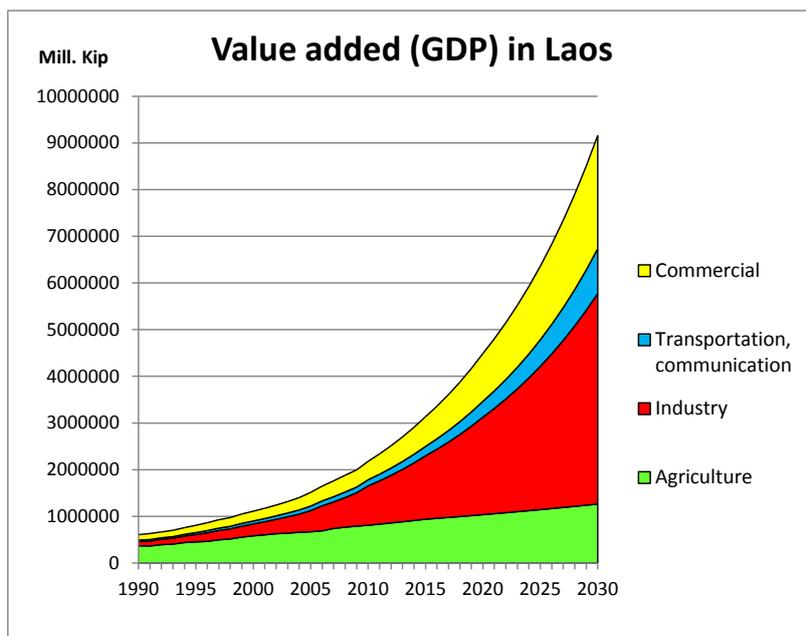


Figure 31. Economic growth in different sectors in Laos in the 'Mobile Laos' scenario.

Table 2. Annual changes in the value added in different sectors in Laos in the 'Mobile Laos' scenario.

Annual percentual changes									
GDP	Fill in the future annual growth rates (%) in the yellow cells								
	1990-95	1995-98	1998-2001	2001-06	2006-10	2010-15	2015-20	2020-30	
Agriculture	4.1 %	4.4 %	5.4 %	2.7 %	4.1 %	3.0 %	2.0 %	2.0 %	
Industry	12.2 %	11.2 %	9.1 %	13.9 %	11.9 %	10.0 %	9.0 %	8.0 %	
Transportation, communication	5.8 %	8.7 %	8.0 %	8.8 %	5.7 %	9.0 %	11.0 %	11.0 %	
Commercial	6.0 %	6.4 %	5.4 %	7.5 %	5.7 %	10.0 %	10.0 %	9.0 %	
Total	5.9 %	6.4 %	6.8 %	6.8 %	7.2 %	7.5 %	7.4 %	7.4 %	

Figure 32 illustrates the changes in the shares of GDP of different economic sectors.

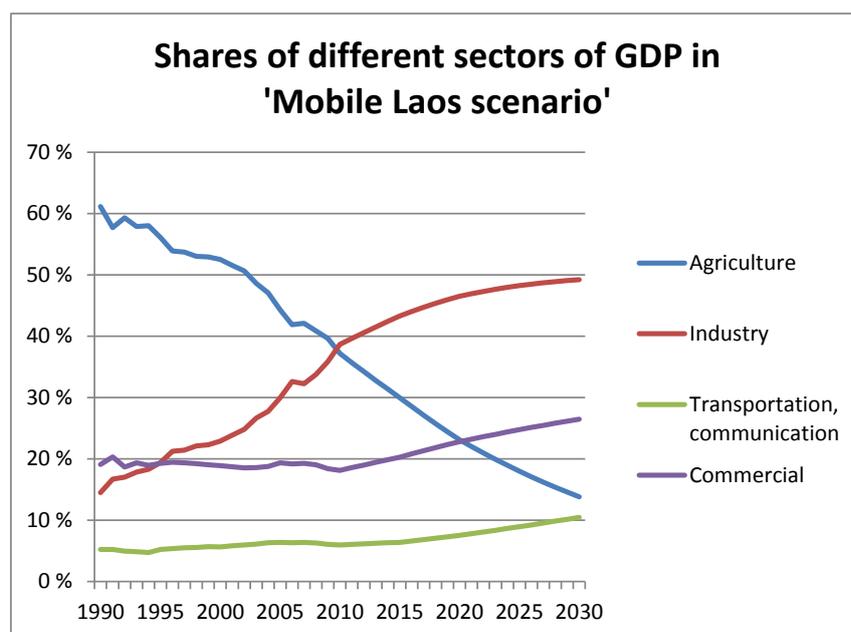


Figure 32. Changes in the shares of GDP of different economic sectors in 'Mobile Laos scenario'.

In the 'Mobile Laos' scenario the electricity consumption is lower than in the BaU scenario mainly due to the lower growth of the industrial sector as can be seen in Fig. 33.

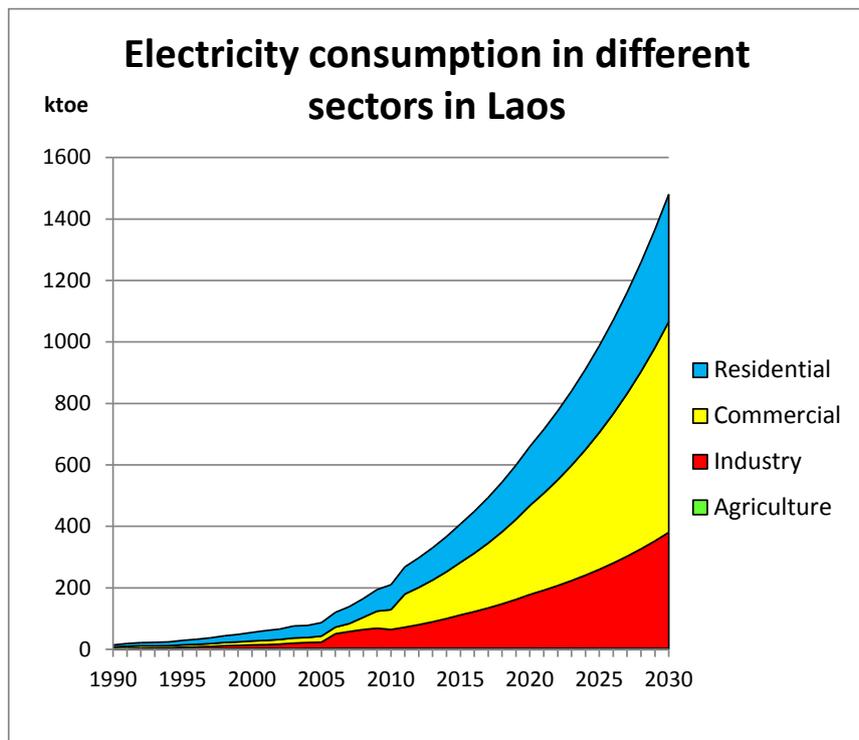


Figure 33. Electricity consumption in different sector in 'Mobile Laos' scenario.

In the 'Mobile Laos' scenario the sectoral final energy consumption indicates clearly the fast growth in the transport sector.

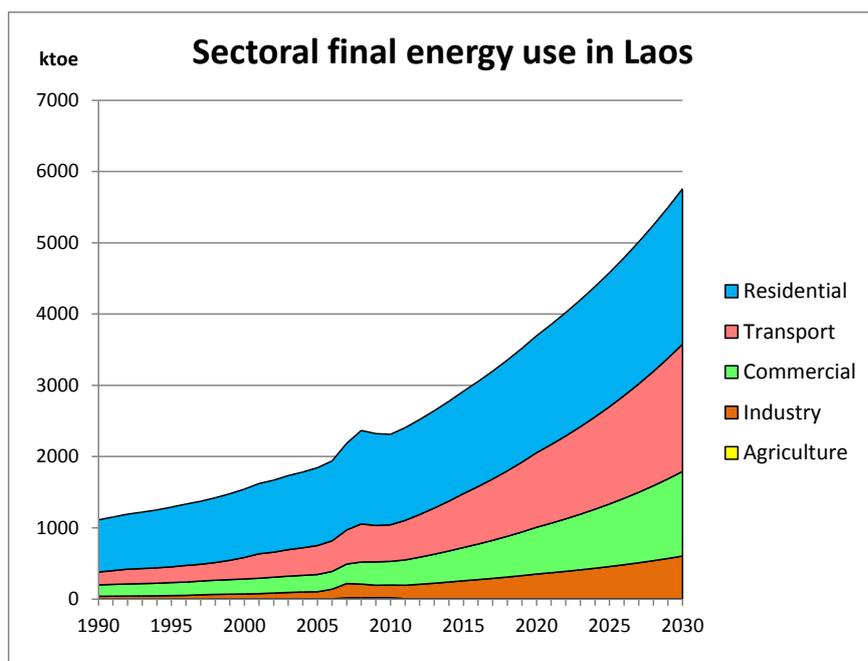


Figure 34. Sectoral final energy use in the 'Mobile Laos' scenario.

The total fuel consumption in 'Mobile Laos' scenario is given in Fig. 36. Here the considerable growth in transport fuels can be easily seen as well as in Fig. 37. The shares of energy consumption in different sectors are reported in Fig. 35.

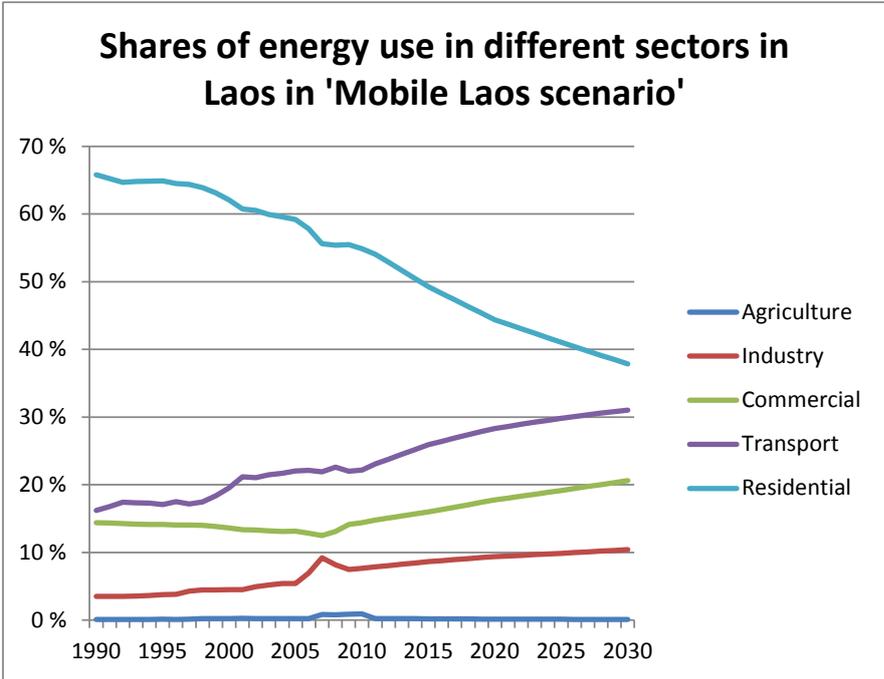


Figure 35. Changes in shares of energy use of different sectors in the 'Mobile Laos' scenario.

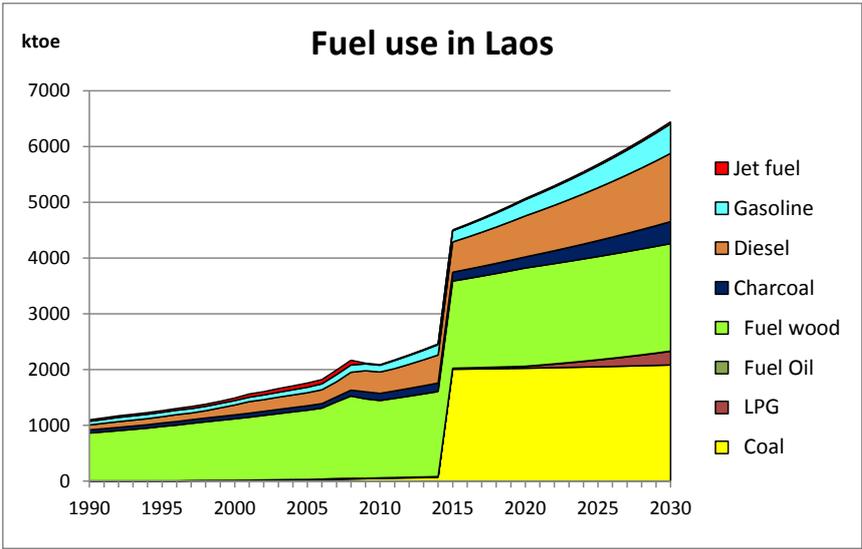


Figure 36. Use of different fuels in the 'Mobile Laos' scenario.

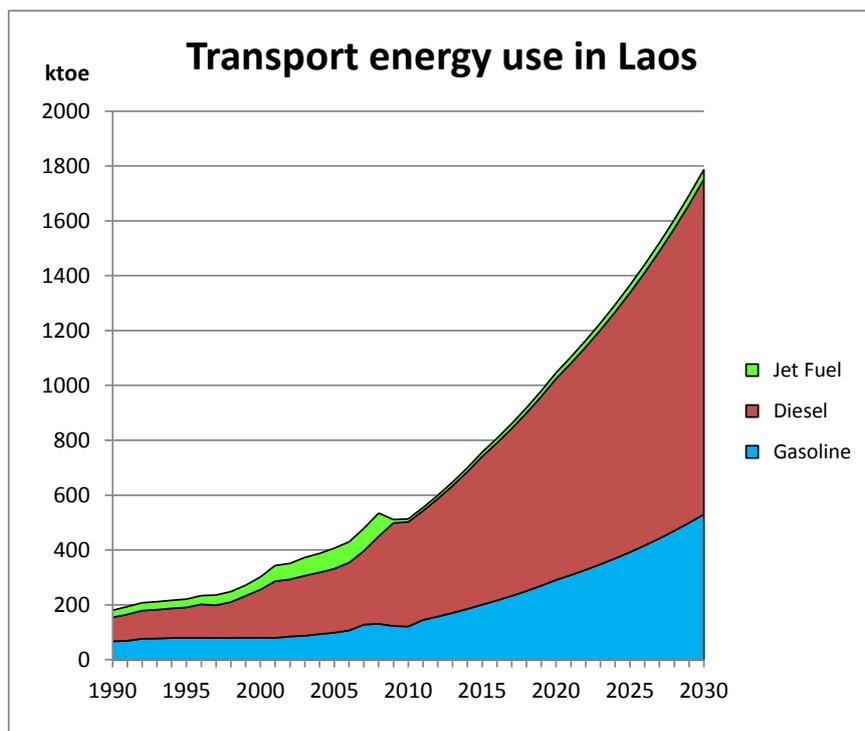


Figure 37. Energy use in the transport sector in the 'Mobile Laos' scenario.

3.3.3 Industrial Laos Scenario

In the 'Industrial Laos' scenario, the industry sector is growing very fast, over 10% annually. In this scenario the industrial growth is thought mainly to come from the introduction of metal industry in Laos. This will increase the electricity intensity of industrial production. Also other industries grow and the impacts on commercial and transport sectors can be seen in the scenario.

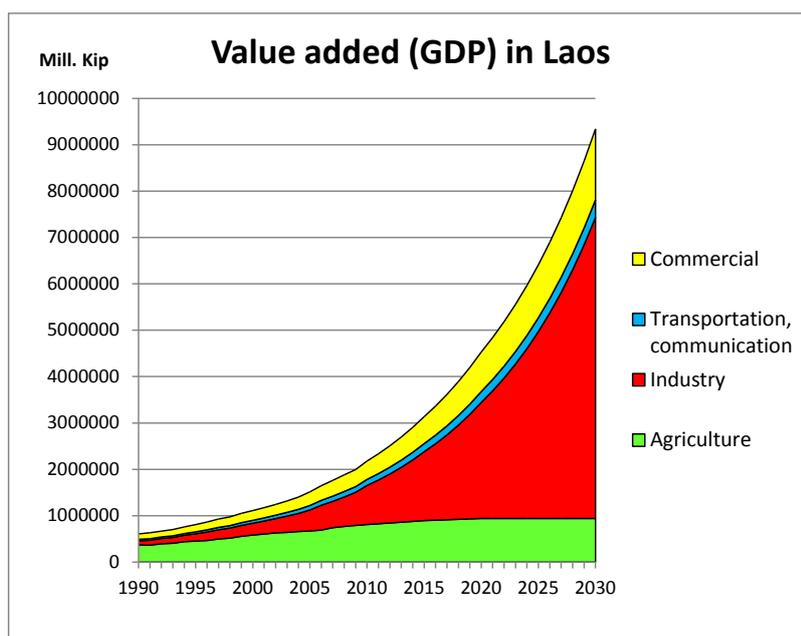


Figure 38. Economic growth in different sectors in Laos according to the 'Industrial Laos' scenario.

Table 3. Annual economic growth in Laos in the 'Industrial Laos' scenario.

Annual percentual changes									
GDP	Fill in the future annual growth rates (%) in the yellow cells								
	1990-95	1995-98	1998-2001	2001-06	2006-10	2010-15	2015-20	2020-30	
Agriculture	4.1 %	4.4 %	5.4 %	2.7 %	4.1 %	2.0 %	1.0 %	0.0 %	
Industry	12.2 %	11.2 %	9.1 %	13.9 %	11.9 %	12.0 %	11.0 %	10.0 %	
Transportation, communication	5.8 %	8.7 %	8.0 %	8.8 %	5.7 %	6.0 %	6.0 %	5.0 %	
Commercial	6.0 %	6.4 %	5.4 %	7.5 %	5.7 %	8.0 %	8.0 %	6.0 %	
Total	5.9 %	6.4 %	6.8 %	6.8 %	7.2 %	7.5 %	7.6 %	7.5 %	

Figure 39 illustrates the changes in the shares of different economic sectors of the GDP. In this industrial scenario' the share of industry grows considerably and reaches 70 % of GDP in 2030. The share of agriculture drops in this scenario from 60 % to 10 %.

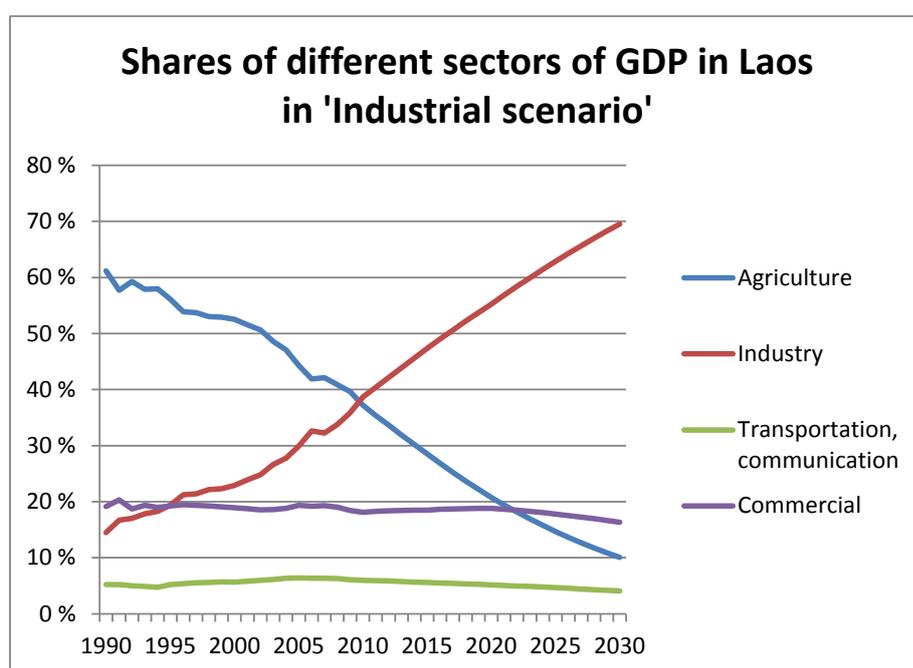


Figure 39. Changes in GDP shares of different economic sectors in 'Industrial Laos scenario'.

The electricity consumption growth in the 'Industrial Laos' scenario is quite high due to the growth of heavy industry which consumes a lot of electricity in the processes, especially in aluminum production.

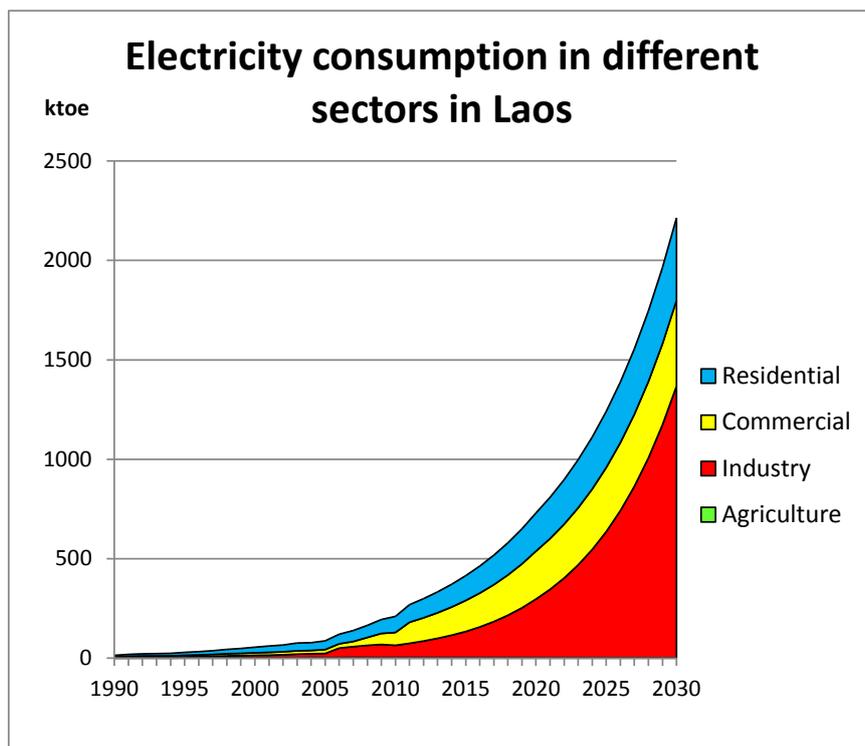


Figure 40. Electricity consumption in different sectors in the 'Industrial Laos' scenario.

Sectoral final energy consumption and use of different fuels as well as industrial energy use in the 'Industrial Laos' scenario are given in Figs. 41, 43 and 44.

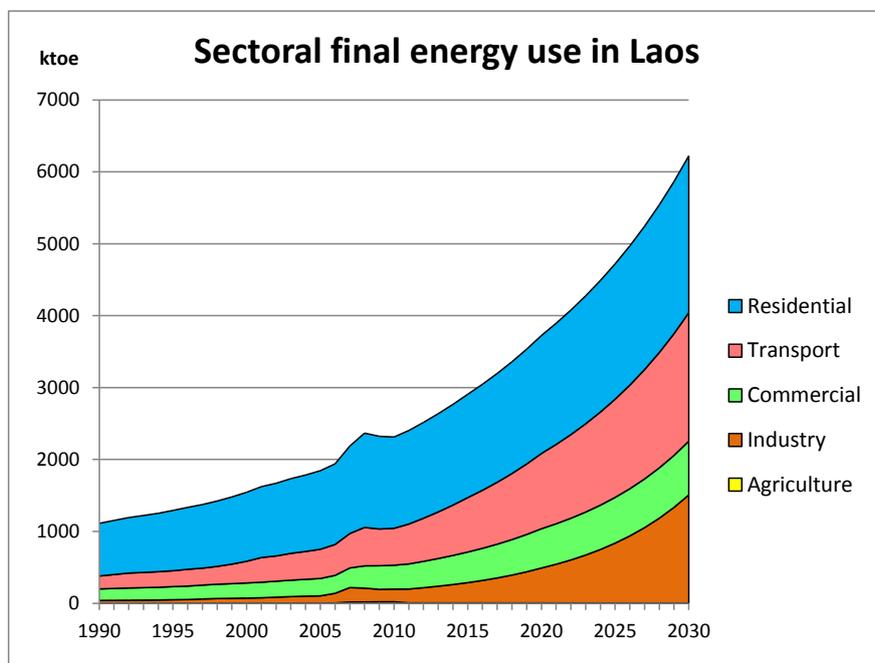


Figure 41. Sectoral energy use in the 'Industrial Laos' scenario.

Fig. 42 shows the changes of the shares of different sectors of the final energy consumption. In this scenario the share of industrial energy consumption increases fast but remains still below the residential and transport energy consumption.

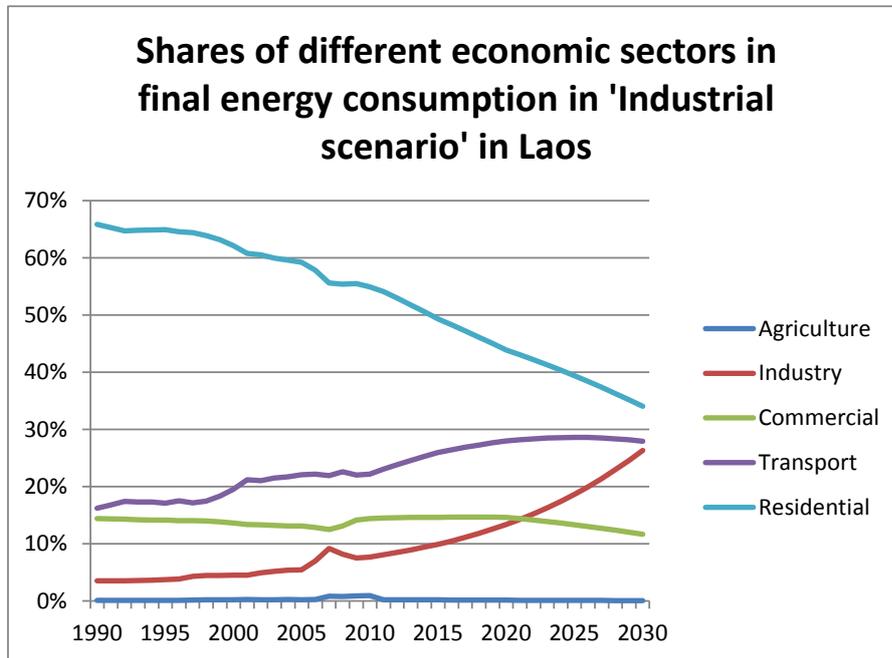


Figure 42. The shares of energy consumption in different sectors in Laos in the 'Industrial scenario'.

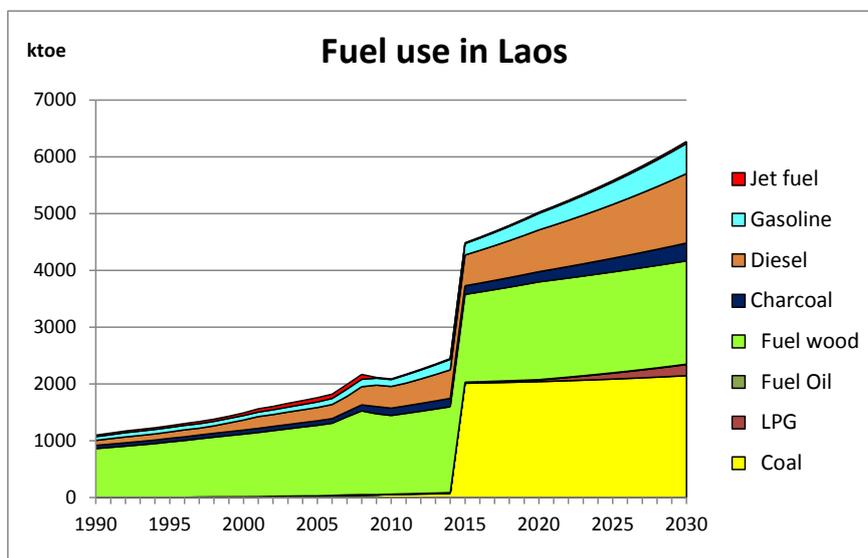


Figure 43. Use of different fuels in the 'Industrial Laos' scenario.

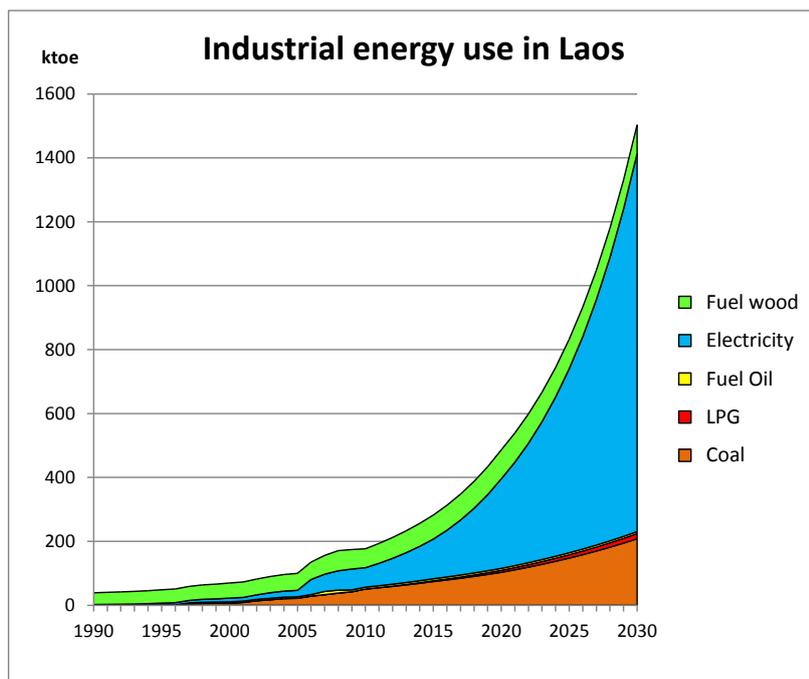


Figure 44. Energy use in the industrial sector in the 'Industrial Laos' scenario.

3.3.4 Agro-service Laos Scenario

In the 'Agro-service Laos' scenario the agricultural sector and the service sector are growing faster than in the other scenarios. In this scenario the agricultural sector is producing higher value added products, such as organic food, for the markets and export. Especially the growing demand in Chinese middle class for high quality food products is one driving force in this scenario. Also the growth of tourism and related services including high quality restaurant services are increasing the value added of production. Fig. 45 and Table 4 indicate the economic development in different sectors in the 'Agro-service Laos' scenario.

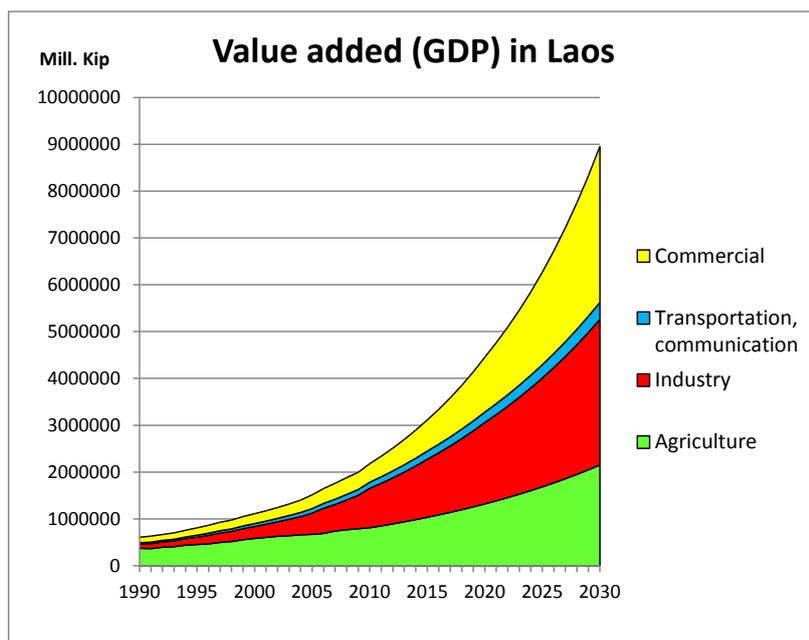


Figure 45. Economic development in the 'Agroservice Laos' scenario.

Table 4. Annual production growth in different sectors in the 'Agroservice Laos' scenario.

Annual percentual changes									
GDP	Fill in the future annual growth rates (%) in the yellow cells								
	1990-95	1995-98	1998-2001	2001-06	2006-10	2010-15	2015-20	2020-30	
Agriculture	4.1 %	4.4 %	5.4 %	2.7 %	4.1 %	5.0 %	5.0 %	5.0 %	
Industry	12.2 %	11.2 %	9.1 %	13.9 %	11.9 %	8.0 %	7.0 %	6.0 %	
Transportation, communication	5.8 %	8.7 %	8.0 %	8.8 %	5.7 %	6.0 %	5.0 %	5.0 %	
Commercial	6.0 %	6.4 %	5.4 %	7.5 %	5.7 %	11.0 %	12.0 %	11.0 %	
Total	5.9 %	6.4 %	6.8 %	6.8 %	7.2 %	7.4 %	7.4 %	7.2 %	

Fig. 46 shows the changes in the shares of GDP of different sectors in Laos. In this 'Agro-service scenario' the share of industrial production does not grow above 40 % while the service sector becomes the largest economic sector.

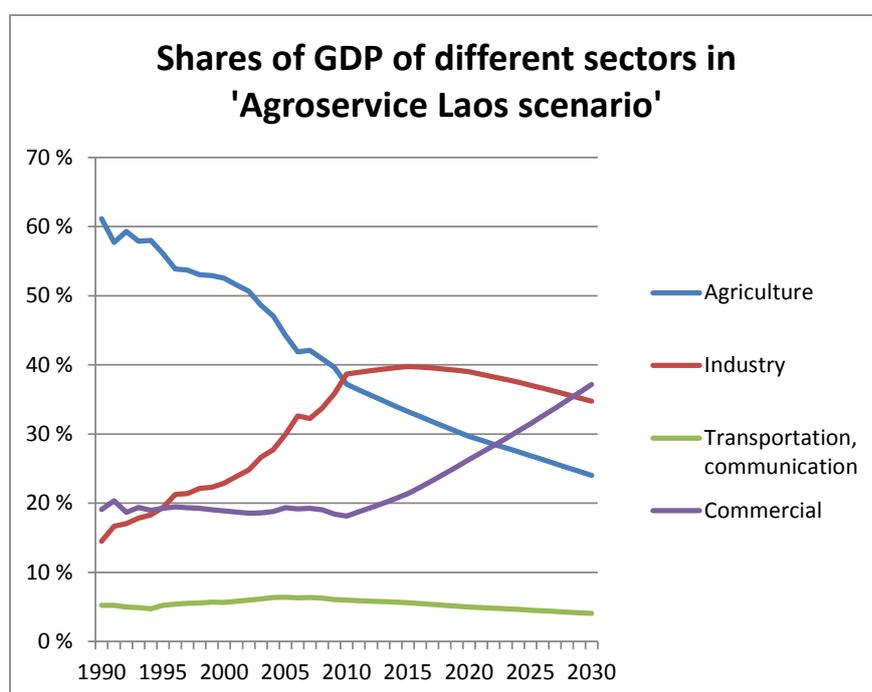


Figure 46. Changes in the shares of GDP of different economic sectors in 'Agro-service Laos scenario'.

The electricity consumption in the 'Agro-service Laos' scenario (Fig. 47) is considerably lower than in 'Industrial Laos' scenario and in the BaU scenario.

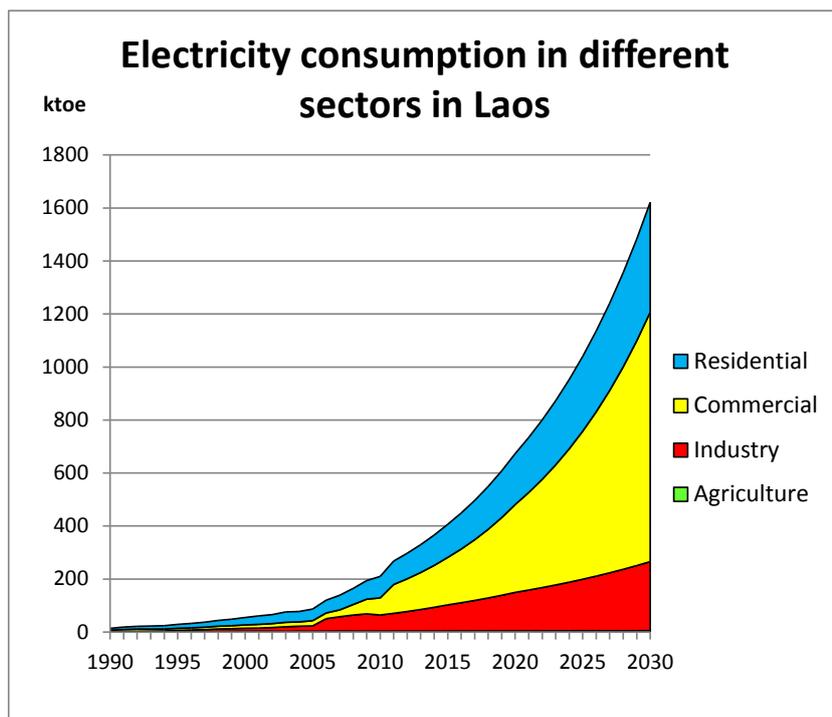


Figure 47. Electricity consumption in different sectors in the 'Agro-service Laos' scenario.

The sectoral final energy use and use of different fuels in the 'Agroservice Laos' scenario is presented in Fig. 48 and 50.

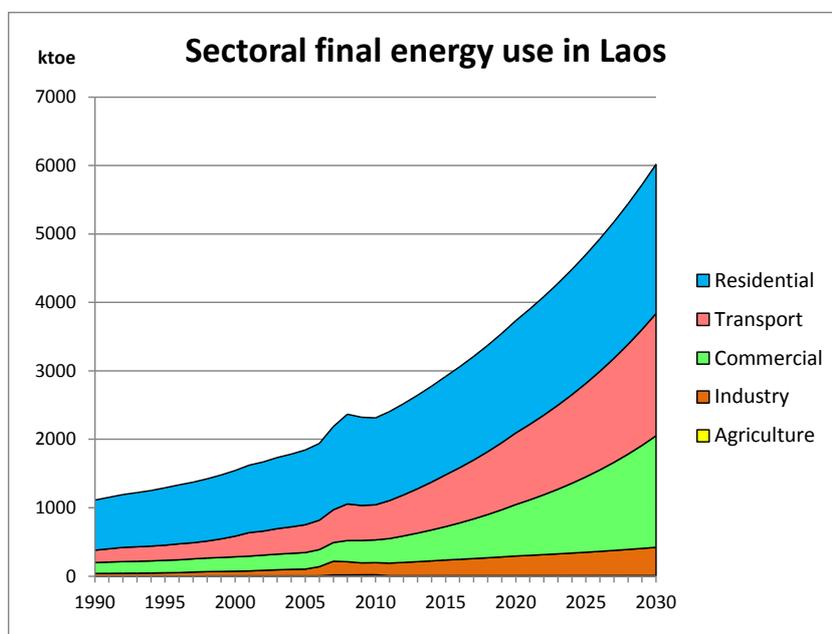


Figure 48. Sectoral energy use in the 'Agro-service Laos' scenario

The changes in the shares of energy consumption are depicted in Fig.49.

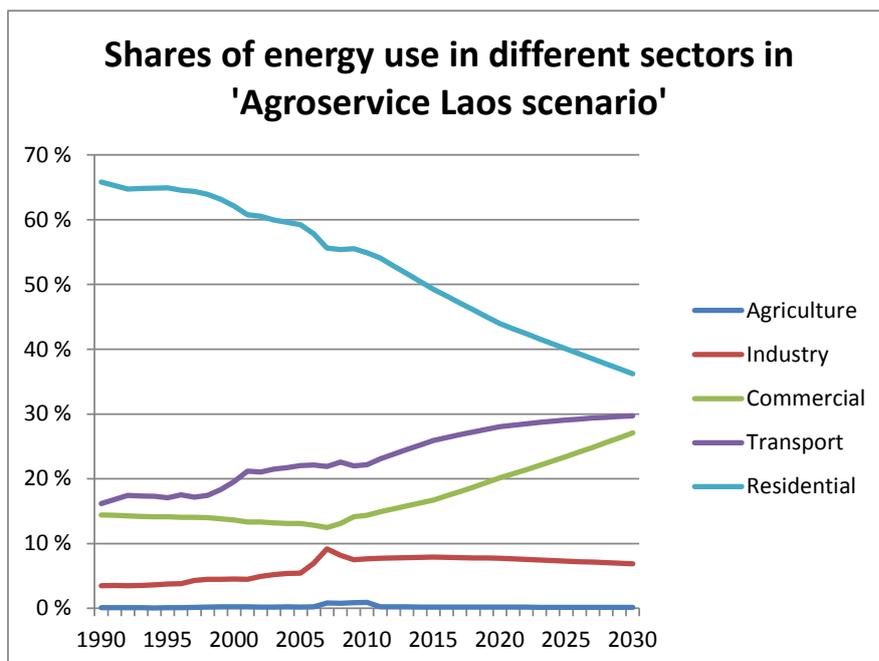


Figure 49. Changes in shares of energy consumption in different sectors in 'Agroservice Laos scenario'.

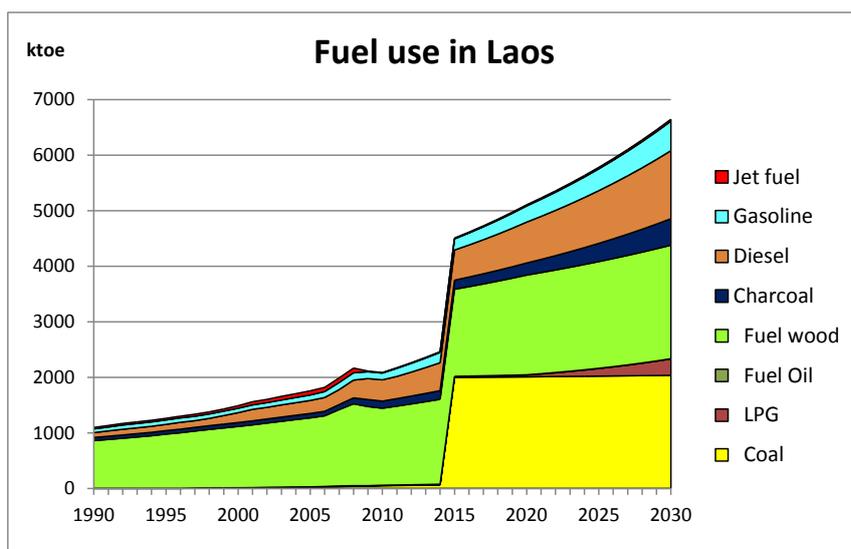


Figure 50. Use of different fuels in the 'Agroservice Laos' scenario.

Energy use in commercial sector and agricultural sector is depicted in Figs. 51 and 52. In this scenario the energy use in agricultural sector is increasing due to the considerable increase in the production volume.

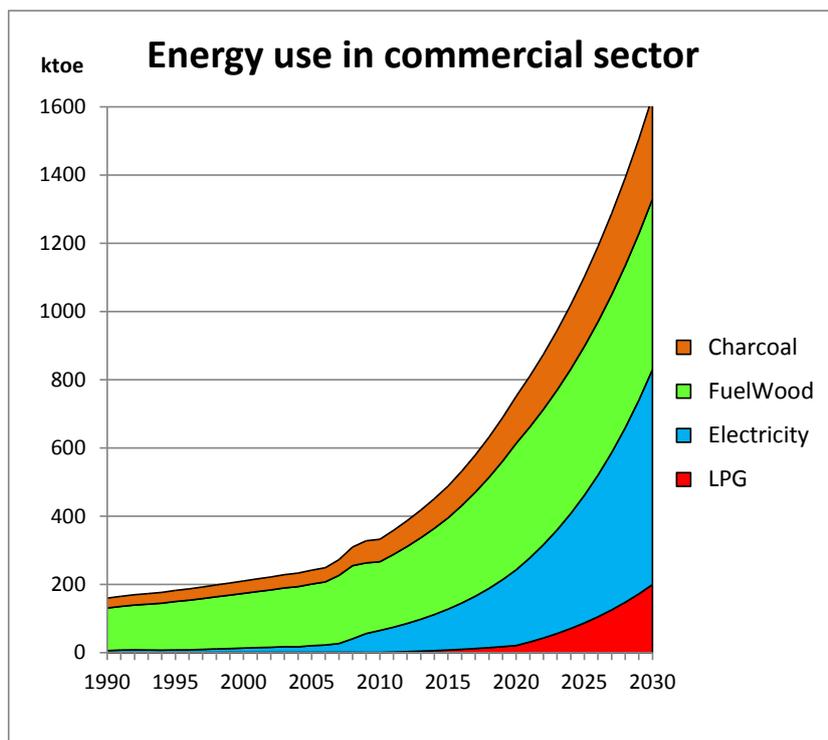


Figure 51. Energy use in the commercial sector in the 'Agroservice Laos' scenario.

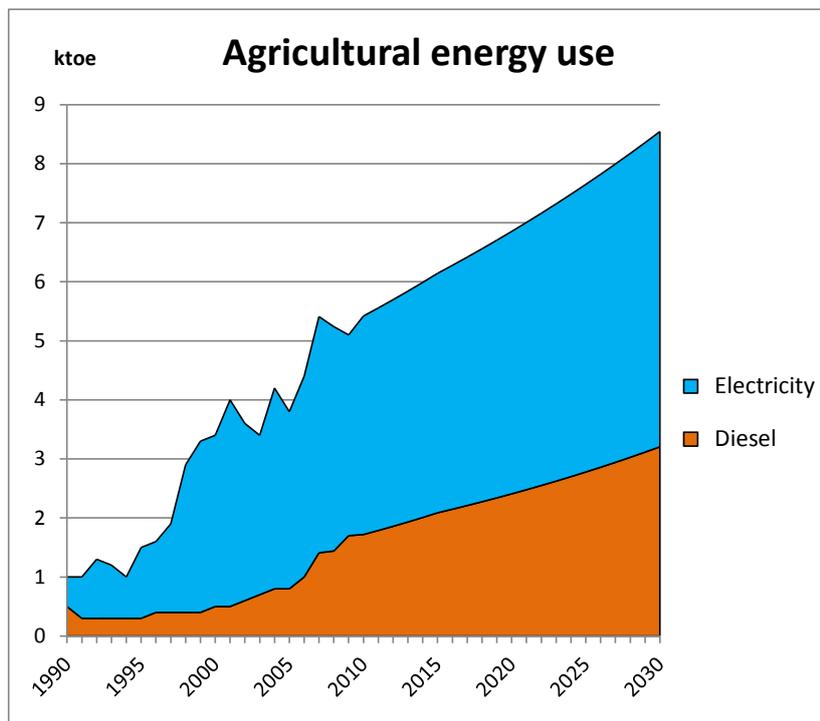


Figure 52. Energy use in agricultural sector in the 'Agroservice Laos' scenario.

4. DISCUSSION AND STRATEGIC REFLECTION

When we look at the different scenarios that are presented above we have to think what could be the driving forces to realize the different scenarios and what are the implications of these scenarios for the life of people in Lao PDR. The developments described in the scenarios do not take place automatically, but they require policy decisions of for instance investments. Crucial questions in this regards are where to invest and what kind of foreign investments are available for these purposes. What are the government priorities and where should it allocate the revenues?

One possible future development path is industrial development based on the mining of local mineral resources and processing them for global markets. There has been discussion for example of the utilization of the bauxite resources and the start of aluminium production in Laos. The production of alumina from bauxite and further processing of it to aluminium requires huge amount of energy. This can be seen as one possible development path since the mineral and energy resources for the processing do exist in Laos. The possible benefits and related costs of the processing have to be balanced against alternative ways of using these resources, such as direct export of bauxite and electricity. The global market situation and price are important determinants of the economics of the alternatives. In addition, the possible environmental and social impacts related to the utilization of these resources have to be taken into account.

The development of the mining and processing of the mineral resources also requires investments in transport sector infrastructure, education, etc. The above mentioned scenarios should be developed in much more detail to take into account all these possible interlinkages between different sectors that are affected by the development investments. For instance the 'Agro-service Laos' scenario should take into account the impacts of the development of small scale processing industry for the organic agricultural products, their transport and trade as well as the required education and training of the producers, changes in land use, availability of productive land and labour force, etc.

Important questions in the planning process are how to respond to the interlinked challenges. The main drivers of the different development paths should first be analysed carefully. Then the interlinkages between different sectors and activities should be taken into account. In the planning several possible development paths should be analysed –this means building of different scenarios. Different models should be used in the planning to include different viewpoints. Top-down models provide different views of the processes than bottom-up models as well as different micro, macro and global models.

In the planning process feedback from different experts is needed in order to get a balanced view of different problems and alternatives related to the scenarios. One important issue in the development of the planning process is the investment in capacity building. Especially when different energy and resource planning models are used the understanding of their properties, advantages, deficiencies, applicability and usefulness is important. This point of view is highly important in the contexts of (1) 5 year plans, (2) natural

resource planning, (3) energy production planning and (4) investment planning, (5) educational and capacity planning and (6) planning and forecasting of national and regional electricity consumption.

Energy demand scenarios are one strategic key element of professional energy sector planning. In this e-book we have presented new energy demand scenarios, which are based on best updated data base of Lao PDR planning authorities. In Laos there have not been too many energy demand scenarios and planning models before. From this perspective our analyses are providing vital new information and knowledge for the ministries of Lao PDR.

In the future one key challenge is to connect this planning approach to other planning systems of energy sector. Also the integration of other sector planning procedures will be a big challenge.

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APPENDIX

POPULATION MODEL

The population scenarios are based on the following assumptions and data using a model developed by Juha Panula-Ontto:

- Main source for data is Population and Housing Census 2005 including adequate data on current population accounts and fertility and mortality rates, but not migration
- Population and Housing Census 2005 reports age-cohort-specific fertility rates for Lao PDR and province-specific fertility rates for all ages. Age- and province-specific fertility rates used in model have been estimated from this information
- Fertility in age group 15-24 drops 2% annually in Vientiane Capital and 3% annually in other provinces
- Fertility in age group 25-39 drops 2% annually in all provinces
- Fertility in age group 40-44 drops 0.5% annually in all provinces
- Population and Housing Census 2005 reports Lao PDR infant mortality (mortality in age group 00-00) at 70/1000 and mortality in age group 00-04 at 97/1000
- Relative provincial levels of infant mortality are reported and used as a proxy indicator for mortality in age group 01-04
- Life expectancy for males and females are reported for each province, so mortality rates for age group 05-115 are calculated so that the reported life expectancies are realized
- In this example, infant mortality rates drop in Vientiane Capital 8.5% annually and in other provinces 5.5% annually
- mortality in age group 01-04 drops in Vientiane Capital 6% annually and in other provinces 4% annually
- mortality in age group 05-64 drops 0.5% annually in all provinces
- mortality in age group 65-74 drops 1% annually in all provinces
- Population and Housing Census 2005 gives estimates of total net migration for all provinces
- Current migration rates are estimated from this information
- The migration profile (which provinces the migration is directed to) is assumed to be the same in all provinces:
 - e.g. Vientiane capital receives the same share of migrants from each province
 - Migration to Vientiane Capital from all provinces grows 5% annually till 2020, then drops 1% annually till 2030
 - Migration to Luangnamtha grows 1.5% annually within the entire period
 - Migration to other provinces with currently positive migration flows, i.e. Bokeo, Vientiane Province, Borikhamxay and Sekong drops 2% annually within the entire period

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