Netherlands Enterprise Agency

POTENTIAL FOR DEPLOYMENT OF RIVER RUN-OFF TURBINES IN LAO PDR

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Private Sector Development Study – MAT17LAO01

POTENTIAL FOR DEPLOYMENT OF RIVER RUN-OFF TURBINES IN LAO PDR

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Table of Contents

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ACRONYMS

AC	:	Alternate Current
BoQ	:	Bill of Quantity
DC	:	Direct Current
ECIE	:	Electric Construction and Installation Enterprise
EDF	:	Électricité De France
EDL	:	Électricité Du Laos
EGCO	:	Electricity Generation Company of Thailand
EIA	:	Environmental Impact Assessment
EPC	:	Engineering, Procurement and Construction
EPD	:	Department of Energy Promotion and Development
G2G	:	Government-To-Government
GoL	:	Government of Laos
GoNL	:	Government of The Netherlands
HP	:	Hydro Power
IGS	:	Intermittent Generation Source
IIPD	:	International Investment Promotion Department
IREP	:	Institute for Renewable Energy Promotion
IRR	:	Internal Rate of Return
JV	:	Joint Venture
kW	:	Kilowatt
kWh	:	Kilowatt hour
kW_p	:	Kilowatt peak
LGU	:	Local Government Unit
LIRE	:	Laos Institute for Renewable Energy (Ministry of Science & Technology)
MoEM	:	Ministry of Energy & Mines of Lao PDR
MOU	:	Memorandum of Understanding
MW	:	Megawatt
NTPC	:	Nam Theun Project Company
PPA	:	Power Purchase Agreement
PPP	:	Public Private Partnership
PSD	:	Private Sector Development
PV	:	Photovoltaic
RROT	:	River Run-Off Turbines
SHP	:	Small Hydro Power
USD	:	United States Dollar
W_p	:	Watt peak

EXECUTIVE SUMMARY

Background

The Laos government aims to increase its power generation capacity from 6,441 MW to 30,653 MW by 2030 for electricity exports to Thailand, Vietnam and Cambodia. The expected capacity for hydropower to be added in the coming 13 years is 18,977 MW, approximately 44% of the total capacity of planned power plants. While large scale traditional hydropower projects (with an average size that is more than 220MW) find resistance from NGO's due to their negative social and environmental impacts and have to follow lengthy procedures of the intergovernmental Mekong River Commission (MRC), the Government of Laos (GoL) has put regulations in place to promote small hydro power (SHP), defined as equal or less than 15 MW.

It is in the above context of development of the energy sector and, in particular through the growth of SHP's, that the GoL welcomes the Dutch manufactured river-flow turbines for deployment without the above negative impacts. Both 'Made in Holland' technologies i.e. Tocardo turbines and Oryon Watermills, are welcomed to contribute to a rapid expansion of hydropower capacity.

This PSD Study presents possibilities for the deployment of the above Dutch power generation technologies and sets the stage for a results-oriented approach that aims at installing the first 10 MW of river run-off turbines in order to install over 1,377 MW up to 2030 worth over USD 1.3 billion of investments.

Methodology and Analysis

This PSD study focused on two streams of opportunities i.e. commercially viable feed-in-grid projects over 100 MW and off-grid electrification. The Consultant collected a wide range of financial, technical, fiscal, legal, social and economic data and information, based on policy documents, project information sheets, technical reports, a mini workshop with experts and interviews with public and private entities in Lao PDR and in The Netherlands, including the Dutch manufacturers of turbines, Dutch financial institutions and government agencies.

The desk-study resulted into criteria for the identification of 20 potential sites for the commercial deployment of the river run-off turbines. A roadmap, strategy and follow-up actions have been prepared for the commercial introduction of the technology and the integration of it in future hydropower projects.

Key Findings and Recommendations

1. Lao PDR has a hydropower potential of over 30 GW. It has a fairly developed power grid infrastructure i.e. transmission and distribution networks, including dedicated cross-border transmission lines, which are continuously reinforced to ensure that the export of electricity to Thailand, Vietnam and Cambodia is affordable, reliable and of good quality. The country will expand its existing 45 power projects to 429 projects by 2030. Over 90% of the existing projects are owned by foreign companies and – with that – Lao PDR has demonstrated to have a policy framework in place and an investment climate to close international power agreements in public-private settings and honor its execution.

2. The Ministry of Energy and Mines (MoEM), through its Institute for Renewable Energy Promotion, welcomes the new Dutch technologies, in particular if it is commercially deployed and is able to set a new standard for small hydropower expansion in the country.

Such new technologies directly contribute to the targets set by the Government of Lao PDR in the Paris Agreement (i.e. the Intended Nationally Determined Contribution, INDC). MoEM would need technical expert support with adding capacity to set standards for the integration of such new technologies in the new and future hydropower projects. Such new standards would aim at the full utilization of kinetic energy in outflowing waters at hydropower dams instead of continuing with building energy-dissipation structures in spillways and outflow canals.

3. Both Tocardo and Oryon Watermills can be deployed in the rivers and canals in Lao PDR on the basis of their technical characteristics and their own optimal operating conditions. In general, Tocardo turbines are efficient in streams with a velocity larger than 2 m/s, while Oryon Watermills are efficient in areas with a flow of 1 m/s or more. A technical feasibility study would need to define which technology is to be deployed at which site and in which configurations (including mix) and quantities.

4. The above technologies could together make up for the addition of 1,377 MW up to 2030, adding up USD 1.3 billion of investments. This is a significant market opportunity that could help Lao PDR to add 5-10% of additional hydropower to the existing and future capacity in streams where currently energy is "wasted" e.g. spillways and outflow canals designed to reduce velocity of outflowing water in order to avoid risks for erosion; with the new available technologies, outflowing streams can now be utilized to tap additional energy without extensive approval procedures and large scale engineering interventions.

5. This study has identified 20 sites, as the result of a mini expert workshop, where an estimated total of 177 MW can be deployed within the next 3 years and for which an estimated total investment of USD 250m – 300m is required. The key reason for selecting existing sites versus developing new sites is that spillways and outflow canals are already in operation and under relatively controlled conditions (i.e. stable hydrology and hydraulic characteristics, geotechnical structures, clear ownership and management and low risk of floating debris).

6. Commercial deployment can be assured if the PPA tariffs will be in the range of USD 0.06 – 0.08 per kWh and a project IRR of 10-12% can be achieved by structuring equity: debt at a ratio of 30 : 70 and ensuring an interest rate of between 4-6% per annum for a period of 12-15 years. A Dutch government credit guarantee will certainly contribute to achieve such terms for a loan from Dutch financing institutions. Initial Dutch Government co-financing support for demonstration, feasibility or investment preparation studies will be perceived by stakeholders as full trust in the Dutch technologies and increase the attractiveness among investors for the first 10 MW project. The Government of Lao PDR need to offer incentives for introducing these new technologies by way of allowing a corporate tax of not more than 10%, exemptions from import duties of equipment and facilitate efficient processing of permits and licenses.

7. Business opportunities are not only limited to the deployment of Dutch technologies, but also for Dutch hydraulic knowhow, Dutch contractors specialized in complex hydraulic and structural engineering and the Dutch capital market (e.g. development and commercial banks, pension funds, private equity companies and the emerging crowd-funding market). With such trusted engagement from the Dutch renewable energy sector, internationally operating investments partners could be attracted as well to help an accelerated deployment of RROTs.

8. This study recommends the deployment of a first batch of 10 MW of river run-off turbines at one single site (Nam Theun 2 Power Company) or at 2-3 sites depending on deals that could be closed with the existing owners of the hydropower companies. An estimated investment of USD 18m – 20m will be required to build and operate this power plant by 2019. Interests were expressed by several parties in Laos, Singapore and The Netherlands, such as: Tocardo, WEnergy Global, Strukton Group, EDL, ECIE, ING Bank Singapore and a Japanese investment firm. Other parties that could be approached for possible engagement are, for example: InfraCo Asia, Asia Infrastructure Investment Bank (AIIB), ABP Pension Fund, FMO, IFC, Nam Leuk 1+2 Power Corporation, the Nam Theun 2 Power Corporation, EGCO, CK Power PLC and BAM International.

9. The study recommends the establishment of a Consortium of Companies that can sign a Memorandum of Understanding with the Ministry of Energy and Mines to start the process of executing the first 10 MW. A Technical and Financial Feasibility Study must be carried out to demonstrate its commercial viability and – therefore - its bankability (an Investment Decision Level Study).

10. Oryon Watermills are suitable for rural/off-grid electrification with minimum capacity of 50 kW systems in low-velocity streams near communities. The DRIVE program of the Dutch Government (RVO) could offer co-financing for such development relevant rural electrification projects and as such it still might be worthwhile to explore if these projects are of interest to Dutch companies. Such projects will need to be operated in close partnerships with local village councils and village-entrepreneurs.

1. INTRODUCTION

1.1. Background and Purpose of the Study

The Laos government aims to increase its power generation capacity from 6,441 MW to 30,653 MW by 2030 for electricity exports to Thailand, Vietnam and Cambodia. Currently, the installed capacity for hydropower is 4,558 MW, coal-fired power of 1,878 MW and sugarcane-based biomass energy of 5 MW. The expected capacity for hydropower to be added in the coming 13 years is 18,977 MW, approximately 44% of the total capacity of planned power plants. The remaining expansion will be by coal, lignite, wind, solar and biomass power plants[1].

While large scale traditional hydropower projects (with an average size that is more than 220MW) find resistance from (1) NGO's due to their negative impacts on the environment and on indigenous communities and (2) the intergovernmental Mekong River Commission (MRC) for negative impacts on down-stream countries, the Government of Laos (GoL) has put regulations in place to promote small hydro power (SHP), defined as equal or less than 15 MW. Companies, foreign and local, have signed MoU's for over 200 SHP projects with an average capacity between 5-7 MW.

It is in the above context of development of the energy sector and, in particular through the growth of SHP's, that the GoL welcomes the Dutch manufactured river-flow turbines for deployment without the above negative impacts. Both 'Made in Holland' technologies i.e. Tocardo turbines and Oryon Watermills, are welcomed to contribute to a rapid expansion of the targeted hydropower capacity.

The green growth ambitions of the GoL are evolving and a series of national workshops were organised with assistance of the Global Green Growth Institute (GGGI) in collaboration with the Lao Ministry of Planning and Investment (MPI) and the National Economic Research Institute (NERI). Lao PDR is a signatory of the Paris Agreement and its Intended Nationally Determined Contribution (INDC, Paris Climate Agreement, 2015) clearly states the country's commitment to increase the share of small-scale renewable energy to 30% of total energy consumption by 2030.

In addition, the GoL welcomes Dutch excellence in construction of such hydro-projects (and other infrastructure) to contribute to improving the construction standards and practices in the country.

While the country is strengthening its national transmission and distribution power infrastructure with financial support from the World Bank and the Asian Development Bank, the GoL is also calling for public and private partners to contribute to its national renewable energy development goals and boosting access to power for communities to 90% and up by 2020. The strengthened power grid will enable intermittent sources to feed-in the grid without disruptions and power losses.

The national vision of the GoL is clear. Laos is open for foreign investors and technology providers, demonstrated by encouraging foreign ownership of power generation assets in the country. The current foreign ownership of hydropower plants and transmission lines in Laos is approximately 60%, developed since 1998, which is expected to increase to around 70-80% by 2030.

Rules and regulations are in place in Laos for private sector to fully and/or partially own hydropower assets.

[1] Consolidated List of Power Projects Nationwide in Laos, updated version 31/12/2016 (version 7), Department of Energy Policy and Planning, consolidated by Division of Electric Power Generation Source Planning.

This PSD study will aim at composing a tangible business framework focused on enabling Dutch (and where possible also international) private sector (both Dutch technology manufacturers and capital institutions/investors) to form partnerships with public and private companies from Laos to enable the commercial deployment of river run-off turbines in Lao PDR.

The purpose of this PSD study is to identify and define prospects for:

(1) Feed-in-grid renewable energy to contribute to the national targets of Lao PDR to increase its small hydropower capacity, both for the purpose of export of electricity to neighbouring countries and to narrow the gap of the increasing national demand;
(2) Off-grid electrification of energy-poor communities in rural areas through micro-grids powered by renewable energy sources to boost green rural development in Lao PDR.

1.2. Methodology & Approach

The study will focus on two types of opportunities:

(1) Renewable energy for feed-in-grid contributing to the electricity export targets of Lao PDR: what are opportunities of 'river run-off technologies' (RROTs), such as the Tocardo Turbines and/or the Oryon Watermills. The study, initially, had to identify at least 10 river sites that would be suitable for serial or parallel deployment of RROTs reaching > 5-10MW per site and replicable to > 100MW. However, thanks to the support of IREP, 20 sites were identified.

(2) Renewable energy in hybrid micro-grids, i.e. powered by river flow energy and/or in combination with solar PV energy and the use of energy storage systems (ESS) to electrify off-grid communities on a 24/7 basis and boost green growth. The study, initially, would identify at least 3-5 tangible locations that are suitable for commercial or semi-commercial deployment of such systems. However, analysis of data showed that the commercial operation of off-grid systems is not feasible with the current state of technology and tariff-policy of Laos. Alternative business models will be mentioned in this report.

The Consultant collected data and information (e.g. documents analysis, interviews with experts and decision-makers and three site visits) on the following:

(i) Technical data sets and location profiles
(ii) RE Policy/Regulatory framework: terms and conditions set by the relevant authorities
(iii) Investment/PPP constructions, Joint Venture requirements: shareholding structure local/foreign ratios; dividend payment;
(iv) Fiscal Incentives, including import tax/VAT exemptions and withholding taxes for Dutch companies;
(v) Power Purchase Agreement (for Feed-in-Grid): terms & conditions, currency?
(vi) Power Supply Agreement for off-grid electrification: waiver for exclusive service area for 15-20 years, tariff-pricing policy and rural electrification incentives?
(vii) Key risks assessment and mitigation measures
(viii) Potentials for Government-to-Government cooperation in institutional and capacity building activities: enhancing legal and regulatory frameworks, special circulars for enabling private sector engagement in off-grid electrification.

The following steps have been followed to complete this PSD study:

1. Desk study:
   Focus on existing regulatory frameworks and decision-making procedures for energy investment projects in Laos; pricing policies; fiscal incentives; short and long-term energy developments.

2. Direct interactions with key Government stakeholders in Laos to prepare data and information related to the Dutch technologies; site field visits: orientation meetings, discussing data/information and zooming in on potential sites and sizes based on hydrological, hydraulic, topographical and policy data and information.

   Communicating with GoL stakeholders on the selection of possible sites suitable for the deployment of RROTs; a concentrated effort to tap from expert knowledge through a mini project development workshop aiming to technical/conceptual aspects, explore possible business structures and corresponding terms & conditions by the respective authorities in Laos, and exploring how a fast-track project execution could look like, including roles and responsibilities of key stakeholders.

3. Processing of field findings; communicating with RVO and NL Embassy Officials in Bangkok and Singapore. Technical meetings with Tocardo and Oryon Watermills on data and information (including videos of possible sites) collected and a 'first-glance' on technical and financial aspects of deploying the respective technologies in Laos.

4. Writing of Draft Report and Presentation for Stakeholders.

5. A visit to Laos to present the draft-final outcomes to stakeholders as well as Dutch technology companies and financial companies to collect their feedback for the final report.

5. Submission of FINAL REPORT to RVO, including follow-up steps and other recommendations.

1.3. Structure of the Report

This PSD report presents the scope of the study in Chapter 1, followed by Chapter 2 with a brief profile of Laos, including its economy, the energy market and investment climate. Chapter 3 describes the deployment strategy for both proposed Dutch technologies, while Chapter 4 shows the way forward towards feasibility study and implementation options.

2. KEY ECONOMIC CHARACTERISTICS OF LAO PDR

2.1 Social and Economic Characteristics

Lao PDR is a landlocked country with an area of approximately 236,800 km^2, sharing borders with Thailand China, Myanmar, Vietnam and Cambodia. It is mostly mountainous with altitude variations and almost 50% of the land area is covered by woodland and forests. Lao PDR has high annual rainfall and has an abundance of water resources, primarily originating from the Mekong River within the country's borders.

Figure 2.1.a: Overall Map of Laos
(Source: The World Factbook, 2017)

Lao PDR is categorized as a least developed country with a lower-middle income economy. It is one of the fasted growing economies in the East Asia and Pacific region with a GDP growth averaging 8% over the last decade. Development is however uneven and poverty remains widespread. In 2016, 23% of the population lived below the national poverty line. The country's main economy is based on the use of its natural resources and is driven by forestry, agriculture, hydropower, and minerals. Other growing industries are construction, services (foreign direct investment) and tourism, triggered by growing regional integration.

Table 2.1.a.: Key Economic Indicators of Laos in Year 2016

Population	6.9 million
GDP	USD 15.9 billion
GDP growth	6.8%
GNI per capita	USD 2,150
Inflation rate	1.6%
Debt to GDP ratio	68%

The Worldbank projects the country's GDP to grow at approximately 7% per year between 2017-2019.

2.2 Power Sector

Overall Profile

Lao PDR is an electricity access success story. In 1995, only 16% of households had access to electricity, triggering the government to set a target for 90% access by 2020. This target has been achieved as soon as 2016. In Nov 2016, the country's installed capacity was 6,300 MW, electrifying 90.5% of its 6.9 million inhabitants. Electricity generation in 2015 was 16,500 GWh, of which domestic demand is 4,700 GWh with an 8-10% growth rate per year.

The power sector plays a major role in the economy of Lao PDR and strives for two national priorities: firstly to promote economic and social advancement by providing a reliable and affordable domestic power supply and secondly to earn foreign exchange from electricity exports. Electricity is the country's number-one export commodity accounting for roughly 30% of all exports and has been an important income element in the country's US 12.7 billion GDP (2015).

Laos has an abundant surplus of electricity generation. The current domestic demand for electricity is 3,100 GWh or an estimated equivalent of 585 MW out of the 6,441 MW installed or 34,364 GWh produced. This means that the export of electricity is 31,264 GWh or an equivalent of 5,856 MW. Approximately 90% of the electricity generated is exported to Thailand, Cambodia, and Vietnam. Thailand is the main market, requiring an installed capacity in Lao PDR of 7,000 MW, while Vietnam requires 3,000 MW and Cambodia 2,000 MW.

Lao PDR actively plans to expand its electricity export further in South East Asia. In 2014, the Laos-the Thai-Malaysia-Singapore power transmission project was launched in Vientiane and Lao PDR will play a key role as a power provider, with hydropower as the primary source of energy and which accounts for 79% of its primary energy mix. Other sources are coal (20%), biomass/sugarcane (1%) and solar PV (currently on 6 MW at utility scale) and solar PV for rural off-grid electrification and for home-systems.

Overview of Hydro Power

Lao PDR is one of the richest countries in SEA in terms of hydropower resources with theoretical hydroelectric potential of about 30,653 MW. The country's geographic location includes a significant part of the Mekong River basin and its tributaries (around 35% of the Mekong's total inflows). Out of this theoretical potential, 18,000 MW are technically exploitable and by end of 2016 only 4,558 MW was installed (approx. 25%)[2]. Out of this 18,000 MW, 2,000 MW is the exploitable potential for small hydropower (≤ 15 MW).

Lao outlined continued plans for hydropower development. Based on Version 7 of the Consolidated List of Power Projects issued 31 December 2016 by the country's Department of Energy Policy and Planning, (DEPP), Lao is projecting additional hydropower installed capacity of 6,018 MW by 2020 and a further 16,548 MW planned after 2020. In total over 200 new small hydropower (SHP) projects (< 15 MW) being developed and for which MOU's have been signed for completion after 2020. Clearly, Laos is encouraging investments in SHPs.

Interesting to mention that, while both large and small hydropower projects are on the expansion list of Laos, the Ministry of Energy & Mines is also planning approximately 3,370 MW of lignite/coal

[2] 2015_Lao Government Electricity Statistics Yearbook 2015 and the Consolidated List of Power Projects Nationwide, 31/12/2016

power plants, 80 MW of solar PV, 20 MW of biogas and it signed MOUs for wind power projects (unknown capacity) for completion after 2020.

Table 2.2.a. below shows a total overview of the status of all power projects in Laos, including hydropower, coal/lignite, solar PV, biogas and wind power.

Table 2.2.a.: Overview of Status of Power Projects in Laos

	Project Qty	**Capacity (MW)**	**Energy (GWh/year)**
Existing projects	45	6,441	34,364
Expected completion in 2020	50	6,618	31.944
Expected completion in 2025	46	3,581	16,425
Expected completion in 2030	66	4,485	18,292
MOU signed	222	9,528	31,627
Total	**429**	**30,653**	**132,652**

Bilateral and Multilateral Agencies

The energy sector of Laos is not donor-aid, but highly private sector investment driven i.e. over 90% of the power plants are owned by private enterprises from France, China, Thailand, Japan, Vietnam and Laos. Rural electrification programs attracted attention from the Governments of Japan and France[3]. Other donor agencies, such as from Finland and New Zealand, are engaged in policy studies, capacity building and training of MoEM staff and related institutions.

For example, in 2015, New Zealand announced a US$200m assistance package to ASEAN over the next three years[4]. A significant portion of this supports Laos through aid programs, including scholarships for training programs at the Mekong Institute in Thailand as the Mekong River runs through Laos and is a major source of hydro generation, allowing Laos to export electricity. The Government of Finland is providing support aiming at developing the environment-sector administration in Laos, e.g. environmental permit procedures, regional planning and waste management, and to promote environmental awareness. Finland is now also granting development cooperation funds to support the preparation of a renewable energy strategy.

The Global Green Growth Institute (GGGI) is involved in facilitating several government agencies to align on the climate agenda. The World Bank and ADB are engaged in the improvement of power transmission and distribution infrastructure.

The cooperation between the Governments of Laos and The Netherlands would need to cross-connect with the above existing relations and programs aiming at enhancing the deployment of RROTs in the Mekong River Basin section in Laos.

[3] NAMA for the Renewable Energy Sector of Lao PDR, UNDP, 2013

[4] https://mfat.govt.nz/en/countries-and-regions/south-east-asia/laos/

Rural Electrification

Over 90% of the population in Lao PDR will have access to electricity by 2020 through improvements in the existing transmission and distribution networks. By 2025, the Government of Lao PDR has targeted 98% of its citizens to have access to electricity. These off-grid communities could not be electrified by extension of the grid in an economically viable manner.

Initially, the Government of Lao PDR promoted home solar systems, but that program has not been satisfactory. Lack of payment for maintenance and replacement of components of these home solar systems have been the main cause of failure. However, the government intends to increase productivity of remote communities, for which more electricity will be required, i.e. beyond just 1-2 light bulbs.

The Institute for Renewable Energy Promotion (IREP) of the Ministry of Energy and Mines is promoting the use of solar PV powered micro-grids for off-grid electrification of communities. It conducted a pre-feasibility study for such micro-grids in five villages in the Nam Ou River basin, with support and expertise from Taiwan[5]. These villages, and many more in Lao PDR, are very remote and difficult to access i.e. transport through rivers that can last from 20 minutes to 3 hours and only with the use of small diesel powered boats. This level of accessibility will certainly form an obstacle in transporting solar panels and inverters, or a containerized power pack or a small Oryon Watermill (see paragraph 3.1 of this study).

The villagers are mostly self-sustained with simple agriculture, animal farming and fishing. Common agricultural products include corn, rice and garlic; garlic could be sold in market for 20,000 kip/kg (= USD 2.4/kg). Common expense items include food, health, tuition, and tax. Land tax is 50kip/m² for living areas, and 50,000kip/hectare (= USD 6/ha) for other agricultural use.
A typical village would consist of 50-60 households (or a population size of 200 - 400 people) with a collective monthly income of Kip 200,000 (= USD 24) on average per household. Currently a few households are able to use kerosene (USD 2.4/month), candles (USD 1.8/month) or in some cases also pico-hydro generators (that are considered to impose high risks on safety). Some villages have a primary school, but no health clinics. Such villages would require approximately 30-50 kW power generation capacity and a small distribution (micro) grid.

The Ministry of Energy and Mines encourages public-private partnerships for rural electrification through micro-grids and is allowing a tariff for power of USD 0.10 – 0.12 per kWh (approx. Kip 1,000/kWh). Village companies and the Laos Institute for Renewable Energy (LIRE) are studying possibilities for off-grid electrification. However, with the above tariffs it will be a challenge for private enterprises to design, build, own and operate micro-grids for such small villages with such a low income. While in rural areas the willingness to pay for power may be high, the ability to pay is very low at this stage of development. In addition, collection of bills in remote areas will not be commercially attractive as it is time-consuming and with certain risks, such as safety and security of personnel.

The villages are far away from markets and/or tourist attraction sites and therefore lack drivers for economic development. Power supply will strengthen social development in first instance for which the Consultant would recommend the use of Oryon Watermills (e.g. 50 kW units, see paragraph 3.1 of this report) possibly combined with solar PV and batteries to power such communities. Given the income profile of the households, any such electrification projects may not be of interest to commercial parties without a partial subsidy or grant, either by the GoL, or Development Aid

[5] Nam Ou Solar Villages Project, Project Concept Report, IREP/MoEN, 2017

Agencies and/or by non-profit NGOs. The DRIVE programme of rvo.nl could offer co-financing for such development relevant rural electrification projects and as such it still might be worthwhile to explore if these projects are of interest to Dutch companies. Such projects will need to be operated in close partnerships with local village councils and village-entrepreneurs.

UNDP and the Ministry of Energy and Mines of Lao PDR proposed a Nationally Appropriate Mitigation Action (NAMA)[6] aiming at creating opportunities for a sustainable and low carbon development of Lao PDR through rural electrification i.e. use of mini-grids in Rural Productivity Zones (RPZ). In the first phase the NAMA aims to establish eight mini grids. This will provide electricity to around 1,000 households and around 6,000 people. Over the 15-year lifetime of the NAMA, emission reductions will reach around 13,000-14,000 tonnes of CO_2eq. The total cost of the NAMA is estimated at around US$3.4 million. This includes support to cover the investment costs of the technical intervention as well as extensive capacity-building e orts. In total, the Government of Lao PDR is committed to providing around 14 per cent of the required funding. The remaining 86 per cent is expected to come from NAMA donors.

There are four (4) mini grids in Lao PDR, built between 2003 -2008, mainly powered by mini hydro, solar and diesel. All funded by aid agencies from Japan and France. All four systems are operated and run by the local community.

The Government of the Netherlands could consider becoming a NAMA donor and contribute to the expansion of mini-grids in RPZs in Lao PDR using the Oryon Watermills as a source of power. However, without a NAMA contribution (or subsidy) private companies will not initiate or invest in rural electrification projects. Going forward in this PSD study, the rural electrification part will not be addressed any further.

2.3 Investment Climate

The Lao Government has supported and encouraged the private sector to invest in the energy sector. Out of the installed 6,441 MW in 2016, over 90% is owned by Independent Power Producers (IPPs). The remaining 10% is owned by Électricité du Laos (EDL), a state-owned corporation, that owns and operates electricity generation, transmission, and distribution assets[7].

Since 1998, the country clearly demonstrated its readiness and experience in dealing with foreign private sector investors in the energy sector as over 56% of all existing power projects are owned by foreign companies and operated under Power Purchasing Agreements issued in several types of currencies e.g. USD and THB.

The government energy policies are aiming the following goal:

- Increase electrification rate to 98% by 2025
- Increase access to electricity by grid extensions
- Make modern energy more affordable and accessible for every Lao citizen in remote areas (rural electrification);
- Increase energy export to boost national socio-economic development: increase power export to 12,000 MWh by 2020, 7,000 MWh to Thailand and 5,000 MWh to Vietnam.
- Promote energy efficiency and conservation;

[6] NAMA for the Renewable Energy Sector of Lao PDR, UNDP/MoEN, 2015

[7] Investment incentives for sustainable development: The case of Lao PDR, a publication by International Institute of Sustainable Development in 2014.

- Increase the share of renewable energy in total energy supply by 30% in 2025 including blending 10% of biofuels in the transportation sector.

At the moment, there is still no electricity selling tariff regulations for Renewable Energy in Lao PDR. The selling tariff of electricity generated from RE projects is currently based on negotiations between producers and EDL on a case-by-case basis. Currently, PPAs for hydropower are closed with EDL between USD 0.057 (rainy season, approx. 5 months from June-October) – 0.077 (dry season, approx. 7 months from November-May) per kWh, while solar PV PPAs - as an exceptional test case - has been closed at USD 0.08/kWh. EDL considers the PPA tariff of solar PV relatively high and intends to focus on hydropower that has a tariff around USD 0.065/kWh.

The Department of Energy Policy and Planning (DEPP) is in the process of preparing the policy for electricity selling tariffs for different RE sources.

The following incentives, however, are available and relevant to hydropower generation:

- Income tax is generally set at 24% (the Law on Investment Promotion: MFA, 2012) and is negotiable in the range of 10-24% for natural resources businesses, depending on the specific business or project characteristics and commercial targets to be achieved by investors. In any case, a dividend tax is charged at 10%. Custom duties at 0% for renewable energy (i.e. SHP projects < 15MW).
  However, investment in economically backward regions is encouraged through tax exemptions. The country is divided into three zones, classified by the condition of the local infrastructure.

Table 2.3.a.: Overview of Incentives for Investments in Hydropower Projects in Laos

Zone	**Profit tax exemption period (years)**	**Profit tax rate during reduction period (%)**	**Regular tax rate** *(%)*
Zone 1 Mountainous, plain and plateau zones where there is no economic infrastructure to facilitate investments	7 years	-	10%
Zone 2 Mountainous, plain and plateau zones with limited economic infrastructure that can support investments to some extent	5 years	7.5% for three years	15%
Zone 3 Mountainous, plain and plateau zones where there is sufficient infrastructure to support economic activities	2 years	10% for two years	20%

- Exemption from profit tax in the next accounting year, if the net profit derived from business activities is used for business expansion
- Duty free exemptions (Investment Promotion Law by GIFT, 2014).

All investments in renewable energy projects in Lao PDR (grid-connected or off-grid systems) are entitled to duty-free exemptions for imported components (production equipment and machinery). On top of these incentives, the International Institute for Sustainable Development investigated additional incentives which apply to concession investments in hydropower, mining, agriculture,

forestry and tourism, the biggest sectors of Foreign Direct Investment in Lao PDR to date. These incentives are negotiated on a case-by-case basis and agreements are kept confidential.

For hydropower, the Department of Energy Promotion and Development (EPD) of the Ministry of Energy and Mines offers investors the following incentives:

- Free access to land (including areas to be flooded)
- A waiver on land conversion fees (US$15,000 per hectare)
- A waiver on withholding taxes on repatriated net profit
- Unlimited use of foreign labour in both skilled and unskilled functions
- Extended concession periods of 25-30 years
- Waivers on other taxes and duties and offshore banking facilities

In general, joint ventures companies are required to allow the State-owned companies to participate for at least 20% shareholding. These State-owned companies could waive that right.

3. TAPPING THE SPILL: DEPLOYMENT OF DUTCH TURBINES IN LAOS

3.1 Two Types of Technologies

Tocardo Turbines

Tocardo International BV, founded in 2008, is a Dutch-based company that designs and manufactures turbines that are suitable for a broad range of locations i.e. tidal and river run-off flows. The company was founded by water technology experts with an extensive background in shipping, ship building and civil engineering. For more information: http://www.tocardo.com
For river run-off flows, Tocardo manufactures the R1-turbines, each with a capacity of 125 kW. See illustrations and technical characteristics below.

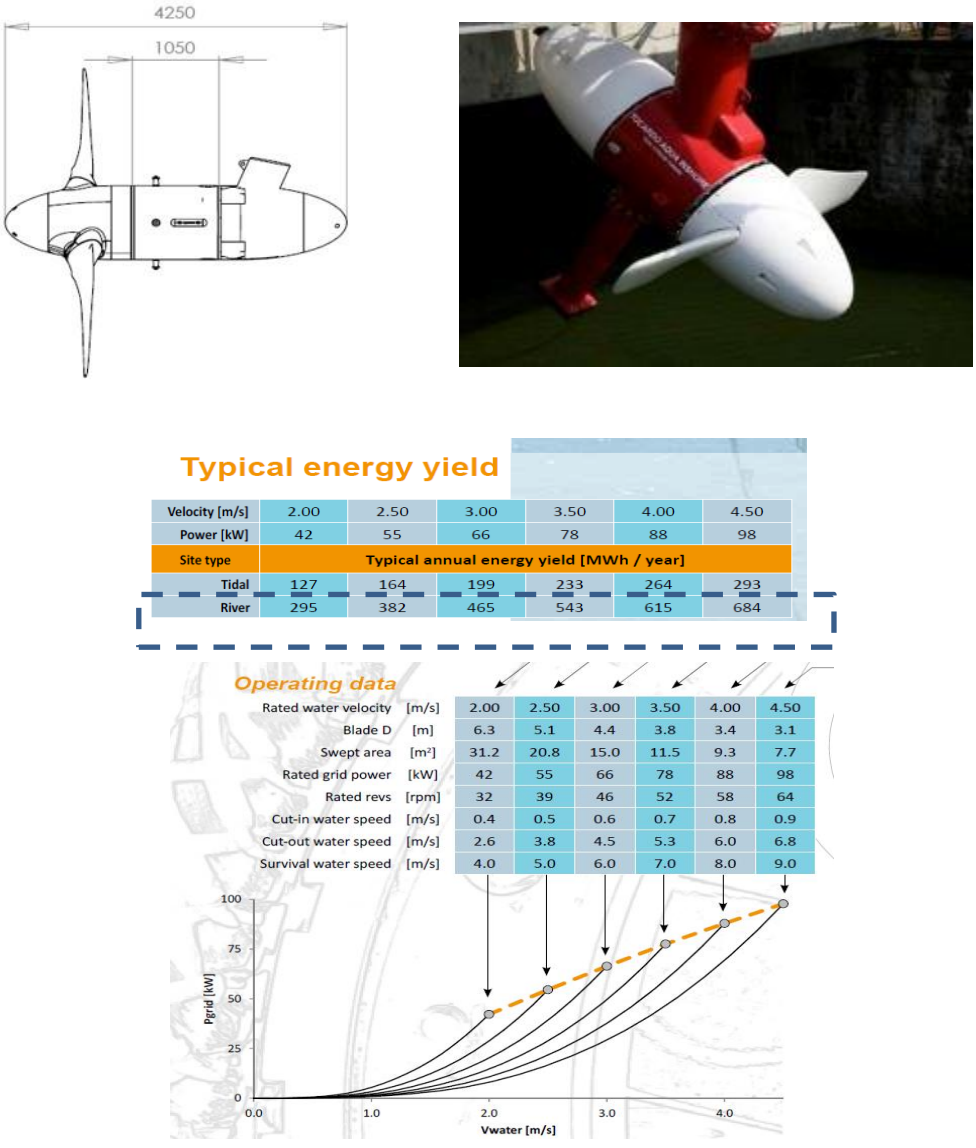


Figure 3.1.a: Illustrations of the Tocardo Turbine T1/R1 and Technical Characteristics

The Tocardo turbines are durable technologies i.e. the blades are made of carbon fiber and the equipment requires an overall inspection every 5 years. The performance is monitored in real-time,

providing data on power, rotations and the temperature inside turbines. There is no start motor as the rotation automatically starts at a water flow speed of 2 m/s.

As an example for sites in Laos, in rivers and canals with a minimum flow of 2 m/s, the Tocardo turbines could be placed at a 50m distance from each other to tap from the flow that is expected to have recovered up to 95%. For each row a floating body is available to equipped 3 or 4 turbines. The turbines in operation are under water, but the system will be designed for easy installation, access and maintenance when required. The floating system is modular and can be deployed in line with no limitations for repetition. In Figure 3.1.b an example of 4 rows is given with 3 or 4 turbines installed (total 14). For installation of each module four anchor points (2 on both dike sides) are required. This anchor points can be, for example, large concrete blocks. The design of these blocks is dependent on the soil conditions and local available materials. A feasibility study should address the optimal distances between turbines and the configurations and shall be based on a hydraulic simulation using site-specific data.

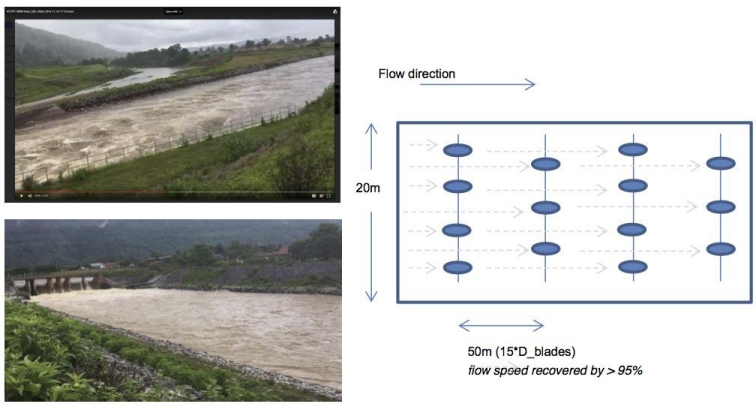


Figure 3.1.b: Example of configuration of Tocardo Turbines T1/R1 in rivers and canals

Tocardo turbines require approximately 6 months for manufacturing, approximately 2 months of shipping from The Netherlands and transportation to the site in Laos and 4-6 months of installation on site.

Oryon Watermills

The Oryon Watermills are manufactured by Deepwater Energy BV, a Dutch-based company, established in 2012. The Oryon Watermills are the result of a collaborative partnership between Pasman Motoren, Siemens (Germany) and Twin Valleys. More information can be found on: http://www.english.oryonwatermill.com

The Oryon Watermill is a modular hydropower unit, with a vertical axis turbine, which can be adapted to the local water flow that could vary between a minimum of 1 m/s to a maximum of 10 m/s. The unit is placed on the bottom of rivers, in river cribs, in dams or at bi-directional tidal currents. The installation in rivers generally requires a narrowing of the cross-section (bottom and shores) to increase the velocity of water flowing into the mill. With a narrowed cross-section, the water level will be increased and require illustrations are shown in Figures 3.1.c and 3.1.d.

The distance between the watermills in a river could be between 200 – 300 meters, depending on the velocity of water. This physical characteristic makes Oryon Watermills suitable for relatively slow moving waters in long stretches of rivers or irrigation canals i.e. not the short-stretch of outflow

canals of hydropower dams in Laos, in particular the canals that would not tolerate significant changes in the cross-section.

Oryon Watermills require approximately 8-10 months for manufacturing, approximately 2 months of shipping from The Netherlands and transportation to the site in Laos and approx. 2 months of installation on site.

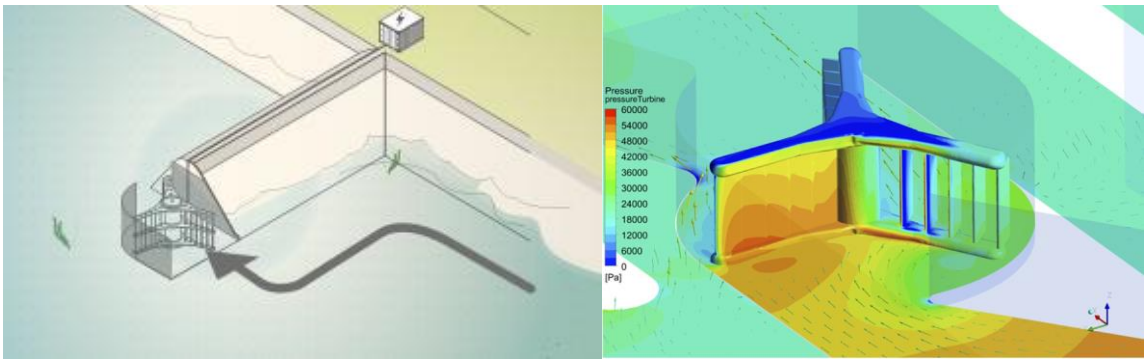


Figure 3.1.c : Example of an Oryon Watermill in a river or canal

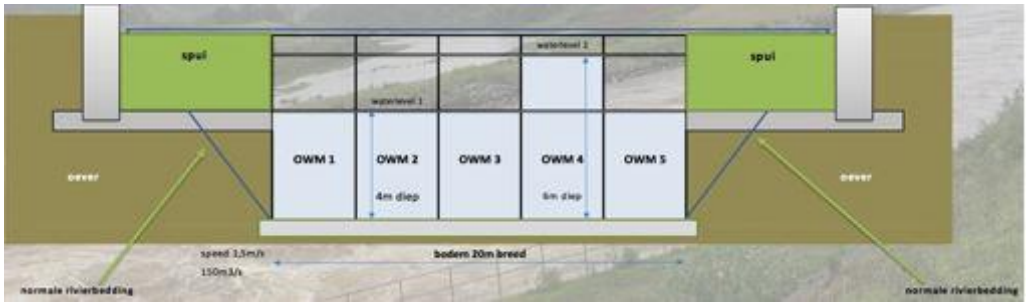


Figure 3.1.d: Example of a typical cross-section of a power plant using Oryon Watermill

3.2 The Potential in Lao PDR for River Run-Off Turbines

Out of 43 existing hydropower plants in Lao PDR (see Annex 1 showing a map with all sites), experts from public and private entities - gathered at a Mini Workshop held at the Ministry of Energy and Mines on 28 June 2017 – identified 20 potential sites that would meet the following criteria for the installation of river run-off turbines (RROTs):

1. Site accessibility over land i.e. access roads for container transport to keep logistic costs as low as possible;
2. Offering Water Control Structures/Spill Ways/Bridges with a minimum velocity of water > 2.0 m/s during the entire year (data sets must be available with the dam operator and/or the Department of Hydrology);
3. With a minimum average depth of approx. 4-5m to enable the blades to be designed at optimum sizes;
4. On a relative short distance from the grid/sub-station/power house (< 500m) to keep loss of energy and transmission costs relatively low;

5. Willingness of the existing dam owner to allow the installation of additional power generation capacity. Almost all dedicated canals or outflow structures of hydropower dams are part of the property of the respective hydropower company who has obligations on proper water management and for guaranteed discharge of water directly and indirectly into the Mekong River. Installing RROTs would, therefore, need to be done in partnership (and possibly co-ownership) with the existing owners, of which some who were present at the mini-workshop held in Vientiane on 28 June 2017 showed interest.
6. Willingness of bridge owners to allow the installation near or below their civil structures. Most bridges are owned and operated by the Ministry of Transport & Communications; only a few are owned by private entities. Also on such sites, the engagement of the existing owners and operators would be required for the installation of RROTs.

Criterion #2 was formulated to ensure reliability of sufficient discharge due to active water management protocols, presence of historical hydraulic, hydrology, geo-technical data and information about the existing civil engineering structures.

The list of sites[8], consisting of 17 hydropower sites, 2 bridges and 1 waterfall area, is shown in table 3.2.a. below. The Consultant estimates a minimum potential of 177 MW of RROTs could be installed on existing hydropower sites i.e. both, Tocardo and Oryon Watermills could be optimally configured in streams depending on the run-off velocity and profile; this would be approximately 4-5% of the total existing installed capacity of hydropower in Lao PDR that can be added as "small hydropower" capacity within 3 years and in a commercially viable manner. For installation of RROTs at bridges and in waterfall areas a survey would need to be carried out to determine the capacity.

Table *3.2.a: List of Potential Sites for the installation of RROTs*

No.	Name of Potential Sites	Existing Capacity (in MW)	Estimated Minimum Potential Capacity for RROTs (in MW)
1	Nam Song	6	2
2	Nam Nguem 1	155	5
3	Nam Nguem 2	615	20
4	Nam Luek 1-2	100	5
5	Theun Hin Boun (+ extension)	220	15
6	Nam Theun 2	1075	50
7	Nam Luek	60	5
8	Nam Mang 3	40	5
9	Nam Hin Boun	30	5
10	Xe Xet 1	45	5
11	Xe Xet 2	76	5
12	Nam Ngiep 1	240	15
13	Nam Ngiep 2	180	10
14	Nam Ngiep 3A	44	5
15	Nam Ngiep 3B	45	5
16	Xekhaman 3	250	15
17	Nam San 3A	69	5
18	Hu Sadam Bridge	NA	TBD
19	Hu Pha Pheng waterfall	NA	TBD
20	Pak Lay Bridge	NA	TBD

[8] More details on the sites can be found in the Consolidated List of Power Projects Nationwide (up to 31/12/2016), Version 7, Department of Energy Policy and Planning, Ministry of Energy and Mines, LAO PDR

The Consultant visited three sites during the PSD Study, which are: Nam Song, Nam Theun-2 and Theun Hinboun.

The Nam Song site is a typical example where RROTs can be installed in or near water management structures, such as Control Drop-structures, Bridges or Fusegate Structures with sufficient depth for the blades to rotate and the presence of super structures that could possibly serve as support for the structures of the RROTs. In such areas RROTs could tap the energy flow potential in a cost-effective manner adding 2% additional power generation capacity at water management structures and 30% at large hydropower dams with long and dedicated outflow canals. See figure 3.2.a.

Figure 3.2.a: Example of a Water Control Structure in the Nam Song Dam Area

The Nam Theun-2 and Theun Hinboun sites are typical examples of human-made outflow canals, varying from 25km at Nam Theun-2 dam to approximately 4km at the Nam Hinboun dam. Such outflow canals are dedicated to guarantee discharge of water to the Mekong River. Such outflow canals are very suitable for RROTs as they are fully fenced on both sides of the shores, not used for transportation and with low risk of floating debris.

In such canals the RROTs could tap the energy flow potential in a cost-effective manner and add 5-10 percent additional power generation capacity through a fast-track procedure for approvals and financing. A key issue for the use of such canals for the installation of RROTs will be to ensure that existing water management structures and bridges are not compromised on their existing functions. See figure 3.2.b.

Figure 3.2.b: Example of Human-made Canals for dedicated water discharge of the Nam Theun-2 Dam

RROTs for Climate Resilience?

Climate change has the potential to impact the hydropower sector through changes in rainfall and water availability, protracted drought events, significant variation in historical temperature regimes, and more frequent and severe weather events, including floods. As such, many countries are seeking a better understanding of climate-change impacts, and are beginning to build climate adaptation strategies and climate resilience into their plans[9].

In Lao PDR, the Department of Hydrology and other agencies confirmed the differences in water availability in rivers and reservoirs i.e. rainy season lasts approximately 5 months from June till October and the dry season for 7 months from November till May. According to the Department of Hydrology, no significant changes in the data sets have been recorded that could point out to climate impacts in Lao PDR.

However, Lao PDR will not be exempted from the impacts of global or regional climate change and the expectations are that climate extremes will occur and water availability will be affected. In rainy seasons, there may be much more water discharged in rivers, canals and reservoirs, while in dry seasons much lesser water will flow. Given the technical characteristics of RROTs and their ability to capture the kinetic energy from water flows in rivers and canals near dams and bridges, RROTs are considered to be an important contributor to climate resilience. If traditional hydropower dams will face a reduction in electricity production due to severe draughts, the outflowing water will be able to partially compensate for that.

9 Hydro Power Status Report 2016, International Hydro Power Association, United Kingdom

3.3 Four-Steps Approach for Deployment of RROTs in Lao PDR

Given the potential capacity for RROTs, the implementation could take place in four steps, as follows:

- Step 1: a first commercially viable project of 10 MW to be commissioned by the end of 2019 at one single site or more, which would require an investment of approximately USD 18m-20m. This size of a project has been selected as it is considered to be of a minimum size for project finance by banks and equity investors, while also achievable on sites identified.
- Step 2: replication on several sites with a total installed capacity of the remaining 167 MW at existing hydropower sites to be realized between from 2020 – 2022, requiring an investment of USD 250m – USD 300m.
- Step 3: installation of a minimum of 50MW at bridges and new areas, such as waterfalls, from 2022 and beyond requiring an investment of USD 100m – USD 150m; also replication of RROT projects at over 50 new hydropower projects that are expected to be completed by 2020 (for example another 200 MW of RROTs, requiring an investment of approximately USD 250m-300m).
- Step 4: RROTs integrated from beginning in outflow channels of hydro projects scheduled for completion by 2030. The estimated potential is 1,000 MW in over 300 hydropower projects scheduled projects.

Step 1-2 will also set the standards for the planning and installation of RROTs as an integral part of new upcoming hydropower plants in the period from 2020 onwards, opening up a large potential for RROTs at over 300 new hydro power sites to be developed and made operational by 2030 (see Table 2.2.a). RROTs are able to capture the last portions of energy in flowing waters at outflow canals and water management structures. They would serve the goals of the government of Lao PDR to reduce carbon emissions through the promotion of small hydropower systems.

As the market for RROTs could start with approximately 200MW from 2019-2022, the big potential is estimated at over 1,000 MW in the period after 2022, requiring an investment of approx. USD 1 billion, assuming that the price of RROTs will decrease as it will become a common technology which is used globally. In order to achieve such smart and integrated use of RROTs, the planning and integration capacity among public and private sector stakeholders would need to be developed to enable such key parties to benefit from new emerging and environmental friendly hydro power technologies.

The approach or 'roadmap' is illustrated in figure 3.3.a below.

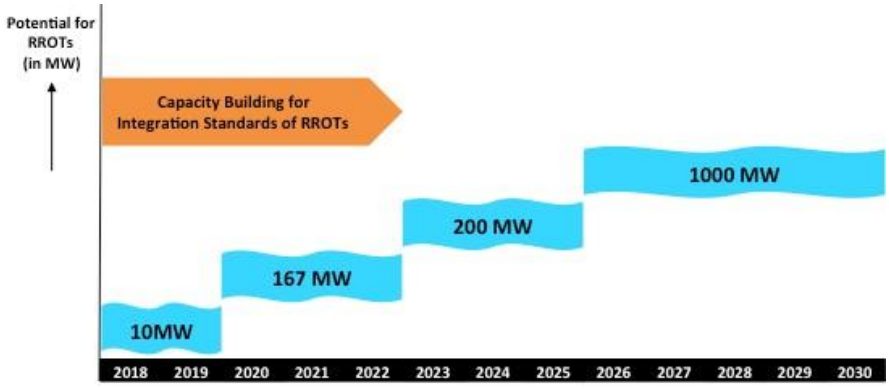


Figure 3.3.a: Roadmap for deployment of RROTs and Capacity Building for Replication through Integration

Figure 3.3.a. above shows a total minimum potential for RROTs in Lao PDR of 1,377 MW up to 2030. Starting with a 10MW project will demonstrate commercial operation of RROTs i.e. “seeing is believing”. After this first project, the deployment of RROTs could take place along the following commercial tracks:

1. The first 10MW will demonstrate that Dutch Manufacturers, Contractors, Investors, the Dutch Government and the Government of Lao PDR and local private companies have full trust in the RROT-technologies. It will demonstrate commercial operation of a new technology that can be developed and commercially deployed in less than 24 months and generate good cash flow. This project will be brought to the attention of all other owners of hydropower companies in Lao PDR.

2. The Dutch-Lao consortium continues to replicate RROT projects on other sites within the same business model as the first project or forms JV companies with owners of new hydropower companies. After commissioning or a few years later, the Dutch consortium could transfer/sell their shares to the local partners and exit the project.

3. Owners of hydropower companies in Lao would be inspired to purchase RROTs from the Dutch manufacturers and install these at their own sites, with or without further engagements of Dutch contractors, consultants and/or investors.

As mentioned in paragraph 2.3 of this report, about 90% of hydropower companies is owned by private - local and foreign - parties. These owners would need to be encouraged to engage in the formation of partnerships for the deployment of RROTs on their properties i.e. outflow canals, spillways, water drop control structures etc. These owners could also be convinced with clear feasibility studies and commercial operation of RROTs to become shareholders in joint venture companies and/or simply purchase the RROTs for full ownership and operation.

3.4 Procedures for Initiation and Execution of Hydropower Projects in Laos

The Government of Lao PDR, through its Ministry of Energy and Mines, has put in place new and simplified procedures for the development, installation and operation of small hydropower projects, as follows:

- For hydropower projects equal or less than 5MW, decisions are taken and permits are issued by the Local Provincial Government.
- For hydropower projects between 5 – 100 MW, decisions are taken and permits are issued by the National Government;
- For hydropower projects of more than 100MW, decisions are taken by the Parliament and permits are issued by the National Government;

RROTs fall under the first category mentioned above, hence subject to approval by local governments even though in one single outflow canal a series of RROTs, making up for a total of 50 MW, would be more than 15 MW, such a series should be considered to be 50 installations of each 1MW that will not cause any significant damage to environment or reduce committed discharge of water to the Mekong River given the characteristics of the technologies.

The process for project development, execution and operation as per the International Investment Promotion Department (IIPD) is as follows:

1. Signing of a Memorandum of Understanding (MoU) between a Consortium of Companies and the IIPD; in this MoU key indicators (e.g. size of project, locations, estimated investments and rate) must be mentioned;
2. The Consortium of Companies has 18 months to complete a detailed feasibility study and an Initial Environmental Examination (IEE) as an extensive EIA may not be required. During this period, the company shall apply for and acquire local government permits. This will provide a tariff and IRR, which will be the base for signing a Tariff-MoU with EDL and subject for negotiations for local investment and a Power Purchase Agreement (PPA).
3. Signing of Tariff-MoU with EDL.
4. The Consortium of Companies receives 12 months to finalize detailed engineering plans for project execution. Documents to be approved by relevant authorities: IIPD, Ministry of Energy and Mines. Financial close for loans to be achieved.
5. Start of construction.

The Ministry of Energy and EDL recommended the following procedure:

1. Signing Memorandum of Understanding (MoU) between Consortium of Companies and the Ministry of Mining and Energy. In this MoU the intentions are clearly articulated and derived from the PSD study i.e. with emphasis on commercial deployment of new renewable energy technologies, capacity building and investments.
2. Carry out a feasibility study of identified sites and focus on a first investment project. Determine tariff for PPA, identify local co-investment partners, get permits from local government agencies for small hydropower and secure EIA documents. This feasibility study shall also lay the basis for a detailed roadmap for the commercial deployment of the first batch of RROTs i.e. for installation in the next 2-3 years.
3. Sign a Tariff-MoU with EDL and negotiate and sign a PPA.
4. Sign an MoU with IIPD with the purpose to negotiate the best possible fiscal incentives.
5. Ensure financial close.
6. Start Construction

The Consultant has combined the above procedures and recommends several steps in Chapter 4 of this PSD study.

4. THE WAY FORWARD

4.1 Steps for Cooperation and Execution

The next steps towards executing the first 10 MW of RROTs in Lao PDR are proposed:

1. Formation of a Consortium (Dutch/International consisting of technology providers, contractors and equity and debt investors) facilitated by the Dutch Government and through a Letter of Intent to be signed by all interested parties.
2. Signing a Memorandum of Understanding (MoU) between Consortium of Companies, preferably supported by the Dutch Government and the Ministry of Energy and Mines, expressing the intention to develop and invest in RROT projects in Lao PDR and to carry out an extensive feasibility study for a first set of 10MW of RROTs with a Masterplan and Roadmap for the next 167 MW of RROTs (see Terms of Reference in Annex 2). As part of this cooperation a team of decision-makers from public and private sector in Lao PDR would make a study trip to The Netherlands to be exposed to the RROT technologies.
3. Identify interested local joint venture parties i.e. owners of existing hydropower dams who would be willing to participate as co-investors/co-owners of the project and therefore allowing their site to be subject to a feasibility study and provide access to data and information. Likely parties are State Owned Enterprises, such as Électricité du Laos (EDL) or Electric Construction and Installation Enterprise (ECIE), which could hold a maximum of 20% shares in joint venture companies. Foreign companies who could show interests for joint ventures are, for example, Électricité de France (EDF), Electricity Generation Company of Thailand (EGCO) and Sinohydro China.
4. Signing of MoU between Dutch Consortium Parties and the Local JV parties expressing their interest to cooperate on the Feasibility Study and to set up a JV company for the construction and operation of RROTs.
5. Execution of the Feasibility Study for 10 MW by a consortium of engineers and manufacturers of RROTs. This feasibility will focus on cost-effective engineering, detailed designs and financial cost/benefit modeling leading to a tariff per kWh (and/or a tariff strategy) under different scenarios of operation and with fair Internal Rates of Return (IRR) for investors. The Feasibility Study shall also include an Environmental Impact Assessment (EIA) for Small Hydropower Project and as per regulations set by the respective authorities in Lao PDR.
6. Application of Permits with the Local Government Authorities.
7. Signing of a Tariff MoU with EDL, followed by negotiations to conclude a Power Purchasing Agreement (PPA) between the JV company and EDL.
8. Signing of a Memorandum of Agreement (MoA) between the JV company and the International Investment Promotion Department (IIPD) to agree on benefiting from fiscal incentives provided by the Government of Lao PDR. Annexes to this MoA are, among other documents: Tariff MoU, outcomes of the Feasibility Study, including detailed engineering plans and an Environmental Impact Assessment. If fiscal incentives granted, then
9. Come to Financial Close and
10. Commence Construction
11. Commission the Project
12. Start commercial operation

Action points #7 and #8 can be done in parallel with each other.

4.2 Factors for Commercial Viability of Projects

RROTs can be commercially deployed (with PPA tariffs at USD 0.06 – 0.08 per kWh generating a project IRR of around 10-12%) in Lao PDR if the following minimum conditions can be met:

1. For the first 10 MW project, the costs for the feasibility study (estimated at USD 250,000 – 300,000), would benefit from government co-financing in order to avoid pressure as a full expense for the project company;
2. Project financing to be structured such that the equity: debt ratio is at a 30 : 70 level and with interest rates of 4-6% for loan tenure of at least 12-15 years as PPA's are signed for 20 years;
3. Equity funds to be mobilized from Dutch RROT manufacturers, Dutch, regional and local energy companies (EDL, ECIE), Dutch/local contractors, Dutch pension-funds, corporate investors and possibly emerging Dutch crowd-funding companies;
4. Dutch commercial banks in a consortium with the Dutch FMO Development Bank and possibly regional or international bank to join their resources for debt finance at favorable terms and conditions, backed up by credit guarantees by the Dutch Government.
5. Government of Laos to granting attractive fiscal benefits by allowing a 10% corporate tax regime and an assurance of zero (0) percent import duties on equipment i.e. to enable new small-scale hydropower technologies to enter into Laos and add over 1.3 GW of power without any threat to the Mekong River.
6. Government of Laos to facilitate efficient processing of building permits and licenses for building and operation of the RROT projects, including the facilitation of negotiations to conclude PPAs (in USD currency).
7. Dutch Government support for capacity building of the Ministry of Energy and Mines aiming at enabling design rules and regulations for the integration of RROTs in outflow canals and spillways of hydropower dams that currently being initiated or planned in Lao PDR.

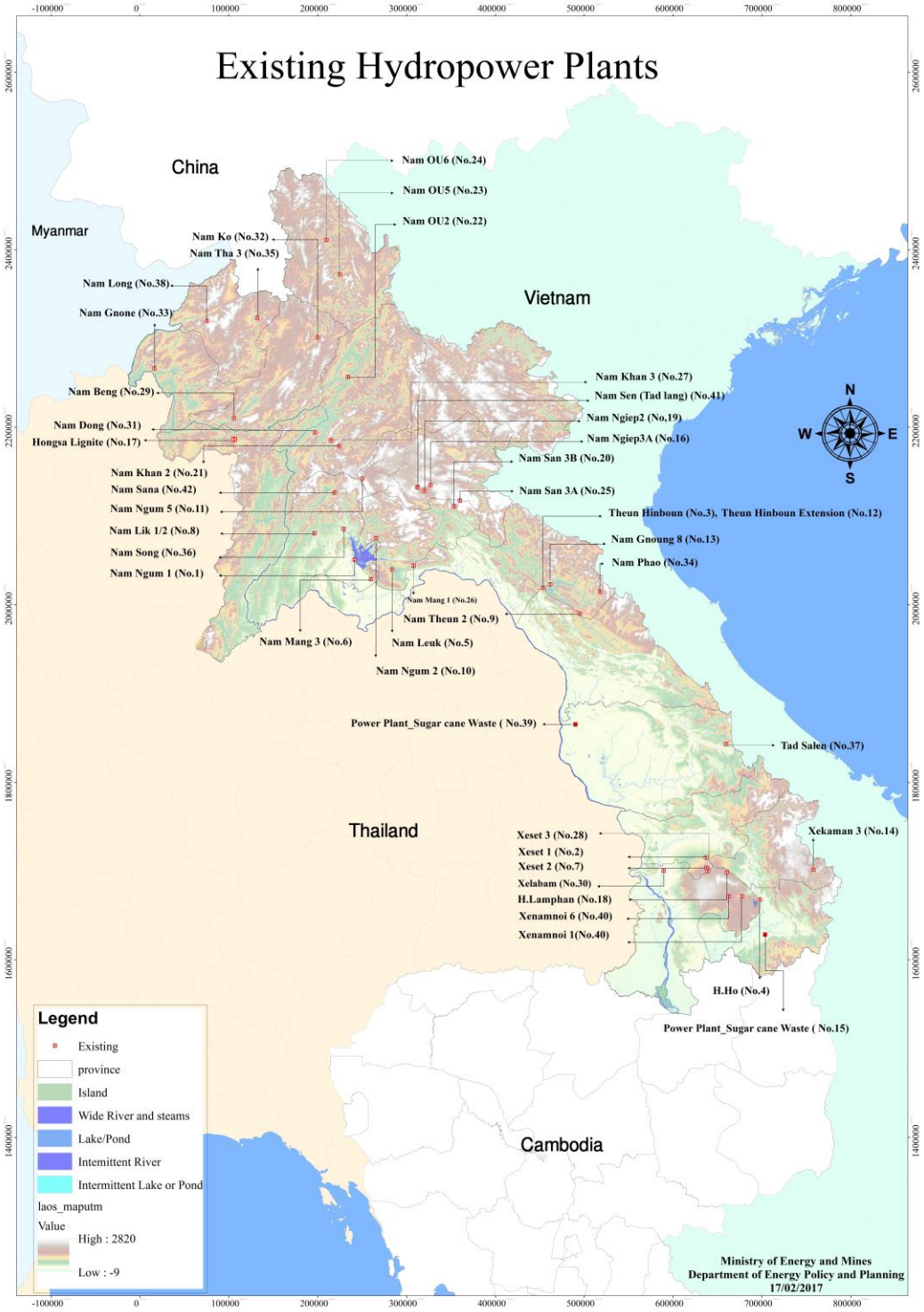
4.3 Indicators of Relevance for Development

For Dutch Government engagement and support it is important to measure development impact using the following key indicators of relevance to the deployment of RROTs in Lao PDR:

1. Improvement of private sector and investment climate of Lao PDR;
2. Increasing trade and investment volumes for Companies from The Netherlands and Lao PDR;
3. Exposure and focused training of senior staff of key agencies (e.g. MoEM and at least 5 local private power companies participating in the JV) from Lao PDR in new design and engineering standards for hydropower projects;
4. A new set of design and engineering guidelines for hydropower projects using RROTs as an integrated technology to generate additional power from energy in spillways and outflow canals. This set of guidelines must be endorsed by relevant authorities and communicated among the parties involved in developing new hydropower projects in Lao PDR.
5. To have completed and commissioned the first 10 MW (approx. USD 18-20 million investment) of RROT Project(s) setting the stage for the continuation of installation of another 167MW from 2020 – 2022 (approx.. USD 250 – 300 million investments).
6. Dutch credit guarantees (e.g. Dutch Good Growth Fund, DGGF) to be positioned to enable innovation in small hydropower generation in Lao PDR by use of Dutch RROTs and leveraging investments;
7. Creating additional job opportunities in Lao PDR and The Netherlands;

ANNEXES

ANNEX 1: Map of Existing Hydropower Plants in LAO PDR



ANNEX 2: Key Elements of a Feasibility Study for 10 MW RROTs

In addition to general international guidelines for a techno-economic feasibility study for a hydropower project, the RROTs would need to focus on the following aspects:

Technical Feasibility

1. Carry out a hydraulic/hydrodynamic survey on all 20 sites mentioned in table 3.2.a, aiming to map the water velocity (m/s) and cross-sectional profiles (depths) in the outflow canals or spillways. Use hydrodynamic models to estimate the velocity and depths for rainy and dry seasons.
2. Based on velocity and depths, determined the possible dimensions/size of the RROTs (technology selection i.e. Tocardo Turbines and/or Oryon Water Mills).
3. Based on outcomes of (1), prepare a list of priority sites (or select one specific site) where 10 MW's of RROTs can be deployed. Use hydrodynamic models to configure the RROTs such that the highest energy yields could be achieved with the selected technology or combinations of that.
4. Design the required civil and mechanical engineering structures to install RROTs on the specific location/site and based on the design parameters of Tocardo Turbines and/or Oryon Water Mills. These engineering structures need to be cost-effective and shall not cause any additional risk to the existing canals or adjacent structures during construction and operation stages of the project.
5. Design the required electrical engineering systems to transport the generated electricity from the site to the nearest grid-connection point, including a grid-impact assessment.
6. Prepare a project execution plan, including the logistics, use of installation equipment available in Laos and a timeline for construction and commissioning.
7. Prepare an operations and maintenance plan, including data management and logistics, and costs.
8. Prepare a Bill of Materials and Cost Estimate for the project.
9. Based on the above, prepare a masterplan for replicability of the installation of RROTs

Financial and Investment Viability

1. Prepare a matrix of all possible risks during stages of project development, construction and operations and translate that into quantitative impacts on the cost/benefit ratios.
2. Use the estimated electricity production data (and estimated losses) to generate projections of financial statements (i.e. cash-flow analysis, P&L and Balance Sheet) using different power production scenarios (rainy/dry seasons).
3. Use the above for the calculation of the Project IRR and IRR on Equity over a lifecycle of 20 years (or more in close communications with the manufacturers of the RROTs).
4. Generate alternatives on the above under different equity/debt ratios and risk parameters (i.e. through a Monte Carlo Simulation)
5. Based on the above, prepare a master overview IRRs for all sites based on assumptions of replicability.

Environmental and Social

1. Carry out an Environmental and Social Impacts Assessment for Small Hydropower Projects, specifically using RROTs, as per the regulations in Lao PDR.

Approvals and Permits

1. List all permits that are required to start construction work.
2. List all permits that are required to start operation of the power plant.
3. Draft a template for a Power Purchase Agreement using existing formats and customizing to the RROTs, if required.

ANNEX 3: Photo Impressions of PSD Study Meetings in Lao PDR

Photo 1:
Introducting the PSD Study to Dr. Sinava Souphanouvong, Vice Minister of Energy & Mines of Lao PDR, by Mr. Robbin Mulder (Regional Business Development Officer ASEAN/NL Embassy Singapore), June 6th, 2017

Photo 2:
Mini-Workshop and Brainstorming Session at the Ministry of Energy & Mines of Lao PDR, June 28, 2017

Photo 3:
Feedback on the Draft PSD Study at the Ministry of Energy & Mines of Lao PDR, September 18, 2017

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