CLIMATE CHANGE

Strategic Environmental Assessment of Lebanon's Renewable Energy Sector

December 2014

This document should be referenced as:

MoE/UNDP (2014). Strategic Environmental Assessment of Lebanon's Renewable Energy Sector. Beirut, Lebanon.

The United Nations Development Programme (UNDP) is the UN's global development network, advocating for change and connecting countries to knowledge, experience and resources to help people build a better life. We are on the ground in 166 countries, working with them on their own solutions to global and national development challenges. As they develop local capacity, they draw on the people of UNDP and our wide range of partners.

For more information

http://climatechange.moe.gov.lb/
climatechange@moe.gov.lb

The climate change project management team

Vahakn Kabakian, Project Manager
Lea Kai Aboujaoudé, Project Officer
Yara Daou, Project Research Assistant
Leila El Sayyed, Economist
Mary Awad, Project Assistant

UNFCCC focal point

Samar Malek, Acting Head of Service of Environmental Technology, Ministry of Environment

Disclaimer

The contents of this document are the sole responsibility of its authors, and do not necessarily reflect the opinion of the Ministry of Environment or the United Nations Development Programme, who will not accept any liability derived from its use.
This study can be used for policy-making, research, teaching and private study purposes. Please give credit where it is due.

Strategic Environmental Assessment of Lebanon's Renewable Energy Sector

Reference project
National Action Programme to Mainstream Climate Change into Lebanon's Development Agenda

Executed by
Ministry of Environment

Financed by
Lebanon Recovery Fund, a Lebanese Government led programme established on the occasion of the Stockholm Conference

Implemented by
United Nations Development Programme, Lebanon

Authors
This report has been prepared by ELARD (www.elard-group.com) in association with LDK (www.ldk.gr):
Nathalie Antoun
Lara Bou Ghanem
Yaakoub El Hage
Ricardo Khoury
Evie Litou
Savvas Louizidis
Costis Nicolopoulos
Joelle Salameh
Rana Zbeidy

Main reviewers
Vahakn Kabakian
Leila El Sayyed

Table of Contents

ACRONYMS

BAU	Business as Usual
CAPEX	Capital Expenditures
CBA	Cost-Benefit Analysis
CBD	Convention on Biological Diversity
CCCU	Climate Change Coordination Unit
CCGT	Combined Cycle Gas Turbine
CdTe	Cadmium Telluride
CF	Capacity Factor
CSP	Concentrating solar power
EDL	Electricité du Liban
EE	Energy Efficiency
EIA	Environmental Impact Assessment
ELARD	Earth Link & Advanced Resources Development
EMP	Environmental Management Plan
ESCO	Energy Service Company
EU	European Union
FIT	Feed-in-Tariffs
GEF	Global Environment Facility
GHGs	Greenhouse Gases
GHI	Ground Horizontal Irradiation
GoL	Government of Lebanon
HFO	Heavy Fuel Oil
HPP	Hydropower Plant
HV	High Voltage
IBA	Important Bird Area
ICZM	Integrated Coastal Zone Management
IPP	Independent Power Producer
LCEC	Lebanese Center for Energy Conservation
LCOE	Levelised Cost of Electricity
MoE	Ministry of Environment
MoEW	Ministry of Energy and Water
MoF	Ministry of Finance
NBSAP	National Biodiversity Strategy and Action Plan
NEEAP	National Energy Efficiency Action Plan

NERB	National Electricity Regulatory Body
NGO	Non-Governmental Organization
NPMPLT	National Physical Master Plan of the Lebanese Territory
NREAP	National Renewable Energy Action Plan
NWSS	National Water Sector Strategy
O&M	Operation and Maintenance
OPEX	Operational Expenditures
PPP	Policy, Plan, Program
PV	Photovoltaic
RBM	River Basin Management
RE	Renewable Energy
RES	Renewable Energy Strategy
ROW	Rights-of-Way
SEA	Strategic Environmental Assessment
SMAP	Short and Medium-term Priority Environmental Action Programme
SMEs	Small-Medium Enterprises
TPPs	Thermal Power Plants
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNDP	United Nations Development Programme
VOC	Volatile Organic Compound

الملخص التنفيذي

قامت الحكومة اللبنانية، من خلال الإعلان وزارة الطاقة والمياه لعام ٢٠٠٩ والخطة الاستراتيجية الوطنية لقطاع الكهرباء لعام ٢٠١٠، بوضع هدف إستعمال مصادر الطاقة المتجددة لتصل الى حوالً ١٢% من احتًياجات لبنان للإنتاج الكهربائً والحراري بحلول العام ٢٠٢٠.

ولتحقيق هذا الهدف قامت وحدة التعاون لتغيرات المناخ (CCCU) بإعداد ونشر دراسة في أيلول ٢٠١٤ بعنوان "مزيج الطاقة المتجددة الأمثل لقطاع الطاقة بحلول عام ٢٠٢٠: التكاليف الاستثمارية المترتبة على لبنان". وتستند الدراسة على تقييم انتاجية مصادر الطاقة المتجددة في البلاد من حيث طاقة الرياح والطاقة الشمسية الفولتوضوئية (PV) والطاقة الشمسية المركزة (CSP)، والطاقة الكهرمائية. تشمل نتائج الدراسة عدد من السيناريوهات التي تعتمد على توقعات الطلب على الكهرباء ومصادر الطاقة المتجددة المختلفة للوصول الى المزيج الأمثل من مصادر الطاقة المتجددة مع الأخذ بعين الاعتبار التكلفة المترتبة على الحكومة.

تم إعداد التقييم البيئي الاستراتيجي لقطاع الطاقة المتجددة في لبنان بالتوازي مع إعداد دراسة الـ CCCU بهدف تحديد الآثار البيئية والاجتماعية الرئيسية لتطوير مزارع الرياح، ومزارع الطاقة الشمسية الفولتوضوئية (PV)، ومحطات الطاقة الكهرمائية ووضع الإجراءات المناسبة لتخفيض التأثيرات السلبية وزيادة الاستفادة من الآثار الإيجابية. فضلاً عن توفير مجموعة من التوصيات التي ستعتمدها مختلف الجهات الحكومية لتعميم المفاهيم والمبادئ البيئية في استراتيجية الطاقة المتجددة في البلاد. ويهدف التقييم البيئي الاستراتيجي أيضاً الى مساعدة الأطراف التي تعمل على وضع خطط العمل للطاقة المتجددة وبرامج التنفيذ، ومشاريع واسعة النطاق في فهم :١) الوضع الراهن من الناحية التقنية والبيئية والاجتماعية والاقتصادية و٢) الأطر القانونية والمؤسساتية والمالية التي تنظم القطاع و٣) الآثار البيئية لتطوير مشاريع الطاقة المتجددة والطرق السليمة للتخفيف من آثارها السلبية.

تشمل دراسة CCCU سيناريوهين بناءاً على تطبيق تقنيات الطاقة المتجددة الثلاث المعتمدة وهي: الرياح, الطاقة الشمسية الفولتوضوئية, و الطاقة الكهرمائية حيث تصل مشاركة الطاقة المتجددة في السيناريو الأول (C1) إلى ١٢% من احتًياجات لبنان للإنتاج الكهربائً والحراري و٢٠% في السيناريو الثاني (C٢). اعتمدت دراسة تقييم البيئي الاستراتيجي على سيناريو الـ ١٢% (C1) ليكون متوافقاً مع الأهداف الوطنية المحددة. بعد تحديد السيناريو الذي سيتم تقييمه في التقييم البيئي الاستراتيجي و تحديد الأطر القانونية والمؤسساتية والتنظيمية للمشروع، تضمن التقييم البيئي الاستراتيجي الخطوات التالية:

i. تقييم الظروف الأساسية (Baseline Conditions) المتعلقة بتقنيات الطاقة المتجددة من الناحية الفنية والبيئية،
ii. تطوير إطار التقييم البيئي الاستراتيجي (SEA Framework) من ناحية الأهداف والمؤشرات،
iii. تحليل البدائل (Analysis of Alternatives) المحددة وهي ١) السيناريو C1 و ٢) الوضع الراهن/عدم تطبيق المشروع من النواحي البيئية والاجتماعية والاقتصادية،
iv. تحديد وتقييم الآثار الإيجابية والسلبية (Impacts Assessment) المحتملة الناجمة عن تطبيق السيناريوC1،
v. تطوير خطة الإدارة والمراقبة البيئية (Environmental Management Framework)،
vi. تطوير توصيات (Recommendations) تشمل ١) توصيات لدمج نتائج التقييم الاستراتيجي في الاستراتيجية الوطنية للطاقة المتجددة، ٢) ادراج نتائج التقييم البيئي الاستراتيجي في السياسات والخطط الوطنية، ٣) متطلبات تقييم الأثر البيئي، و٤) التدابير والإجراءات القانونية والمؤسساتية والمالية.

المزيج الأفضل للطاقة المتجددة لقطاع الطاقة عام ٢٠٢٠: التكاليف الاستثمارية المترتبة على لبنان

قامت الدراسة بتحديد المزيج الأفضل للطاقة المتجددة والتكلفة المترتبة على الحكومة في ثلاثة سيناريوهات تهدف إلى استثمار إمكانات الطاقة المتجددة في بلاد مع مراعاة تأمين الطلب على الكهرباء بحلول عام ٢٠٢٠ وهي: العمل بالشكل المعتاد (BAU) والسيناريوC1 الذي يهدف إلى تأمين ١٢% من الطاقة الكهربائية من مصادر الطاقة المتجددة، والسيناريو C2 الذي يهدف إلى تأمين ٢٠%.

تستند سيناريوهات C1 و C2 على استخدام ثلاث تقنيات للطاقة المتجددة ١) طاقة الرياح و ٢) الطاقة الفولتوضوئية الشمسية (PV) و ٣) الطاقة الكهرمائية. لم تشمل هذه السيناريوهات الطاقة الشمسية المركزة (CSP) بسبب كلفتها العالية. من جهة أخرى لم تلحظ الدراسة الطاقة العضوية وطاقة الرياح البحرية والطاقة الجيوحرارية وطاقة حركة المد والجذر نظراً لعدم وجود دراسات كافية من الناحية التقنية والمادية مع تقديرات واقعية للتكاليف.

نظراً لصعوبة تحديد كمية الطلب الحقيقي للكهرباء بحلول عام ٢٠٢٠ في لبنان، تم دراسة ثلاث حالات للطلب في كل من السيناريوهات وهي :كمية طلب منخفضة وكمية طلب متوسطة وكمية طلب مرتفعة.

تم تقييم السيناريوC1 كجزء من التقييم البيئي الاستراتيجي هذا في حين لم يتم أخذ السيناريو C2 في الحسبان نظراً لكون السيناريو C1 يعكس الهدف ١٢% الذي وضعته الحكومة. على ضوء النمو السكاني والطلب على الكهرباء، فقد تم اعتبار الطلب المتوسط كأكثر الحالات واقعية.

I. تقييم الظروف الأساسية

تم جمع البيانات الأساسية بالنسبة لإمكانات الطاقة المتجددة والظروف البيئية، من مجموعة متنوعة من الوثائق والمنشورات والدراسات القائمة. كما و تم جمع البيانات الأساسية أيضاً والتحقق من صحتها مع مختلف أصحاب المصلحة.

الطاقة الريحية:

يملك لبنان إمكانات ريحية مهمة (أطلس الرياح، ٢٠١١)، وعلى الرغم من عدم استثمارها من قبل فقد تم إدراجها في الخطط متوسطة وطويلة الأمد لهيكلة وتطوير قطاع الطاقة. أظهرت دراسات توليد الطاقة الكهربائية من الرياح أنه في حال كان متوسط سرعة الرياح أعلى من 6.5م/ثانية، فإنه يمكن توليد طاقة كهربائية بما يعادل 139،12 جيجا واط ساعي/ السنة، أي ما يعادل 80.9٪ من إجمالي الطلب على الكهرباء في عام ٢٠٠٩. ومع ذلك فإن استعمال طاقة الرياح في البلاد في الوقت الحاضر غير موجودة بشكل عملي.

تتمثل المناطق الرئيسية التي تم تحديدها على أن لها إمكانات كبيرة لطاقة الرياح بشمال عكار (مناطق البقيعة ووادي خالد) والضنية ومنطقة في البقاع تقع شمال-غرب مدينة بعلبك. وعند دراسة التداخلات بين المناطق ذات الرياح العالية المحتملة مع مختلف المواقع البيئية الحساسة فقد تم تحديد ثلاثة مواقع ذات أهمية بيئية عالية وهي مناطق هجرة الطيور في وادي عودين ومرجحين والمنتزه الطبيعي المقترح في عكار وجرود الضنية وجرود الهرمل.

الطاقة الفولتوضوئية الشمسية:

يملك لبنان قدرة على توليد طاقة فولتوضوئية شمسية يمكن أن تصل إلى ١١٠ غيغا واط في مناطق مرشحة تقع في الضنية/بشري والهرمل والبقاع (طفيل وعين الجوز) وزحلة. وتعادل هذه القيمة إنتاج سنوي للطاقة الكهربائية يصل إلى ١٨٠،٠٠٠غيغا واط ساعي، أي ما يقرب ١٥ مرة من الطاقة المنتجة حالياً من محطات الطاقة الحرارية في البلاد.

عند دراسة التداخل بين المناطق ذات الاحتمالية العالية لتوليد الطاقة الفولتوضوئية مع مختلف المواقع البيئية الحساسة؛ فقد تم تحديد مواقع ذات أهمية بيئية عالية وهي: ١) محمية اليمونة الطبيعية, ٢) المنتزه الطبيعي المقترح في عكار وجرود الضنية وجرود الهرمل, ٣) المنتزه الطبيعي المقترح في قاديشا والأرز، ٤) المنتزه الطبيعي المقترح في تنورين ونهر إبراهيم.

الطاقة الكهرمائية :

تبلغ استطاعة انتاج محطات الطاقة المائية المبنية حالياً ٢٨٠ ميغا واط في حين أن طاقة التوليد الفعلية لها هي190ميغا واط نظراً لكون هذه المحطات قد تم بناءها منذ عدة عقود ويصل عمر بعضها لـ ١٠٠ سنة. ولذلك، فإن توليد طاقة الكهرمائية إضافية ممكن عن طريق:

- إعادة تأهيل المحطات القائمة: يمكن أن يؤدي إعادة تأهيل محطات الطاقة الحالية إلى إضافة ما لا يقل عن ١٥% عن إنتاج الطاقة الحالية لهذه المحطات والتي ستؤدي إلى توليد طاقة كهربائية إضافية بحوالي 129 غيغا واط ساعي/سنة وزيادة متوسط عامل الانتاج لجميع المحطات إلى ٤٢,٣% (القيمة الحالية ٣٧,٢%)،
- بناء محطات جديدة: تم تحديد 32 مواقعاً جديداً محتملاً ويمكن تقسيمها إلى فئتين: محطات كهرمائية على مجاري الأنهر: بانتاجية محتملة تصل إلى ٢٦٣ ميغا واط ومحطات كهرمائية مع سدود: بانتاجية محتملة تصل إلى ٣٦٨ ميغا واط.

عند دراسة التداخلات بين مناطق محطات الطاقة الكهرمائية الحالية والمقترحة مع مختلف المواقع البيئية الحساسة، نجد أنه لا يوجد أي محطة طاقة كهرمائية ضمن أي محمية طبيعية، ومع ذلك فإنه تقع بعض المحطات المقترحة على طول فوالق

ما يمكن أن يشكل مصدر قلق بالنسبة للسلامة العامة خاصةً في حال وجود سدود. محطات الطاقة الكهرومائية، وخاصة التي تعتمد على السدود، لديها آثار بيئية سلبية هامة تم تقييمها بشكل تفصيلي في دراسة التقييم البيئي الاستراتيجي.

II. إطار أهداف ومؤشرات التقييم البيئي الاستراتيجي

تم تطوير إطار أهداف ومؤشرات التقييم البيئي الاستراتيجي لتوجيه تحليل البدائل ورصد المؤشرات البيئية والاجتماعية والاقتصادية الرئيسية. تم إعداد هذا الإطار بالتشاور مع أصحاب المصلحة الرئيسيين وعلى أساس القضايا ذات الأهمية لقطاع الطاقة المتجددة والتي هي ذات أهمية وطنية كذلك.

III. تحليل البدائل

تم النظر في دراسة التقييم البيئي الاستراتيجي هذه في بديلين وهما: (١) السيناريو الأول الذي يتمثل بالوضع الحالي ولا يتضمن تطوير مصادر الطاقة المتجددة في لبنان و(٢) السيناريو الثاني والذي يمثل طلب متوسط على الكهرباء لتطوير مصادر الطاقة المتجددة عبر السيناريو C1. تم مقارنة السيناريوهات من ١) الناحية البيئية والاجتماعية باستعمال إطار أهداف التقييم البيئي الاستراتيجي (SEA Framework) و٢) من الناحية الاقتصادية عبر تحليل تكاليفها وايراداتها. أظهر تحليل البدائل أن السيناريو الذي يتضمن العمل على تطوير مصادر الطاقة المتجددة هو السيناريو الأنسب من النواحي البيئية والاجتماعية والاقتصادية.

IV. تقييم الآثار البيئية والاجتماعية والاقتصادية

تم تقييم الآثار الإيجابية والسلبية للسيناريو الأنسب بحسب مرحلة تحليل البدائل وهو السيناريو C1 في حالة طلب متوسطة على الكهرباء. إن لتنفيذ هذه السيناريو آثاراً إيجابية على نوعية الهواء وتغير المناخ والعوامل الاجتماعية والاقتصادية المختلفة (الصحة وخلق فرص العمل والدخل والاقتصاد الوطني، الخ)؛ والتي تتعلق بشكل أساسي بالتحول عن استخدام الوقود الأحفوري.

فيما يتعلق بالآثار السلبية، أظهرت الدراسة أن لمصادر الطاقة الفولتوضوئية الشمسية أقل التأثيرات البيئية، يليها طاقة الرياح وأخيراً الطاقة الكهرمائية للمحطات التي تعتمد على السدود. إن الآثار السلبية الرئيسية الناجمة عن تنفيذ مشاريع الطاقة المتجددة يمكن اختصارها كالتالي:

- التأثيرات على الأحياء الطائرة الناجمة عن مزارع الرياح (الطيور المائية والطيور المهاجرة بشكل خاص),
- التأثيرات على المحميات والمنتزهات الطبيعية المقترحة، لا سيما في المنتزه الطبيعي المقترح في عكار وجرود الضنية وجرود الهرمل بشكل أساسي نظراً للتداخل بين منطقة المنتزه ومنطقة ذات إمكانيات عالية للطاقة الريحية,
- تأثيرات بيئية على المناطق التي تقع قبل و بعد محطات الطاقة الكهرومائية، و بشكل أساسي محطات الطاقة الكهرمائية التي تعتمد على السدود,
- التأثيرات على استخدام الأراضي والمناظر الطبيعية، نظراً للمساحة الكبيرة المطلوبة وحصول تداخلات بصرية وخلافات على الاستخدامات الأخرى للأراضي.

V. خطة الإدارة والمراقبة البيئية

تتضمن خطة الإدارة والمراقبة البيئية المقترحة استراتيجيات التخفيف والمراقبة لمعالجة الآثار السلبية التي تم تحديدها كما وتقترح إطاراً مؤسساتياً لتنفيذ توصيات التقييم البيئي الاستراتيجي وخطوة الإدارة البيئية وتحديد أدوار الجهات المعنية الرئيسية المشاركة في هذه العملية؛ بالإضافة إلى متطلبات بناء القدرات العامة.

VI. التوصيات

بعد تحليل الآثار والفوائد المحتملة المرتبطة بتنفيذ السيناريو C1، وبعد التشاور مع الجهات المعنية الحكومية وغير الحكومية، وصل فريق التقييم البيئي الاستراتيجي إلى استنتاج مفاده أن تنفيذ استراتيجية الطاقة المتجددة هو مفيد للبلاد على مختلف المستويات (اقتصادية وبيئية واجتماعية، الخ) ومع ذلك، وبهدف تجنب مخاوف بيئية معينة قد تظهر عند تنفيذ السيناريو C1 فقد تم وضع عدد من التوصيات. ملخص هذه التوصيات هو كما يلي:

١. توصيات لدمج نتائج التقييم الاستراتيجي في الاستراتيجية الوطنية للطاقة المتجددة:

- إعادة النظر في المواقع المحتملة وتجنب تلك المواقع التي تتقاطع مع المناطق البيئية الهامة (مثل محمية اليمونة الطبيعية بالنسبة للطاقة الشمسية الضوئية (PV) والمناطق ذات الأهمية للطيور المهاجرة بالنسبة لمزارع الرياح)،
- النظر في المناطق ذات الانتاجية التقنية الأقل بالنسبة للرياح والطاقة الضوئية الشمسية وعدم حصر الدراسة بالمناطق ذات الانتاجية الأعلى في استراتيجية الطاقة المتجددة،
- تقليل عدد محطات الطاقة الكهرمائية الجديدة التي تعتمد على السدود (إن أمكن)،
- مراجعة مناطق المحطات الكهرمائية مع الأخذ بالاعتبار موضوع العوامل الزلزالية،
- النظر في القرب من شبكة الكهرباء وادراج هذا الموضوع في تكلفة التنفيذ،
- الأخذ في الاعتبار جميع النقاط المذكورة أعلاه وتطوير سيناريوهات ترتكز على جمع مصادر مختلفة من الطاقات المتجددة لتحقيق هدف الـ ١٢% مع اعتبار حالة طلب واحدة على الكهرباء.

٢. توصيات لادراج نتائج التقييم البيئي الاستراتيجي في سياسات وخطط الجهات العامة المعنية

الجهات العامة الرئيسية المعنية	الأدوار الرئيسية و المسؤوليات
وزارة البيئة	• بناء القدرات لضمان أن موظفي وزارة البيئة على بينة من التقييم البيئي الاستراتيجي، و خاصة متطلبات تقييم الأثر البيئي. • انطلاقاً من تحديد متطلبات تقييم الأثر البيئي (ضمن هذا التقييم البيئي الاستراتيجي)، وضع مبادئ توجيهية لكل تقنيات الطاقة المتجددة لتوجيه المطورين والاستشاريين البيئيين (على غرار منشورات CEDRO عام ٢٠١٢: "تقييم الأثر البيئي لتطوير مزارع الرياح: تقرير التوجيهي")؛ • التأكد من أن تقارير تحديد نطاق العمل لدراسات تقييم الأثر البيئي الخاصة بالطاقة المتجددة متوافقة مع متطلبات التقييم البيئي الاستراتيجي؛ • وضع تشريعات محددة لتطوير مشاريع الطاقة المتجددة، مثل تحديد الحد الأدنى للمسافات الفاصلة بين مزارع الرياح من مختلف استعمالات الأراضي على غرار القرارات 52/1 و 8/1، • تنظيم حملات توعية وورش عمل لتوعية المطورين، والوزارات الأخرى، والعامة حول الطاقة المتجددة وتأثيراتها البيئية والاجتماعية والمتطلبات القانونية (مثل قانون تقييم الأثر البيئي)، • اعطاء التقييم البيئي الاستراتيجي وضعاً قانونياً والتصديق عليه من خلال قرار وزاري أو مرسوم (نظراً لآثاره على مختلف القطاعات) من أجل أن يصبح وثيقة ملزمة، • تعيين شخص من وزارة البيئة للتنسيق والمتابعة مع وزارة الطاقة والمياه لادراج العناصر البيئية في الاستراتيجية الوطنية للطاقة المتجددة التي يجري تطويرها.
وزارة الطاقة والمياه	• انشاء هيئة/لجنة مسؤولة عن تنسيق العمل بين مختلف ادارات ومصالح الوزارة من أجل ١) وضع استراتيجيات متكاملة للسياسات والخطط والمشاريع (PPP)، ٢) تجنب وضع استراتيجيات متضاربة، و ٣) الإشراف على وضع وتنفيذ استراتيجيات وزارة الطاقة والمياه. مثل: o تنسيق العمل بين فريقي استراتيجية الطاقة المتجددة والاستراتيجية الحرارية وضم هدف الـ ١٢% للطاقة المتجددة في استراتجية الطاقة الحرارية، o تنسيق العمل بين فريقي استراتيجية الطاقة المتجددة واستراتيجية قطاع المياه لتطوير إمكانات الطاقة الكهرومائية في لبنان، وتجنب المشاريع المتضاربة، • انشاء هيئة وطنية للطاقة تكون مسؤولة عن تنظيم جميع المسائل المتعلقة بالطاقة :الطاقة المتجددة، الوقود الثقيل والغاز، الخ، • التنسيق مع وزارة البيئة لإدراج المتطلبات البيئية في دفاتر الشروط الخاصة بالطاقة المتجددة والطلب من مقدمي العروض توضيح آلية إدراج المتطلبات البيئية في عروضهم، ومراجعة العروض المقدمة مع أخذ المتطلبات البيئية بعين الاعتبار، • تقييم التكاليف المتكبدة من قبل مشغلي مزارع الرياح عند اغلاق التوربينات خلال مواسم هجرة الطيور واستيعاب هذه التكاليف في المناقصات، ووضع حل لتعويض هذه الخسائر

الجهات العامة الرئيسية المعنية	الأدوار الرئيسية و المسؤوليات
	من قبل الحكومة, و ◆ التنسيق مع الوزارات الأخرى التي تملك قضايا متضاربة مع مشاريع الطاقة المتجددة مثل وزارة الزراعة.
وزارة الزراعة	◆ تعيين صلة وصل/شخص لـ: o استعراض توصيات التقييم البيئي الاستراتيجي المتعلقة بالغابات والأراضي الزراعية (مثل حظر تنفيذ مشاريع الطاقة المتجددة في الغابات الكثيفة، وتشجع مزارع الرياح على الأراضي الزراعية، الخ), o تنسيق العمل مع وزارة البيئة من جهة ووزارة الطاقة والمياه من جهة أخرى في الاتفاق على المبادئ التوجيهية المتعلقة بالغابات والأراضي الزراعية واختيار مواقع تنفيذ مشاريع الطاقة المتجددة, o التنسيق مع المجلس الأعلى للتنظيم المدني لتنظيم استخدام الأراضي في الأراضي الزراعية وذلك لمنع بيع مساحات ضخمة من الأراضي لصالح مشاريع الطاقة المتجددة. كما وينبغي تعزيز آليات الاستخدام التشاركي للأراضي (co-exploitation/co-farming), ◆ إجراء حملات توعية، بالتعاون مع وزارة البيئة ووزارة الطاقة والمياه، لتثقيف المزارعين حول مشاريع الطاقة المتجددة، وتسليط الضوء على فوائد تطوير مزارع الرياح على أراضيهم، وتعزيز التعاون الزراعي، وإشراكهم في العملية.
أصحاب العلاقة في التخطيط المدني	هناك حاجة لتحديد مناطق مناسبة لتنفيذ كل تقنية من تقنيات الطاقة المتجددة. لذلك أحد أهم التوصيات هو ادراج ضمن الخطة الشاملة لترتيب الأراضي اللبنانية مواقع مخصصة لتنفيذ مشاريع الطاقة المتجددة بالتعاون مع مختلف الأفرقاء المعنيين (المجلس الأعلى للتنظيم المدني, مجلس الإنماء والإعمار, وزارة البيئة, وزارة الزراعة, وزارة الطاقة والمياه, المجلس الأعلى للخصخصة, الخ) وذلك لإستبعاد المساحات في المناطق الحساسة من أي إضطرابات محتملة جراء إنشاء محطات بإستعمال الطاقة المتجددة .
المجلس الأعلى للخصخصة	◆ ضمان دمج المتطلبات البيئية في وثائق المشاريع والمناقصات المتعلقة بإعادة بمشاريع الطاقة المتجددة ◆ تعميم المتطلبات البيئية في جدول أعمال القطاع الخاص

٣. التوصيات التي تغطي متطلبات تقييم الأثر البيئي

يجب على طلبات ووثائق مناقصات تنفيذ مشاريع الطاقة المتجددة أن تشمل متطلبات تفصيلية لدراسات تقييم الأثر البيئي لتخويل المقاولين بأخذها في عين الاعتبار في عروضهم وأسعارهم. تتماشى التوصيات المعروضة في الجدول أدناه مع تدابير التخفيفة المحددة في التقييم البيئي الاستراتيجي, موضوع هذه الدراسة.

تقنية الطاقة المتجددة	المتطلبات دراسات تقييم الأثر البيئي لمشاريع الطاقة المتجددة (عند الاقتضاء)
مزارع الرياح	◆ دراسة للطيور في المنطقة مدتها سنة واحدة على الأقل, ◆ نتائج دراسة علمية لتقييم الطيور والخفافيش (بما في ذلك مواقع التعشيش، والمستعمرات، المجاثم، وممرات الهجرة) في موقع المشروع وتأثير المشروع عليها, ◆ تحليل البدائل مع النظر في تشكيلات مواقع التوربينات المختلفة واعتماد التشكيل الأقل تأثيراً على الأحياء الطائرة. كما و يجب في تحليل البدائل أن يتم النظر في مواقع مختلفة واعتماد المواقع التي لها أقل تأثير على الأحياء الطائرة, ◆ استخدام طرق علمية لاكتشاف وتقييم ورصد آثار مزارع الرياح على الطيور,

تقنية الطاقة المتجددة	المتطلبات دراسات تقييم الأثر البيئي لمشاريع الطاقة المتجددة (عند الاقتضاء)
	◆ تدابير وقائية في حال وجود طيور وخلال مواسم الهجرة (مثل توقيف التوربينات عن العمل أو الحد من سرعة دوران العنفات)، ◆ دراسة الضوضاء مع نمذجة للضجيج (noise modeling)، ◆ نمذجة بصرية ثلاثية الأبعاد (visual 3D modeling) ومنهجية إحصائية لدراسة نسبة ضوء الشمس، الميزات المحلية للرياح ولمزرعة الرياح ل=من أجل الوصول الى تقييم كمي لتأثير ظل العنفات واحتمال إزعاج السكان المحليين، ◆ وصف تفصيلي لبرامج العمل التي تسمح بالتحكم بالعنفات الريحية وايقافها عن العمل عند الضرورة، ◆ وسائل لتخفيف انعكاس الضوء ووهجه، ◆ دراسة اجتماعية واقتصادية تظهر الاستخدام التشاركي للأراضي بين استخدامات الأراضي الموجودة والمشروع ، ◆ الية استملاك الأراضي وعملية التعويض، و ◆ دليل/اثباتات لعملية التشاور مع المجتمعات المتضررة ومشاركتها في مرحلة تصميم المشروع وجميع مراحل دراسة تقييم الأثر البيئي.
مزارع الطاقة الفوتوضوئية الشمسية	◆ تحليل توافق استخدام الأراضي لاثبات أن المشروع لا يؤثر على أي أرض محظورة أو منطقة محمية، ◆ دراسة جدوى اقتصادية تتضمن تحليل التكاليف والفوائد (Analysis Costs-Benefits) لتركيب محطات الطاقة الكهرضوئية الشمسية وتبرير أي تغيير في الاستخدامات الحالية للأراضي، ◆ نمذجة بصرية ثلاثية الأبعاد (visual 3D modeling) تبين الوسائل المعتمدة لضمان إدماج المشروع في المناظر الطبيعية المحيطة، ◆ نشاطات إدارة النفايات وإعادة التدوير والتخلص النهائي من مختلف النفايات المنتجة، خاصة النفايات الخطرة التي تحتوي على كادميوم تلوريد (CdTe)، و ◆ الية استملاك الأراضي وعملية التعويض، و ◆ دليل/اثباتات لعملية التشاور مع المجتمعات المتضررة ومشاركتها في مرحلة تصميم المشروع وجميع مراحل دراسة تقييم الأثر البيئي.
محطات الطاقة الكهرمائية	◆ مراقبة الحياة البرية والغطاء النباتي في المناطق التي تعلو السدود وتدنوها لتوثيق التغيرات في الغطاء المائي النباتي والحيواني التي يمكن أن يسببها المشروع، يجب ان يمتد التنوع الحيوي الموثق (النباتي والحيواني) لسنة واحدة على الأقل للنظر في الفصول الأربعة، ◆ ينبغي أن يشمل تحليل البدائل ما لا يقل عن ٣ مواقع مختلفة للمشروع وإثبات أن الموقع المختار لديه أقل التأثيرات على البيئة والمجتمعات المحلية، ◆ توقعات توفر واستخدام المياه في المستقبل تدل على أنه من غير المحتمل حدوث صراعات كبيرة على المياه بين مستخدمي المياه، يجب أن يتضمن التحليل الآثار المتوقعة من تغير المناخ على المياه، ◆ خطة طوارئ في حال فشل السد بما في ذلك تقييم المخاطر، ◆ خطة إدارة السدود، ◆ خطة إدارة أحواض الأنهار، ◆ طرق وخطة مراقبة تدفق المياه، ◆ طرق وخطة مراقبة نوعية المياه، ◆ تحليل مفصل للآثار على استخدام الأراضي والمجتمعات المحلية، بما في ذلك الية استملاك الأراضي وعملية التعويض، ◆ دليل/اثباتات لعملية التشاور مع المجتمعات المتضررة ومشاركتها في مرحلة تصميم المشروع وجميع مراحل دراسة تقييم الأثر البيئي.

٤. التوصيات القانونية، المؤسساتية والمالية

- مراجعة وتنفيذ قانون قطاع الكهرباء رقم 462 ليتطرق الى موضوع الطاقة المتجددة بشكل أوضح،
- تنفيذ قانون الشراكة بين القطاع العام والقطاع الخاص (Public Private Partnership) لتشجيع استثمارات القطاع الخاص في مجال الطاقة المتجددة،
- مراجعة وتنفيذ مسودة قانون الحفاظ على الطاقة لمعالجة ليشمل موضوع الطاقة المتجددة بشكل أوضح،
- وضع نظام لتعريفات التغذية (feed-in tariffs) والتدقيق في مجال الطاقة (energy audits)،
- الإشارة ضمن التشريعات المستقبلية للمباني الخضراء والمعايير الحرارية اللبنانية،
- إعادة هيكلة وخصخصة مؤسسة كهرباء لبنان، و
- إنشاء هيئة وطنية للطاقة تكون مسؤولة عن تنظيم جميع المسائل المتعلقة بالطاقة والتي يمكن أن تكون هيئة تنظيم قطاع الكهرباء

EXECUTIVE SUMMARY

The Government of Lebanon (GoL), through a Ministerial Declaration in 2009 and the Ministry of Energy and Water's (MoEW) Policy Paper for the Electricity Sector in 2010, has set the target of 12% of total energy supply from renewable energy (RE) sources by 2020.

To meet the set 12% target, the Climate Change Coordination Unit (CCCU)[1] has prepared and published a study in September 2014 entitled "*Optimal Renewable Energy Mix of the Power Sector by 2020: Investment Cost Implications for Lebanon*". The study is based on an assessment of the country's renewable energy capacity potential in terms of Wind Power, Solar Photovoltaic (PV), Concentrated Solar Power (CSP) and Hydropower. The study's results include an optimal energy mix along with the cost burden to the Government in a number of demand projections (demand cases) and RE integration scenarios.

The Strategic Environmental Assessment (SEA) of Lebanon's Renewable Energy Sector has been prepared in parallel to the CCCU study with the aim of identifying the main environmental and social implications of the development of large scale wind farms, PV farms, and hydropower plants; developing measures to minimize the significance of negative impacts and increase the benefits of positive impacts; as well as providing a set of recommendations to be adopted by various government entities to allow the mainstreaming of environmental concepts and principles into the country's RE strategy. The SEA also aims at assisting parties working on developing RE action plans, implementation programmes, and large-scale projects in understanding 1) the current technical, environmental and socio-economic baseline, 2) the legal, institutional, and financial frameworks governing the sector, and 3) the environmental impacts of developing large-scale projects and proper ways to mitigate adverse ones.

The CCCU study includes two scenarios based on the deployment of the same three RE technologies: one reaching a 12% RE share and the second a 20% RE share. The SEA adopted the 12% scenario (Scenario C1) to be in line with the set national targets. Following the determination of the Scenario to be assessed in this SEA along with the relevant legal and financial framework, the SEA process followed the below six steps further detailed below:

I. Assessment of the **baseline conditions** related to three RE technologies from a technical and environmental point of view;

II. Development of the **SEA Framework** of objectives, indicators and targets;

III. **Analysis of alternatives** comparing Scenario C1 to the Business as Usual case (no action) against the developed framework and costs and benefits criteria;

IV. **Impacts assessment** identifying potential positive and negative impacts arising from the deployment of Scenario C1;

V. Development of the **Environmental Management Framework**; and

[1] The CCCU is a project unit at the MoE managed by the UNDP

VI. Development of **Recommendations** covering: 1) the integration of the SEA findings into the RE Strategy, 2) mainstreaming the SEA findings into national policies and plans, 3) EIA requirements, and 4) Legal, institutional, and financial measures.

The Optimal Renewable Energy Mix of the Power Sector by 2020: Investment Cost Implications for Lebanon

The study determines the optimal energy mix and the cost burden to the Government in three scenarios aiming to incorporate the country's RE capacity potential along the assumption of meeting the demand by 2020: Business as Usual (BAU), Scenario C1 with a target of 12% electricity generation from RE sources, and Scenario C2 with a more ambitious target of 20%.

Scenarios C1 and C2 are based on the deployment of three renewable energy technologies: 1) Onshore wind power, 2) Solar photovoltaic (PV), and 3) Hydropower. With the exception of the solar Concentrated Solar Power (CSP), no bioenergy, offshore wind, geothermal energy, or tidal power have been taken into consideration due to lack of potential estimates and/or complexity in conducting realistic representative cost-benefit estimates. For CSP, its higher levelised cost of electricity as shown in the optimization exercise resulted in its exclusion.

Given the uncertainties in estimating the real electricity demand by 2020 in Lebanon, three demand cases were developed for each of the scenarios: Low Demand, Medium Demand, and High Demand.

Scenario C1 was assessed as part of this SEA while Scenario C2 was not considered given that C1 reflects the 12% target set by the Government. In terms of population growth and electricity demand, the Medium Demand case has been retained being considered as the most realistic and credible case.

VII. Assessment of Baseline Conditions

Baseline data, in terms of RE potentials and environmental conditions, were collected from a variety of existing documentations, publications and studies. Baseline data were also collected and validated with various stakeholders.

Onshore Wind:

Lebanon has a reasonable wind potential (see e.g., the wind atlas, finalized in 2011) and despite the lack of investments, wind power has been included in the mid-long term energy plans for the restructuring and development of the power sector. Studies showed electricity generation from wind power, in sites above average wind speed of 6.5 m/s, amounts to approximately 12,139 GWh/y, equivalent to 80.9% of the total electricity demand in 2009. Yet wind power in the country is at present practically non-existent.

The main areas identified as having considerable wind energy potential are Akkar's far north (Boqaiaa and Wadi Khaled regions), Donniyeh and in an area in the Bekaa to the North West of Baalbek. When overlaying the high wind potential areas with various sensitive ecological sites, three areas of concern were identified: migratory birds' bottlenecks of Wadi Oudine and Marjhine and Akkar, Upper Donniyeh, and Upper Hermel Natural Park.

Solar Photovoltaic:

Lebanon has a potential for PV that could reach up to 110 GW, with candidate areas of high potential located in Donniyeh/Bcharreh, Hermel, Bekaa (Tfail and Ain Joz), and Zahleh. This amount corresponds to annual electricity generation of 180,000 GWh, almost 15 times the present generation from the TPPs (Thermal Power Plants) of the country.

When overlaying the high PV potential areas with various sensitive ecological sites; various areas of concern were identified: Yammouneh Nature Reserve, Akkar, Upper Donniyeh, and Upper Hermel Natural Park, Qadisha and Cedars Natural Parks, and Tannourine and Nahr Ibrahim Natural Park.

Hydropower:

The current installed capacity of hydropower plants in Lebanon is about 280 MW but the actual generation capacity is 190 MW because many of the plants have been in service for several decades, some of them for 50-100 years. Therefore, potential for new capacity from hydropower generation exists either from:

- The rehabilitation of existing plants: at least 15% of additional generation capacity is possible from rehabilitating hydropower plants, which corresponds to additional electricity generation of about 129 GWh/y and an increase of the average capacity factor of all plants to 42.3% (from current 37.2%); and
- The construction of new plants: 32 new potential sites[2] were identified and can be split into two categories: Run of river schemes: potential capacity of 263 MW and Peak schemes (with dams): potential capacity of 368 MW.

When overlaying existing and potential hydropower plants with various sensitive ecological sites, it appeared that no hydropower plants fall within Nature Reserves, however a number of proposed sites are located along faults, which could pose a safety concern in case of dam failure. Nevertheless, hydropower plants, particularly HPPs with dams, might still have significance ecological impacts upstream and downstream, and these are further assessed in the SEA study.

VIII. SEA Framework of Objectives, Indicators and Targets

An SEA framework of objectives, indicators and targets has been developed to frame the analysis of alternatives and monitoring of key environmental and socio-economic indicators. The framework was prepared in consultation with key stakeholders and based on issues of relevance to the renewable energy sector and that are of national relevance.

IX. Analysis of Alternatives

Two alternatives have been considered in this SEA study: (1) the BAU scenario (i.e. no development of renewables in Lebanon) and (2) the Medium Demand Case for the development of renewables (Scenario C1); both scenarios were compared using the SEA framework of objectives as well as an analysis of their costs and benefits. The analysis demonstrates that proceeding with the renewable energy scenario is the preferred SEA scenario and has a better contribution towards achieving the SEA targets as compared to the BAU scenario and contributes to substantial cost savings.

[2] Sogreah (2012). Plan Directeur de l'Hydroélectricité au Liban: Rapport Phase 2: Schéma Directeur

X. Environmental and Socio-Economic Impacts Assessment

The positive and negative impacts of the preferred SEA scenario (C1 medium demand case) were then further assessed using standard impact assessment methods to evaluate the significance of each impact.

Implementation of the C1 medium demand scenario has positive impacts on air quality, climate change, and various socio-economic factors (health, job creation, income, national economy, etc.); mainly related to the shift from electricity generation by fossil fuels.

In terms of adverse impacts, solar PV appeared to have the least adverse impacts, followed by wind, and finally hydropower – *mainly HPPs with dams.* The main adverse effects caused by the deployment of RE projects are:

- Effects on avifauna caused by the deployment of wind farms (waterbirds and migratory birds in specific)
- Effects on natural parks and areas, mainly in the Akkar Natural Park given the overlap between the Park's area and the high wind energy potential area
- Effects on upstream and downstream ecology that can be caused by hydropower, mainly HPP with dams;
- Effects on land-use and landscape, given the large surface area needed and the visual intrusion the facilities might cause as well as conflict with other economic uses of the land.

XI. Environmental Management Framework (EMF)

The developed EMF includes mitigation and monitoring strategies to address the identified adverse impacts; proposes an institutional framework for the implementation of the SEA recommendations and EMF specifying the roles of the main stakeholders involved in the process; in addition to general capacity building requirements.

XII. Recommendations

Following the analysis of potential impacts and benefits associated with the implementation of Scenario C1, and following consultations with governmental and non-governmental stakeholders, the SEA team has reached the conclusion that the implementation of a renewable energy strategy is beneficial for the country at various levels (economical, ecological, social, etc.) however, and in order to avoid certain environmental concerns that might rise when implementing the 12% RE deployment, a number of recommendations covering the following main four aspects have been developed. A summary of these recommendations is as follows:

5. Recommendations for integrating SEA findings in the RES

- Reconsideration of the high potential sites and removal of the ones overlaying with important ecological areas (such as Yammouneh Nature Reserve for PV and areas of importance for migratory birds for Wind farms);
- Consideration of wind and PV lower potential sites and not limiting the Optimal Mix / Renewable Energy Strategy to the highest potential sites;
- Reduction of, if possible, the number of new hydropower plants associated with dams;

- Review of the locations of hydropower plants while considering seismicity factors;
- Consideration of the proximity to the electricity grid and its cost implications;
- Taking into account all the above points and developing various mixes and scenarios reaching the 12% target for the same electricity demand case.

6. *Recommendations for mainstreaming the SEA findings into the policies and plans of concerned public entities*

Major Public Entity Involved	Main Roles and Responsibilities
Ministry of Environment	◆ In-house capacity building to ensure that MoE staff are aware of the SEA, especially EIA requirements; ◆ Starting from the identified EIA requirements in this SEA, further develop guidelines for each RE technology to guide developers and environmental consultants (similar to the CEDRO 2012 publication: "Environmental Impact Assessment for Wind Farm Development: A Guideline Report); ◆ Ensure scoping reports for RE EIA studies duly integrate the SEA requirements in their scope of work; ◆ Investigate the need to develop specific regulations for RE project developments, an example would be minimal separation distances of wind farms from various land uses and features, and enact these regulations into decisions similarly to Decisions 52/1 and 8/1; ◆ Organize awareness campaign and workshops to educate developers, other ministries, and the public about RE and its environmental and social impacts and legal requirements (e.g. EIA Decree); ◆ Give the SEA a legal status and ratify it through a Ministerial Decision or Decree (given its implications to different sectors) in order for it to become a binding document and that starts to be effectively implemented; ◆ Assign a focal point from the MoE to coordinate and follow up with the MoEW on the integration of environmental components into the RE strategy being developed.
Ministry of Energy and Water	◆ Create a body/committee responsible for coordinating the work between the various entities of the Ministry to 1) develop complementary strategies and large scale PPP, 2) avoid the development of conflicting strategies, and 3) oversee the development and implementation of the MoEW's strategies; for example: o Coordinating the work between the teams of the RE Strategy and Thermal Strategy and integrating the RE target (12%) in the thermal energy policy paper, and o Coordinating the work between the teams of the RE Strategy and Water Sector Strategy for the development of Lebanon's hydropower potential and avoiding conflicting projects ◆ Create a National Energy Authority that shall be responsible to regulate all energy related matters: renewables, HFO, gas, etc.

	◆ Coordinate with the MoE to list environmental requirements in RE tender documents, ask bidders to include their approach to meeting environmental requirements, and review submitted approaches, those being a main criteria in the evaluation process; ◆ Assess the cost incurred by the wind farm operators when shutting down turbines during bird migration seasons; request the internalization of these costs in bids, and devise a solution to compensate these losses by the Government; and ◆ Coordinate with other ministries having cross-cutting issues such as the MoA over irrigation projects and locations of RE projects.
Ministry of Agriculture	◆ Assign a focal point to: o Review SEA recommendations related to forests and agricultural lands (e.g. ban development of RE projects in dense forests, encourage wind farms on agricultural lands, etc.); o Coordinate the work with the MoE on one hand and the MoEW on another to agree on guidelines related to forests and agricultural lands and choice of location of the RE development projects; and o Coordinate with the DGUP to regulate land use in agricultural land so as to prevent massive selling of the lands for wind/solar PV projects. Co-exploitation/ co-farming mechanisms should be promoted to this end, whereby seasonal activity is factored in. ◆ Conduct awareness campaigns, in collaboration with the MoE and MoEW, to educate farmers about RE projects, highlight the benefits of developing wind farms on their lands, promote co-farming, and engage them in the process.
Urban Planning Stakeholders (DGUP, HCUP, CDR)	There is a need to earmark areas suitable for the development of each RE technology. Urban planning in Lebanon involves several stakeholders, mainly DGUP, HCUP, and CDR. An important recommendation would therefore be to include RE areas in the NPMPLT after consultation with the various urban planning stakeholders along with MoE, MoA and MoEW, to exclude sensitive zones from any potential disturbances from RE development.
Higher Council for Privatization (HCP)	◆ Ensure environmental requirements are integrated in project documents and tenders related to RE projects ◆ Mainstream environmental requirements into private sector's agenda

7. Recommendations covering EIA requirements

Specific EIA requirements detailed in the SEA should be included in the tender documents of RE developments to allow the bidders to prepare adequate scopes and associated prices and integrate these requirements in the project's timeframes. These measures are in line with the mitigation measures and presented in the table below.

RE Technology	Requirements to be included in project specific EIA studies (where applicable)
Wind Farms	• An ornithological study over at least one year; • Results of a scientific study evaluating avian and bat use (including the locations of active nest sites, colonies, roosts, and migration corridors) of the project area and the likely impacts of the project; • Analysis of alternatives should consider various configurations for the siting of the turbines and demonstrate that the selected configuration has the least impact on avifauna; analysis of alternatives should also consider different sites within the intended development area and demonstrate that selected site has least impacts on avifauna; • Means to be utilized for the detection, assessment and monitoring of the effects of wind farms on birds; • Preventive measures following detection of birds and during migratory seasons (such as selective turbine shut down or reduction of speed rotation); • Acoustic study with noise modeling; • A visual modeling and a statistical approach taking into account the sunlight fraction, local features of wind and of the wind farm to quantitatively assess the probability of a perception of the flickering effect and possible disturbance to local residents; • Details of the software configuration allowing the shutdown of the blades during the flickering times if one to three housing units are affected; • Means to mitigate reflection and glare; • Socio-economic study demonstrating how existing land-uses can be integrated within the project and possible co-use of the land; and • Land expropriation and compensation process. • Evidence of early consultation with affected communities and their participation in the design process throughout the EIA study.
Solar PV Farms	• Land-use compatibility analysis to demonstrate that the project does not affect any restricted land or protected area; • CBA analysis for large PV installation to justify change in land use; • Visual modeling showing adopted means to ensure integration of the project in the surrounding landscape; and • Waste management/recycling practices and end disposal of various generated waste streams; namely hazardous waste containing parts such as CdTe; • Land expropriation and compensation process; and • Evidence of early consultation with affected communities and their participation in the design process throughout the EIA study.
Hydro Power Plant	• Baseline wildlife and vegetation monitoring upstream and downstream the dam's site to document changes in aquatic flora and fauna that could be caused by the project; documented biodiversity (flora and fauna) should span at least one year to consider 4 seasons;

	• Analysis of alternatives should consider at least 3 different sites for the project and demonstrate that selected site has least impacts on ecology and local communities; • Projections of future water availability and use demonstrating that significant conflicts for water are not likely to occur among different water uses; the analysis should consider the projected impacts from climate change; • Contingency plan in case of dam failure including risk assessment; • Dam management plan; • River basin management plan; • Flow monitoring methods and plan; • Water quality monitoring methods and plan; • Detailed analysis of impacts on land-use and communities, including land expropriation and compensation process; • Evidence of early consultation with affected communities and their participation in the design process throughout the EIA study.

8. Legal, institutional, and financial recommendations

- Revision and implementation of the electricity sector Law No. 462 to address more explicitly renewable energy sources;
- Implementation of Public Private Partnership (PPP) Law to encourage private sector investment in the RE sector;
- Revision and implementation of the Energy Conservation Draft Law to address more explicitly renewable energy sources;
- Including a regime for feed-in tariffs and energy audits;
- Addressing under future legislations the Green Buildings Code and the Lebanese Thermal Standards;
- Restructure and corporatization of EDL; and
- Creation of a National Energy Authority, which could be the NERB[3].

[3] NERB: National Electricity Regulatory Body

1 INTRODUCTION

The Government of Lebanon (GoL), through a Ministerial Declaration in 2009 and the Ministry of Energy and Water's (MoEW) Policy Paper for the Electricity Sector in 2010, has set the target of 12% of total energy supply from renewable energy sources by 2020.

To meet the set national target, a *National Energy Efficiency Action Plan* (NEEAP) for the years 2011-2015 has been developed by the Lebanese Center for Energy Conservation (LCEC)[4] and adopted by the GoL. An updated version of the NEAAP, covering the years 2016-2020 has been finalized. To complement the NEEAP, *a National Renewable Energy Action Plan (NREAP)* is being developed to structure the accomplishment of the 12% target.

As part of the *National Action Programme to Mainstream Climate Change into Lebanon's Development Agenda* project of the United Nations Development Programme (UNDP), Earth Link & Advanced Resources Development (ELARD) in association with LDK Consultants Engineers and Planners S.A. (LDK) (hereinafter referred to as "the Consultants") were appointed by the UNDP to provide professional services for The Preparation of the Strategic Environmental Assessment (SEA) of Lebanon's Renewable Energy Sector.

The purpose of this SEA Report is to specifically evaluate the likely environmental and social effects of introducing and developing renewable energy activities in Lebanon according to the procedures outlined in the SEA Decree 8213/2012. The SEA is a tool to assist the MoEW to integrate, at the earliest possible stages of decision making, major environmental, social, and economic concerns into the NREAP.

The only available and complete documentation that was provided to the Consultant's team, is an alternative analysis attempt prepared by the UNDP Climate Change Coordination Unit (CCCU) team[5], entitled "*Optimal Renewable Energy Mix of the Power Sector by 2020: Investment Cost Implications for Lebanon*"[6] presenting scenarios for Renewable Energy Strategy (RES) deployment in the country by 2020. This document constitutes until present, the only realistic approach toward a RES and formed the basis for the SEA preparation.

The main purpose of this SEA is to assist parties who are working on developing renewable energy action plans, implementation programmes, and large-scale projects in understanding 1) the current technical, environmental and socio-economic baseline, 2) the legal, institutional, and financial frameworks governing the sector, and 3) the environmental impacts of developing large-scale projects and proper ways to mitigate adverse ones.

This report also highlights the gaps and needs, mainly from a technical and legislative perspective, and provides a set of recommendations to be adopted by various government entities to allow the mainstreaming of environmental concepts and principles into the country's RES.

[4] In collaboration with MED-ENEC, the EU funded MED-EMIP project, the League of Arab States and the regional center for renewable energy and energy efficiency (RCREEE), and based on the World Bank Study: Energy Efficiency study in Lebanon, 70302, Econoler International REF5515, December 2009.

[5] Vahakn Kabakian (Project Manager) and Leila El Sayed (Economist)

[6] http://climatechange.moe.gov.lb/Library/Files/Uploaded%20Files/Renewable%20Energy%20-%20Investment%20Cost%20-%20Final%20Version.pdf

This Report is structured into the following chapters:

- **Chapter 1** presents an overview of the renewable energy sector in Lebanon at a policy level, and the study being assessed as part of this SEA;
- **Chapter 2** presents the adopted SEA methodology;
- **Chapter 3** analyzes the current legal and policy frameworks governing the renewable energy sector in Lebanon, identifies the legal gaps, and presents an overview of the current financial and fiscal measures;
- **Chapter 4** presents the technical and environmental baseline conditions: summaries of the RE potentials are first presented, followed by an environmental and socio-economic assessment of the high potential areas including land use/land cover and proximity to sensitive ecological and cultural sites;
- **Chapter 5** describes the public consultations and participatory approach adopted during the development of this SEA;
- **Chapter 6** provides the SEA framework providing overall guidance and direction to assess the RES as well as its impacts, especially on areas of concern and key issues;
- **Chapter 7** presents the assessed alternatives and includes a comparative analysis covering environmental and socio-economic parameters as well as costs and benefits;
- **Chapter 8** details the major likely environmental and socio-economic impacts arising from the implementation of the selected alternative. The findings of Chapters 3 and 4 allowed the identification of impacts at the local and national level;
- **Chapter 9** presents the environmental management framework developed, including mitigation measures to alleviate identified adverse impacts, the institutional setup needed for the implementation of this SEA, and the capacity building requirements;
- **Chapter 10** offers a set of recommendations covering multiple aspects, allowing the implementation of the SEA and the integration of its findings at various levels.

PART 1: BACKGROUND AND METHODOLOGIES

2 The Renewable Energy Strategy (RES)

One of the main drivers of the RES is the energy crisis in Lebanon. Although the reform of the Lebanese energy sector has featured as a priority for several governments, the failure of the various governments, through the state electricity monopoly Electricité du Liban (EDL), to ensure reliable electricity supplies continues to underline the profound energy crisis in the country. The consequences of failing energy sector and unreliable electricity supplies present impediments to the country's economic and social development.

The energy situation in Lebanon is characterized by three major shortcomings:

1. The shortage of electricity generation capacities and therefore supplies. As a result, energy consumers suffer from daily electricity blackouts and rely on private electricity generators, running on costly and polluting fuel.
2. The high dependence on oil, which dominates Lebanon's energy mix in terms of electricity generation and the transport sector; leaving the country extremely vulnerable to oil price increases.
3. The deficit EDL is facing from subsidized rates in addition to the substantial difference between production cost and selling price.

The urgency to exploit the country's renewable energy potentials and help alleviate the energy crisis is the main driver behind the development of the renewable energy sector in Lebanon.

2.1 National Renewable Energy Strategy

To meet the set national targets of 12% energy supply from renewable energy sources by 2020, LCEC[7] has developed a National Energy Efficiency Action Plan (NEEAP) for the years 2011-2015. The NEEAP paves the way towards achieving the national target of 12% renewable energy by 2020 and comprises 14 national initiatives covering the sectors of 1) Energy Efficiency (EE), 2) Renewable Energy (RE), and 3) Financial, legislative, and awareness raising.

An update of the first NEEAP was prepared in 2016, covering the years 2016-2020. The updated NEEAP includes only EE related actions with a wider scope compared to the first NEEAP.

To complement the 2nd NEEAP, the LCEC is developing a National Renewable Energy Action Plan (NREAP), and has updated the NEEAP for the years 2016-2020; in principle, the NREAP will elaborate in detail the specific roadmap that will lead to the accomplishment of the 12% target through an optimal RE mix.

The NREAP aims at achieving 12% electricity supply from RE in 2020. The strategy, currently under preparation, shall include three (3) main parts[8]:

[7] in collaboration with MED-ENEC, the EU funded MED-EMIP project, the League of Arab States and the regional center for renewable energy and energy efficiency (RCREEE), and based on the World Bank Study: Energy Efficiency study in Lebanon, 70302, Econoler International REF5515, December 2009.

[8] Based on personal communication with Dr. Joseph Al Assad and Pierre Khoury

1- Electricity baseline including an electricity reform plan, a baseline scenario, and security of supply;

2- Techno-economical assessment which will present the optimal RE mix to meet the 12% target, covering the technical aspects such as decentralized generation and interconnection to the grid; and

3- Legal, financial, and institutional framework highlighting the needed institutional setup, needed legislative texts, financial aspects, as well as economic opportunities in terms of industry and job creation.

2.2 Optimal Renewable Energy Mix of the Power Sector by 2020: Investment Cost Implications for Lebanon

2.2.1 Background and Methodology

The Climate Change Coordination Unit (CCCU), a project unit at the MoE managed by the UNDP, has been working on the topic of renewable energy in Lebanon, among its various working sectors and themes of interest.

The CCCU team[9] has prepared and published a study in September 2014 entitled "*Optimal Renewable Energy Mix of the Power Sector by 2020: Investment Cost Implications for Lebanon*" – *referred to in the SEA report as RES* – with an objective to incorporate the country's RE capacity potential along the assumption of meeting the demand by 2020. The study determines the optimal energy mix and the cost burden to the Government in a number of scenarios, and showcases the importance of renewable energy in the portfolio of electricity supply under the cost criterion.

The CCCU study constitutes until present the only realistic approach toward a RES that can form the baseline for the SEA and subsequent work. Yet, it is worth noting that this document has been discussed with the Ministry of Energy and Water, including LCEC, and relevant stakeholders (MoE, MoF, UNDP CEDRO, etc.) in order to synchronize the efforts and develop the actual NREAP.

In brief, the CCCU study includes the following elements:

1. Description of the performed analysis and the model used to allocate the optimum RE mix. In the present work, cost optimization modeling was utilized, which in fact, consists of a least cost planning approach;
2. Presentation of results in terms of RE mix for the different cost model options;
3. Financial analysis, including a presentation of main elements for a proposed feed-in-tariff mechanism, as well as total costs to the economy of every scenario; and
4. Conclusions and policy recommendations.

In that context, the CCCU study determines the RE mix of several scenarios based only on techno-economic parameters, not taking into account factors such as:

- Proximity to the grid;

[9] Vahakn Kabakian (Project Manager) and Leila El Sayed (Economist) http://climatechange.moe.gov.lb/viewfile.aspx?id=214

- Sensitive animal habitats;
- Energy security; and
- Investment risk.

The above factors in practice may result in a certain change of the specific RE mix in every scenario due to rendering some high RE potential projects as non-feasible due to economic and other reasons. Quantitative analysis taking into account these factors is the subject of subsequent studies.

2.2.2 Strategic Scenarios and Cases

The CCCU study determines the optimal energy mix and the cost burden to the Government in a number of scenarios, and showcases the importance of renewable energy in the portfolio of electricity supply under the cost criterion. Three scenarios aiming to incorporate the country's RE capacity potential along the assumption of meeting the demand by 2020 are presented in the study: Business as Usual (BAU), Scenario C1 with a target of 12% electricity generation from RE sources, and Scenario C2 with a more ambitious target of 20% (Table 2-1).

Table 2-1 Developed Scenarios

Scenario	Electricity Demand Assumption	RES Share	Variants
Business As Usual (BAU)	Stable at current level	Variable	No additional RES
C1	Increasing	12%	Low, medium and High electricity demand increase
C2	Increasing	20%	Low, medium and High electricity demand increase

The scenarios C1 and C2 include the deployment of three renewable energy technologies: **1) Wind power, 2) Solar photovoltaic** (PV), and **3) Hydropower**. With the exception of solar Concentrated Solar Power (CSP), no bioenergy, or geothermal energy have been taken into consideration due to lack of credible potential estimates and complexity in conducting realistic representative cost-benefit estimates. CSP has not been considered due to its higher levelised cost of electricity as shown in the optimization exercise.

For the purpose of this SEA, Scenario C1 will be assessed while Scenario C2 will not be considered given that Scenario C1 reflects the target set by the Government for coverage of 12% of final electricity production from RE in 2020, while Scenario C2 exceeds this target.

For wind power and PV, sites with the highest technical potential have been assessed in the study mentioning their capacity factors but not their exact geographical siting. Capacity factors retained in the presented scenarios for wind power ranged between 22 and 42.1 for scenario C1 whereas the selected sites under this scenario corresponded to capacity factors form 34.8 to 42.1. Similarly for PV, PV ranged between 16.6 and 20.8 and the selected sites refer to locations with capacity factors from 19.5 to 20.8.

The hydropower potential is based on an optimization of existing HPPs in addition to new plants. The new plants were selected based on the Sogreah study "Plan Directeur de l'Hydroélectricité au Liban: Rapport Phase 2: Schéma Directeur" published in June 2012.

Table 2-2 presents a list of the new HPPs considered in the RES, including the effective capacity in Megawatts (MW) for each plant and whether they include a dam or operate on Run of River Mode (RRM).

Table 2-2 New Hydropower Plants Considered in the RES (C1 Scenario)

New Hydropower Plant	Effective Capacity (MW)	Operating Mode
Janneh (Ibrahim)	100	***Dam***
Boqaata (El Kelb)	39	***Dam***
Chamra (El Kelb)	30.7	RRM
Daraya (El Kelb)	25.3	RRM
Hdaine (Ibrahim)	24	RRM
Blat (Litani)	21	RRM
El Mara	11.2	RRM
Centrale Qarn	9.7	RRM
Khardaleh (Litani)	9.5	***Dam***
El Boum (Damour)	6.7	RRM
Sir (Sukkar)	7.1	RRM
El Ouatie (Nahr Sir)	6.5	RRM
Ibrahim 4 (Ibrahim)	5.2	RRM
Bchamine (Abou Ali)	5.9	RRM
Mayrouba (El Kelb)	5.1	RRM
Qattine (Nahr Sir)	4.9	RRM
Yammouneh	4.7	RRM
Boustane (Kfarhelda) (El Jouz)	4.5	RRM
Aval Joun (Awali)	4.0	RRM
Beit Chlala (El Jouz)	3.4	RRM
Mtaile (Barouk) (Damour)	3.2	RRM
Kfarsir (Litani)	2.6	***Dam***
Centrale Mechmech	2.5	RRM
Dammour	2.2	***Dam***
Nahr Al Bared	1.9	***Dam***
Sir (Bared sup)	1.8	RRM
Jezzine (Awali)	0.55	RRM
Chabrouh (El Kelb)	0.4	RRM

Given the uncertainties in estimating the real electricity demand by 2020 in Lebanon *(as current supply falls short of today's demand, and due to the existence of self-powered generation and black-outs in many Lebanese areas)*, three demand cases were developed for each of the scenarios presented in Table 2-1:

1. **Low growth**: based on historical GDP growth and electricity consumption calculated for the years between 2001 and 2011, electricity demand will reach **21,571 GWh** by 2020.
2. **Medium growth**: based on the assumption of 4,000 MW demand, and a capacity factor of 0.85, electricity demand will reach **29,784 GWh** by 2020; which corresponds to a 6.5% annual linear increase from 18,000 GWh in 2012.
3. **High growth**: based on the upper-end of demand increase forecasts in Lebanon at 8% annually (Dagher and Ruble, 2010) to generate a high demand case, electricity demand will reach **33,215 GWh** by 2020.

The link to the full CCCU study is presented in Appendix 1.

3 SEA Methodology

This section provides an introduction to SEA and the benefits it brings to the control of project-level environmental impacts. It continues by outlining the requirements of SEA in Lebanon. The proposed SEA methodology, complying with these requirements, is detailed next.

3.1 SEA Definition

SEA has been defined by Partidário (1998) as a "systematic, on-going process for evaluating, at the earliest appropriate stage of publicly accountable decision-making, the environmental quality, and consequences, of alternative visions and development intentions incorporated in policy, planning or programme initiatives, ensuring full integration of relevant biophysical, economic, social and political considerations".

The SEA therefore, is a planning and decision-aid tool which aims to bridge the gap between strategic initiatives and project-level Environmental Impact Assessment (EIA) by providing a systemic analytical approach which can identify and address issues of resource use, efficiency and sustainability, providing as such a step further towards a fully integrated planning approach promoting and enhancing sustainable development.

SEA is pre-defined by identified issues, needs and priorities and evaluates the environmental and socio-economic impacts of policies, plans and programs. It usually covers large geographical areas and is conducted at a regional level. As such, the SEA has the opportunity to address impacts of actions at a strategic level.

The SEA will facilitate the preparation of EIAs for specific components of a plan for example by providing an important amount of information to the EIA preparer, especially with respect to baseline conditions, environmental impacts, and possible mitigation and monitoring measures.

- When properly implemented, the SEA:
- Provides for a high level of environmental protection;
- Improves the quality of policy, plan and programme making;
- Increases the efficiency of decision-making; and
- Helps prevent costly mistakes.

3.2 SEA Requirements

The SEA process is governed by Decree 8213/2012 which defines the mandatory procedures to be followed for the assessment of potential environmental impacts of any policy, plan, program (PPP), study, investment or organization proposal that tackles an entire Lebanese region or an activity sector, in order to ensure that these activities are compliant with conditions related to health, public safety, the protection of the environment and the sustainability of natural resources.

The legal text defines the scope of the SEA, the different phases, review procedures, screening methodology, validity of the PPP, and the content of the scoping and final reports. Table 3-1 presents the various stages of an SEA along with the requirements of each stage.

The adopted methodology throughout the SEA development process, presented in section 3.3, was developed in line with the Lebanese legal and technical requirements.

Table 3-1 SEA Process Components

SEA Stage	Description
Screening	◆ To determine whether the proposed strategic action (plan or program) requires SEA
Scoping	◆ To delineate the zone of influence of the proposed plan or program (Geographical coverage, time span, sector of activity and social groups) ◆ To establish the range of issues and level of detail to be included in the assessment ◆ To decide on the significant impacts to be considered ◆ To determine data collection requirements
Stakeholder involvement	◆ To inform and ascertain the opinion of all those who are likely to be affected by the proposed plan or program ◆ To determine what tradeoffs are acceptable ◆ To identify implementation needs and mechanisms
Analysis of Alternatives	◆ To identify, analyze and compare the impacts of the different shortlisted alternative options ◆ To evaluate the technical and financial feasibility of alternative options ◆ To determine the consistency of the components with pre-set objectives and priorities ◆ To evaluate the compatibility with current legal, institutional and planning frameworks ◆ To determine the "most suitable strategic option" and means of implementation
Performing the assessment	◆ To identify, analyze and compare the impacts of the most suitable strategic option selected ◆ To propose a relevant EMP for reducing or eliminating negative impacts and enhancing environmental opportunities
Submission of SEA report	◆ To document the methodology and findings of the SEA
Peer review and integration of SEA findings	◆ To ensure that the assessment has proceeded in a scientific and objective manner ◆ To verify that all significant impacts have been considered ◆ To determine whether the "most suitable strategic option" has been proposed ◆ To determine the feasibility and suitability of the EMP ◆ To review, amend or reformulate the proposed plan or program
Decision making	◆ To decide whether to adopt, amend or reject the proposed plan or program
Monitoring and quality assurance	◆ To evaluate performance with respect to set objectives ◆ To monitor implementation and assess the continued suitability of the EMP ◆ To assess the efficiency of the SEA process in "greening" public decisions.

Adapted from the Strategic Environmental Assessment and Land Use Planning in Lebanon Training Manual, MoE, UNDP, 2005

3.3 SEA Process

The fact that the RES was being developed while the SEA was being conducted constituted an added value to the project: the SEA and RES run in tandem and the outcomes of the SEA will be integrated into the RES leading to early collaborative agreement resulting in several benefits, namely:

- Identifying and accounting for environmental, social, cultural and economic concerns, assets and constraints;

- Adverse impacts minimization and proper environmental management throughout the development of the RES;
- Early consideration of alternatives and minimizing the risk of late surprises and conflicts;
- Consultations between the RES team, the SEA team and other stakeholders (ministries and relevant authorities, universities, research centers, NGOs, etc.) leading to a wider acceptance of the strategy;
- Avoiding delays, reducing costs and ultimately gaining approval of the strategy sooner than if the SEA and RES were carried out in series.

The SEA process chronologically follows the four main phases detailed in Figure 3-1: Inception, Scoping, Analysis of Alternatives, and SEA Report. Another main phase of the SEA process is Stakeholders Consultation, conducted in parallel to these four steps.

In addition to the Stakeholders Consultation and Analysis of Alternatives, three core elements allowing the development of the SEA are Baseline Studies, development of the SEA Framework of Objectives and Indicators, and Impacts Assessments.

The methodology adopted to cover these core elements is detailed in the following sub-sections.

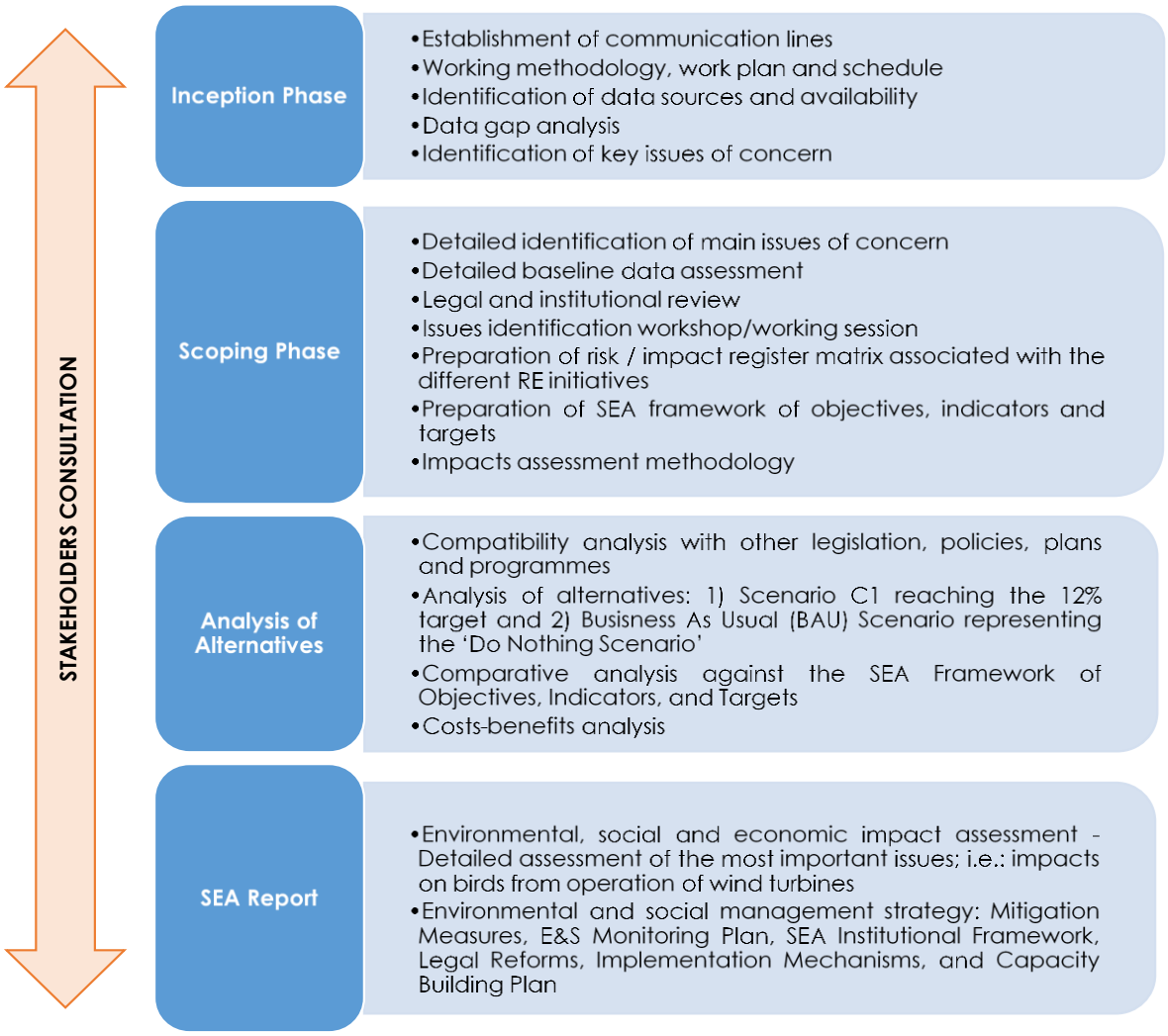


Figure 3-1 SEA Methodology

3.3.1 Methodology to Establish Baseline Conditions

Collecting baseline information is a tool providing evidence base for current states of the environment, society, and economy of the country in general and more specifically of the potential RE development areas.

Understanding the current state of the environment is necessary to predict the likely future changes resulting from the implementation of the RES or from the lack of action should it not be implemented. Baseline conditions also help in the development of the SEA framework, especially in terms of objectives and measurable indicators.

For the purpose of this report, the baseline conditions are presented by RE technology: potentials and related environmental baseline. These sections present an overview of the RE potentials in Lebanon (wind, hydropower, solar, bioenergy, and geothermal), their geographical localization and the environmental and social baseline conditions at these locations in terms of: Land Use/Land Cover, Ecological Hot-Spots, and Cultural Heritage assets.

Baseline data, in terms of RE potentials and environmental conditions, was collected from a variety of existing documentations, publications, studies, and programmes. Baseline data was also collected and validated with a multitude of stakeholders during the scoping workshop held by the Consultants' team and described in section 6.

The Geographic Information System (GIS) was used as a tool to map and analyze environmental constraints at the country's level and in RE potential areas; the main mapped components are land use and biodiversity hot spots (nature reserves, Himas and other protected areas, important birds areas (IBAs), migratory birds routes, birds' bottlenecks, etc.). This mapping tool was also used to locate existing or potential RE infrastructures, as well as proximity to the electricity grid.

3.3.2 SEA Framework Methodology

This is a major milestone in the SEA process whereby specific objectives, targets and indicators are defined.

An objective is a statement of what is intended, specifying a desired direction of change and devised to test the environmental effects of the strategy or to compare the effects of alternatives. The development of objectives was largely guided by the results of the legal assessment, baseline studies and consultation with stakeholders. The SEA objectives were derived from environmental protection objectives and to ensure proper implementation of the RES.

The project team conducted an exhaustive search on the indicators subject. It was found that the creation of new indicators is always a hard and time consuming process that usually involves a great level of subjectivity. It would also require a great amount of information and data processing, which was considered ineffective, given that a lot of scientific and systematic work has been carried out on the subject while the relevant results have already been released and are available for use.

Based on the above, the Consultants' team decided to use readily available indicators and conducted an extensive search for the collection of available sets of indicators that are measurable at the national level.

The data collected was subjected to an evaluation of their representativeness, the spherical coverage of the environmental issue they referred to, as well as the coverage of the whole range of environmental issues that could be relevant to the RES implementation. A draft framework was developed in the scoping phase and validated with the UNDP and MoE.

3.3.3 Analysis of Alternatives Methodology

An integral part of the SEA process is the assessment of alternatives to address key issues related to the RES from an environmental, socio-economic, and financial perspective. The Consulting Team reviewed alternative scenarios for the RES development prepared by the UNDP Team and provided guidance in formulating comprehensive alternative scenarios with regards to the RES development that have features compliant with the requirements of an SEA, i.e., different scenarios reflecting the target set for coverage of 12% of final electricity production from RE in 2020.

Selected scenarios were assessed against the various sustainability factors identified in the SEA framework. Each scenario was weighed against the selected key themes and a preferred alternative was selected. The reasoning behind selecting the preferred alternative accounts for the existing baseline conditions, the objectives set by the SEA framework and professional opinion.

Table 3-2 summarizes the adopted scoring scheme that was used to assess the various alternatives.

Table 3-2 Analysis of Alternatives Scoring Scheme

Scoring Value Ranges	Details of Scoring Value
+4 to +6	Very positive – option can significantly contribute towards meeting objectives
+1 to +3	Positive – option can contribute towards meeting objectives
0	Neutral – no positive nor negative contribution of the option towards meeting objectives
-1 to -3	Negative – option can lead to a diversion away from the objectives
-4 to -6	Very negative – option can lead to a significant diversion from the objectives

Based on this methodology, the alternative scenarios were assessed and their effect on each aspect was assigned a score. Scores assigned to each alternative were summed to give a (total) final score. The alternative with the highest score is thus considered the preferred alternative scenario and the one with the lowest score is to be reconsidered or rejected.

The Consultants' team performed as well a cost-benefit analysis of alternatives, based on the modelling results developed by the UNDP team, and extracted comparatively the relevant costs to the economy from each scenario.

3.3.4 Impacts Assessment Methodology

The main purpose of this component of the SEA process is to provide an analysis of the impacts associated with the development of the RES and focusing on the preferred alternative selected on the AoA phase.

Generally, environmental impact assessment from a policy implementation is characterized by great degrees of uncertainty due to the following reasons:

- The generic nature of the main policy parameters may downgrade particular items that could be proven significant (in terms of environmental importance), during programme's implementation.
- The broad baseline environmental conditions that are investigated prior to programme's implementation, is likely to prevent the profundity under which particular environmental changes may be mitigated.

A systematic prediction and assessment of the environmental sustainability effects, including health, economic and social factors was conducted. The process was semi-quantitative and assessed effects in terms of their magnitude and scale, whether they are positive or negative, the likelihood of them occurring and whether they are reversible or irreversible.

The main steps followed during impacts assessment are as follows:

Identification of impacts: for each environmental and socio-economic issue of concern, the sources of potential impacts were identified using screening matrices. Impacts were further defined as being either direct, indirect or cumulative.

Impact significance: **Given the broad aspect of the SEA, and the limited amount of details normally available, the multi-criteria analysis presented in**

Table 3-3 was used to assess the impacts' significance.

The score given to each impact criterion is based on the severity of the parameter assessed and ranks from -3 to +3. The overall significance level of each impact, after adding the scores given to each criterion, ranged from -12 to +12 and was assessed as detailed in Table 3-4 below.

Table 3-3 Impacts Multi-Criteria Assessment

Impact	Primary Characterization	Abbreviation	Weight
Type	Positive	POS	+
	Neutral	NEU	0
	Negative	NEG	-
Intensity	Major	MAJ	+/- 3
	Moderate	MOD	+/- 2
	Minor	MIN	+/- 1
	Negligible	NEGL	0
Duration	Short term	SHT	+/- 1
	Mid term	MDT	+/- 2
	Long term	LOT	+/- 3
Reversibility	Temporary	TEMP	+/-1
	Permanent	PERM	+/-2
	Cumulative	CUM	+/-3
Extent	Local	LOC	+/- 1
	Regional	REG	+/-2
	National	NAT	+/-3
Origin	Primary	PRI	
	Secondary	SEC	

Table 3-4 Impacts Significance Rating

Total Scoring		Significance Rating
-12 to -9	***Negative***	**High**
-8 to -5		**Medium**
-4 to -1		**Low**
0	***Neutral***	
1 to 4	***Positive***	**Low**
5 to 8		**Medium**
9 to 12		**High**

3.3.5 Stakeholders Engagement Methodology

An integral part of the SEA is stakeholders' consultation whereby stakeholders are informed about the project and its development at an early stage and are engaged throughout the process; stakeholders' values, concerns and interests are consequently built into the development of the RES.

Stakeholders were engaged throughout the SEA process, mainly through two multi-stakeholder workshops: Scoping workshop and SEA Review workshop (refer to section 6) and via several formal and informal meetings and communications.

3.4 SEA Team

3.4.1 ELARD

Earth Link and Advanced Resources Development (ELARD) is a regional consultancy firm specialized in the fields of environmental and water resources management. ELARD was first established in Lebanon, in 1996, and has quickly grown to become one of the leading environmental consultancy firms in the Middle-East and Gulf regions. ELARD is staffed with about 100 experts including environmental engineers, ecologists, geologists, hydrogeologists, hydrologists, water and wastewater management experts, solid waste management experts, GIS specialists as well as versed specialists in strategic planning, training and capacity development. ELARD operates in most countries of the region via its offices located in Beirut, Damascus, Abu Dhabi, Dubai, Tripoli (Libya) and Baghdad (Iraq).

ELARD has extensive experience working in Lebanon for both the public and private sectors, being a leading national environmental consultancy firm.

The firm has a wide-ranging experience in the SEA field having participated in the development of the SEA Decree and the SEA guidelines for Lebanon, and conducted various SEA studies in Lebanon and in other countries of the region; in addition to experience in the Renewable Energy sector and the environmental and social issues related to their development.

3.4.2 LDK

LDK Consultants (LDK) has been established in 1968 in Greece and is a renowned Greek consultancy, leading major international projects in more than 80 countries around the globe, operating in a multitude of developing and developed countries and markets, in Eastern Europe, Asia the Middle East and Africa offering a full range of services.

The company employs 90 full-time employees and more than 200 external collaborators. Its multilingual staff and associates are specialized in all relevant disciplines. LDK offers the full range of services in all phases of the project cycle, including investment analysis, appraisals, detailed design, technical assistance, project management and evaluation. LDK's Environmental Department has a long list of private clients, while at the same time, it assists international organisation, IFIs, as well as Ministries and other public bodies in technical assistance projects and policy making. The company is certified with TUV-CERT (20.12.1995) as fulfilling the ISO 9001 quality system for Engineering, Planning & Consulting.

Since September 2010, LDK has been included in the "Strongest Companies in Greece" community developed by the ICAP Group. The "Strongest Companies in Greece" is a community of enterprises that are ranked at the highest Credit Ratings of ICAP Group. ICAP Group is recognized by the Bank of Greece as an External Credit Assessment Institution and by the European Central Bank as an Accepted Rating Tool Source.

In addition to its environmental capabilities, the firm has a strong energy consulting department providing energy management, renewable energy sources, rational use of energy, energy conservation, power generation, transmission and distribution, cogeneration and district heating,

hydrocarbons, solid fuels, emerging technologies (fuel cells, etc.), national and regional energy planning, and energy policy related consultancy.

PART 2: SEA INPUTS AND RESULTS

4 Legal and Financial Framework

4.1 Analysis of Legal and Policy Frameworks and Compatibility

The aim of this section is to identify the main applicable Lebanese and international environmental legislation, policies, standards and guidelines associated with the project.

It is worth noting that the Lebanese legal and institutional framework lags in the RE sector; the legal texts related to the RE sector are either not enforced, not ratified and still in a "draft" status, or need updating.

4.1.1 Overview of Legislation

The main legislative texts setting the framework for this SEA are those related to electricity generation, renewable energy, and the SEA and EIA process as detailed in the subsequent sections.

4.1.1.1 Electricity and Renewable Energy

Decree No. 16878 of 1964 established the Electricité du Liban (EDL) as an autonomous state-owned entity under the authority of the MoEW. This legislative text entrusts the generation, transmission and distribution of electricity across Lebanon to EDL. Article 4 of the Decree provides that no license, concession or permit generation, transmission or distribution of electricity may be granted to another entity. Pursuant to this Decree, EDL benefits from a monopoly on the production, transfer and distribution of electric power in Lebanon.

As such the private sector may not enter the market of electricity and sell its production, whether through conventional or renewable resources, except through the project tenders organized from time to time by the MoEW, subject to the availability of necessary funding. Projects financing is mainly governed by EDL Investment System Regulation through **Decree No. 7580 of 1974,** and Tender Regulation through **Decree No. 2866 of 1959**.

Alongside EDL, four (4) private concessions (Zahle, Jbeil, Aley and Bhamdoun) and three (3) private/semi-private hydroelectric power plants (Nahr Ibrahim, Kadisha, and Al Bared) are generating electricity.

In 2002, the parliament adopted **Law No. 462 of 2002** on the Organization of the Electricity Sector which sets an updated legal framework for regulating the electricity sector in Lebanon. The main provisions of this legal text are as follows:

1- Provision for the privatization of all or some of the distribution and production activities of the electricity sector (transmission to remain with the public sector). The proposed privatization model starts with the Council of Ministers (COM) creating joint stock companies, called "privatized companies" and subject to the commercial law licensing procedures. Two years following the establishment of a privatized company, the government may offer up to 40% of the share of the privatized company, through public

auction or tender. In addition, the law provides for the licensing of Independent Power Producers[10] (IPPs).

2- Creation of an independent sector regulatory body: the 'National Electricity Regulatory Body' (NERB) to regulate and monitor the electricity sector and to issue licenses to the Privatized Companies established pursuant to the law and IPPs.

3- Defining the NERB roles and responsibilities, which include:
   a. Preparing studies, decrees and regulations' projects;
   b. Promoting investment and encouraging competition in the electricity sector; and fixing the ceiling of prices of production services, tariffs, subscription and service fees, fines, etc.;
   c. Setting technical and environmental standards relevant to the electricity sector;
   d. Issuing, renewing, suspending, amending and canceling licenses or authorizations;
   e. Controlling and monitoring the compliance of the licenses and authorization holders with the laws and regulations;
   f. Corporatization/restructuring of EDL and enhancing its overall resources and capabilities.

In 2006, **Law No. 462** was then amended by **Law No. 775 of 2006** (no longer relevant) and recently replaced by Law No. 288 of 2014 as a temporary measure for "one year" and "two years" respectively during which the Council of Ministers shall be in charge of granting the production permits and licenses upon the proposal of the MoEW and the MoF, this until the members of the regulatory commission, described under Law No. 462, are appointed and start carrying out with their tasks. The main strengths of Law No. 462 of 2002 is that it allows for the establishment of a regulatory commission in charge of elaborating the important details pertaining to the introduction of RE and energy conservation. Nevertheless, the lack of political agreement has prevented the establishment of the NERB, and hence the implementation of Law 462. The main gaps and weaknesses of Law 462 are that it does not directly nor specifically include feed-in tariffs[11], except by the authority given to the NERB in the preparation of Transaction Dossiers, and does not promote or regulate specific aspects of RE in a comprehensive manner. Complementary laws and decrees are needed to complete the legal framework related to renewable energy.

The LCEC prepared in 2010 the 'Energy Conservation Draft Law' for the promotion of energy efficiency and renewable energy in Lebanon. This draft law has not yet been approved by the Lebanese Parliament. The draft law offers a legal framework for energy audits, energy efficiency standards and labels, financial incentives for energy efficient appliances and net-metering and the institutionalization of the LCEC.

In terms of private electricity provision, an informal structure for electricity subscription (private generators) is provided by the private sector in the status quo of electricity supply shortage and

[10] An Independent Power Producer is an entity, which is not a public electric utility, but which owns and/or operates facilities to generate electric power for sale to a utility, central government buyer and end users.

[11] A feed-in tariff is a policy mechanism designed to accelerate investment in RE technologies. It achieves this by offering long-term contracts to renewable energy producers, typically based on the cost of generation of each technology.

governed by **Circular No. 10/1 issued in 19/03/2011** issued by the Ministry of Environment, for the monitoring of the operation of electric generators.

On another note, the Higher Council for Privatization, which was established pursuant to Law No. 228 of 2000 for regulating privatization in Lebanon, has been working on a Public Private Partnership (PPP) law since 2006. A first draft PPP law was approved by the COM in 2007, and in 2010 another draft PPP law was proposed to the Parliament. Since then the PPP draft law has undergone a number of modifications, following discussions with ministers and other stakeholders such as judges, lawyers, until it reached its current improved draft version.

This initiative follows Lebanon's commitment made on January 25 of 2007 under the Paris III arrangement to promote PPPs by assigning to the private sector the biggest role in rebuilding the infrastructure and delivering public services through different partnerships with the public sector.

The main weaknesses of the current legal framework are:

1- EDL quasi-monopoly;

2- The absence of institutions and legislations dedicated to regulating RE projects and the absence of comprehensive incentives to promote investment in RE;

3- Law 462 is not being implemented and needs updating to adequately cover all aspects of renewable energy generation (Law No. 775 of 2006 and Law No. 288 of 2014 are both amendments to Law No. 462 of 2002 on a temporary basis); and

4- Project tenders regulations are not conducive to promoting participation of the private sector in RE - for example, the MoEW can reject or cancel the tender without having to justify such actions. It is worth mentioning that this is the case for all the tenders in the Public Sector. Hence the necessity and role of the NERB in setting the grounds for attracting the private sector participation.

4.1.1.2 Strategic Environmental Assessment

The SEA decree has been endorsed and issued by the Lebanese government as **Decree No. 8213 dated May 24, 2012**, which sets principles and measures necessary to assess the environmental impacts of policies and developments planned for a large area or a whole sector in Lebanon. The SEA Decree comprises thirteen articles that address the objectives of the regulation, definitions, as well as various stages of the national SEA process including screening, scoping, implementation, and review of the SEA report, in addition to the period of validity, and the appeal process.

3.1.1.3 Environmental Impact Assessment

The EIA decree was approved and endorsed by the Council of Ministers under decision number 56 dated 28/03/2012 and was published in the Official Gazette under Decree no. 8633 on August 16, 2012. The EIA Decree comprises sixty-eight articles that address the objectives of the regulation, definitions, as well as various stages of the national EIA process such as screening, scoping, implementation, and review of the EIA report, in addition to the period of validity, and the appeal process.

The EIA decree also lists all the activities for which EIA or permit conditions are mandatory, and those that only require an Initial Environmental Examination (IEE) (Annexes 1, 2 and 3 of the EIA

decree). Annex I identifies that projects aiming at producing energy (without specifically mentioning renewable energy projects) should undergo the EIA process.

4.1.2 Relevant International Conventions, Treaties and Protocols

The main treaties and conventions ratified by Lebanon and relevant to energy and renewables are summarized in Table 4-1.

Table 4-1 Relevant International Agreements

Agreement	Brief
United Nations Framework Convention on Climate Change (UNFCCC)	Sets the framework for intergovernmental efforts regarding climate change. The objective of the treaty is to stabilize greenhouse gas concentrations in the atmosphere. It was signed in 1992 and ratified by virtue of Law No. 359 of 1 August 1994.
Kyoto Protocol	The Kyoto Protocol is an international agreement linked to the UNFCCC, which commits its Parties by setting internationally binding emission reduction targets. The Protocol places a heavier burden on developed nations considering them principally responsible for the current high levels of GHG emissions. Lebanon ratified by virtue of Law No. 738 of November 2006.
International Renewable Energy Agency (IRENA)	Promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. The statute was signed by Lebanon in 2009.
Euro-Mediterranean Energy Partnership HY-PA	The main objective of the HY-PA is to promote and stimulate the application of Renewable Energy and Hybrid Systems in Mediterranean Partner Countries (MPC) for the provision of sustainable energy services based on locally available resources and to support policy making activities in the field of Renewable Energies. The HY-PA comprises three competent actors from Europe: Germany, Greece and France, as well as four Mediterranean Partner Countries Jordan, Lebanon, Morocco and Tunisia.
Convention on Biological Diversity (CBD)	This convention promotes sustainable development and recognizes all sources of biological diversity which include plants, animals and microorganisms as well people, medicines, fresh air, water and a healthy environment to live in. The CBD was signed by Lebanon during the United Nations Conference on Environment and Development (UNCED) also called "Earth Summit" in Rio de Janeiro on June 5, 1992 and ratified in August 1994 by Law No. 360.

Furthermore, the Convention on the Conservation of Migratory Species of Wild Animals (CMS) also known as the "Bonn Convention" was signed in 1979 in Bonn and entered into force in 1983. This convention aims at conserving terrestrial, marine and avian migratory species throughout their range. Although Lebanon is still not yet a Party to the CMS, it is among the countries participating in the convention's Agreements or Memorandums of Understanding.

4.1.3 Relevant Policies, Plans and Programmes

National policies, plans or programmes addressed energy and renewables for the first time in Lebanon in 2010-2011 as part of the restructuring of the energy sector.

1- The National Policy Paper for the Electricity Sector

This policy paper was proposed in 2010 by the Minister of Energy and Water and tackles the addition of generation capacity to cover the existing gap and commits to meeting these additions through at least 12% RE. This policy paper was approved by the Council of Ministers' Decision No. 1 dated 21 June 2010 consists of ten integrated and correlated strategic initiatives which are focused on remedying the problems of the energy sector in respect to infrastructure, supply and demand, and the legal framework.

The National Policy Paper is a realistic implementation program for the essential rehabilitation and improvement of the electricity sector to respond to the economic, social and political Lebanese needs. This Paper considers corporatization to be the best solution for the revitalization of EDL. The objective of this policy was to set norms and standards for the provision of safe and fair electric services with greatest quality and at lowest cost. The policy will progressively rearrange and increase the existing tariff to eradicate the financial deficit in the electricity sector and establish a balanced budget for EDL to eventually reduce the financial burden on the citizens.

This policy is committed to launch, support and reinforce all public, private and individual initiatives to adopt the utilization of renewable energies to reach 12% of electric and thermal supply. The policy's main points, with regards to the restructuring of the legal framework for the Energy Sector and the development of RE and EE initiatives, are:

- Initiating the process of revising and amending Law 462 with concerned parties;
- Beginning with the current legal status of EDL governed by Decree 4517 in order to avoid delays in the execution of the strategy;
- Adopting a Law for the establishment of new power plants with all possible technologies and encouraging all kinds of Public Private Partnership to facilitate the transition and ensure proper continuity between the current and future legal status;
- Corporatization/restructuring of EDL and enhancing its overall resources and capabilities, through the amendment of Law 462;
- Setting norms and standards for the provision of electric services that are safe, equitable and fair with the best quality and lowest cost;
- Adoption of the Energy Conservation Law;
- Modification of legislation to allow feed-in tariffs for individual RE Power Producers; and
- Implementation of the Lebanese Thermal Standards for buildings as a mandatory law.

2- National Energy Efficiency Action Plan for Lebanon 2011-2015 and 2016-2020 (NEEAP)

The NEEAP which is based on the Arab Energy Efficiency Guidelines, was officially adopted by the COM in Decision No. 26 of year 2011. It includes 14 independent but interrelated national initiatives

of energy efficiency and renewable energy. Among these, five initiatives include proposals for enhancing the legal and regulatory framework; these include:

- Adopting the draft Energy Conservation Law, including the institutionalization of LCEC.
- Institutionalizing the Lebanese Center for Energy Conservation (LCEC) as the National Energy Agency for Lebanon.
- Adopting a Lebanese Building Code that would include energy performance standards set for both existing and new buildings. In addition to reviewing and updating the thermal standards for Lebanese buildings and setting mechanisms to incorporate these codes in practice.
- Promoting Energy Audits and ESCO Business. The policy paper proposes the set-up of the National Energy Efficiency and Renewable Energy Action (NEEREA) as a national financing mechanism to provide the ESCOs with financial, fiscal, and technical incentives to promote energy audit activities. NEEREA is also providing subsidies for EE and RE investments.
- Promoting the use of energy efficient equipment in households and other commercial buildings; this includes focusing on electrical equipment and establishing a national energy efficiency standard. In 2010, mandatory standards for the Compact Fluorescent Lamp and the Solar Water Heating were outlined in Decree No. 5305 dated 28 November 2010, approved as per Decision No. 38 of 21 September 2010 by the Council of Ministers. Enforcement status of these standards is not clear.

The second NEEAP, which is developed using the EU format, starts with a national baseline, and presents national objectives to be reached by 2020. It includes a number of EE initiatives distributed along two major axes: primary energy savings and end-use measures. The first axis deals with measures in the energy generation, transmission, and distribution network. The second axis deals with measures in the following sectors: building, industry, SMEs, agriculture, mobility and transport, and public services and facilities.

3- The Lebanese Center for Energy Conservation (LCEC)

The LCEC was created in 2002 as part of a UNDP project at the MOEW, and gradually established itself as an non-governmental organization within the MOEW, and addresses both conservation of energy and renewable energy, as well as awareness raising on energy efficiency

4- UNDP - CEDRO

CEDRO is a UNDP Project created in 2007, in partnership with the MoEW and the CDR, to manage the country's EE and RE demonstration project for the recovery of Lebanon and complement the national power sector reform strategy.

CEDRO's mandate includes:

- Implementation of end-use EE and RE demonstration projects;
- Assisting in alleviating barriers to increased penetration of EE and RE applications;
- Public awareness on climate change, energy consumption, RE and EE applications;

- Increasing the availability of validated data on energy consumption patterns and EE and RE; and
- Supporting in the formulation of a national sustainable energy strategy and action plan.

In this context, CEDRO's projects and public studies include, but are not limited do, the National Wind Atlas for Lebanon, the National Bioenergy Strategy for Lebanon, the potential for hydro power, solar energy and waste to energy from wastewater treatment plants sludge, and most recently the National Geothermal Atlas of Lebanon.

5- The National Physical Master Plan of the Lebanese Territory

The National Physical Master Plan for the Lebanese Territory (NPMPLT) was issued by the CDR in 2005, and approved by decree no. 2366 on 20 June 2009, as a strategic development plan for the territory of Lebanon to which all public authorities are bound. The NPMPLT defines the principles of development in various regions, clarifies the basics of territorial usage for all areas; and proposes facilities and sites of planned activities, specifying their objectives, dimensions and locations.

Therefore the NPMPLT is a planning tool to be considered when assessing the potentials and constraints of RE implementation in certain areas. The plan defines sites of ecological heritage, major landscapes, geologic heritage, protected natural sites and those poorly protected or unprotected, in addition to the agricultural domain of national interest. Currently, a draft decree is under preparation to also include in the NPMPLT the migratory birds' sensitive areas (IBAs and migratory bottlenecks) so these areas can be further protected by law. As such, the baseline conditions summary maps presented in section 1 take into consideration the national and regional parks and major protected areas suggested by the NPMPLT as well as the birds' sensitive areas.

The NPMPLT also indicated the important shoreline stretches to be preserved, which need to be considered when further studying the offshore wind power potential.

6- The National Water Sector Strategy

The MoEW has prepared the National Water Sector Strategy (NWSS) which was adopted by the Council of Ministers under Decision No. 2 of 9 March 2012. The overall goal of the NWSS is 'to ensure water supply, irrigation and sanitation services throughout Lebanon on a continuous basis and at optimal service levels, with a commitment to environmental, economic and social sustainability'.

The strategy targets key outcomes that would improve water services and make them more financially and environmentally sustainable through improving both the infrastructure and management practices. This goal is to be attained through a combination of infrastructure and policy and institutional initiatives. The strategy proposes a number of dams to be developed, which could all be potential sites for hydropower installations.

The NWSS is currently subject to an SEA study which is expected to be completed in November 2014.

7- The National Biodiversity Strategy and Action Plan

The Government of Lebanon (GoL) has ratified the CBD in 1994 and as a signatory country, has undertaken the necessary steps to fulfil its commitments towards the CBD by developing and publishing its National Biodiversity Strategy and Action Plan (NBSAP) in 1998 followed by an amendment in 2005. Currently, Lebanon is in the process of updating its NBSAP following new CBD guidelines; the new strategy is expected in January 2016.

The aim of the NBSAP is the conservation and sustainable use of biological diversity integrating, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies; such as the NRES.

8- Lebanon's Marine Protected Areas Strategy

The Lebanon Marine Protected Areas Strategy was developed in 2012 to support the management of important marine habitats and species in the country. The main goal of the strategy is the establishment of a network of marine protected areas, established and managed within an integrated marine management framework that contributes to the health of Lebanon's sea and marine environment. The following objectives were developed to achieve this goal:

- To establish a more systematic approach to marine protected areas planning and establishment;
- To enhance collaboration for the management and monitoring of marine protected areas;
- To increase awareness, understanding and participation of the local community in the marine protected areas network; and
- To link Lebanon's network of marine protected areas to Mediterranean networks.

This strategy needs to be considered when further studying offshore wind power potential.

4.1.4 Compatibility Analysis

The "Optimal Renewable Energy Mix of the Power Sector by 2020" developed by the Climate Change Coordination Unit (CCCU) within the MoE, which constitutes the only available and complete documentation in hand and was adopted as the RES for the SEA, sets the following main targets:

- Ensure continuous policy support from the government to provide an enabling environment and promote renewable energy investments in the power market;
- Implement and amend Law No. 462 of 2002 so that it covers all aspects of renewable energy generation;
- Increase the electricity tariff paid by end-users, as to cover some of the costs of meeting nationwide electricity demand by 2020;
- Implement a technology-specific and size-specific FIT scheme in order to increase private investors' confidence in the renewable energy market; and
- Conduct further studies and incorporate other criteria such as energy security, environmental considerations and investment risk.

Table 4-2 below presents a compatibility analysis of the proposed RES with the existing legislations, plans and programmes directly related to the energy sector.

It can be concluded from the table below that the RES is relatively compatible with existing programmes and policies related to the energy sector in terms of direction and recommendations with the exception of Decree No. 16878 of 1964 that is outdated, and Law 462, which needs to be updated. The next step forward consists of taking serious actions and financial and regulatory measures in order to promote the efficient penetration of RE into the energy sector.

Table 4-2 Legal Compatibility Analysis

Lebanese Existing Legislation, Policies and Plans	Points of Compatibility / Incompatibility with Optimal Renewable Energy Mix of the Power Sector by 2020: Investment Cost Implications for Lebanon	Overall Compatibility
Decree No. 16878 of 1964	• **Compatibility:** - None • **Incompatibility:** - This law is set for the establishment of EDL as an autonomous state-owned entity under the authority of the Ministry of Energy and Water. - Given the escalating financial and administrative problems from which EDL suffers and the production shortages as well as the weak monitoring of electricity usage and regulation of private generators, this EDL Decree would need to be replaced by Law No. 462 in accordance with the recommendations put forth in the Optimal Renewable Energy Mix.	X
Law No. 462 of 2002	• **Compatibility:** - Law No. 462 governs the organization of the electricity sector in Lebanon and introduces a semi-privatization system. The law also introduces the National Electricity Regulatory Body (NERB). These converge with the Optimal Renewable Energy Mix principles and broad lines. • **Incompatibility:** - This law does not provide any specific provisions in respect to renewable energy sources and production. It is also not being implemented to date. This law does not introduce a FIT scheme as suggested by the Optimal Renewable Energy Mix, except by the authority given to the NERB in the preparation of Transaction Dossiers.	✓

Lebanese Existing Legislation, Policies and Plans	Points of Compatibility / Incompatibility with Optimal Renewable Energy Mix of the Power Sector by 2020: Investment Cost Implications for Lebanon	Overall Compatibility
The Energy Conservation Draft Law	◆ **Compatibility:** - This draft law aims for the promotion of renewable energy and energy efficiency by offering a legal framework for energy audits, energy efficiency standards and labels, financial incentives for energy efficient appliances, and net-metering. - The draft provides an institutional framework for the LCEC by granting it all required and relevant powers in respect to renewable energy projects and initiatives. - The draft exempts renewable energy applications from taxes and custom duties. ◆ **Incompatibility:** - There are insufficient provisions which define or mention any renewable energy sources in the EC draft law. It requires application decrees that further elaborate on renewable energy provisions. - The draft is very brief and grants all powers to the LCEC. - This draft does not provide for a FIT scheme. - The Optimal Renewable Energy mix recommends that Law No. 462 covers all aspects of renewable energy generation.	✓
Lebanon's commitments in the Copenhagen Climate Summit	◆ **Compatibility:** - This paper sets short-term objectives for renewable energy until 2015, which include initiating the process of revising and amending Law No. 462 of 2002 and allowing feed-in tariffs in compliance with the Optimal Renewable Energy Mix. ◆ **Incompatibility:** - None	✓

Lebanese Existing Legislation, Policies and Plans	Points of Compatibility / Incompatibility with Optimal Renewable Energy Mix of the Power Sector by 2020: Investment Cost Implications for Lebanon	Overall Compatibility
Policy Paper for the Electricity Sector	• **Compatibility:** - This paper sets short-term objectives for renewable energy until 2015 which include initiating the process of revising and amending Law No. 462 of 2002 and allowing feed-in tariffs in compliance with the Optimal Renewable Energy Mix. • **Incompatibility:** - None	✓
National Energy Efficiency Action Plan for Lebanon (NEEAP 2011-2015)	• **Compatibility:** - This policy focuses on promoting a "renewable energy mix", energy audits and ESCO businesses, the use of energy efficient equipment, electricity generation from wind and solar energy. It converges with the Optimal Renewable Energy Mix in this respect. • **Incompatibility:** - None	✓
National Solid Waste Management Plan (NSWMP)	• **Compatibility:** - This NSWMP amends and complements the municipal solid waste management plan of 2006 and also advocates Waste-to-Energy (WtE) technologies for large cities. To date, there is no specific legislation which governs Solid Waste Management (SWM). There is however a draft law prepared in 2005 on the Integrated Solid Waste Management under the METAP and approved in 2012 by the Council of Ministers, but is still under review by the Parliament. • **Incompatibility:** - *The Optimal Renewable Energy Mix does not include energy generation from solid waste.*	X

4.1.5 Conclusion and Identified Legal Gaps

The section above pertaining to the existing legal and regulatory framework for energy clearly shows that Lebanon did not introduce yet a special legislation for renewable energy sources. Nevertheless, renewable energy sources are being explored locally based on private and independent initiatives. It should be noted that most private and independent initiatives are leveraged by either public initiatives (NEEREA loans) or international grants with close collaboration with governmental entities (UNDP, CEDRO).

Among the multiple problems of the energy sector in Lebanon, the negative impact led by EDL's quasi monopoly over the generation, distribution and transmission of electricity is an important obstacle to the deployment of renewable energy, not to mention its financial deficit and administrative status.

Therefore, it is currently challenging for investors to undertake projects/initiatives relating to renewable energy due to the lack of a binding legal framework.

It is also worth noting that the legal framework governing the sector is too weak as Decree No. 16878 of 1964 governing EDL's exclusivity is still being enforced while Law No. 462 of 2002 for the privatization and liberalization of the sector is still not applied. The implementation of the said law is nevertheless insufficient in respect to renewable energies since Law No. 462 of 2002 not sufficiently address renewable energy and FIT. The draft Energy Conservation Law also requires application decrees promoting and regulating RE.

4.2 Financial Analysis

4.2.1 Existing Financial and Fiscal Measures

In terms of financial and fiscal measures, the two major initiatives that have been introduced for promoting RES in Lebanon are the 1) NEEREA and 2) Net Metering.

NEEREA

The National Energy Efficiency and Renewable Energy Action (NEEREA) is a national financing mechanism initiated by the Central Bank of Lebanon in collaboration with the MoEW, including LCEC, the MoF, the UNDP, and the EU.

NEEREA allows private sector entities (individuals, SMEs, or corporate bodies) to apply for subsidized loans for any type of EE and/or RE projects. The facility covers loans by any Lebanese commercial bank with very low interest rate, ranging from 0.325 – 1.075% and a repayment period of up to 14 years, in addition to a grant amount released after the project is implemented. NEEREA has had a substantial increase in its portfolio of financed projects during the last two years (until November 2014) and at present comprises about 200 projects with a total budget of about 200 million USD. Rooftop PV projects have widely benefited from this initiative.

Net Metering

Considerations for net-metering started in March 2010 with the involvement of EDL technical and legal teams, MoEW advisors, including LCEC, and UNDP CEDRO project. The mechanism was

eventually adopted by EDL in July 2011 and as a result, net metering is now applicable in Lebanon. However, the current power outages constitute a technical obstacle preventing beneficiaries from acquiring the expected financial benefits from this mechanism via exporting electricity to the grid, which decreases confidence of potential investors in the actual level of investments repayment. As a result, PVs are used until present mainly for off-grid or in hybrid applications, which implies high levelised costs of electricity production from the increased cost of investments required for energy storage (i.e. : batteries, inverters, etc.), which imply higher CAPEX and OPEX for those producers compared to grid connected projects.

Additional initiatives targeting RES such as feed-in tariffs have not yet been introduced, though it is stipulated that respective provisions will be included within the revision of the Energy Law (No 462). Particular details on the applicable areas have not yet been disclosed.

4.2.2 Donor Support

Thanks to the support of the EU, UNDP and GEF, as well as other governments (e.g, the Governments of Spain, China, etc.), Lebanon has been able to promote renewable energy sources either by developing national strategies and action plans (NEEAP) or by creating project initiatives. For instance, CEDRO received from the Government of Spain funds to support in assessing RE potential in Lebanon and promoting renewable energy and energy efficiency. The MoEW has also received funds from GEF, the EU, the Governments of China, Greece and others for the development of the NEEAP, NEEREA, and other policies, establishing partnerships with the public and private sectors, and implementing renewable energy and energy efficiency projects in the country.

4.2.3 Externalities

In certain cases, a RES is not feasible from a financial perspective i.e. the project developer is unable to fully recover project costs of capital and operation and achieve the desired return. There are specific costs and benefits, related to the implementation and operation of a project which are not accounted for by the project developer/owner but which may affect the economy/society in general. When such "external" costs and benefits ("externalities") are taken into account, the financial image of the project may change considerably. The analysis of such externalities for specific projects or groups of projects may lead to the introduction of subsidies or other types of financial or fiscal incentives to project developers, thus undertaking on behalf of the society part of the cost of the project corresponding to benefits that the project may generate for the society. Alternatively, social costs can be internalized through, for example emission taxes.

Environmental externalities of electricity generation vary considerably depending on the primary energy and the technology used. Fossil fuels have high external costs (which are transferred to the public and future generations) whereas for RES they are significantly lower. The most important negative externalities related to electricity generation from fossil fuels are:

- GHG emissions;
- Air, water and soil pollution and concurrent health effects;
- Cost to the economy due to imports of fossil fuels;
- Risks to energy security due to dependency on foreign supplies; and
- Electricity price volatility due to volatile fossil fuel costs.

At quantifiable terms, relevant surveys indicate that external costs for oil fired power consumption are in the range of 3-11 €¢/kWh, for gas fired 1-4 €¢/kWh, whilst for RES they are in the range of 0-1 €¢/kWh *(source: Owen, 2004)*.

For RE, externalities are significantly lower and are usually project or site dependent. The most characteristic ones to be noted are:

- Visual impact of wind, hydro and new transmission lines. There may be visual effects from new lines or large installations usually related to wind or hydro, however valuing any damages is not simple, since the alternatives to local people must be assessed;
- Biodiversity impact related primarily to onshore and offshore wind; and
- Devaluation of properties; this has been occasionally mentioned and is proportional to proximity and size of installations and usually refers to wind parks.

The procedure for internalizing externalities includes specification/calculation of monetary values to reflect the external costs of differing technologies, and thereafter establish actions entailing price signals that favour sustainability e.g.:

- Devising mechanisms for "internalising" them into market prices, such as an "energy tax", as noted above;
- Reforms in fiscal and credit systems that favour sustainable energy solutions. Price reforms lead inherently to more rational energy use; and
- At government level phasing out fossil fuel subsidies and perverse other subsidies that distort trading.

Further analysis and quantification is out of the scope of this study. As a general note though it should be stressed that the financial mechanisms currently applied today towards RES, particularly Feed-in-Tariffs, which is the most widely applied, cannot be considered as market distortion interventions, it can be rather said that they partly correct the electricity market which does not internalize external impacts.

4.2.4 Costs and Benefits

In general, the deployment of RE is expected to result in significant direct and indirect benefits to the economy of a country, whereas costs are mostly related to local/micro scale level.

Whereas cost and benefit analysis of the specific alternative scenarios of the RES is analytically presented in section 8.3, and analytical socio-economic impacts per technology are presented in section 9, the table below provides an introductory overall view of commonly associated important direct and indirect costs/benefits from RE along with quantifiable relative indicators where applicable.

Table 4-3 Costs/Benefits from RES

Costs/Benefits	Quantity
Creation of new markets and new job opportunities,	Wind: about 0.2 jobs / MW (O&M) in OECD countries[12] PV solar: about 0.3 jobs / MW (O&M) in OECD countries
Decrease in neighboring land values	Not in all cases, effect is adverse if access infrastructure is improved
Creation of new and innovative touristic attraction site	Refers primarily to certain wind or small hydro sites
Economic savings and reduction of the deficit in the national energy bill due to decreasing amounts of fossil fuels used	Can reach up to 9 billion USD/year in Lebanon, if accounting also Value of Lost Load for electricity demand not covered
Reduction in electricity price	If compared to the cost of local diesel generators
Better electricity access and coverage	That refers to areas (notably rural and remote) with no or intermittent electricity access
Additional grid and transaction costs	Grid costs: costs of extension and reinforcement of transmission and distribution grids associated with RES deployment. Transaction costs: costs between market participants, e.g. forecasting, contracting, reporting etc.
Increase of local investment opportunities	Due to less complicated planning and construction procedures, local construction and engineering can be developed and local added value easily created
Additional costs for reserve	As a result of backup capacity to keep needed supply for peak power due to intermittent character of RES; in the specific case this is not likely due to low level of RES and variability within tolerance levels of the system
Effects on climate	Reduction of GHG emissions

[12] *Source: IRENA, The Socio-economic Benefits of Solar and Wind Energy, 2014*

5 Baseline Conditions

Knowledge about the baseline conditions is crucial in the SEA process because it allows to:

- Identify existing environmental problems requiring attention;
- Assess current economic and social conditions along with their consequences on the environment;
- Identify significant factors or geographical areas that could preclude the implementation of the proposed plan or program;
- Provide a basis for assessing the potential impacts of the proposed plan;
- Provide a starting point for impact monitoring and auditing; and
- Provide sufficient information so that decision makers and reviewers unfamiliar with the sector or geographic scope can develop an understanding of the proposed plan as well as the potential consequences resulting from its adoption.

Available baseline data, in terms of RE potentials and related environmental baseline per RE technology, included in the assessed study (wind energy, solar energy from PV and hydropower), was collated from a number of sources and references and is presented in the following sub-sections.

Summaries of the RE potentials are first presented, followed by an environmental and socio-economic assessment of the high potential areas including land use/land cover and proximity to sensitive ecological and cultural components.

Consequently, in effect, viable areas for RE development are smaller, considering the environmental and social constraints and factors, presented in the following sections.

For each technology a summary map was prepared showing the relevant environmental and social components that could be affected by the implementation of renewable energy projects, these components include:

- Natural Reserves;
- Important Bird Areas;
- Birds Migratory Routes and Migration Bottlenecks13;
- Proposed Natural and Regional Parks (as per the NPMPLT);
- Land use background showing urban settlements; and
- RE high potential areas per technology.

The visualization of potential RE areas, sensitive ecological and cultural locations and urbanized areas on the same map allows for a first screening amongst the potential identified locations for RE production; the further from all three, the better from an environmental and social perspective.

[13] Migration Bottleneck is a site at which, during well-defined seasons of the year, large numbers of migratory birds regularly pass through or over. These sites are mainly land on either side of the narrowest crossing point, or straits of a large water body, across which birds may funnel in dense, often low flying flocks.

5.1 Wind Power

Lebanon has a reasonable wind potential as reported in studies and estimates until present - primarily the wind atlas which was finalized in 2011- and despite the lack of investments, wind power has been included in the mid-long term energy plans for the restructuring and development of the power sector. More specifically:

- The "Policy Paper for the Electricity Sector", prepared and submitted by the Ministry of Energy and Water includes within action 1.f the introduction of wind power via the private sector by building wind farms (60 – 100 MW);
- EDL Master plan has foreseen a 1% share in energy supply from wind in 2013 i.e., a generation capacity of 30 MW in 2013, and 60 MW in 2018 (1.5% of the demand). In practice though, this target has not been achieved due to delays in the development of the first large wind power installations in the country.
- The NEEAP of 2010 foresees the construction of wind farms for power generation through Independent Power Producers (IPP) with a capacity of 100-200 MW by 2014, whereas there are estimates for the easy possibility to install 400 to 500 MW by 2020[14].

However, progress made up to date at the institutional, regulatory and investment levels denotes a significant deviation compared to the above mentioned mid-term targets since only a few micro-wind systems have been installed through demonstration initiatives. This has been delayed, and is foreseen to start implementation in 2015.

5.1.1 Onshore Wind Potential

Onshore wind in Lebanon has been recently studied through a UNDP/CEDRO project related to the wind atlas for Lebanon. This study can be considered as the first essential step, practically indicating sites where further assessment including wind measurements would be followed up before investment decisions are made.

As part of the wind atlas development, correlations of monthly mean wind speeds between meteorological stations located around Lebanon were made using a meso-scale computational model, which yielded average wind speeds at 50 m and 80 m heights and a resolution of 100 m. The work was at a large extent based on existing measurements.

There are several constraints that are expected to reduce the proposed potential areas for wind farms developments. A number of these constraints were taken into consideration as part of the wind atlas preparation works while others were not; the considered constraints consisted of:

- Areas of high population density;
- Areas of high political instability;
- Military sites;
- Commercial interests (e.g. mining, fisheries, etc.);
- Civilian aviation sites;
- Areas in close proximity to radar or telecommunication sites;
- National parks;

[14] MoEW-RFP Wind Energy Power Project, ToR for the first utility scale wind farm in Lebanon, March 2013

- Conservation areas, e.g., Cedar forests;
- Historic sites; and
- Sites of religious significance.

However a number of other parameters were not considered in the Wind Atlas study, namely:

- Migratory bird flight routes and bottlenecks;
- Sensitive animal habitats- including IBAs; and
- Proximity to transmission lines.

Moreover, sites close to the consumption centers and transmission lines should have a priority for wind farms (refer to section 8.2).

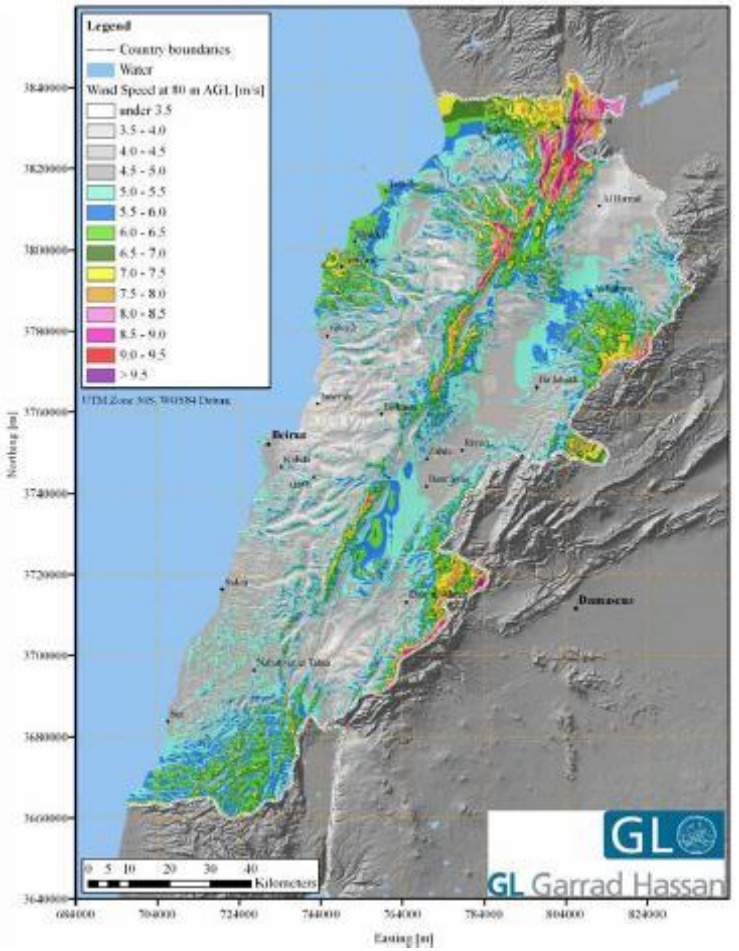
The key results from this study with regards to wind potential on the basis of various assumption scenarios are summarized in Table 5-1.

Table 5-1 Outline of Results on Wind Potential in Lebanon[15]

Scenario	Max Slope (degrees)	Wind Potential
1. Baseline/average speed: Average wind speed > 6.5 m/s at 80 m above ground level/ installation density of 8 MW/km^2	17	6.1 GW
2. Baseline/ low speed: Wind speed 10% lower than scenario 1[16]	17	2.5 GW
3. Baseline/high speed: Wind speed 10% higher than scenario 1	17	12 GW
4. Low slope/average speed: Average wind speed > 6.5 m/s at 80 m above ground level	8	3.8 GW
5. Low slope/low speed: Wind speed 10% lower than scenario 4	8	1.5 GW

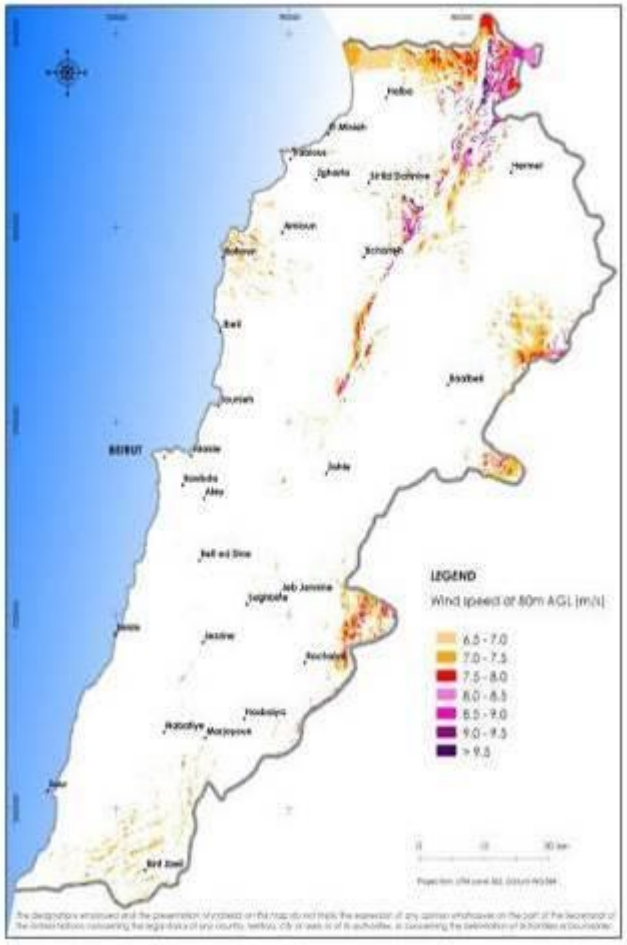
The map shown in Figure 5-1 shows wind potentials at 80 m above ground level while the one shown in Figure 5-2 illustrates selected locations corresponding to the last scenario, i.e., wind potential of 1,500 MW.

[15] Source of data: CEDRO, The National Wind Atlas of Lebanon, 2011.
[16] i.e. all modelled wind speeds are reduced by 10%



(Source: CEDRO (2011). National Wind Atlas)

Figure 5-1 Main Wind Map at 80 m Above Ground



(Source: CEDRO (2011). National Wind Atlas)

Figure 5-2 Areas Technically and Financially Viable for Wind Farm Development Assuming a Conservative 8 Degree Slope Limit

In that context, for the sites above average wind speed of 6.5 m/s and based on the identified technical potential, corresponding electricity generation from wind power amounts to approximately **12,139 GWh/y[17], equivalent to 80.9% of the total electricity demand in 2009** (MoEW, 2010). Table 5-2 shows the potential capacity and the potential power output based on different wind speeds.

Table 5-2 Estimated Electricity Generation from Wind for Different Wind Speed Ranges

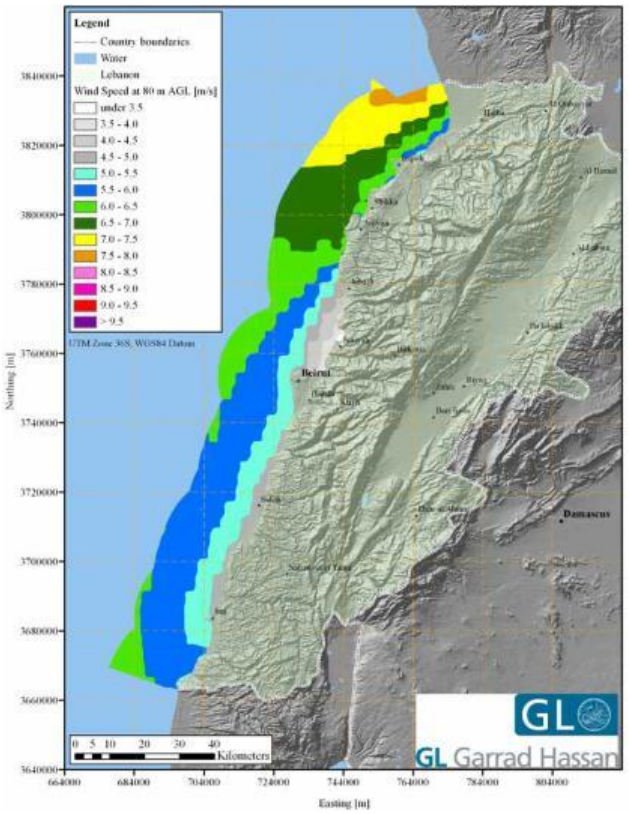
Average annual wind speed (m/s)	Assessment Capacity factor (%)	Area in km²	Approximate Potential capacity (MW)	Approximate total potential power output (MWh)
6.5 – 7	22.0	294.4	2,355	4,538,556
7 – 7.5	25.1	187.6	1,500	3,298,140
7.5 – 8	28.2	92.8	743	1,835,448
8 – 8.5	31.4	48.0	384	1,056,246
8.5 – 9	34.8	24.8	199	606,648
9 – 9.5	38.4	12.7	102	343,112
> 9.5 (assumed 10 m/s)	42.1	15.7	125	460,995
Total		**676**	**5408**	**12,139,145**

As mentioned, wind power in the country is at present practically non-existent. During 2013, MoEW launched a tender for the construction of a 50 to 100 MW wind farm, and the procedure is still on-going. The selected contractor will build, own and operate the wind farm that can sell electricity for 20 years to EDL (+ 5 years option).

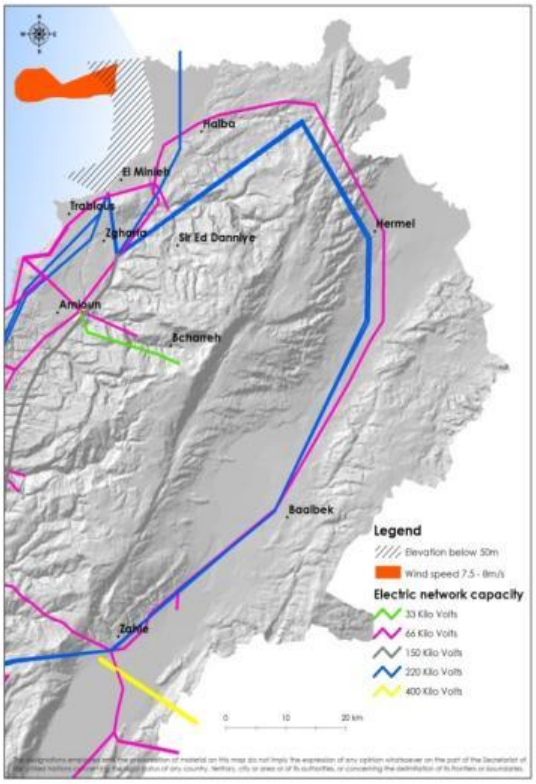
5.1.2 Offshore Wind Potential

The same wind flow modelling methodology as with onshore wind was carried out to determine the wind speed variation at heights of 50 m and 80 m for the offshore region lying within 20 km of the Lebanese coastline. The derived wind map which is though based on a very preliminary concept, is shown below in Figure 5-3.

[17] Source (Shawon et al., 2013)



(Source: CEDRO (2011). National Wind Atlas)



(Source: CEDRO)

Figure 5-3 Offshore Potential Areas

The selected areas for potential offshore sites referred to average wind speeds between 7.5 and 8.0 m/s, which is to the far north of Lebanon and corresponds to an area of approximately 60 km^2, which after filtering to select areas with a sea depth less than 50 m is confined to 13 km^2, as shown above. This area corresponds to a total potential of **66 MWe.**

5.1.3 Environmental and Social Conditions

The main areas identified as having considerable wind energy potential are Akkar's far north (Boqaiaa and Wadi Khaled regions), Donniyeh and a region in the Bekaa to the North West of Baalbek.

5.1.3.1 Onshore Wind Potential

As shown in Figure 5-4 to Figure 5-6 the land use/land cover in the areas identified as having high onshore wind energy potential include agriculture, forest/green cover, urban fabric and bare land. *It is worth noting that the agricultural lands shown in Figure* 5-4 *correspond to the Akkar Boqaiaa Plain which is the second most important agricultural area in Akkar and very prone to flooding events.*

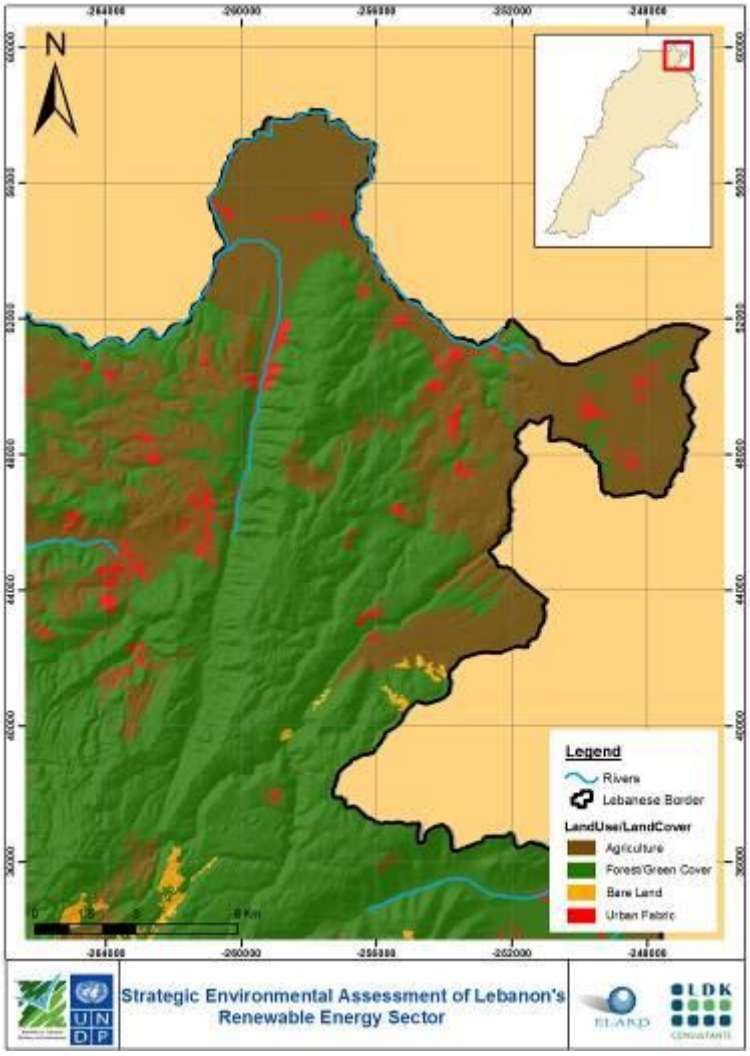


Figure 5-4 Land Use in High Wind Potential Area 1 – North Akkar

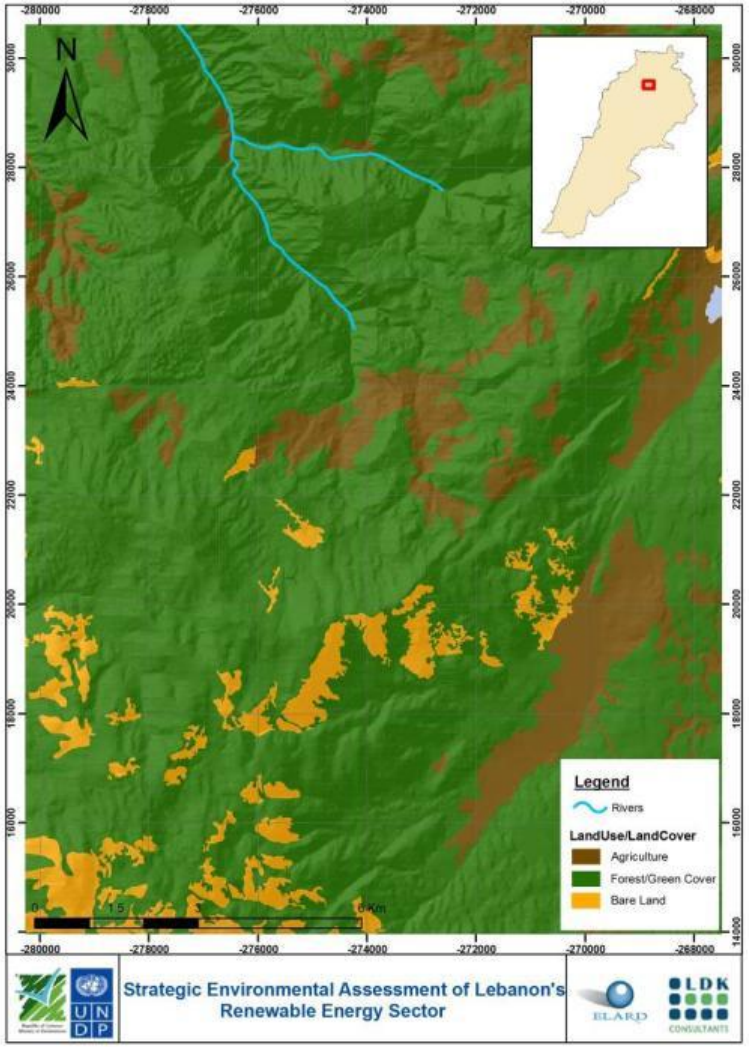


Figure 5-5 Land Use in High Wind Potential Area 2 – Donniyeh

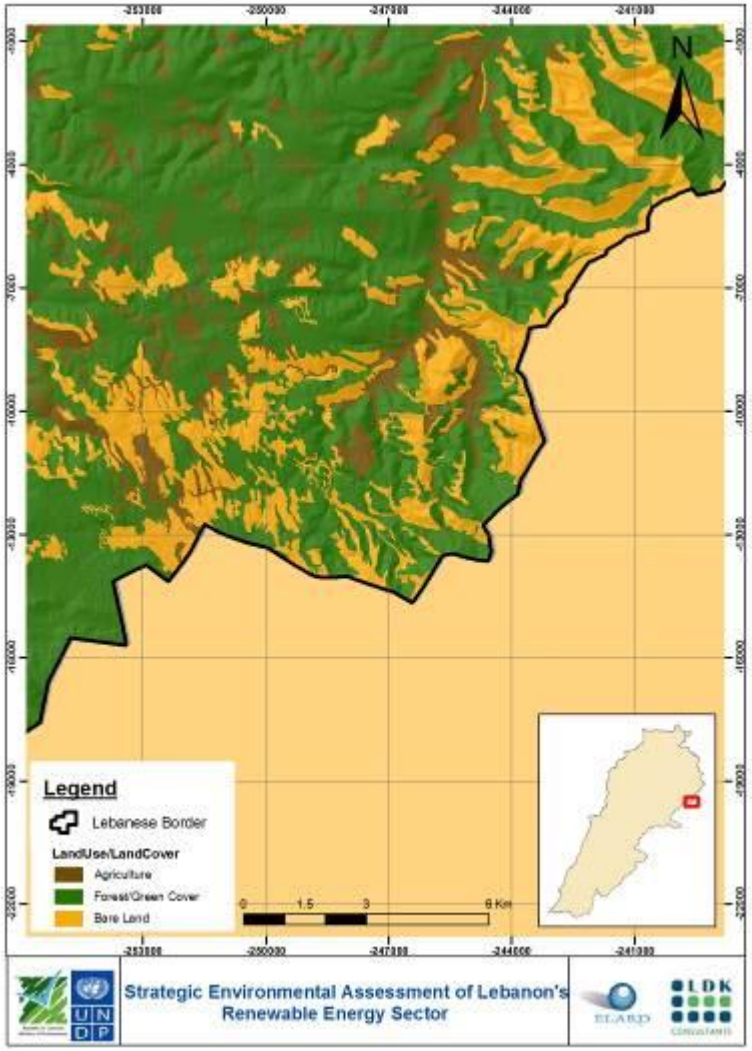


Figure 5-6 Land Use in High Wind Potential Area 3 – North West of Baalbek

Table 5-3 indicates the closest distances from high wind potential areas to important ecological and cultural sites. As detailed in Table 5-3 and shown in Figure 5-10, the North Akkar wind potential area encompasses the Wadi Oudine birds bottleneck and has an overlapping area extending 0.5 to 1.5 km within the suggested Akkar, Upper Donniyeh and Upper Hermel Natural Park; while the Donniyeh area falls fully within the suggested Natural Park and overlaps a section of the Marjhine birds' bottleneck.

No ecological hot spots or cultural heritage sites protected by legal texts were identified within high wind potential areas; except for the Akkar part which falls within the Natural Park that is in the course of being created.

Table 5-3 Distances from Wind Energy Potential Areas to Closest Important Sites

Wind Energy Potential Site	Site Extension	Close Important Ecological/Cultural Site	Distance
North Akkar	The wind energy potential site in North Akkar extends over an area with an approximate diameter of 19 km	Cheikh Zennad Wetland	26 – 45 km
		Karm Chbat Nature Reserve	3 – 22 km
		Qammoua	9 – 28 km
		Migratory birds bottleneck of Wadi Oudine	*Falls within the RE potential area*
		Akkar, Upper Donniyeh, and Upper Hermel Natural Park	*Potential overlapping area within the RE potential area*
Donniyeh	The wind energy potential site in Donniyeh/Bcharreh extends over a stretch of approximately 16 km	Horsh Ehden Nature Reserve	4 – 20 km
		Cedar Forest	2 – 18 km
		Qannoubin Valley	6 – 22 km
		Tannourine Cedars Forest Nature Reserve	11 – 27 km
		Yammouneh Nature Reserve	6 – 22 km
		Migratory birds bottleneck of Marjhine	*Overlapping area extending 0.5 to 1.5 km within the RE potential area*
		Akkar, Upper Donniyeh, and Upper Hermel Natural Park	*The RE potential area falls within the Park*
North West of Baalbek	The wind energy potential site in North West of Baalbek extends over an area with an approximate diameter of 16 km	Semi-Desert of Ras Baalbek	15 – 31 km
		Ruins of Baalbek	19 – 35 km

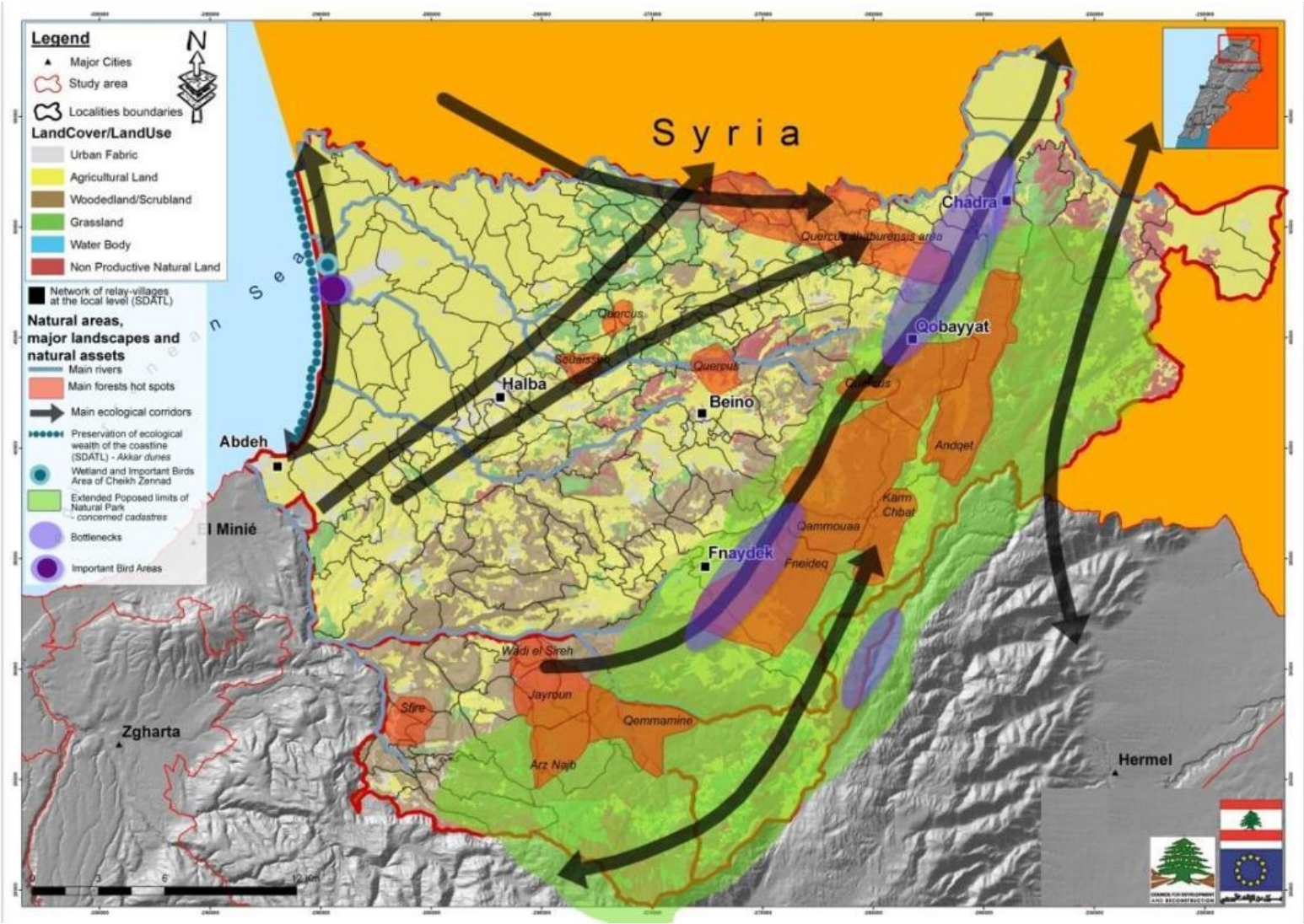
Akkar, Upper Donniyeh, and Upper Hermel Natural Park

In 2005, the NPMPLT identified the forests of Akkar, Upper Hermel and Upper Donniyeh as an entity with exceptional landscape and biodiversity assets (Dar Al-Handasah (Shair & Partners) - IAURIF, 2005). "Based on the exceptional quality of the natural areas of this region, the preservation status of this zone and its very low urbanization rate", the NPMPLT suggested the establishment of this entity as a Natural Park.

In addition to the exceptional landscape and heritage features, the area is also home to a rich biodiversity. It hosts three major and drastically different eco-zones – the Mediterranean (West and North), the Alpine (high altitudes of the North of Mount Lebanon) and the Irano-Turanian (North of the Bekaa valley) – and embraces four Mediterranean vegetation zones – the Euro-Mediterranean, the Supra-Mediterranean, the Mountainous Mediterranean and the Oro-Mediterranean (ECO-MED, 2013). The morphological differences between plain and mountains within the region lead to a diversity of climate, hydrology, soil and vegetation; all of which are considered assets for agricultural production and tourism. Moreover, the area harbors the key representative forest communities of the North Lebanon governorate and is considered as the green reservoir of the area sheltering high rates of genetic, specific and ecosystem diversity (Cluchier, 2013).

In terms of avifauna, the Upper Mountains of Akkar consist of four important locations, each of which qualifies for an IBA designation on its own: Wadi Jouhanam, Mechmech, Fneideq and Qammouaa. The presence of globally threatened species is the main reason behind considering the region as an IBA, in addition to the occurrence of endemic and biome restricted species and soaring birds. A total of 13,189 birds belonging to 134 species were counted in the region. Moreover, the park includes two migratory bottlenecks: Oudine Valley and Marjhine.

The exact limits of the Natural Park are still being considered and will depend upon the municipalities and localities that will be willing to adhere to the Park Charter; and the legislative texts, institutional arrangements and action plans governing its implementation and operation are under development as well. The development of wind farms in the area will be constrained by the limits of the Park.



(Source: ELARD (2014). Elaboration d'un schéma régional d'aménagement et de développement durable du territoire (SRADDT))

Figure 5-7 Schematic Delineation of the Natural Park in the NPMPLT

5.1.3.2 Offshore Wind Potential

Figure 5-8 shows the land use of the areas facing sites identified as having high offshore wind energy potential. The coastal stretch facing the high offshore wind potential is the site of an important birds' area: the Cheikh Zennad Wetland and an airport, currently not operational, the René Mouawad Airport (Qleyaat Airport), that is being considered for rehabilitation and exploitation in the Strategic Sustainable Development Plan that is currently being developed for Akkar.

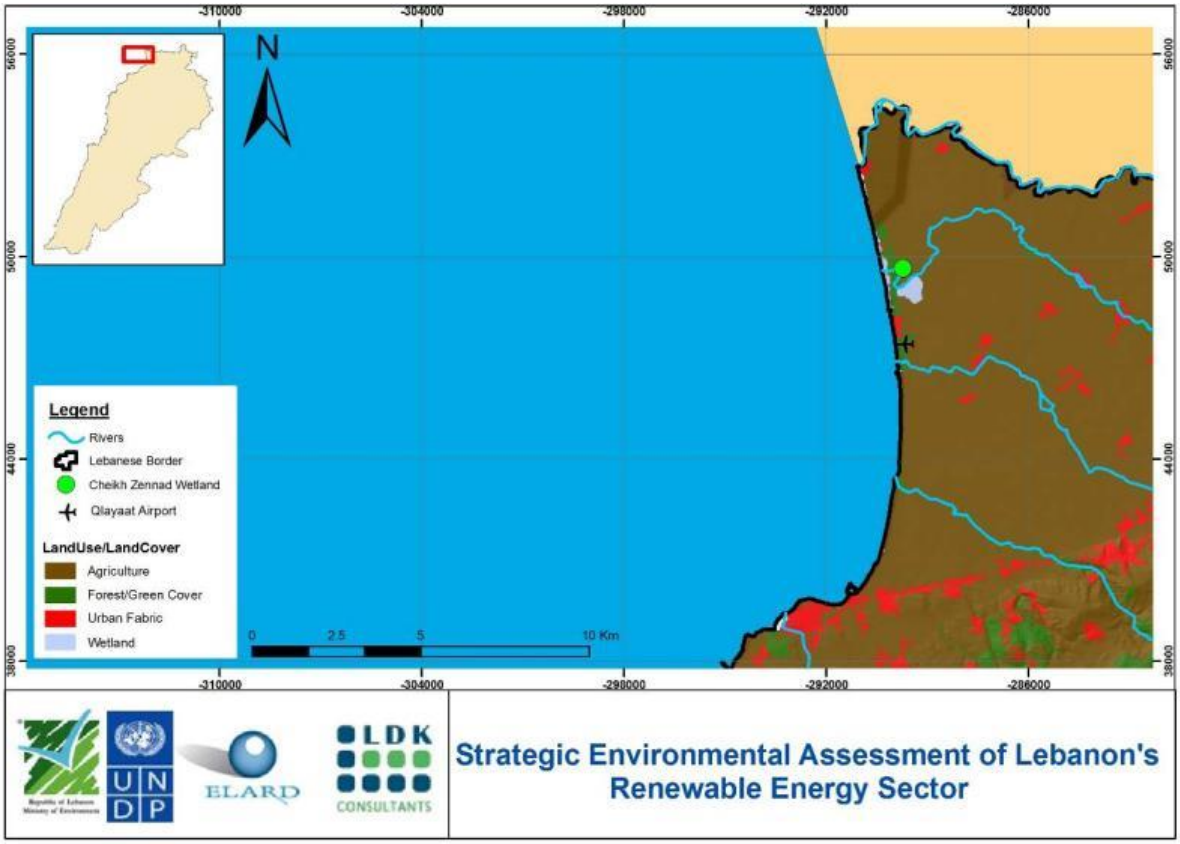


Figure 5-8 Land Use and Important Sites facing Areas of High Offshore Wind Energy Potential

The Cheikh Zennad wetland, located on the coast of Akkar about a half km inland from the Mediterranean, is a series of derelict salt pans rich in mudflats (Figure 5-9) and is one of the three wetlands in Lebanon considered by A Rocha as particularly significant in terms of waterbirds. The main encountered waterbirds species being:

- Grey Heron *Ardea cinerea*
- Teal *Anas crecca*
- Avocet *Recurvirostra avosetta*
- Grey Plover *Pluvialis squatarola*
- Golden Plover *Pluvialis apricaria*
- Lapwing *Vanellus*
- Ringed Plover *Charadrius hiaticula*
- Dunlin *Calidris alpina*
- Little Stint *Calidris minuta*
- Redshank *Tringa totanus*
- Black-Headed Gull *Larus ridibundus*

(Source: SMAP III Final Workshop Marseilles: ICZM Policy Note- Making the Case for Protecting Cheikh Zennad Lebanon, 2009)

Figure 5-9 Cheikh Zennad Wetland

Cheikh Zennad is also considered important in terms of cultural heritage. The Necropolis of Cheikh Zennad is located some 150 m from the village itself. The excavation of the Necropolis started in 1924. It revealed some 26 rock-cut tombs. The artifacts that were found in the sarcophagi are now exhibited in the National Museum of Beirut. One of them, a Rhyton (drinking horn in the shape of a pork head) is dated from the 5th century B.C., and is considered a very precious find, since very few examples are attested in this region.

5.1.3.3 Summary Map

The map below shows the locations of the high wind energy potential sites and various sensitive ecological sites; namely Nature Reserves, Important Bird Areas, Birds Migratory Routes, Migratory Bottlenecks, and Proposed Natural and Regional Parks (as per the NPMPLT).

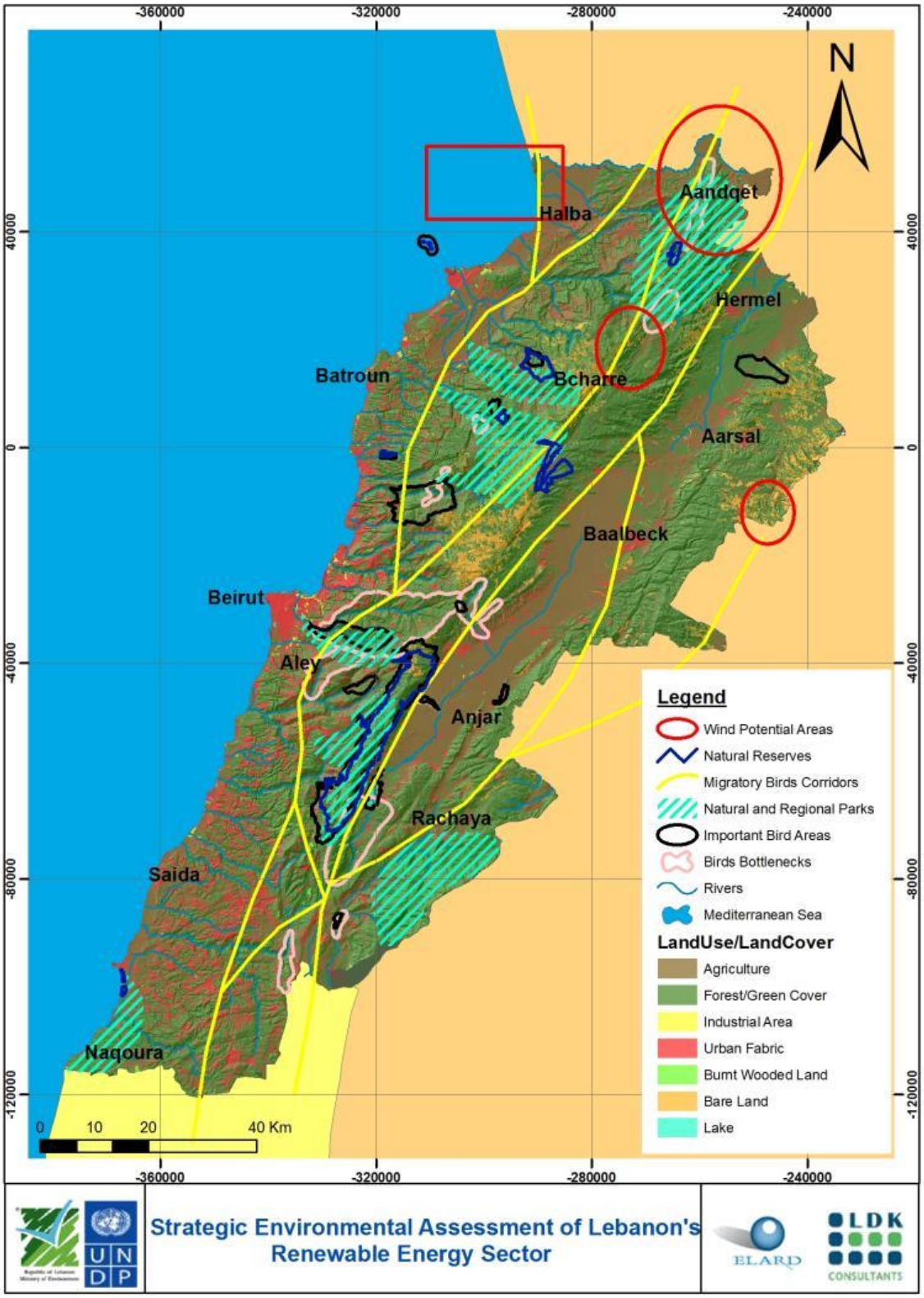


Figure 5-10 High Wind Energy Potential Areas and Sensitive Ecological Sites

5.2 Solar Photovoltaics

Solar photovoltaic (PV) is a solar energy harvesting technology which uses cell arrays to capture solar energy and convert it into direct current electricity. Lebanon has a significant potential for PV, backed by the high solar irradiance levels, the relative lack of dust or sand and a relatively mild climate that ensures a more optimal operation in terms of efficiency.

The Spanish Government funded UNDP_CEDRO 1,2,3 has completed approximately solar PV 70 sites (ranging from 1 kWp to 3 kWp per site) across various public sector institutions in Lebanon, with a total capacity of over 100 kWp. Additional installations of 10 sites are planned, with a total capacity of 1.5 MWp (ranging from 100 – 300 kWp/site), funded by EU, and EU-MEDSOLAR under the UNDP CEDRO project. The first phase of a demonstration project is underway for a 1 MWp PV plant on a constructed ceiling over a stretch of the Beirut River. Additional government led PV installations are planned in Zahrani which could reach 3 MWp. The GEF funded UNDP – DREG (Small Decentralized Renewable Energy Power Generation) project is planned to install decentralized PV with a total capacity nearing 3 MWp (ranging from 100 – 650 kWp per site.

Calculation of the economic potential for PV power in Lebanon has been conducted at a preliminary stage (CEDRO), taking into account relevant constraints to ensure technical viability, environmental sustainability, and social security. In that context constrained use, i.e. areas excluded from PV sites referred to:

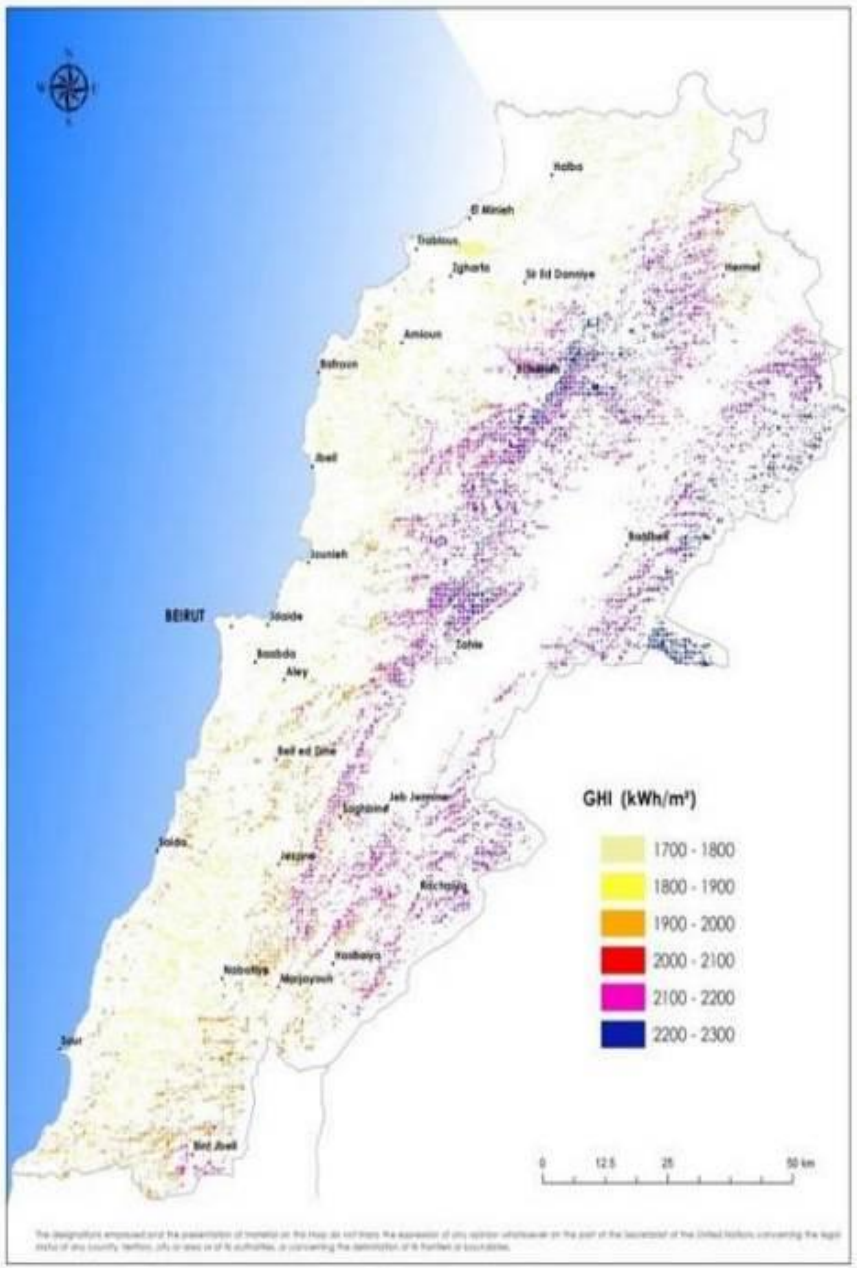
- Agricultural land;
- Forest areas;
- Historic sites;
- Wetland and water bodies;
- Slopes of more than 35°;
- Slopes not facing south (when land is not flat); and
- Areas with a surface below 8,000 m^2 (based on a PV potential capacity of 8,000 m^2/MW).

In that context, it has been concluded that there is a potential for PV in Lebanon that could reach up to **110 GW**, with candidate areas shown in Figure **5-11** below. This amount corresponds to annual electricity generation of **180,000 GWh,** almost 15 times present generation from the TPPs (Thermal Power Plants) of the country. Table **5-4** summarizes the Solar PV Potential in Lebanon, whereas Figure **5-11** shows the potential land areas for PV farms in Lebanon as per horizontal irradiation levels.

Table 5-4 Solar PV Potential in Lebanon [18]

GHI	Area (in km²)	Assumed App. capacity Factor* (%)	Potential capacity in MW (assuming 8,000 m²/MW)	Potential power output (MWh)
1700 – 1800	36.6	16.6	4,575	6,633,750
1800 - 1900	124.3	17.3	15,537.5	23,632,537.5
1900 - 2000	187.3	18	23,412.5	34,884,625
2000 – 2100	188.7	19.5	23,587.5	40,240,275
2100 – 2200	269	20.1	33,625	59,247,250
2200 - 2300	70.46	20.8	8,807.5	16,029,650
Total			**109,545**	**180,668,088**

[18] Source: CEDRO



(Source: CEDRO, from www.solar-med-atlas.com)

Figure 5-11 Potential Land Areas for PV Farms in Lebanon as per Horizontal Irradiation Levels

5.2.1 Environmental and Social Conditions

The main areas identified as having considerable PV potentials are located in Donniyeh/Bcharreh, Hermel, Bekaa (Tfail and Ain Joz), and Zahleh.

Figure 5-12 to Figure 5-15 how the land use of the areas identified as having high solar photovoltaic potential. No known protected cultural heritage sites were identified in areas with high solar photovoltaic potential. However, these areas consist of forest/green cover and agricultural land primarily, followed by bare land.

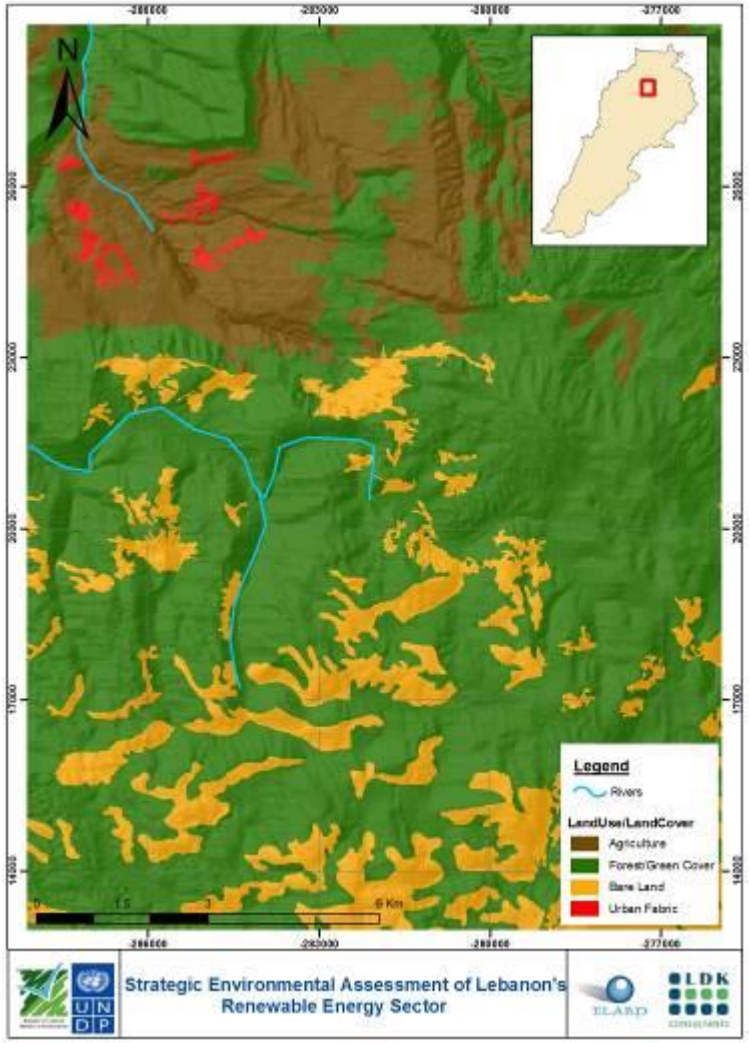


Figure 5-12 Land Use in High PV Potential Area 1 – Donniyeh/Bcharreh

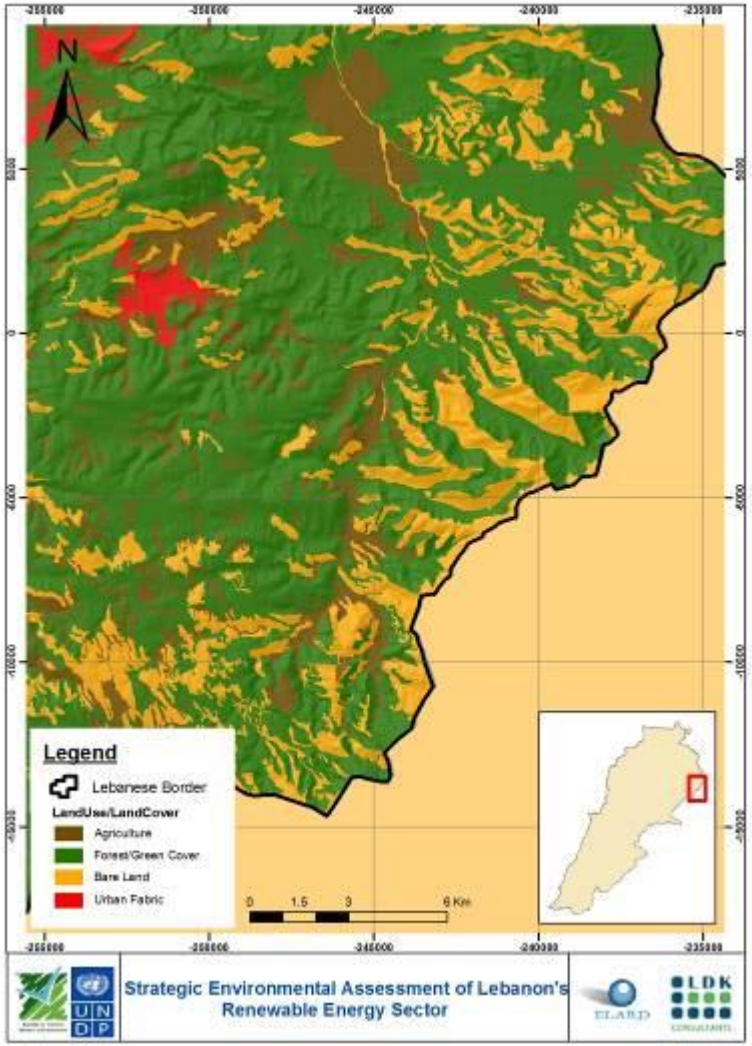


Figure 5-13 Land Use in High PV Potential Area 2 – Hermel

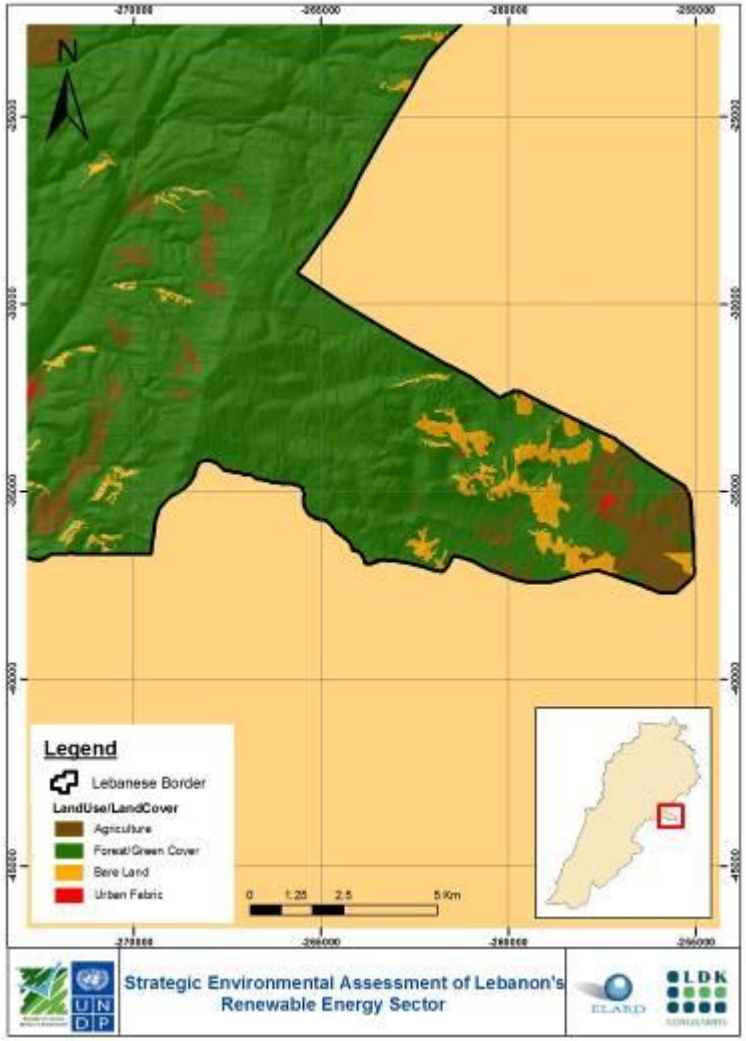


Figure 5-14 Land Use in High PV Potential Area 3 – Bekaa

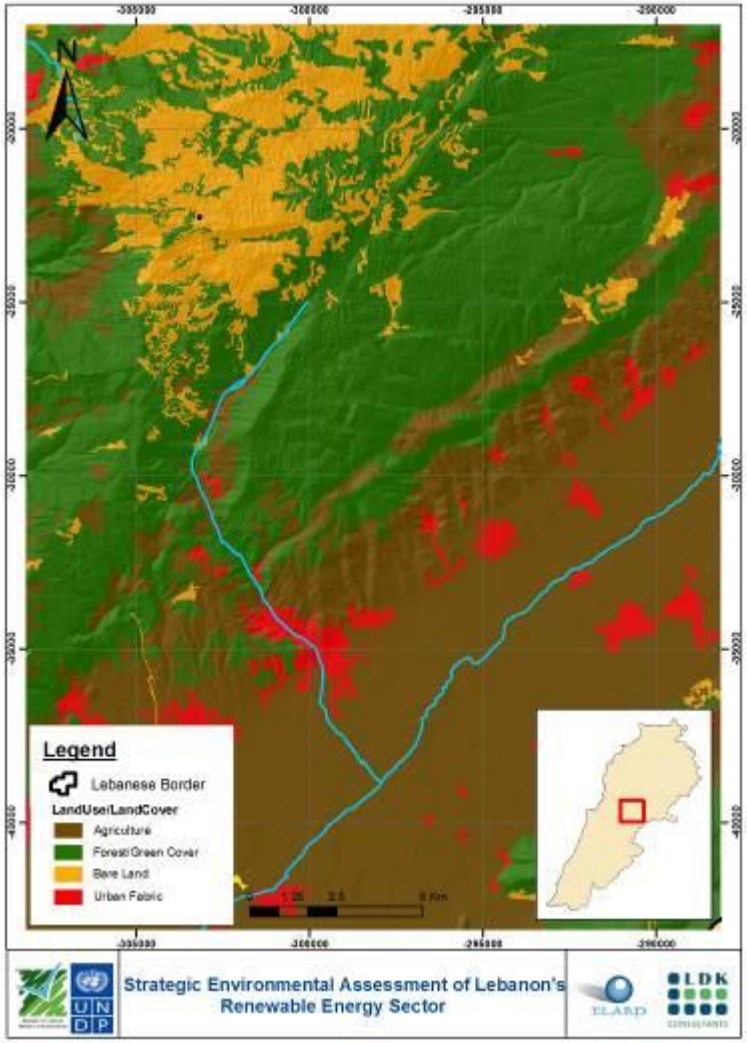


Figure 5-15 Land Use in High PV Potential Area 4 – Zahleh

Table 5-5 indicates the closest distances from solar PV high potential areas to important ecological and cultural sites. As detailed in Table 5-5 and shown in Figure 5-16, the Donniyeh/Bcharre solar energy potential area overlaps several proposed Natural Parks and the Yammouneh nature reserve.

Table 5-5 Distances from Solar PV Energy Potential Areas to Closest Important Sites

Wind Energy Potential Site	Site Extension	Close Important Ecological/Cultural Site	Distance
Donniyeh/ Bcharreh	The solar PV energy potential site in Donniyeh/Bcharreh extends over a stretch of approximately 16 km	Horsh Ehden Nature Reserve	4 – 20 km
		Cedar Forest	2 – 18 km
		Qannoubin Valley	6 – 22 km
		Tannourine Cedars Forest Nature Reserve	11 – 27 km
		Yammouneh Nature Reserve	*Overlapping areas with the reserve*
		Akkar, Upper Donniyeh, and Upper Hermel Natural Park	*Overlapping areas with the Park*
		Qadisha and Cedars Park	*Overlapping areas with the Park*
		Tannourine and Nahr Ibrahim Park	*Overlapping areas with the Park*
Hermel	The solar PV energy potential site in Donniyeh/Bcharreh extends over a stretch of approximately 11 km	Semi-Desert of Ras Baalbek	13 – 24 km
Bekaa	The solar PV energy potential site in Bekaa extends over a stretch of approximately 12 km	Ruins of Baalbek	13 – 25 km
Zahleh	The solar PV energy potential site in Zahle extends over an area with an approximate diameter of 3 km	Shouf Nature Reserve	10 – 13 km
		Hima Anjar Kfar Zabad	13 – 16 km
		Ammiq Wetland	16 – 19 km

Yammouneh Nature Reserve

The Yammouneh Lake and surrounding area was declared a nature reserve by Law 10 of 20/2/1999. The reserve is located 27 km northwest of Baalbek on the north-eastern side of the Mount Lebanon range where Jebel al Makmel meets Jebel al Mnaitra. The reserve extends over a 1,600 hectare area of reserve at an altitude of 1,400-2,000 m above sea level and is known for its distinguishing juniper trees. The remains of a Phoenico-Greco-Roman temple lie on the shore of the lake.

The provision of PV facilities in the reserve's footprint is to be avoided.

Akkar, Upper Donniyeh, and Upper Hermel Natural Park

The exact limits of the Natural Park and the extent of protection throughout are still being defined, and the legislative texts and action plans governing its implementation and operation are under development as well. The provision of PV facilities in the area will be subject to the extent of protection set forth as the Park is progressively created, and will require a careful environmental and social assessment.

More information about the Park is provided in section 5.1.3.

Qadisha and Cedars Park

The Qadisha Valley site and the Forest of the Cedars of God (Horsh Arz el-Rab) are located in northern Lebanon. The Qadisha Valley is located North of Mount-Lebanon chain, at the foot of Mount al-Makmel and West of the Forest of the Cedars of God. The Holy River Qadisha, celebrated in the Scriptures, runs through the Valley. The Forest of the Cedars of God is located on Mount Makmel, between 1,900 and 2,050 m altitude and to the East of the village of Bcharreh.

The Qadisha Holy Valley is protected by Ministerial Orders 13/1995 and 60/1997 enacted by the Ministry of Culture, by Order 151/95 enacted by the MoE, and by the Antiquities Law 166/1933. In addition, the Qadisha Valley and Cedars of God were registered in 1998 by UNESCO as a world heritage site. The Qadisha valley is one of the most important early Christian monastic settlements in the world. Its monasteries, many of which are of a great age, stand in dramatic positions in a rugged landscape. Nearby are the remains of the great forest of cedars of Lebanon, highly prized in antiquity for the construction of great religious buildings. The NPMPLT defined the valley and the high circus of Qadisha as one of the six regions that are best prepared for regional natural park projects.

The high PV potential area overlaps an area of the Park beyond the cedars forest, and therefore does not overlap with the Qadisha Valley nor the Cedars of God. The provision of PV facilities in the area will be subject to the extent of protection set forth as the Park is progressively created, and will require a careful environmental and social assessment. Moreover, once the exact limits of the Park are delineated, the high potential PV areas might not be within the Park limits.

Tannourine and Nahr Ibrahim Park

The proposed Tannourine and Nahr Ibrahim regional park includes the Tannourine Cedars Forest Nature Reserve and the historical valley of Nahr Ibrahim (Adonis Valley). The NPMPLT defined it as one of the six regions that are best prepared for regional natural park projects.

The Tannourine Cedars Forest Nature Reserve was created under Law No.9 on February 25, 1999. The reserve is managed by the Tannourine Cedars Forest Nature Reserve Committee in cooperation with the MoE. The reserve includes one of the largest and densest cedar forests in Lebanon with 80% cedar trees.

The river bed of the Nahr Ibrahim is protected by the MoE while the valley itself is famed for both its historical and religious significance. A wild and beautiful area, in pagan times a pilgrimage road ran along its north side to Afqa, scene of the tragic love story of Venus (Astarte) and Adonis. The valley encompasses an Ottoman bridge built in 1806, structures of a Roman Aqueduct, and Mashnaqa, the Roman temples of Yanuh, Aqoura and Afqa.

The high PV potential area appears to overlap with an area of the Park to the North of Tannourine Nature Reserve, and thus does not overlap with the reserve nor the Nahr Ibrahim Valley. Moreover, once the exact limits of the Park are delineated, the high potential PV area might not be within the Park limits. In all cases, the provision of PV facilities in the area will be subject to the extent of protection set forth as the Park is progressively created, and will require a careful environmental and social assessment.

5.2.1.1 Summary Map

The map below shows the locations of the high solar energy potential sites and various sensitive ecological sites; namely Nature Reserves, Important Bird Areas, and Proposed Natural and Regional Parks (as per the NPMPLT).

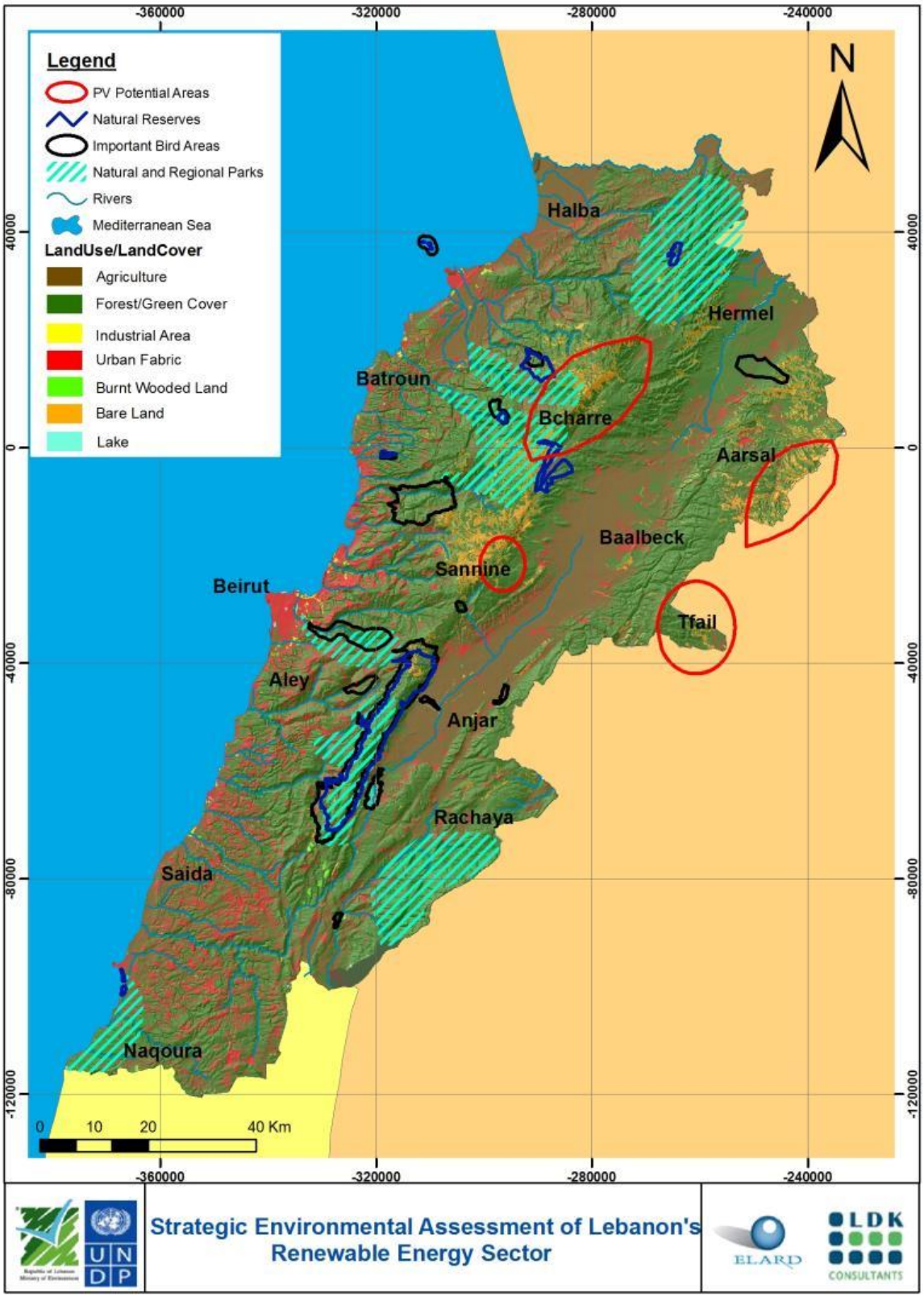


Figure 5-16 High Solar PV Energy Potential Areas and Sensitive Ecological Sites

5.3 Hydropower

5.3.1 Current Capacity and Potential

The installed capacity of hydropower plants in Lebanon today is about 280 MW but the actual generation capacity is 190 MW, since many of the plants have been in service for several decades, some of them for 50-100 years. Therefore, potential for new capacity from hydropower generation exists either from the rehabilitation of existing or the construction of new plants, which within the electricity sector policy paper (2010) has been quantified to range between 40 and 120 MWe.

The energy produced from hydropower plants has been variable in the last years, ranging from 4.5% of the total production (Litani, Nahr Ibrahim and Bared)[19] to 8.7% in 2012 primarily due to the rehabilitation of HPPs in place, as shown in Table **5-6**. However it must be highlighted that with regards to Litani HPP which is at present the largest plant, electricity production is expected to be reduced to almost 30% of current levels, due to Conveyor 800 project which foresees diversion of a large share of water to the south for irrigation purposes.

Table 5-6 Electricity from Existing Hydro Power Plants in Lebanon[20]

River/Plant	Establishment	Capacity (WM)	Year of Construction	2012 Yearly Production	Rehabilitated Plant Yearly Production* (GWh)	Increase in production from rehabilitation (%)
Kadisha Valley / Bcharreh, Mar Licha, Blaouza II, Abu-Ali	La Kadisha - Société Anonyme d'Electricité du Liban Nord	21	1924, 1932, 1957, 1961	72	82	14
Litani-Awali/ Markaba, Awali, Joun	Litani Water Authority	199	1961, 1964, 1967	680	775	14
Nahr Ibrahim/ Chouane, Yahchouch, Fatri	Société Phénicienne des Forces de Nahr Ibrahim des Eaux et Electricité	32	1951, 1955, 1961	92	105	14
Nahr Al Bared/ Al Bared 1, Al Bared 2	Al Bared Concession	17	1936	54	62	15
Safa Spring /Richmaya-Safa	Electricité du Liban	13	1931	20	23	15
Total Hydro		**282**		**918**	**1,047**	**14**
% of Total Energy				8.70%	7.91%	-

[19] Source: policy paper for the Electricity Sector, G. Bassil, June 2010.
[20] Source: CEDRO

Note: Apart from Kadisha and Litani, no rehabilitation actions have been initiated in any of the other hydro power plants.

Potential for development of hydropower in Lebanon refers to either rehabilitation of existing plants or construction of new ones:

1) Rehabilitation of existing plants

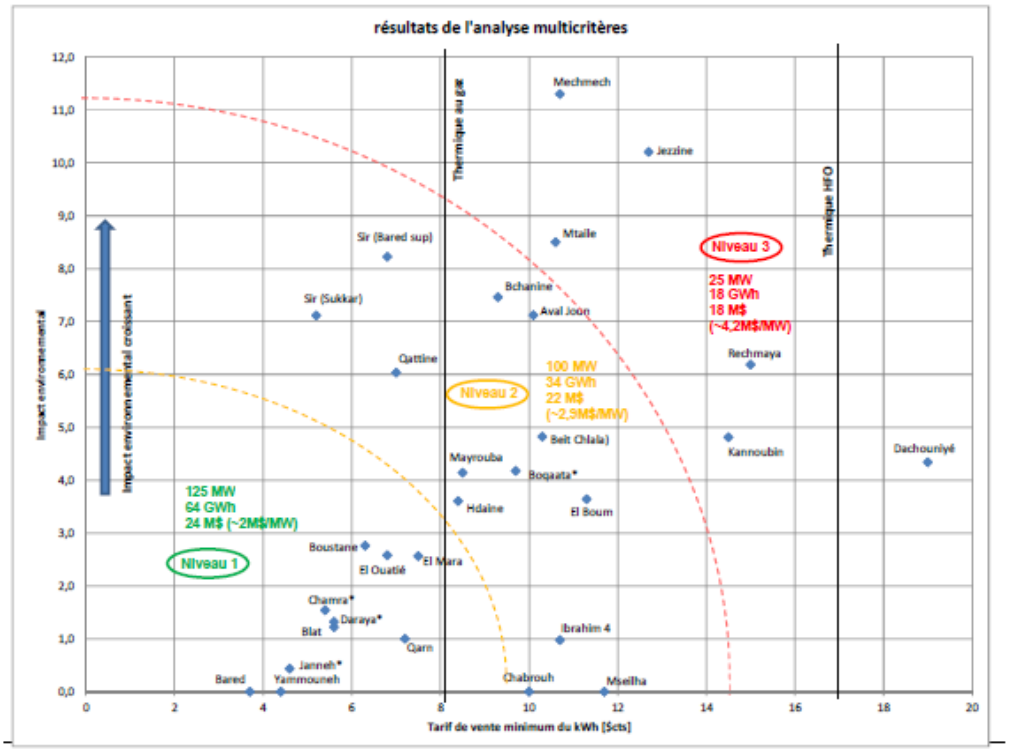
It has been estimated that at least 15% of additional generation capacity is possible from rehabilitating hydropower plants, which corresponds to additional electricity generation of about **129 GWh/y** and an increase of the average capacity factor of all plants to 42.3% (from current 37.2%).

2) New plants

A Master Plan Study for the hydroelectric potential of Lebanon along the main river streams has been prepared by Sogreah for the MoEW, which identified the potential arising from 32 new sites (non mini-Hydro - a special study is to be launched in 2014), split into two categories:

- Run of river schemes: potential capacity of 263 MW (1,271 GWh/y);
- Peak schemes (with dams): potential capacity of 368 MW (1,363 GWh/y).

Analysis of these sites in terms of financial viability resulted in the selection of the most promising ones and allocation into three major categories as shown in Figure 5-17.



(Source: Sogreah (2012). Schema Directeur Hydroelectrique Du Liban)

Figure 5-17 Potential New HPPs in Lebanon Categorized According to Financial Viability

In brief, this analysis concluded that additional **250 MWe** of new hydro power plants, producing about **1200 GWh/y,** can be financially viable:

- Approximately 125 MW of new hydropower supply is viable at exceptionally favorable locations with low environmental impact and relatively low levelised costs;
- 100 MW are additionally available and viable, yet relatively less favorable than the first trench;
- 25 MW that also exist require special attention to the environmental impacts.
- All three trenches have levelised costs lower than current average generation costs of EDL.

5.3.2 Non-River Sources

The potential for hydropower from non-river sources has been studied recently (CEDRO projects). Candidate sites for such schemes are:

- Irrigation channels and conveyors;
- Wastewater treatment plants;
- Thermal power plants' outfall pipes; and
- Distribution networks of drinking water;

The relevant potential has been calculated to reach 8-15 MW. The study performed a site assessment for 20 sites and selected 13 of them with a potential amounting to **5 MW** and electricity production of about 25,000 MWh/y that can be financially viable, half of which refers to existing thermal power plants.

5.3.3 Environmental and Social Conditions

Figure 5-18 shows the location of the main identified locations for hydropower generation, (including existing plants and potential plants from river and non-river sources) over a land use/land cover background.

The summary map includes the main rivers and Nature Reserves. Proposed Natural and Regional Parks (as per the NPMPLT) are not included given that hydropower plants can be developed within Parks, especially run of river mode plants not requiring building dams.

As shown in the map, no hydropower plants fall within Nature Reserves.

The map also shows the locations of the main faults in the country to be avoided while siting HPP, specifically those associated with dams.

5.3.3.1 *Summary Map*

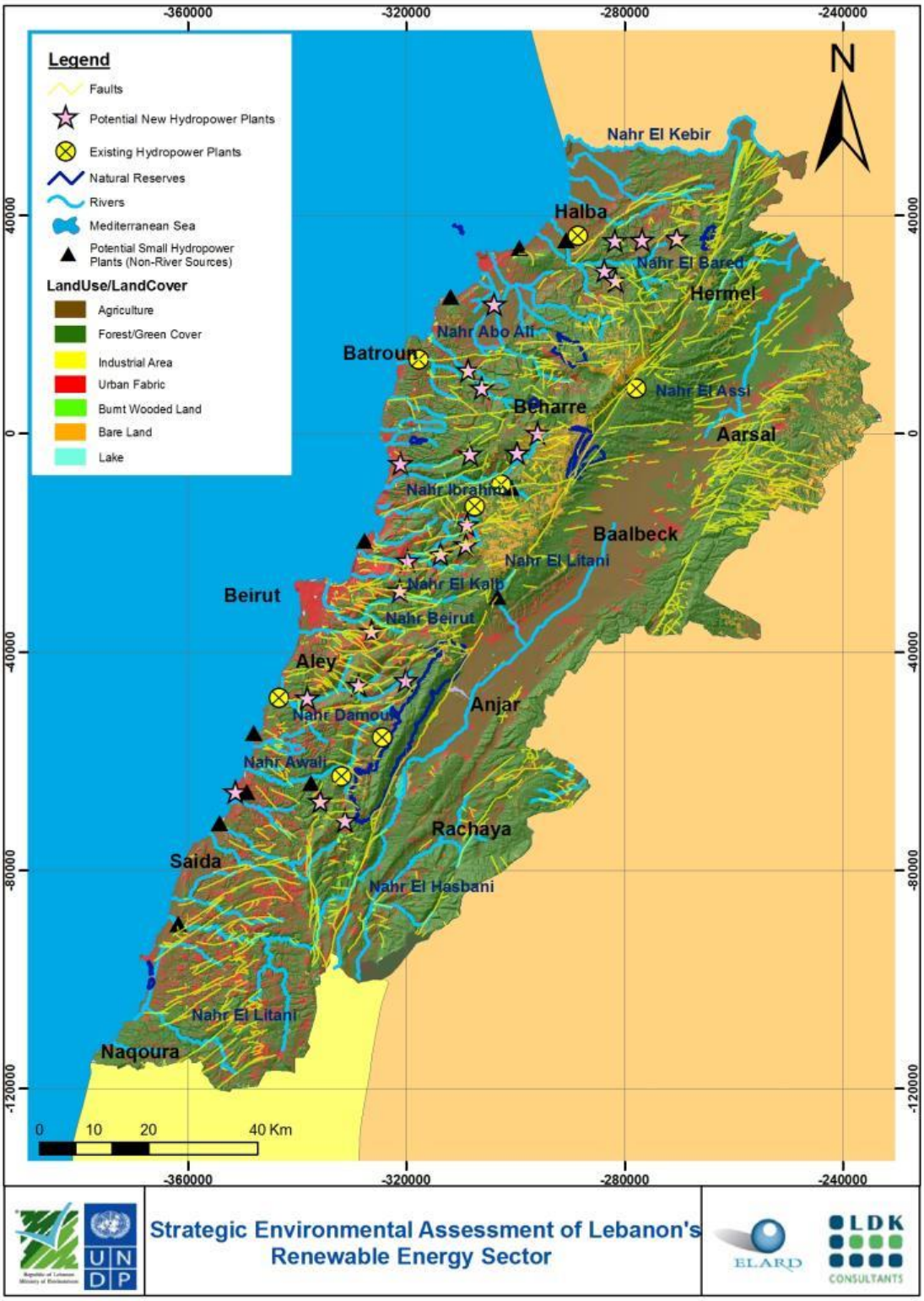


Figure 5-18 Existing and Suggested Hydropower Plants and Sensitive Ecological Sites

6 Public Consultation

An integral part of the SEA is stakeholders' consultation whereby stakeholders are informed about the project and its development at an early stage and are engaged throughout the process; stakeholders' values, concerns and interests are consequently built into the development of the RES.

In this context, two multi-stakeholder workshops were organized by the Consultant's team with the support of the UNDP and the MoE as part of the SEA study: 1) Scoping consultation workshop and 2) SEA Review workshop. The main objectives of the workshops are to engage stakeholders in the process through soliciting their views and suggestions and ensuring their involvement in the decision making process.

Both workshops were structured in a similar manner and included three parts: (1) frontal presentations, (2) participatory sessions structured into working groups, and (3) a plenary presentation of the working groups' outcomes.

Invitations to the workshops were sent to a wide range of stakeholders; around 135 parties were invited, including local and international organizations, academic institutions, research centers, governmental authorities, funding agencies, and the private sector.

The scoping consultation workshop took place on Wednesday, January 29, 2014 at the MoE's Green Conference Room with a total of 41 participants. The main goals of this first workshop were informing stakeholder about the project and work methodology, presenting the outcomes of the scoping phase, validating baseline findings, identifying potential concerns, and developing the SEA framework.

The SEA review workshop was held at the Gefinor Rotana Beirut Hotel on Friday October 24, 2014. The number of participants reached 35. The main goals of the second workshop were the validation of baseline maps and sensitive media per RE technology, the validation of the identified impacts and proposed mitigation measures, and discussion of the legal and institutional frameworks.

Discussions, outcomes, and results of the workshops were incorporated in the SEA report. The full workshop reports are included in Appendices 2 and 3.

7 SEA Framework of objectives, targets and indicators

This is a major milestone in the SEA process whereby specific objectives, targets and indicators are defined. Objectives can define a change in direction and can be formed from Government policy or from the interpretation of baseline study findings. Objectives usually define broad goals for development whereas targets are specific and define quantitative goals for each objective. Indicators are individual aspects of a target that through monitoring provide data for assessing whether an objective is being met.

The overall process is designed to provide a means of defining aspirational or specific development goals and for assessing whether they will be or are being achieved. The use of indicators has, for many years, been a well-established practice for mapping of the current situation and tracking the trends of key economic, demographic and social elements. The expansion of use in areas directly or indirectly related to the environment was thus a natural consequence, both due to the aggravation and severity of many environmental issues, and due to the increased gravity that the environmental dimension has obtained in policy and social growth control.

The Framework provided overall guidance and direction to assess RES options as well as the impacts of the adopted strategy, especially on areas of concern and key issues.

The preparation of the framework was largely guided by the results of the legal assessment, baseline studies and consultation with stakeholders.

The developed objectives, targets and indicators are presented in Table 7-1.

Table 7-1 SEA Framework

Sustainability Factors	Objectives	Targets/ Sub-objectives	Indicator	Description
Ecosystem Protection (Air)	Control air pollutant levels	Reduce SO_2 emissions	Sulphur dioxide emissions per capita	*kg SO_2/person; Target: 0* Sulfur dioxide (SO_2) is the major cause of acid rain, which degrades trees, crops, water, and soil. SO_2 can also form hazardous aerosols under certain atmospheric conditions. Sulfur dioxide (SO_2) deposition has detrimental impacts on aquatic and terrestrial ecosystems, and it is also harmful to human health. SO_2 is produced by the energy sector, industry, transportation, domestic and Agricultural Waste Burning (AWB).
		Prevent acidic deposition	Acidification exceedances from anthropogenic sulphur deposition	*Percentage of total land area at risk of acidification exceedances*. Target: 0 Exceedances of critical SO_2 loading represents an indicator for ecosystems under stress due to acidification from anthropogenic sulfur deposition.
		Reduce NOx emissions	Anthropogenic NOx emissions per populated land area (2)	*Tonnes/km²* Metric tonnes NOx emissions per populated land area (at 5 or more persons per square km) NO_2 is a harmful gas, even at relatively low concentrations. NO_x contribute to the formation of acidic species, which can be deposited by wet and dry processes. NO_x can also increase the formation of ozone at ground level when mixed with VOCs in the sunlight atmosphere.
Ecosystem Protection (Water)	Preserve water resources quantity and quality	Reduce water withdrawals	Change in water quantity	Area-weighted percent reduction of mean annual river flow from "natural" state owing to water withdrawals and reservoirs (%); *Target: 0* Water withdrawals and reservoir construction and management have negative impacts on river ecosystems, wetlands and floodplains, affecting the biodiversity of aquatic ecosystems. Water withdrawals and consumptive water use is estimated separately for the irrigation, livestock, household and industrial sectors.
		Prevent eutrophication	Water quality (Dissolved oxygen concentration) (3)	*Milligrams dissolved oxygen per litre water (mgDO/l) Target: national standards set* A measure of eutrophication, which has an important impact on the health of aquatic resources and ecosystems. High levels correspond to low eutrophication of surface water bodies
		Control salinity and metal concentrations in water	Water quality (Electrical conductivity) (3)	*Micro-Siemens per centimetre (µS/cm) Target: national standards set* A widely used bulk measure of metals concentration and salinity. High levels of conductivity correspond to high concentrations of metals.
		Prevent eutrophication	Water quality (Phosphorous concentration) (3)	*Milligrams phosphorus per litre water (mg/l) Target: national standards set* A measure of eutrophication, which affects aquatic resources health. High levels correspond to high levels of eutrophication.
		Control water turbidity	Water quality (Suspended solids) (3)	*Milligrams suspended solids per litre water (mg/l) Target: national standards set* A measure of water quality and turbidity.
		Ensure compliance of water quality with national standards	pH, nitrates, phosphate, cadmium, fecal coliforms (3)	*Existing national indicators Target: national standards set* Exceedance of national standards relating to water quality leads to adverse impacts on human health and aquatic ecosystems.
		Ensure water availability	Percentage of land under severe water stress (2)	*Percentage of national territory in which water consumption exceeds 40 percent of available water (%) Target: N/A* The regional distribution of water availability is relative to population and consumption needs and is as important as its overall water availability. This indicator captures the percent of the territory that is under water stress, which will affect the availability of water for environmental services and human well-being.
		Prevent contamination of water resources with pesticides	Pesticide consumption per hectare of arable land (2)	*Kilograms pesticide consumption per hectare of arable land* Excessive use of pesticides in agricultural activities has negative impacts on soil, water, humans health and wildlife
Biodiversity and habitats	Protect and preserve	Protect and preserve birds	Threatened bird species as percentage of known breeding	*Threatened bird species as percentage of known breeding bird species in each country Target: N/A*

Sustainability Factors	Objectives	Targets/ Sub-objectives	Indicator	Description
	biodiversity and habitats		bird species in the country (2)	The percent of breeding birds threatened gives an estimate of a country's success at preserving its biodiversity.
			Change in the number of migratory birds flying through the country	*Percentage change in the number of migratory birds flying through the country, compared to the relevant number of birds, before the RES works are operational* *Target: 0%* The change in the migratory birds count flying through the national corridors, gives an estimate of a country's success at preserving its biodiversity.
		Protect and preserve mammals	Threatened mammal species as percentage of known mammal species in the country (2)	*Threatened mammal species as percentage of known mammal species in each country* *Target: N/A* The percent of mammals threatened gives an estimate of a country's success at preserving its biodiversity.
		Preserve biomes	Terrestrial Protected Area (National Biome Weights) (6)	*Percentage of terrestrial biome area that is protected, weighted by domestic biome area* Target: 17% This indicator measures the degree to which a country achieves the target of protecting 17% of each terrestrial biome within its borders. How well protected areas are managed, the strength of the legal protections extended to them, and the actual outcomes on the ground, are all vital elements of a comprehensive assessment of effective conservation.
		Protect and preserve marine species	Marine Protected Areas (1)	*The percentage of each country's exclusive economic zone that is under protection by a marine protected area (MPA).* *Target:10%* Marine Protected Areas (MPAs) are an essential insurance policy for the future of both marine life and local people. They safeguard the ocean's rich diversity of life and provide safe havens for endangered species, as well as commercial fish populations. Well-designed networks of ecologically representative MPAs can also allow better security against environmental change, such as global warming.
		Protect and preserve animal terrestrial species	Trends in abundance & distribution of selected species (3)	*Proposed national indicator* *Target: national target set* To be monitored by the National Centre for Marine Science (MoE)
		Protect and preserve endangered species	Critical habitat protection (1)	*Percentage of the total Alliance for Zero Extinction (AZE) site area that is within protected areas* *Target:100%* This indicator aims at assigning countries responsibility for the protection of endangered species found at Alliance for Zero Extinction (AZE) sites within their borders. The Alliance for Zero extinction is a joint initiative of 52 biodiversity conservation organisations. It aims to prevent extinctions by identifying and safeguarding key sites selected as the remaining refuges of one or more Endangered or Critically Endangered species.
Forests	Preserve forests	Prevent forest loss	Change in forest cover (6)	*Change in forest cover from 2000-2012(%)* *Target: 0%* This indicator represents the change in forest cover between 2000 and 2012, in areas with greater than 50% tree coverage, owing to deforestation from either human or natural causes, reforestation and afforestation. Forest cover loss is a measure that reflects the decline of forest biodiversity, forest ecosystem services, and forest carbon emissions within a country.
Fisheries	Preserve fisheries	Prevent overexploitation of fisheries	Fish stocks overexploited or collapsed (6)	*Percentage of fish stocks by species that are overexploited or collapsed by an exclusive economic zone.* *Target 0%* This indicator is based on the concept of overfishing which occurs when fishing activity intensifies beyond a sustainable level, and the harvest of a species has reduced that species' capacity to replace its population through reproduction and growth. Fisheries can be categorized into one of several stages of development—developing, exploited, overfished, collapsed and rebuilding—based on a time series of fisheries landings.
Climate change	Reduce the country's GHG emissions	Control CO_2 emissions from all sectors	CO_2 emissions per capita (1)	*kg CO_2 per person* *Target: 1.262* Ratio of the country's CO_2 emissions over total population. Carbon dioxide emissions contribute to climate change. This indicator is used in order to assess the relative carbon efficiency of economies in these three aspects.
			Trend in Carbon Intensity (6)	*Change in CO_2 emissions per unit GDP from 1999 to 2010* *Target: 0.0781* CO2 per unit GDP is a common metric employed in countries to assess the intensity in the output of carbon dioxide emissions. This indicator measures countries' abilities to reduce the intensity of carbon emissions per unit GDP from 2000

Sustainability Factors	Objectives	Targets/ Sub-objectives	Indicator	Description
				to 2010.
		Control CO_2 emissions from electricity generation	Trend in CO_2 emissions per kWh (6)	*Change in Carbon Dioxide Emissions from electricity and heating production (gCO_2 /kWh) Target 0.06* Carbon dioxide emissions per kilowatt hour represents the ratio of CO_2 emissions to the electricity generated by thermal power plants , including conventional electricity plants and combined heat and power, as well as production by nuclear, hydro (exclusion pumped storage production), waste, geothermal and other renewable sources.
		Promote the adoption of renewable energy sources for electricity generation	Renewable electricity (1)	*Renewable electricity production as a percentage of total electricity production (%) Target: 100* This indicator measures renewable electricity production as a percentage of total electricity production. Because the energy sector contributes the largest anthropogenic share of GHG emissions globally, the percent of all energy that comes from renewable sources indicates each country's performance in this critical sector. Emissions from thermal power plants also comprise NOx, SOx and PM that have adverse impacts on human health and the environment.
			RE installed capacity (5)	*Unit: MW of RES developments Target: N/A* This indicator measures the growth of installed capacity of developments of Renewable Energy Sources utilization for energy production, against set targets. Installed capacity increase is used for assessing the RES policy effectiveness, based on reference to previous years' installed capacity.
Soil	Protect wildlife through preserving land	Preserve wild land and inland waters	Percentage of land having very low anthropogenic impact (2)	*Percentage of total land area (including inland waters) having very low anthropogenic impact (%)* The percentage of a country's land area that has low anthropogenic impact is a measure of the degree to which wild lands, which are important for biodiversity conservation, still exist in that country. The indicator measures anthropogenic impact of land and inland waters based on human land uses, human access from roads, railways or major rivers, electrical infrastructure, and population density.
			Percentage of land having very high anthropogenic impact (2)	*Percentage of total land area (including inland waters) having very high anthropogenic impact (%) Target : 0%* The percentage of a country's land area that has high anthropogenic impact is a measure of the degree to which a country's land area is dominated by high intensity land-uses. The indicator measures anthropogenic impact of land and inland waters based on human land uses, human access from roads, railways or major rivers, electrical infrastructure, and population density.
Human health (Air)	Protect human health	Reduce ambient $PM_{2.5}$ levels	Average exposure to $PM_{2.5}$ (6)	*Average Population-weighted exposure to $PM_{2.5}$ in micro-grams per cubic meter Target: 10 µg/m³* Fine suspended particulates contribute to acute lower respiratory tract infections and other diseases such as cardiovascular diseases and cancer. Annual average concentrations of greater than 10 micro-grams $PM_{2.5}$ per cubic meter are known to be injurious to human health.
Human health (Water)		Prevent the occurrence of waterborne illnesses	Access to drinking water (6)	*Percentage of population with access to improved drinking water source (%) Target: 100%* Access to drinking water is an indicator that seeks to measure water quantities as a percentage of a country's population with access to an improved source of drinking water. An improved drinking water source is defined as piped water into dwelling, plot or yard; public tab/standpipe; rainwater collection, etc.
Population change	Reduce population pressure	Keep records of population growth	Percentage change in projected population 2004-2050 (2)	*Percentage change in projected population 2004-2050* The projected change in population between 2004 and 2050 provides an indication of the trajectory of population change, which has an impact on a country's per capita natural resource availability and environmental conditions.
Intermodal environmental parameters (Reducing Waste & Consumption Pressures)	Ensure sustainable development of the population	Control the generation of hazardous waste	Generation of hazardous waste (2)	*Metric tons of hazardous waste to be managed in the country Target: N/A* Most countries in the world are confronting real difficulties in safely disposing of their hazardous wastes. The more hazardous waste generated, the less likely that a long-term sustainable solution can be found for their proper disposal.
		Promote waste recycling	Waste recycling rates (2)	*Percentage of solid waste recycled* in the country *Target: N/A* Waste recycling reduces the impact on the environment by using resources more efficiently and by reducing the stream of waste for landfilling and incineration.
		Reduce citizens' ecological footprint	Ecological Footprint per capita	*Hectares of biologically productive land required per capita Target: N/A*

Sustainability Factors	Objectives	Targets/ Sub-objectives	Indicator	Description
			(2)	*The ecological footprint is a measure of the biologically productive land that is required to sustain a country's population at current consumption levels. Countries whose footprints exceed their own arable land area are consuming at levels that are unsustainable in the long term.*
Intermodal environmental parameters (Eco-efficiency)		Promote energy efficiency	Energy efficiency (2)	*Terajoules energy consumption per million dollars GDP (PPP)* *Target: N/A* The more efficient an economy is, the less energy it needs to produce a given set of goods and services.
Intermodal environmental parameters (Exposure to Natural Disasters)		Control population exposure and vulnerability to natural hazards	Environmental Hazard Exposure Index (2)	*Population-weighted exposure to high levels of environmentally-related natural hazards.* *Target: N/A* Vulnerability to natural disasters is a function of the exposure to hazards (how often and how severe they are), the sensitivity to such hazards (how big the linkages are to social systems), and the resilience within a society to hazard impacts. This measure provides a useful proxy of the exposure term.
Transboundary Environmental Pressures	Reduce Transboundary Environmental Pressures	Reduce the import of polluting goods and raw materials	Import of polluting goods and raw materials as a percentage of total imports of goods and services (2)	*Import of polluting goods and raw materials as a percentage of total imports of goods and services.* *Target: N/A* Countries that import a large volume of commodities that are associated with negative environmental externalities at the point of extraction or processing may not be pursuing an environmentally sustainable path because of the likelihood that their actions are contributing to damage abroad.
Environmental Governance	Promote environmental sustainability	Promote effective environmental governance at the local level	World Economic Forum Survey on environmental governance (2)	*Effective governance is vital for environmental sustainability.* *Target: N/A* This indicator represents principal components of survey questions addressing several aspects of environmental governance: air pollution regulations, chemical waste regulations, clarity and stability of regulations, flexibility of regulations, environmental regulatory innovation, leadership in environmental policy, consistency of regulation enforcement, environmental regulatory stringency, toxic waste disposal regulations, and water pollution regulations.
Economy	Promote sustainable economic development	Promote the use of public transportation and the development of clean fuels	Ratio of gasoline price to world average (2)	*Ratio of gasoline price to world average price* *Target: N/A* Unsubsidized gasoline prices are an indicator that appropriate price signals are being sent and that environmental externalities have been internalized. High taxes on gasoline act as an incentive for public transportation use and development of alternative fuels.
		Promote employment	Employment rate (4)	*Employment rate out of the total labor force (%)* *Target: N/A* Employment reduces poverty and subsequently reduces pressure on natural resources.
		Promote sustainable pricing of RE technologies growth	Cost of RE generation per unit of RE projects' installed capacity (5)	*USD/MW* *Target: N/A* *This is a simple indicator, with very low data requirements.* *Comparison with previous years facilitates assessment.*
		Promote sustainable pricing of RE use	Cost of RE generation per unit of generation (5)	*USD/MWh* *Target: N/A* *This is a simple indicator, with very low data requirements. It is used for assessing a RE policy efficiency, taking into account project's operational costs. Comparison with previous years facilitates assessment.*
			Total Costs (%)	*USD* *Target: N/A* *Compares full cost of premium payments (measured as a percentage of the total wholesale value of generation) with the amount of additional electricity generation that they incentivize (as a percentage of total generation per annum)* *Highlights burden of support costs where policies lead to rapid growth in RE technologies deployment.*
Landscapes	Preserve landscapes	Prevent developments at the expense of scenic views	Number of conspicuous developments already impacting upon sensitive landscapes, vulnerable landscapes and listed highly scenic views, scenic views, scenic view points or routes (4)	*Number of conspicuous developments already impacting upon sensitive landscapes, vulnerable landscapes and listed highly scenic views, scenic views, scenic view points or routes* *Target: 0*

Sources:

1. Evaluating Renewable Energy Policy: A Review of criteria and indicators for assessment, IRENA, UKERC, January 2014
2. 2014 Environmental Performance Index (2014 EPI) Yale Center for Environmental Law and Policy (YCELP), Yale University and Center for International Earth Science Information Network (CIESIN), Columbia University
3. 2012 Environmental Performance Index (2012 EPI) Yale Center for Environmental Law and Policy (YCELP), Yale University and Center for International Earth Science Information Network (CIESIN), Columbia University
4. Strategic Environmental Assessment of the Draft Renewable Energy Strategy for County Mayo, Mayo County Council, Comhairle Countae Mhaigh EO, December 2010
5. 2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship, Yale Center for Environmental Law and Policy, Yale University, Center for International Earth Science Information Network (CIESIN), Columbia University
6. ENPI towards SEIS, LEBANON COUNTRY REPORT

8 Analysis of Alternatives

Developing and comparing alternatives is a key element of the SEA and allows decision-makers to determine how to achieve the strategic actions' objectives at the lowest (social/environmental/economic) cost and greatest benefit. It basically asks "*is this the best strategic action that we can get?*".

8.1 The SEA Alternatives

The alternatives assessed as part of the SEA are the Scenario C1 Medium Demand Case and the BAU scenario. The rationale behind the selection of these alternatives for the analysis are as follows:

- These alternatives are derived from the baseline strategic document (CCCU study) that correspond to actual variable RE sources mix cases;
- The BAU scenario corresponds to the "No Action" alternative which assumes that the electricity supply will remain at the current levels until 2020 and no new generation capacity from Thermal Power Plants (TPPs) or RE sources are added to the system;
- Scenario C1 meets the MoEW 2010 Policy Paper for the Electricity 12% RE target;
- The three demand scenarios of C1 differed with respect to the variability of demand growth, which is a parameter that cannot be influenced and changed on the grounds of this study. Therefore, for this assessment, one of the three demand scenarios was selected which is considered to be the most realistic / credible and at the same time incorporating mature technologies and cost effectiveness: the **Medium Demand Case of Scenario C1.** Specific reasons for selecting this scenario were:
    - It reflects a reasonable average annual electricity demand growth. Even if the derived electricity production in 2020 in this scenario is probably slightly optimistic, it corresponds to the coverage of the entire electricity demand and encompasses large scale RES deployment
    - This scenario reflects deployment of mature RES technologies for which potential has been assessed to a certain level. Particulalry for hydropower, there is significant experience in the country and projections are based on recent estimates and a detailed study completed by CEDRO.
- Scenario C1 reflects the elaboration of three technologies that will most likely be the ones to be deployed at large scale until 2020, taking into account the fact that the LCOE of other options such as CSP is significantly higher, and that other RE sources are still immature and under study in Lebanon (geothermal, bioenergy, tidal energy, offshore wind energy, etc.); and
- Scenario C1 reflects different energy mixes which correspond to maximum possible deployment of small hydropower plants and moderate to high wind and solar penetration, therefore allowing a comprehensive coverage of environmental impacts and mitigation strategies for these technologies.

Based on the above, it is considered that Scenario C1 Medium Demand Case reflects different RE-mixes, which though could have been derived through an alternative assumption base,

corresponds to the most probable implementation case and consequently presents a very adequate baseline for the environmental impact and mitigation analysis.

Table 7-1 presents a summary of the alternatives in terms of assumptions, annual increase in demand, and electricity production. Details for each alternative considered can be found in Appendix 1.

Sections 7.2 and 7.3 below present a comparative analysis between the two scenarios based on environmental and socio-economic factors, as well as costs and benefits.

Table 8-1 SEA Alternatives

Alternative	Assumptions	Annual Increase in Demand	Technology Mixes	RE Shares	Electricity Production
Business As Usual (BAU)	Electricity supply will remain at the current levels until 2020 and no new generation capacity from TPPs or RE sources are added to the system	Stable at current level	**TPPs**: Existing plants; and **HPPs**: Existing plants.	**HPPs:** 2.93% **Wind**: 0% **Solar PV**: 0%	17,600 GWh/y
Scenario C1 Medium Demand	Installed capacity of 4000 MW in 2020 and capacity factor of 85%	6.5%	**TPPs**: Existing plants, plus 2173 MW of new CCGTs; **HPPs**: Rehabilitated existing plants, plus 347 MW of new HPPs on peak demand; **Wind**: 219 MW at high potential sites with capacity factor 42% and 38%; and **Solar**: 604 MW at high potential sites with capacity factor 20% and 21%.	**HPPs**: 5.80% **Wind**: 2.57% **Solar PV**: 3.63%	29,800 GWh/y

8.2 Environmental and Socio-Economic Analysis

The two alternatives were assessed against the various sustainability factors for their environmental and socio-economic impacts, as well as for their contribution towards achieving the relevant environmental objectives. Their consistency and compatibility with national policies, the legislative and institutional framework has also been considered. These sustainability factors were developed as part of the SEA Framework (section 6) and some were merged together during the AoA exercise to avoid repetitions.

In undertaking an assessment of the alternatives, it is important to firstly highlight how the RES can evolve in relation to the SEA. In some instances where plans are subject to an SEA, the plan being assessed may already exist in a preferred format with agreed objectives and policies based on the previous selection of the preferred option. In this situation, there is plenty of opportunity for the SEA to influence the overall direction of the Strategy, as it is being developed in parallel with the RES, providing a good mechanism for mitigating any potential significant adverse effects on the environment.

The two alternatives were rated based on the scoring scheme presented in Table 3-2. As the outcome of this scoring exercise, the "Most Preferred Alternative" emerges as the alternative getting the highest score.

The alternatives analysis and scoring are presented in Table 8-2. As shown in the table, the "Scenario C1- Medium Demand" scored significantly higher than the "BAU Scenario". Thus, there is a clear need for the RES to be implemented in terms of environmental and socio-economic factors, and "no action" is not recommended.

Table 8-2 Analysis and Scoring of Alternatives Against SEA Framework

Objectives	Explanations / Sub-objectives	BAU Scenario	Scenario C1-Medium Demand	Justification/Reasoning
Control air pollutant levels (reduce SO_2 emissions, NOx emissions, PM etc.)		-4	+2	Despite the use of RES for the different scenarios, generating minimal air emissions (HPPs), air pollution levels are different for each case, due to the different installed capacity of new thermal plants.
Preserve water resources quantity and quality	Ensure water availability (land under water stress)	0	-1	Water re-direction occurs at downstream areas of HPPs, which causes local water scarcity. However, water flooding occurs at areas upstream of the reservoirs. Water availability may be reduced due to the withholding of water at reservoirs and HPPs.
	Preserve water resources quality (Prevent eutrophication, control salinity, turbidity)	-1	-1	Water quality may be reduced at HPP reservoirs or downstream of the dams. Eutrophication can occur.
Protect and preserve biodiversity and habitats (birds, mammals, biomes, marine species, animal terrestrial species, endangered species)		-1	-2	Biodiversity is affected downstream of the hydroplants due to the shortage of water availability. Additionally, fish and other species can be affected from the hydroplant's turbines. For the case of wind farms, impacts on birds' populations or flying routes are common. For the case of high solar energy scenarios, impacts on birds and habitats are considered.
Preserve forests (prevent deforestation)		0	-3	Deforestation can be avoided if the right planning is made, however it can occur in order for the new hydro, wind and solar plants to be installed. For the case of the high solar energy production scenarios, the negative impacts on land use are critical, as impacts from the new hydroplants and wind parks are similar.

Objectives	Explanations / Sub-objectives	BAU Scenario	Scenario C1-Medium Demand	Justification/Reasoning
Preserve fisheries		0	-1	Fisheries are only likely to be affected at rivers serving hydropower plants, therefore are considered similar for all C1 scenarios which involve the installation of more hydroplants than the "No action" scenario.
Reduce the country's GHG emissions (Promote the adoption of renewable energy sources for electricity generation)		-6	4	As the "No action" scenario does not involve the installation of new RES, it gets the lowest score. However, the high demand scenario involving the highest installed capacity of RES, it also involves the highest installation of thermal plants, therefore cannot get the highest score of the four scenarios.
Protect wildlife through preserving land		-1	-2	Solar and wind power farms have high demands on land occupancy, which are critical factors for their scores. Hydroplants also have impacts on land uses and wildlife protection, however, their planned capacity in the three C1 scenarios is similar.
Protect human health		-4	2	Human health is protected indirectly by the reduction of air pollution generated from the thermal power plants.
Reduce population pressure (growth rate)		0	0	None of the alternative scenarios is connected to negative effects on population growth.
Ensure sustainable development of the population (reduce citizens eco-footprint)		-2	5	The sustainable development of the population is enhanced by the use of RE in their lives, the increase of energy efficiency and the reduction of their eco-footprint. Additionally energy supply is secured in all three C1 scenarios, increasing quality of life and sustainable development.
Reduce Transboundary Environmental Pressures (Reduce the import of polluting goods and raw materials)		-6	-2	Energy supply shortages are addressed by the import of fossil fuel from other countries. Energy supply is secured in all three C1 scenarios. Import of other goods and materials, is related with the import of components, parts and materials mainly related to solar panels, wind turbines and maintenance consumables. Their polluting effect is not considered major.

Objectives	Explanations / Sub-objectives	BAU Scenario	Scenario C1-Medium Demand	Justification/Reasoning
Promote environmental sustainability		0	2	Environmental sustainability is promoted by the penetration of RES in the energy generation/supply field. All the C1 scenarios have the same level of RES supply.
Promote sustainable economic development	Promote the use of public transportation and the development of clean fuel	-4	3	High taxes on gasoline, when there are no other energy sources, act as an incentive for public transportation use and the development of alternative fuels. However, despite the highest generation of RE under the high demand scenario, there is still a high electricity generation from thermal plants, therefore its score is not the highest.
	Promote employment	1	4	More employment places are generated by the growth of electricity supply levels, relevant investments and works.
	Promote sustainable pricing of RE use	-2	2	According to the CBA performed the low and high demand scenarios can be more beneficial given the right certain circumstances.
Preserve landscapes		-2	-2	Wind farms and solar panels are mainly connected to aesthetic degradation issues, therefore the lowest scores are given to the alternatives involving the highest installation of those RES.
Consistency and compatibility with public policies, legislative and institutional frameworks		0	2	All C1 alternatives are compatible with national legislation and policies.
FINAL SCORE		**-32**	**12**	

8.3 Cost-Benefit Analysis

The CBA of the two alternatives is based on the main inputs and methodology incorporated within the CCCU study and focuses on the Medium Demand Case of Scenario C1. The assumptions considered within the calculations are as follows:

Tariff	14 US-cent/kWh (BAU scenario: 9.6 US-cent/kWh)
Levelised cost of electricity (LCOE)	Based on various estimates taking into account CAPEX , grid connection costs, OPEX; discount rate: 7-12%[21]
RES Financing Mechanism	Feed-in-Tariff (FiT)
FIT level	LCOE of each technology
Losses from TPP	Tariff - LCOE
Losses for RE	Tariff – FiT
Sites for wind and PV	High potential sites selected
Fuel for new TPPs	Heavy Fuel Oil
Value of Lost Load	700 USD/MWh (Policy Paper for the Electricity Sector; 2010)
BAU scenario	The entire amount of baseline electricity (17,218 GWh/y) is produced by the TPP and HPP in place.

The range of LCOE used in the analysis which have been either calculated on a project basis (TPPs, HPPs, new hydro), or estimated on the basis of potential studies and international sources of information, are graphically presented in Figure 8-1.

Table 8-3 presents the main results per technology and specific sites level, showing the results form re-calculations regarding total costs of generation, on the basis of the assumed LCOE, as well as final costs to the government and the economy and net benefits from the incorporation of the RES.

[21] ***Note:*** *In practice it is expected that the actual LCOE of projects will be higher than the figures mentioned in this document, which have been derived on the basis of expected rates of return at a level of 7-12% thus matching international levels. However in Lebanon, due to particular inherent financial, political and other risks, investors anticipated rates of return are expected to be higher (by approximately 25%) than the above mentioned conservative estimates. This applies particularly to projects that will be developed through tendering.*

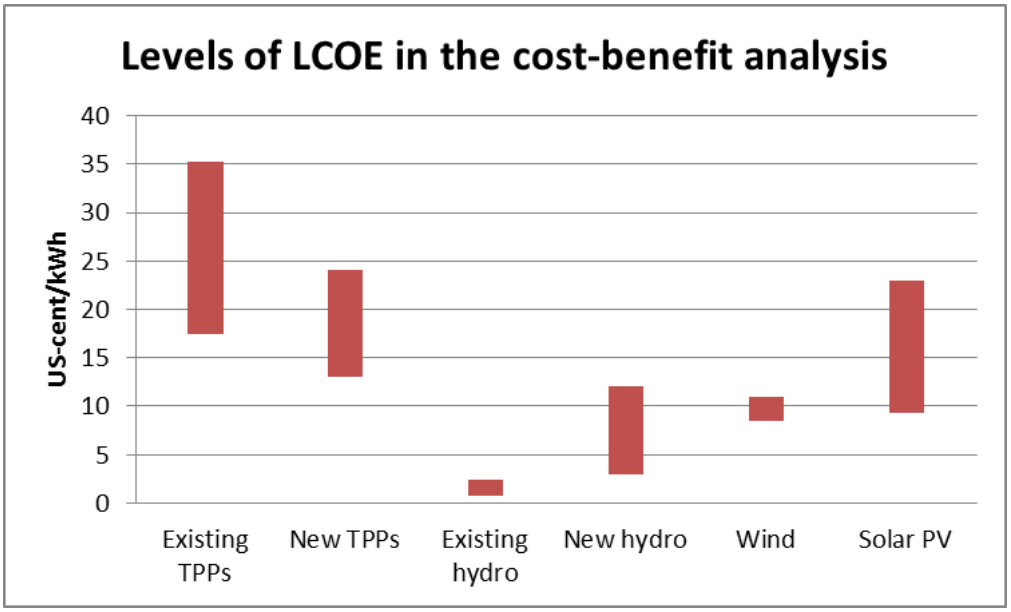


Figure 8-1 LCOE per Technology Used in the CCCU Study

Table 8-3 Total Cost to the Economy of the Alternatives (USD/Year)

	C1 Medium Demand	BAU
TPPs[22]	2,100,099,376	2,405,412,169
RES	-171,795,793	-37,040,000
of which FITs	19,812,939	
Cost of energy not supplied		8,825,897,116
TOTAL	**1,928,303,583**	**11,194,269,285**

The following conclusions can be drawn from the above analysis:

- The BAU scenario results in substantially higher costs to the economy primarily due to the increased cost of energy not supplied. *The level of Value of Lost Load (VOLL) is not justified for the case of Lebanon, but considered to lie within realistic levels on the basis of similar international references* ;
- The trend of increased RES costs in Scenario C1 is due to the lower share of PVs which has a higher LCOE compared to other RE technologies;
- In the case that natural gas is used instead of HFO in the new TPPs, costs will be substantially lower; and

[22] **Note:** mean costs to the economy are based on calculations on the grounds of difference between LCOE and assumed tarrifs, whereas relevant figures presented in the CCCU study are slightly lower, and are attributed to data forecasts from the Ministry of Finance

- It is clear that from the perspective of costs to the economy, Scenario C1 is the preferred option and will result in substantial cost savings.

The graph below illustrates the fluctuation of the total costs to the economy (and the Government for BAU), with the variation of the assumed tariff. This schematic illustration gives a generic overview of the average LCOE associated with the overall energy mix in each scenario. It also indicates that raising the current electricity tariffs to cover part of the costs needed for meeting increased electricity demand within the coming years, is essential to reduce the risk of extreme costs to the Government.

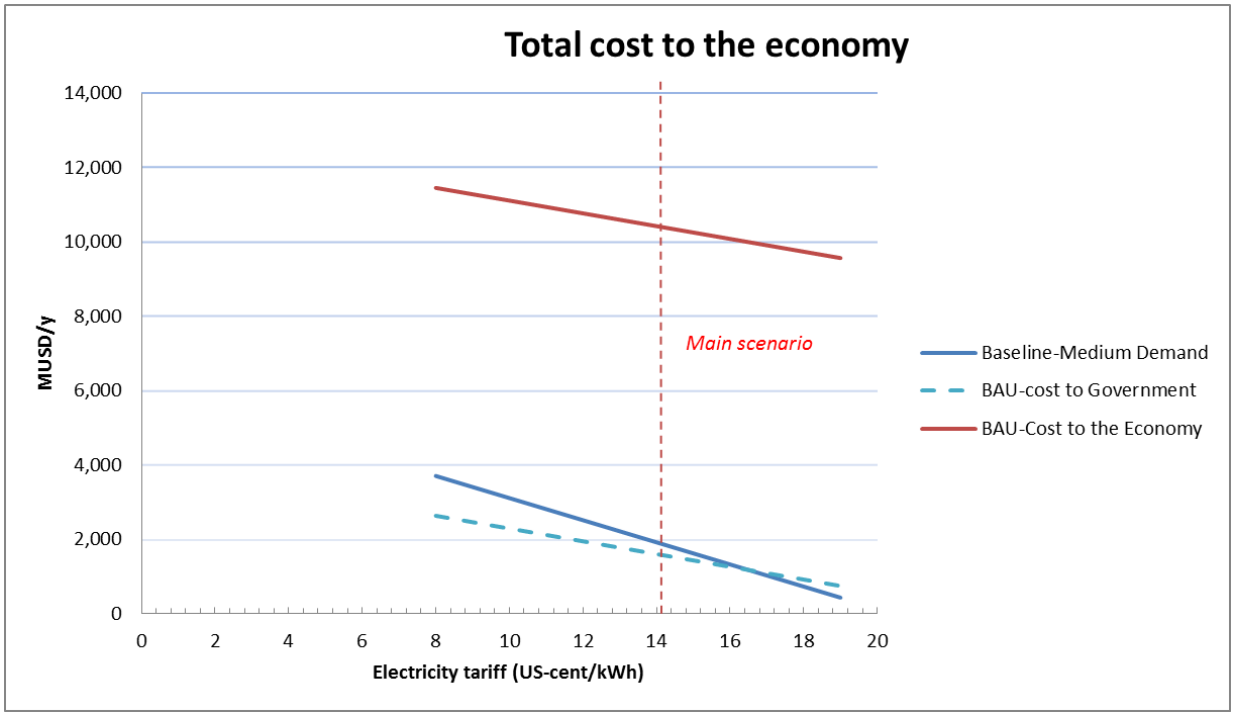


Figure 8-2 Total Cost to the Economy of the Alternatives

Note: the dashed line represents only the cost to Government part of the BAU scenario.

The above analysis shows that C1 Scenario - Medium Demand Case has the lowest costs to the economy; since these two scenarios reflect non equal electricity generation. A more credible indicator to be used in that respect would be the specific cost for each GWh of electricity produced; which was calculated and presented in Table 8-4. In this context, the C1 Scenario shows 73% lower costs to the economy if accounted on specific electricity generation costs.

Table 8-4 Specific Cost of Electricity Produced/Unit

	C1 Medium Demand	BAU
Specific Cost of Electricity Produced (USD/GWh)	64,740	375,833

It is important to mention that Scenario C1 is based on the exploitation of the sites showing the highest resource potential. In practice, the development of RE and particularly wind and PV will be allocated to a wider spectrum of locations that will include also sites with lower RE potential as a result of various technical, financial and other constraints.

A key obstacle that can be highlighted in that respect is proximity to current electricity HV networks of the country. Figure 8-3 below, illustrates the electricity grid along with sites of high RE potential for all three technologies.

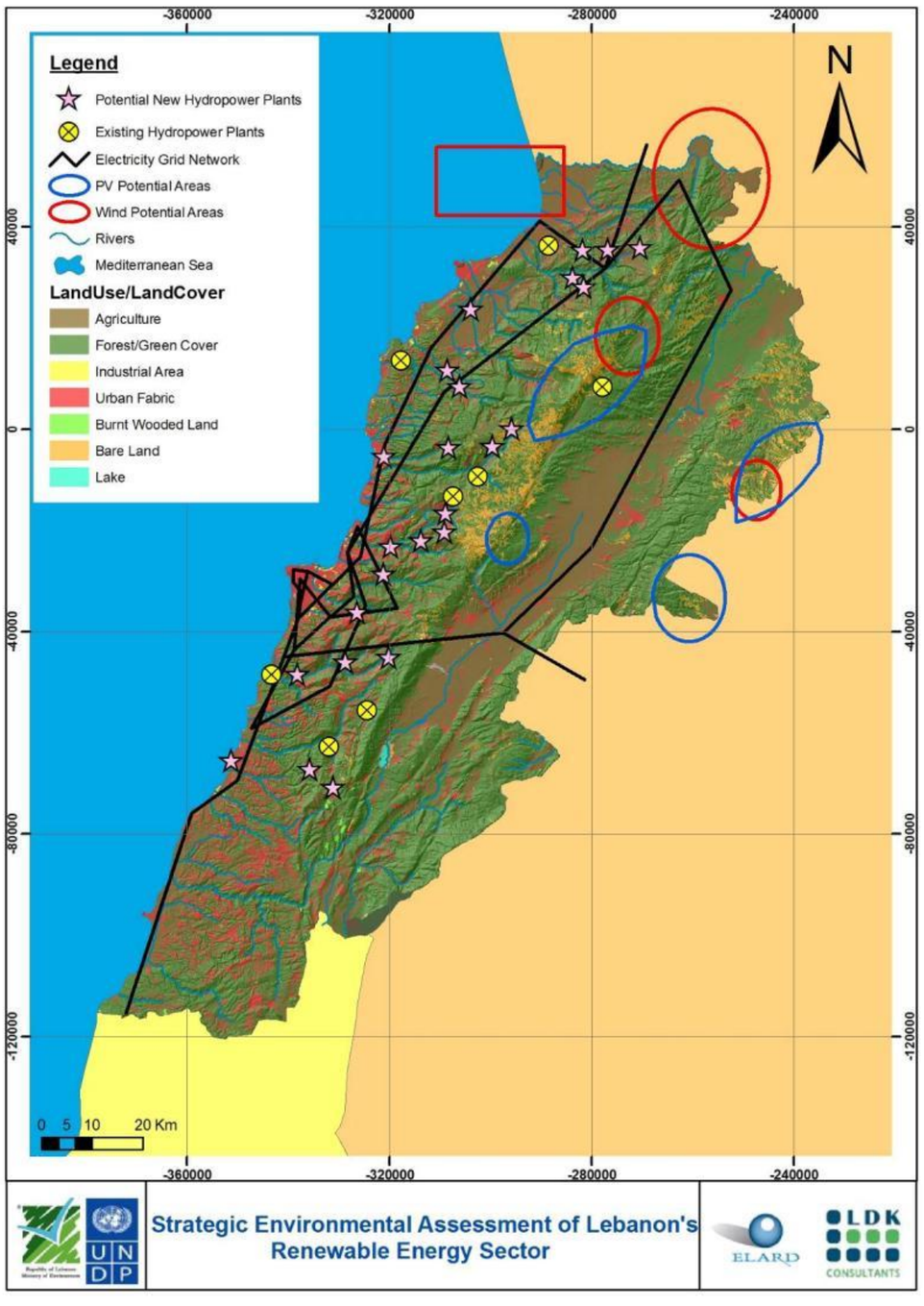
Large distance from the transmission grid will imply high interconnection costs, and therefore may seriously hamper the actual development of projects at these locations. This applies to high capacity wind and large PV installations, especially at the Eastern areas of the country, both of which cannot be connected to the local MV grids.

Of course, the level of risk and implication of this parameter has to be quantified on a case by case basis.

For indicative purposes, Table 8-5 below shows average costs for the connection of medium to large scale RE installations to the HV grid.

Table 8-5 Average Cost of Connection of Medium to Large Scale RE to HV Grid

Case	Example	Substation Costs	Connection Line	Connection Costs
Connection with HV line	Large scale wind farm at large distance from HV grid	ca. 60,000 USD/MW	HV (150 kV)	Ca. 200,000 USD/km
Connection with MV line	Medium size PV farms, e.g. 1 MW, at short distance from MV grid	ca. 80,000 USD/MW	MV (20 kV)	Ca. 30,000 USD/km



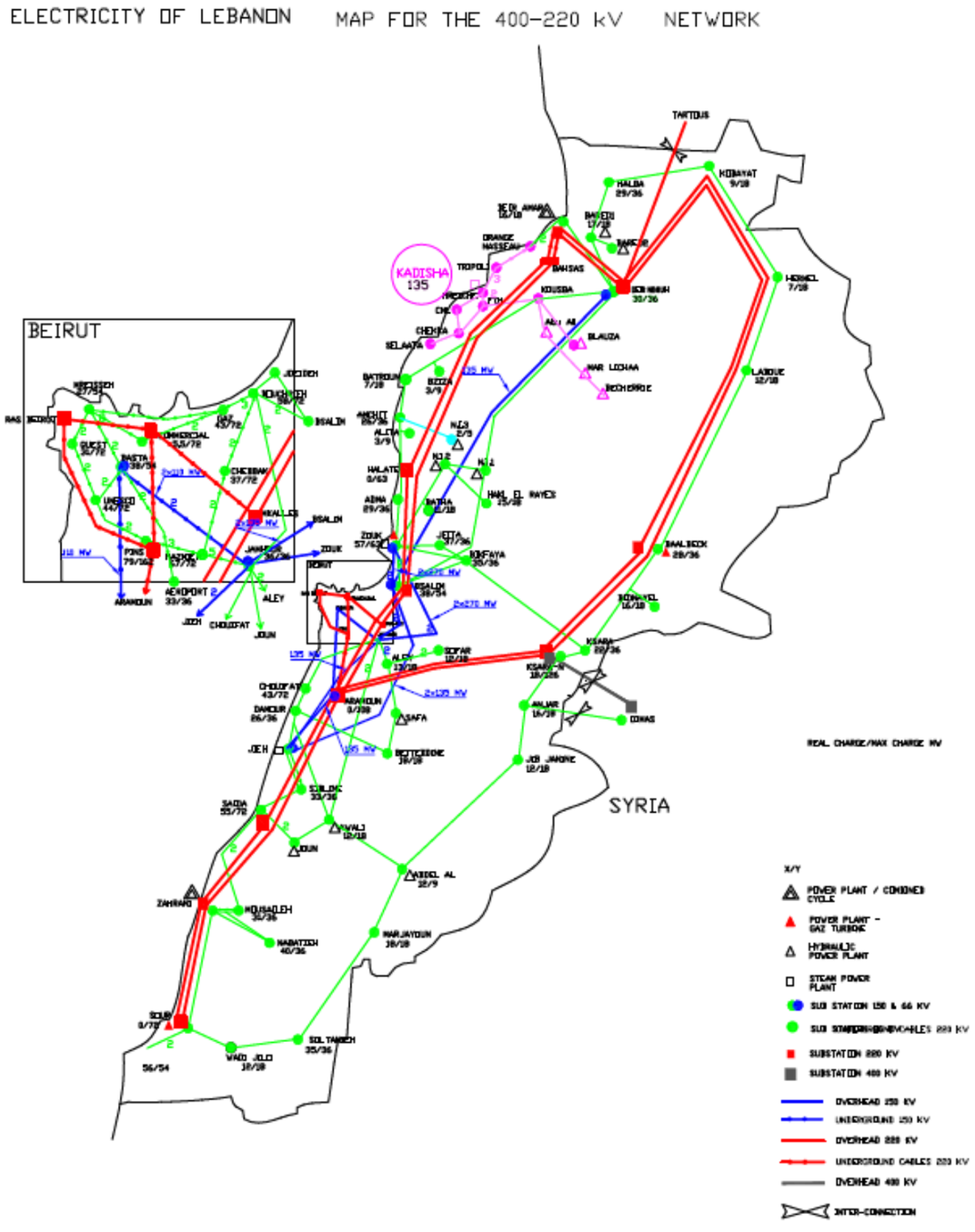


Figure 8-3 High RES Potential Areas and Electricity Grid

9 Environmental and Socio-Economic Impacts Assessment

Generation of electricity from renewable energy sources has the potential to reduce environmental and socio-economic impacts caused by the use of fossil fuels to generate electricity since, unlike fossil fuels, RE sources do not generate atmospheric contaminants or thermal pollution and weigh less on the energy bill, thus being attractive to many governments, organizations, and individuals. Nevertheless, RE facilities have adverse environmental and socio-economic impacts including aesthetic effects, impacts on ecosystems, including the killing of wildlife, especially birds and bats, change in land use, etc.

Following the analysis of alternatives, the "Medium Demand Case"[23] was identified as the most suitable strategic option when compared to the various environmental and socio-economic factors in Table 8-2. The major likely environmental and socio-economic impacts arising from the implementation of the selected alternative are assessed in the following sub-sections.

The impacts assessment process started with an identification of major adverse and positive impacts for each RE technology considered in the optimal mix and the development of an impact significance matrix where identified impacts are assessed *(refer to section 3.3.4)* against various environmental parameters. A brief definition of these parameters as used in this SEA's context is presented in Table 9-1.

Given that the optimal mix scenarios were based on different shares of each technology, a weight was given to each technology based on its share in the chosen alternative (C1 medium demand) – *excluding thermal power shares*. The combination of the three matrices with the respective weights for each technology resulted in an overall impact assessment and significance for the chosen alternative.

Impacts on cultural heritage are assessed as "neutral" since, as detailed in the Baseline Conditions section, no known heritage sites are found at a close distance from RE potential areas. Yet, a more detailed assessment needs to be conducted at the EIA stage.

Construction impacts are common to all electricity-generating facilities and construction activities in general; especially those arising from transportation (roads to and from the plant site) and transmission (roads or clearings for transmission lines) and are not presented in this report. Such impacts would be detailed in project specific EIAs.

The present analysis of environmental and socio-economic impacts sheds the light on major implications from the deployment of the various RE technologies included in the strategy. It does not replace the detailed EIA required for each RE development project given the complexity and differences between the various technologies used in energy generation from each RE source, and following siting and size determination of RE facilities.

[23] It is to be noted that Scenario C1 – medium demand case was selected given that it performed best in terms of scoring when compared against environmental and socio-economic factors in Table 8-11. This selection does not reflect the actual demand but an estimation of the demand,

Table 9-1 Definition of Parameters

Parameter	Definition
Biodiversity	Includes variable living organisms (fauna, flora…), species count, genetic differences among organisms, in addition to the communities and ecosystems in which these organisms live.
Soil	Soil refers to the upper layer of earth that may be dug or plowed and in which plants grow.
Water	Water refers to the various useful and potentially useful sources of water including surface and groundwater.
Air	The mixture of varying amounts of gases, moisture and particulate matter in the surrounding atmosphere.
Climatic factors	The factors affecting the general weather pattern (temperature, rainfall, and wind), of an area (microclimate).
Noise	Unpleasant, unexpected, undesired, or high levels of sounds that harm the activity or balance of human and animal life.
Infrastructure	The basic physical and organizational structures and facilities such as buildings, roads, and electricity infrastructure.
Human health	The state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity.
Economy / Income	The state of a region in terms of the production and consumption of goods and services and the supply of money.
Job creation	The process by which the number of jobs in an economy increases.
Quality of life	The general well-being of individuals and societies, in terms of development, healthcare, politics and employment.
Material assets	Tangible assets such as buildings, houses, machinery and land.
Cultural heritage	Legacy of physical artifacts such as buildings, archaeological sites, and monuments or natural heritage.
Landscape	The visible features of an area of land such as mountains, hills, water bodies, living elements of land cover, different forms of land use, buildings and structures.
Land use	Land use is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it.

9.1 Impacts Per Renewable Energy Technology

9.1.1 Wind Energy

The major potential impacts that could occur from the operation of wind farms as part of the RES are summarized in Table 9-2 while the assessment and significance rating are presented in Table 9-3.

The main impacts from wind energy deployment are impacts on biodiversity, especially flying animals (birds and bats), followed by visual (landscape, aesthetics, and flickering shadows), land use, and lastly noise. Yet, the overall scoring is a high positive number favoring the development of wind farms.

Table 9-2 Main Impacts from the Operation of Wind Farms

Barrier effect[24] and habitat loss	• Adverse impacts on avifauna and bats through the increase in the death rates from collisions with wind farm blades (Upper Akkar is the entry point of soaring birds); • Disturbance when birds' populations change their natural flyway path due to the installations; and • Loss or damage of habitat resulting from turbines and associated infrastructures.
Change in land use and land cover	• Destruction of existing vegetation and habitats; • Partial or total artificialisation of the site (roads, embankments, areas without vegetation, etc.); • Land expropriation issues.
Noise disturbance to nearby settlements and ecosystems	• The aerodynamic noise caused by the blades passing through the air; • The mechanical noise emitted from the mechanical elements of the nacelle, i.e., the generator, gearbox and other parts of the drive-train; • Faunal habitats could be affected by turbine noise.
Visual disturbance to nearby residents	• Visual obstruction to natural landscape can be considered as a negative impact, especially at the first levels of the technology infiltration in the country; • Aesthetic degradation, which is an effect based on subjective perspective of nearby settlements; • Shadow flicker caused when rotating wind turbine blades periodically cast shadows through constrained openings such as the windows of neighboring properties.
Light pollution	• Disturbance from the flaring light on the top of turbines.
Effects on climate and air quality	• Potential positive impacts to the concentration of atmospheric pollutants and GHGs, in particular SO_2, NO_x, PM_{10}, CO_2, mainly emitted by conventional energy production means, entailing a positive impact on human health, vegetation and material assets (i.e. from acidic deposition).
Economic effects	• Creation of a new market and new job opportunities, nearly one new job is created for three megawatts of installed capacity for operation and

[24] A barrier, by definition is a tangible (e.g., wind facility) or an intangible (e.g., radiation or infrasound) disturbance that restricts the free movement, mingling, or interbreeding of individuals or populations of a species.

	maintenance of wind farms; • Decrease/Increase in neighboring land values; • Creation of an innovative touristic attraction site; • Economic savings and reduction of the deficit in the national energy bill due to decreasing amounts of fossil fuels used; • Better electricity access and coverage, especially in rural remote areas.
By-products and wastes disposal	• Industrial and sanitary wastes like lubricating oils, hydraulic fluids, coolants, solvents, cleaning agents and sanitary wastewaters are all produced during operation of wind farms and could have adverse impacts if not properly handled and if released directly into the environment.

Table 9-3 Wind Energy Impacts Significance Matrix

Parameter	Type	Intensity	Duration	Reversibility	Extent	Origin	TOTAL
Biodiversity	NEG	MAJ	LOT	CUM	NAT	PRI	-12
Soil	NEG	NEG	SHT	TEMP	LOC	SEC	-3
Water	NEG	NEG	SHT	TEMP	LOC	SEC	-3
Air	POS	MAJ	LOT	CUM	NAT	SEC	12
Climatic factors	POS	MAJ	LOT	CUM	NAT	SEC	12
Noise	NEG	MIN	LOT	TEMP	LOC	PRI	-6
Infrastructure	POS	MAJ	LOT	PERM	NAT	PRI	11
Human health	POS	MAJ	LOT	CUM	NAT	SEC	12
Economy / Income	POS	MAJ	LOT	CUM	NAT	PRI	12
Job creation	POS	MAJ	LOT	PERM	REG	PRI	10
Quality of life	POS	MAJ	LOT	PERM	NAT	SEC	11
Material assets	NEG	MIN	MDT	PERM	LOC	PRI	-7
Cultural heritage	NEU	-	-	-	-	-	0
Landscape	NEG	MAJ	LOT	PERM	LOC	PRI	-10
Land use	NEG	MOD	LOT	PERM	LOC	PRI	-9
						TOTAL	**30**

9.1.2 Solar Photovoltaics

The major potential impacts that could occur from the operation of solar PV energy generating facilities as part of the RES are summarized in Table 9-4, while the assessment and significance rating are presented in Table 9-5.

The main impacts from solar PV deployment are related to land use from which derives impacts on landscape value, visual intrusions, material assets (mainly land expropriation), and the disposal of generated hazardous waste. Yet, the overall scoring is a high positive number favoring the development of PV energy facilities.

Table 9-4 Main Impacts from the Operation of Solar PV Facilities

Effects on biodiversity	♠ Habitat fragmentation due to the presence of the fenced solar energy facility, utility rights-of-way (ROWs), and access roads.
Change in land use and land cover	♠ Solar energy technology has the adverse impact of occupying a high spatial footprint (in comparison to other RE technologies) that will be obstructed for any other potential use (agriculture, recreation, other land uses / development). Properties would be converted from an agricultural setting to a setting of an energy vehicle production facility or other large industrial complex; ♠ Destruction of existing vegetation and habitats; ♠ Partial or total artificialisation of the site (roads, embankments, areas without vegetation, etc.); ♠ Land expropriation issues.
Visual disturbance to nearby residents	♠ Visual intrusion in case of large scale solar energy development projects would be highly visible in rural or natural landscapes and the disturbed area would continue to contrast with the natural form, line, color, and texture of the surrounding landscape. Visual evidence of a solar field cannot easily be avoided, reduced, or concealed, owing to its size and exposed location; ♠ Aesthetic degradation, which is an effect based on subjective perspective of nearby settlements.
Effects on climate and air quality	♠ Potential positive impacts to the concentration of atmospheric pollutants and GHGs, in particular SO_2, NO_x, PM_{10}, CO_2, mainly emitted by conventional energy production means, entailing a positive impact on human health, and vegetation.
Economic effects	♠ Creation of a new market and new job opportunities; ♠ Decrease/Increase in neighboring land values; ♠ Creation of an innovative touristic attraction site; ♠ Economic savings and reduction of the deficit in the national energy bill due to decreasing amounts of fossil fuels used; ♠ Better electricity access and coverage, especially in rural remote areas.
By-products and wastes disposal	♠ Wastes from PV operation: high-performance solar cells may contain small amounts of Cadmium telluride (CdTe), selenium, and arsenic, and are only hazardous if the solar cell is broken. Damaged cells would need to be characterized and managed as hazardous waste.

Table 9-5 Solar PV Impacts Significance Matrix

Parameter	Type	Intensity	Duration	Reversibility	Extent	Origin	TOTAL
Biodiversity	NEG	MIN	LOT	CUM	REG	PRI	-4
	POS	MIN	LOT	CUM	LOC	SEC	
Soil	NEG	NEG	SHT	TEMP	LOC	SEC	-3
Water	NEG	NEG	SHT	TEMP	LOC	SEC	-3
Air	POS	MAJ	LOT	CUM	NAT	SEC	12
Climatic factors	POS	MAJ	LOT	CUM	NAT	SEC	12
Noise	NEU	-	-	-	-		0
Infrastructure	POS	MAJ	LOT	PERM	NAT	PRI	11

Human health	POS	MAJ	LOT	CUM	NAT	SEC	12
Economy / Income	POS	MAJ	LOT	CUM	NAT	PRI	12
Job creation	POS	MAJ	LOT	PERM	REG	PRI	10
Quality of life	POS	MAJ	LOT	PERM	NAT	SEC	11
Material assets	NEG	MOD	LOT	PERM	LOC	PRI	-9
Cultural heritage	NEU	-	-	-	-	-	0
Landscape	NEG	MAJ	LOT	TEMP	LOC	PRI	-10
Land use	NEG	MOD	LOT	PERM	LOC	PRI	-8
						TOTAL	**43**

9.1.3 Hydropower

The major potential impacts that could occur from the operation of hydropower generating facilities as part of the RES are detailed in Table 9-6 while the assessment and significance rating are presented in Table 9-7.

The main adverse impacts are related to the construction and use of dams, which can greatly affect the flow of rivers (quantitatively and qualitatively), altering ecosystems and affecting the wildlife and populations who depend on those waters. Dams are also associated with resettlement needs and flooding risks (reflected in the negative impacts on quality of life and material assets in Table 9-7.

Table 9-6 Main Impacts from the Operation of Hydropower Plants

Effects on biodiversity	• Terrestrial biodiversity in the downstream areas of the riverbed and riversides may be adversely affected due to the potential withholding of water quantities upstream the dams, in reservoirs for use in power generation in peak demand times; • For the case of "Peak" hydro power plants, due to the fact that the downstream flow is expected to be limited and nutrients flow downstream will be reduced, the overall ecological conditions of the aquatic life could be adversely affected; • For the case of "Run of the River Mode" power plants, where little or no storage of water is provided downstream, the water flow is expected to be slightly smaller than the upstream flow and only for a short stretch of river, therefore, surface water quality and ecological conditions are not expected to be seriously affected; • Fish and other aquatic organisms can be injured and killed by turbine blades; • Changes in water quality due to lack of dissolved oxygen near the bottom of reservoirs can lead to death of aquatic life.
Change in land use and land cover	• Destruction of existing vegetation and habitats; • Partial or total artificialisation of the site (roads, embankments, areas without vegetation, etc.); • Land expropriation issues.
Visual aesthetics	• Visual aesthetics in case of hydropower facilities is a very subjective matter, some view it as an aesthetic improvement to the existing landscape.

Effects on climate and air quality	♠ Potential positive impacts to the concentration of atmospheric pollutants and GHGs, in particular in particular SO_2, NO_x, PM_{10}, CO_2, mainly emitted by conventional energy production means, entailing a positive impact on human health, vegetation and material assets.
Effects on water resources	♠ Adverse impacts could occur in case of river route diversions, especially when those are applied at significant lengths - diverting large amounts of river water reduces river flows, affecting water velocity, depth, temperature, and oxygen concentration; ♠ The presence of a reservoir will change the sediment transport in the river downstream and therefore induce a change on the river sediment balance; ♠ Water loss due to evaporation; and ♠ Risk of eutrophication in dams and reservoirs.
Effects on nearby settlements and infrastructure – *in case of dam construction as part of the hydropower plant*	♠ Conflicts and mismanagement of water shortages; ♠ Risk of flooding upstream the dam; ♠ Risk of flooding downstream the dam; ♠ Impacts due to sediment transport (blockage due to dams); ♠ Dam failure; ♠ Resettlement needs; ♠ Readily available water for irrigation.
Effects on downstream receptors in case of dam failure	♠ Flooding of downstream areas in case of dam failure leading to potential socio-economic and environmental losses
Economic effects	♠ Creation of job opportunities; ♠ Development of recreational and touristic activities; ♠ Economic savings and reduction of the deficit in the national energy bill due to decreasing amounts of fossil fuels used and the better operation of existing facilities; ♠ Better electricity access and coverage, especially in rural remote areas.
By-products and wastes disposal	♠ General industrial waste production from maintenance activities.

Table 9-7 Hydropower Impacts Significance Matrix

Parameter	Type	Intensity	Duration	Reversibility	Extent	Origin	TOTAL
Biodiversity	NEG	MOD	LOT	CUM	REG	PRI	-10
Soil	NEG	MAJ	LOT	PERM	REG	PRI	-10
Water	NEG	MAJ	LOT	PERM	NAT	PRI	-11
Air	POS	MAJ	LOT	CUM	NA	SEC	12
Climatic factors	POS	MAJ	LOT	CUM	NA	SEC	12
Noise	NEG	NEG	SHT	PERM	LOC	PRI	-4
Infrastructure	POS	MAJ	LOT	PERM	NAT	PRI	11
Human health	POS	MAJ	LOT	CUM	NAT	SEC	12
Economy / Income	POS	MAJ	LOT	CUM	NAT	PRI	12

Job creation	POS	MAJ	LOT	PERM	REG	PRI	10
Quality of life	POS	MAJ	LOT	PERM	NAT	SEC	6
	NEG	MOD	SHT	TEMP	LOC	SEC	
Material assets	NEG	MOD	LOT	PERM	REG	PRI	-9
Cultural heritage	NEU	-	-		-	-	0
Landscape	NEG	MAJ	LOT	PERM	LOC	PRI	-9
Land use	NEG	MAJ	LOT	PERM	REG	PRI	-9
						TOTAL	**13**

9.2 Scenario C1 – Medium Demand Case Impacts

It is clear from the analysis above that all three technologies have overall positive impacts and should be implemented. In terms of adverse impacts, solar PV appeared to have the least adverse impacts, followed by wind, and finally hydropower – *mainly HPPs with dams.*

Given that the optimal mix scenarios were based on different shares of each technology, a weight was given to each technology based on its share in the chosen alternative (C1 medium demand) and excluding the thermal power shares. The weights therefore were as follows: 48.3% for hydro, 21.4% for wind, and 30.03% for PV.

The combination of the three matrices with the respective weights for each technology resulted in Table 9-8. Adding the scores of the various environmental parameters gave a total sum of 25, showing the need for implementing the RE optimal mix. Implementation of the C1 medium demand scenario has positive impacts on air quality, climate change, and various socio-economic factors (health, job creation, income, national economy, etc.); mainly related to the shift from electricity generation by fossil fuels.

The main adverse effects caused by the deployment of RE projects impact:

- Effects on avifauna caused by the deployment of wind farms (waterbirds and migratory birds in specific)
- Effects on natural parks and areas, mainly in the Akkar Natural Park given the overlap between the Park's area and the high wind energy potential area
- Effects on upstream and downstream ecology that can be caused by hydropower, mainly HPP with dams;
- Effects on land-use and landscape, given the large surface area needed and the visual intrusion the facilities might cause as well as conflict with other economic uses of the land.

Table 9-8 Impacts' Assessment Summary and Scoring

Parameter	Type	Intensity	Duration	Reversibility	Extent	TOTAL
Biodiversity	NEG	MAJ	LOT	CUM	REG/NAT	-11
Soil	NEG	MIN	MDT	SHT	LOC	-5
Water	NEG	MIN	MDT	SHT	LOC	-6
Air	POS	MAJ	LOT	CUM	NAT	12
Climatic factors	POS	MAJ	LOT	CUM	NAT	12
Noise	NEG	MIN	MDT	PERM	LOC	-5
Infrastructure	POS	MAJ	LOT	PERM	NAT	11
Human health	POS	MAJ	LOT	CUM	NAT	12
Economy / Income	POS	MAJ	LOT	CUM	NAT	12
Job creation	POS	MAJ	LOT	PERM	REG	10
Quality of life	POS	MAJ	LOT	PERM	NAT	10
Material assets	NEG	MOD	LOT	PERM	REG	-8
Cultural heritage	NEU					0
Landscape	NEG	MAJ	LOT	PERM	REG	-10
Land use	NEG	MOD	LOT	PERM	REG	-9
					TOTAL	25

10 Environmental Management Framework

10.1 Proposed Mitigation and Monitoring Strategies

Mitigation refers to the elimination, reduction or control of the adverse effects of the RES, and includes restitution for any damage to the environment caused by such effects through replacement, restoration, compensation or any other means. Practical and implementable mitigation measures shall be proposed to the extent possible.

For each identified significant effect in the Impacts Assessment section (refer to section 9), mitigation measures are proposed as presented in the tables below.

Indicators to monitor implementation of mitigation measures and their effectiveness are also proposed. The monitoring strategy takes into account where relevant existing monitoring schemes that can be used and avoid incurring additional costs. Responsible parties for mitigation and monitoring are proposed as well; unless responsibilities are properly allocated, proposed measures will not be effectively implemented.

Table 10-1 Mitigation Measures for Likely Adverse Impacts of Wind Energy Facilities

Adverse Impact	Proposed Mitigation Method	Party Responsible	Monitoring Indicator
<u>Barrier effect and habitat loss:</u> Adverse impacts on avifauna and bats through the increase in the death rates from collisions with wind farm blades (Upper Akkar is the entry point of soaring birds); and Disturbance when bird populations change their natural flyway path due to the installations. Loss or damage of habitat resulting from turbines and associated infrastructures	• Proper siting of turbines is an important factor, thus no wind farms are to be allowed in Nature Reserves (and in their 500 m buffer zone) and IBAs; • An ornithological study over at least one year must be prepared within the scope of the EIA for any wind farm project; • Evaluation of avian and bat use (including the locations of active nest sites, colonies, roosts, and migration corridors) of the project area by using scientifically rigorous survey methods should be conducted when selecting sites in order to avoid: - areas with known high bird usage; - known bird and/or bat migration corridors or known flight paths; - raptor nest sites; - areas used by bats as colonial hibernation, breeding, and maternity/nursery colonies. • The developer must present and justify in the EIA means to be utilized for the detection, assessment and monitoring of the effects of wind farms on birds, examples of which are the following: - Radar - Thermal Animal Detection Systems (TADS) - Population modeling - Semi-Automatic Scare Tactics with built-in voices. • The developer must consider and present within the EIA other preventive measures such as selective turbine shut down or reduction of speed rotation following detection of birds and during migratory seasons (spring and fall seasons), these must	MoE, MoEW Party operating the wind farm (developer) NGOs working in the field (SPNL, BirdLife, etc.) – mainly for support in studies and monitoring	Threatened bird species as percentage of known breeding bird species in the country Biome protection Trends in abundance and distribution of selected species Critical habitat protection

Adverse Impact	Proposed Mitigation Method	Party Responsible	Monitoring Indicator
	be implemented and monitored at the implementation stage; • To the extent possible, the developer must avoid locating wind energy projects in areas with a high incidence of fog and mist.		
<u>Change in land use and land cover:</u> Destruction of existing vegetation and habitats; Partial or total artificialisation of the site (roads, embankments, areas without vegetation, etc.); and Land expropriation issues.	• Mapping of areas with potential for wind farm development by MoEW in collaboration with MoE, DGUP and CDR in order to exclude sensitive areas. • Recommended to conduct further study and based on international experience, propose methodology and approach in inclusion of sites designated for wind energy facilities in local and regional land use plans and urban strategies; • Wind farms should be installed in areas that have been earmarked for potential wind farm development (to be defined as per the recommendation above) and at a minimum distance from residential areas (e.g. 500- 700 m depending on the size of the turbines) based on wind propagation modelling study included in the EIA study; • No wind farms are to be allowed in Nature Reserves (and in their 500 m buffer zone), IBAs, and forest areas; • Wind farms should be considered within the development of local and regional land use plans and urban strategies; • Promoting the development of wind farms in agricultural areas given the small required footprint and having developers pay rent in exchange for the used amount of surface areas (service roads and pillars) to the land owners – the installation of wind farms in agricultural land should be justified within the EIA in a way to promote social cohesion and integration; • The developer should bear the cost of assessment of land devaluation as a result of the proposed wind energy project;	MoEW CDR DGUP MoA MoE	Forest loss Ecological Footprint of wind farms per capita Number of conspicuous developments already impacting upon sensitive landscapes, vulnerable landscapes and listed highly scenic views, scenic views, scenic view points or routes Percent change in agricultural area following implementation of wind farm projects

Adverse Impact	Proposed Mitigation Method	Party Responsible	Monitoring Indicator
	• In case there are any land expropriation and compensation by the Government, it should be conducted in accordance with relevant legislations: Expropriation Law No. 58/1991 and its amendment No. 8/2006; • Reaching for the public and keeping them informed and engaged in the overall process; and • Giving priority to projects' development on public lands.		
<u>Noise disturbance to nearby settlements and ecosystems:</u> The mechanical noise emitted from the mechanical elements of the nacelle, i.e., the generator, gearbox and other parts of the drive-train; and The aerodynamic noise caused by the blades passing through the air Faunal habitats could be affected by turbine noise.	• As part of the EIA, the developer should present an acoustic study with noise modeling showing that the noise levels at the nearest sensitive receptors are in line with ambient noise levels guidelines; • Wind farms should be installed in areas that have been earmarked for potential wind farm development and at a minimum distance of 500- 700 m from the nearest sensitive receptors.	Developer MoE MoEW	Noise level onsite Number of complaints from nearby residents relating to noise disturbance
<u>Visual disturbance to nearby residents:</u> Visual obstruction to natural landscape can be considered as a negative impact, especially at the first levels of the technology infiltration in the country; and Shadow flicker caused when rotating wind turbine blades periodically cast shadows through constrained openings such as the windows of neighboring properties.	• Wind farms should be installed at a minimum distance of 500-700 m from the nearest sensitive receptors and at a minimum distance of 200 m from roads to avoid reflective shadows disturbance; • The developer should elaborate software configuration allowing the shutdown of the blades during the flickering times if one to three housing units are affected; • A visual modelling and a statistical approach taking into account the sunlight fraction, local features of wind and of the wind farm to quantitatively assess the probability of a perception of the flickering effect and possible disturbance to	DGUP Municipalities Developer MoEW	Number of conspicuous developments already impacting upon sensitive landscapes, vulnerable landscapes and listed highly scenic views, scenic views, scenic view points or routes Number of complaints from nearby residents relating to visual disturbance

Adverse Impact	Proposed Mitigation Method	Party Responsible	Monitoring Indicator
	local residents should be mandated in the EIA for any wind farm development; • The developer should demonstrate in the EIA means to mitigate reflection and glare, e.g. use of non-reflective paints and coatings and avoiding the use of uncoated galvanized metallic surfaces; • Prohibiting commercial messages, advertisements, and graffiti on turbines and towers, unless proper licensing is issued; • Involving the public in decision making regarding visual site design elements for proposed wind energy projects. Possible approaches include conducting public forums; offering tours; using computer simulation and visualization techniques in public presentations; and conducting surveys regarding public perceptions and attitudes about wind energy development; • Installing power cables or lines underground in a manner that minimizes additional surface disturbance; • Integrating turbine arrays and the turbine design with the surrounding landscape. The developer should incorporate the following design elements to achieve this integration: - Create visual order and unity among clusters of turbines (visual units) to avoid visual disruptions and perceptions of disorganized clutter. Create visual uniformity in the shape, color, and size of rotor blades, nacelles, and towers; - The use of tubular towers is recommended to present a simpler profile and less complex surface characteristics and reflective/shading properties; and - Size components in proper proportion to one another to achieve an aesthetic balance between the rotor, nacelle, and tower.		

Adverse Impact	Proposed Mitigation Method	Party Responsible	Monitoring Indicator
Light pollution Disturbance from the flaring light on the top of turbines	• The developer should make provisions so that flashing lights on the turbines are synchronized to flash at the same time; • The developer should arrange that no light reflection occurs below a certain height; and • If possible, design the site so as to make security lights nonessential.	MoEW Developer	Number of complaints from residents relating to disturbance from light
By-products and wastes disposal: Industrial and sanitary wastes like lubricating oils, hydraulic fluids, coolants, solvents, cleaning agents and sanitary wastewaters are all produced during operation of wind farms and could have adverse impacts if not properly handled and if released directly into the environment.	• Implement management plans for all waste streams, including spill prevention and response, storm water management; and • Train employees to promptly contain, report, and/or clean up any oil or hazardous material spill.	Developer MoE MoEW MoIM Municipalities	Generation of hazardous waste Waste recycling rates Wind farm waste volumes and end disposal methods and locations Reports of spills of oil or hazardous materials.

Table 10-2 Mitigation Measures for Likely Adverse Impacts of Solar PV Energy Facilities

Adverse Impact	Proposed Mitigation Method	Party Responsible	Monitoring Indicator
<u>Effects on biodiversity:</u> Habitat fragmentation due to the presence of the fenced solar energy facility, utility rights-of-way (ROWs), and access roads;	♠ Minimize the amount of land disturbance and project footprint; ♠ Develop site fencing in conjunction with MoE and concerned NGOs to prevent site access by and damage to wildlife species and prevent damage from grazing animals; ♠ Establish buffer zones around raptor nests, bat roosts, and other biota and habitats of concern such as rare plants, if site studies show that proposed facilities would pose a significant risk to these species; ♠ Use motion detectors to prevent vandalism; and ♠ Raise public awareness and acceptability of PV projects among the surrounding areas through public consultation as part of EIAs conducted for such projects.	♠ MoE ♠ MoEW ♠ Developer ♠ MoA ♠ Municipalities ♠ Environmental Officers (once the legislation creating the Environmental Police is enacted).	♠ Biome protection ♠ Trends in abundance and distribution of selected species ♠ Critical habitat protection
<u>Change in land use and land cover:</u> Solar energy technology has the adverse impact of occupying a high spatial footprint (in comparison to other RE technologies) that will be obstructed for any other potential use (agriculture, recreation, other land uses / development). Properties would be converted from an agricultural setting to a setting of an energy vehicle production facility or other large industrial complex; Destruction of existing vegetation and habitats; Partial or total artificialisation of the site	♠ Avoiding ecologically sensitive areas or archeological sites in installing developments; ♠ Ban the development of PV farms in highly productive agricultural areas and those classified as agricultural domain of national interest (according to the NPMPLT); ♠ Ban the development of PV farms in forests and Nature Reserves (and in their 500 m buffer zone); ♠ Include in the EIA a CBA analysis for large PV installations to justify change in land use; ♠ Recommended to conduct further study and based on international experience, propose methodology and approach in inclusion of sites designated for solar energy facilities in local and regional land use plans and urban strategies;	♠ Developer ♠ MoE ♠ MoEW ♠ DGUP ♠ CDR	♠ Forest loss ♠ Ecological Footprint per capita for PV projects ♠ Number of conspicuous developments already impacting upon sensitive landscapes, vulnerable landscapes and listed highly scenic views, scenic views, scenic view points or routes

Adverse Impact	Proposed Mitigation Method	Party Responsible	Monitoring Indicator
(roads, embankments, areas without vegetation, etc.); and Land expropriation issues.	♠ Have PV solar energy facilities installed in areas that have been earmarked (to be identified) for potential solar development, including building rooftops; ♠ Land expropriation and compensation to be conducted in accordance with relevant legislations: Expropriation Law No. 58/1991 and its amendment No. 8/2006; ♠ When projects are developed by the Government, projects should preferably be developed on public land; and ♠ In case of expropriation, create an independent judicial committee known as the RE Conflict Resolution Committee (لجنة حل النزاعات المتعلقة بالطاقة المتجددة) to review complaints related to renewable energy projects and to make decisions within a short period of time.		
<u>Visual disturbance to nearby residents:</u> Visual intrusion in case of large scale solar energy development projects would be highly visible in rural or natural landscapes and the disturbed area would continue to contrast with the natural form, line, color, and texture of the surrounding landscape. Visual evidence of a solar field cannot easily be avoided, reduced, or concealed, owing to its size and exposed location; and Aesthetic degradation, which is an effect based on subjective perspective of nearby settlements.	♠ Integrate the solar field and associated facilities design with the surrounding landscape. Developers should incorporate the following design elements to achieve this integration: - Apply appropriate stains/coatings to blend with the project's backdrop if needed; - Employ materials and surface treatments to repeat and/or blend with the existing form, line, color, and texture of the landscape; - Use materials, coatings, or paints having little or no reflectivity whenever possible; and - Consider green fencing as a mitigation measure to reduce any visual disturbance of PV farms to nearby residents.	♠ Developer ♠ MoEW ♠ DGUP ♠ Municipalities	♠ Number of conspicuous developments already impacting upon sensitive landscapes, vulnerable landscapes and listed highly scenic views, scenic views, scenic view points or routes ♠ Number of complaints from nearby residents relating to aesthetic disturbance
<u>By-products and wastes disposal:</u> Wastes from PV operation: high-performance solar cells may contain small amounts of	♠ Create and implement a recycling chain for PV cells, in agreement with manufacturers in order to handle and recycle the PV cells once they are dismantled, since they contain hazardous Cadmium	♠ MoE ♠ MoEW ♠ Developer	♠ Generation of hazardous waste ♠ Waste recycling rates ♠ Waste end disposal methods

Adverse Impact	Proposed Mitigation Method	Party Responsible	Monitoring Indicator
Cadmium telluride (CdTe), selenium, and arsenic, and are only hazardous if the solar cell is broken. Damaged cells would need to be characterized and managed as hazardous waste.	telluride (CdTe) and crystalline silicon. Recycling should also cover glass and aluminum parts; • Implement management plans for all waste streams including hazardous waste management, spill prevention and response, storm water management, and pesticide management (in case of landscaping); and • Train employees to promptly contain, report, and/or clean up any oil or hazardous material spill.	• MoIM • Municipalities • Manufacturers and importers of PV panels	and locations • Reports of accidental spills

Table 10-3 Mitigation Measures for Likely Adverse Impacts of Hydropower Facilities[25]

Adverse Impact	Proposed Mitigation Method	Party Responsible	Monitoring Indicator
<u>Effects on biodiversity:</u> Terrestrial biodiversity in the downstream areas of the riverbed and riversides may be adversely affected due to the potential withholding of water quantities upstream the dams, in reservoirs for use in power generation in peak demand times; For the case of "Peak" hydro power plants, due to the fact that the downstream flow is expected to be limited and nutrients flow downstream will be reduced, the overall ecological conditions of the aquatic life could be adversely affected; For the case of "Run of the River" power plants, where little or no storage of water is provided downstream, the water flow is expected to be slightly smaller than the upstream flow and only for a short stretch of river, therefore, surface water quality and ecological conditions are not expected to be seriously affected; Changes in water quality due to lack of dissolved oxygen near the bottom of	• The developer should ensure that the operational regime for the hydro-electric plant mimics, as far as possible, the seasonal variations in the hydrological cycle and meets environmental flow requirements, and should ensure a minimum flow is maintained at all times; • The developer will manage the reservoir drawdown to optimize native and flood tolerant vegetative growth in littoral zones of the reservoir, and minimize the growth of non-native (and potentially invasive) species; • The developer should conduct regular (preferably continuous) flow monitoring downstream of the dam; • The developer should develop and implement a long-term wildlife and vegetation monitoring and management programme to document changes in aquatic flora and fauna in the reservoir and address any problems that may occur.	• MoE • MoEW • Developer	• Biome protection • Trends in abundance and distribution of selected river and bank species • Critical habitat protection • Fish stocks collapsed • Water flow downstream of the reservoir

[25] The hydropower sector should abide by the recommendations included in the **Strategic Environmental Assessment for the New Water Sector Strategy for Lebanon, developed by the GEF, World Bank, MoEW and Plan Bleu, in collaboration with MoE (203-2015).**

Adverse Impact	Proposed Mitigation Method	Party Responsible	Monitoring Indicator
reservoirs can lead to death of aquatic life.			
<u>Change in land use and land cover:</u> Destruction of existing vegetation and habitats; Partial or total artificialisation of the site (roads, embankments, areas without vegetation, etc.); and Land expropriation issues.	• HPPs should not be allowed in sensitive areas, particularly Nature Reserves (and in their 500 m buffer zone); • Minimize the footprint area to the extent possible in view of project scale and capacity; and • Land expropriation and compensation to be conducted in accordance with relevant legislations: Expropriation Law No. 58/1991 and its amendment No. 8/2006.	• MoE • MoEW • DGUP • Litani River Authority	• Forest loss • Ecological Footprint per capita of hydropower projects • Number of conspicuous developments already impacting upon sensitive landscapes, vulnerable landscapes and listed highly scenic views, scenic views, scenic view points or routes

<u>Effects on water resources:</u>
Adverse impacts could occur in case of river route diversions, especially when those are applied at significant lengths - diverting large amounts of river water reduces river flows, affecting water velocity, depth, temperature, and oxygen concentration;
 	
The presence of a reservoir will change the sediment transport in the river downstream and therefore induce a change on the river sediment balance;
 	
Water loss due to evaporation;
 	
Risk of eutrophication in dams and reservoirs.
	• The developer should conduct regular (preferably continuous) flow monitoring downstream of dam;
	• Regular monitoring of borehole yields in any adjacent community wells;
	• Monitor groundwater chemistry in a representative selection of community wells (e.g., Flow, temperature, salinity, total suspended solids, and conductivity);
	• Guidelines related to downstream environmental flow and diversion of natural river bed / flow should be developed by the MoE;
	• Consider promoting water user associations; and
	• Include projections of future water availability and use in design and EIA study.
		• MoE
		• MoEW
		• Litani River Authority
		• Water Establishments
		• Municipalities
			• Change in water quantity
			• Water quality:
			  • Dissolved oxygen concentration
			  • Electrical conductivity
			  • Phosphorous concentration
			  • Suspended solids
			  • pH, nitrates, phosphates, cadmium, fecal coliforms
			• Percentage of land under severe water stress

<u>Effects on nearby settlements and infrastructure</u> – *<u>in case of dam construction as</u>*	• Development of a dam management plan and including it in relevant EIA studies;	• MoEW • Developer	• Yearly cost of dam management and river basin management

Adverse Impact	Proposed Mitigation Method	Party Responsible	Monitoring Indicator
part of the hydropower plant: Potential conflicts and mismanagement of water shortages; Risk of flooding upstream the dams; Risk for flooding downstream the dam; Impacts due to sediment transport (blockage due to dams); Dam failure; and Resettlement needs.	• Development of a river basin management plan and including it in relevant EIA studies; and • Development of a resettlement and compensation policy framework and resettlement action plan in parallel with relevant EIA studies; • A preparedness plan in case of accidental events should be prepared and include the following: o Contingency plans in reservoir projects; o Risk assessment approach / plan (incorporating zoning); o Early Warning Systems; and o Diversion plans.	• Disaster Risk Management Unit (CoM) • Litani River Authority	• Records of accidental events
By-products and wastes disposal: General industrial waste production from maintenance activities.	• Implement management plans for all waste streams, including spill prevention and response, storm water management, and • Train employees to promptly contain, report, and/or clean up any oil or hazardous material spill.	• MoE • Contractor • MoIM • Municipalities	• Generation of hazardous waste • Waste recycling rates • Waste end disposal methods and locations • Reports of accidental spills.

10.2 Institutional Framework

Figure 10-1 provides an overview of the institutional framework required to implement the recommendations of this SEA. The figure maps out the roles of the main stakeholders involved in the process: the MoEW, the MoE, Project Developer, and EIA Consultant.

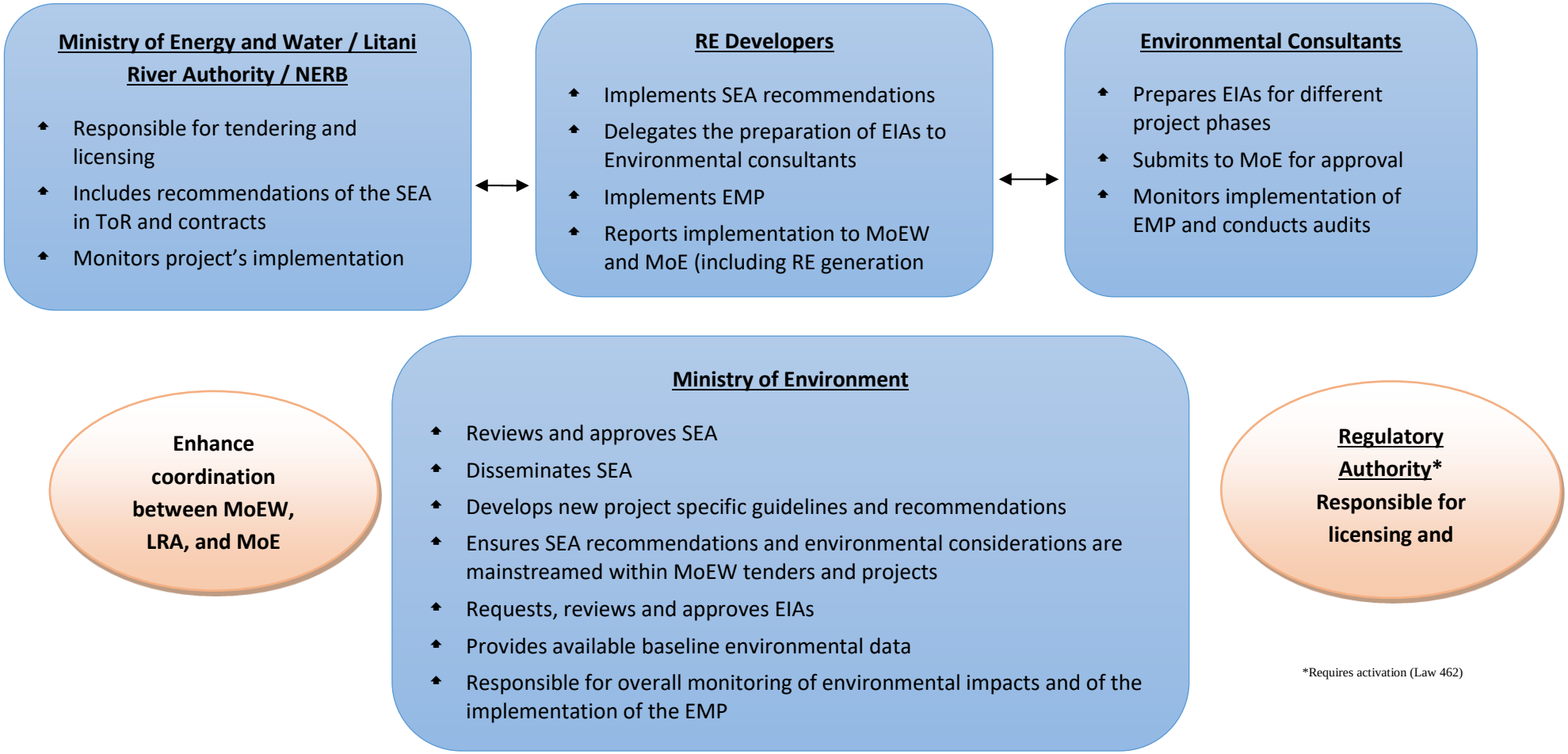


Figure 10-1 Institutional Framework for SEA Implementation

10.3 Capacity Building

Implementation of this EMF requires further capacity building for stakeholders in order to adequately foster it. It is proposed that main stakeholders be trained to become fully familiar with the outcomes of the SEA and the EMF in order to be able to implement it. Several measures are proposed to effectively raise the capacity of stakeholders to implement the requirements of this SEA:

- Training workshops focusing on improving the understanding of local stakeholders, mainly developers, the private sector, and concerned governmental bodies, about the RE sector, its potential impacts and relevant mitigation measures, and understanding the requirements of this SEA;
- Study tours to RE facilities, so that stakeholders acquire practical know-how on how to conduct activities (siting, implementation of mitigation measures, etc.) at such facilities;
- Provision of necessary monitoring and inspection equipment and skills to stakeholders depending on their needs; and
- Introduction of specific programmes in universities and technical schools to prepare the local workforce to serve the RE industry and to maximize local benefits in terms of employment and education.

11 RECOMMENDATIONS

Following the analysis of potential impacts and benefits associated with the implementation of the RES, and following consultations with governmental and non-governmental stakeholders, the SEA team has reached the conclusion that the implementation of RES is beneficial for the country at various levels (economical, ecological, social, etc.) however, and in order to avoid certain environmental concerns that might rise when implementing the 12% RE deployment, a number of recommendations covering the following main four aspects have been developed:

- Recommendations for integrating SEA findings in the RES;
- Recommendations for mainstreaming the SEA findings into the policies and plans of concerned public entities;
- Recommendations covering EIA requirements; and
- Legal, institutional, and financial recommendations.

Checklist summarizing recommendations mitigation measures to be included in tender documents, adopted by developers, and monitored by MoE are provided in Appendix 5.

11.1 Recommendations for Integrating SEA Findings in the RES

The results of the SEA showed that for some sites considered in the RES there are some environmental, social or even technical constraints that should be considered, in order to protect the environment and people while also ensuring the feasibility of RE developments. To this end, it is recommended to essentially incorporate the SEA recommendations into the updated version of the RES before its implementation, mainstreaming, in this sense, the powerful tool of Strategic Environmental Assessment into the actual Strategy development.

I. Wind Power Sites

The results of the SEA showed that the high potential wind power sites considered in the RES include areas overlapping with an IBA (Upper Akkar) and two birds bottlenecks (Wadi Oudine, and Marjhine). The IBA should not be considered for any wind farm development while the bottlenecks can be developed provided that all mitigation measures are respected, namely shutting down the turbines during spring and fall migration seasons. This will in turn reduce the potential electricity generation of such sites –therefore, it is recommended that the contractor internalizes this in their offer – in parallel, this should be clearly stated in the bidding documents.

II. Solar PV Sites

The results of the SEA showed that the high solar PV potential sites considered in the RES include an area overlapping with the Yammouneh Nature Reserve. The reserve section should be excluded from the mix. Forests should also be excluded, and guidelines to prevent the conversion of agricultural land to PV sites should be developed, defining the type and proportion of agricultural land that be partly exploited for PV farms. Bare land remains the most favoured type of land use for PV developments.

III. Wind and PV Lower Potential Sites

The SEA has been based on the demand scenarios stipulated in the CCCU study which resulted in variable penetration rates for wind and solar, related to high potential sites, thus exploiting the full identified technical potential. In practice, due to expected technical and other constraints, RE projects will be implemented at a wider range of areas including ones with lower resource potential.

The level of change on RE mix if significant may in practice have implications on environmental impacts and mitigation. For indicative purposes, this named "low potential scenario" was calculated to determine potential change in the RE mix. The results showed that if wind and PV were to be exploited at sites that exclude the two more attractive RE potential categories, e.g., in wind for sites with less than 9 m/s, that would result in:

- Increased installed capacities of about 50 MW for wind and less than 100 MW solar; and
- Very small (less than 2%) increase in costs to the economy.

Hence, it can be concluded that the main environmental impacts and needed mitigation strategy described in this report will not be affected by the inherent uncertainty in the size and composition of the RES mix. Relevant tables and figures of this analysis are presented in Appendix 3.

IV. New Hydropower Plants

The "*Schéma Directeur Hydroeléctrique du Liban"* classified the new HPPs into three (3) categories based on their environmental impacts – excluding the impacts of dams. The results showed that four (4) plants have high adverse impacts on the environment: Mtaile (Damour), Jezzine, Sir, and Mechmech (Nahr Abou Moussa).

These four HPPs are included in the Scenario C1 of the RES and only cover 5.6% of the overall projected capacity from hydropower. It is therefore advisable to replace these sites with other potential ones or increase the share of other technologies to compensate for the removal of these four sites.

On another note, out of the 29 new HPPs considered in Scenario C1, six (6) are associated with dams Table 2-2) and cover 27.5% of the projected hydropower capacity. Given that the environmental and social impacts of dams are much greater than those of Run of the River Mode plants and that conflicts over water use might arise after dam construction *(such as the Litani Conveyor 800 project which foresees water diversion for irrigation causing a 30% reduction in electricity production)*, it is recommended to downsize the share of HPPs with dams as much as possible.

The choice of HPPs locations did not take into consideration seismicity which is an important risk factor to consider when building dams. It is therefore recommended to review the locations of HPPs associated with dams in this context.

V. Proximity to the Grid

A key obstacle not considered in the study and that can be highlighted in that respect is proximity to current electricity HV networks of the country. Large distance from the transmission grid will imply high interconnection costs and therefore may seriously hamper the actual development of projects at these locations. This applies to high capacity wind and large PV installations, especially at the Eastern areas of the country, both of which cannot be connected to the local MV grids. Of course the level of risk and implication of this parameter has to be quantified on a case by case basis.

VI. Scenarios and Mixes

It is important to mention that the scenarios developed as part of the RES and reaching the 12% national target depend on an external factor of "electricity demand" and include similarities in the energy not allowing for a significant differentiation in terms of environmental and socio-economic criteria. A suggestion would be the development of various mixes and scenarios reaching the 12% target for the same electricity demand case.

11.2 Mainstreaming SEA Findings into the Policies and Plans of Concerned Public Entities

A key objective of the SEA is to achieve greater integration between national policy goals and practical delivery of sustainable development on the ground. This can be achieved when the findings of the SEA are disseminated and mainstreamed into the agendas of the various concerned public bodies; namely MoE, MoEW, MoA, MoPWT (DGUP), CDR, and HCP.

I. Ministry of Environment

The main role of the MoE is to adopt the Renewable Energy Sector SEA as part of its agenda and policies and work on the following:

- In-house capacity building to ensure that MoE staff are aware of this SEA, especially EIA requirements;
- Starting from the identified EIA requirements in this SEA, further develop guidelines for each RE technology to guide developers and environmental consultants *(similar to the CEDRO 2012 publication: "Environmental Impact Assessment for Wind Farm Development: A Guideline Report*);
- Ensure scoping reports for RE EIA studies duly integrate the SEA requirements in their scope of work;
- Investigate the need to develop specific regulations for RE project developments; an example would be minimal separation distances of wind farms from various land uses and features, and enact these regulations into decisions similarly to Decisions 52/1 and 8/1;
- Organize awareness campaigns and workshops to educate developers, other ministries, and the public about RE and its environmental and social impacts and legal requirements (e.g., EIA Decree);
- Give the SEA a legal status and ratify it through a Ministerial Decision or Decree (given its implications to different sectors)in order for it to become a binding document that starts to be effectively implemented;
- Assign a focal point from MoE to coordinate and follow up with the MoEW on the integration of environmental components into the RE strategy being developed.

II. Ministry of Energy and Water

- Create a body/committee responsible for coordinating the work between the various entities of the Ministry to 1) develop complementary strategies and large scale PPP, 2) avoid the development of conflicting strategies, and 3) oversee the development and implementation of the MoEW's strategies; for example:
    - Coordinating the work between the teams of the RE Strategy and Thermal Strategy and integrating the RE target (12%) in the thermal energy policy paper, and
    - Coordinating the work between the teams of the RE Strategy and Water Sector Strategy for the development of Lebanon's hydropower potential and avoiding

conflicting projects such as the Conveyor 800 Water Project which will reduce the hydropower capacity of the Litani hydropower plant by 70%.

- Create a National Energy Authority that shall be responsible to regulate all energy related matters: renewables, HFO, gas, etc.
- Coordinate with the MoE to list environmental requirements in RE tender documents, ask bidders to state their approach to meeting environmental requirements, and review the submitted approaches, those being a main criteria in the evaluation process;
- Assess the cost incurred by the wind farm operators of shutting down turbines during bird migration seasons; request the internalization of these costs in bids, and devise a solution to compensate these losses by the Government.
- Coordinate with other ministries having cross-cutting issues, such as the MoA over irrigation projects and locations of RE projects.

III. Ministry of Agriculture

- Assign a focal point to :
    - Review SEA recommendations related to forests and agricultural lands (e.g., ban development of RE projects in dense forests, encourage wind farms on agricultural lands, etc.);
    - Coordinate the work with the MoE on one hand and the MoEW on another to agree on guidelines related to forests and agricultural lands, and choice of location of the RE development projects; and
    - Coordinate with the DGUP to regulate land use in agricultural land so as to prevent massive selling of the lands for solar RE projects. Co-exploitation/ co-farming mechanisms should be promoted to this end, whereby seasonal activity is factored in.
- Conduct awareness campaigns, in collaboration with the MoE and MoEW, to educate farmers about RE projects, highlight the benefits of developing wind farms on their lands, promote co-farming, and engage them in the process.

IV. Urban Planning

An important criterion in RE development is the location of large-scale projects, and as detailed in the Environmental Management Framework (section10), there is a need to earmark areas suitable for the development of each RE technology. Urban planning in Lebanon involves several stakeholders, mainly DGUP, HCUP, and CDR.

An important recommendation would therefore be to include RE areas in the NPMPLT after consultation with the various urban planning stakeholders along with MoE, MoA and MoEW, to exclude sensitive zones from any potential disturbances from RE development.

URBAN PLANNING STAKEHOLDERS
Directorate General for Urban Planning (DGUP): the DGUP is responsible for developing urban planning regulations and orchestrate urban planning. It defines urban master plans and issues building permits for municipalities that do not have a municipal council or an engineering department.
Higher Council for Urban Planning (HCUP): the HCUP presides the DGUP and consists of the Director Generals of select ministries (Interior and Municipalities, Housing, Transport, Public works, Justice and Environment), representatives from several institutions (CDR), and urban planning specialists. It makes recommendations on urban planning projects and regulations, and large-scale development projects.
Council of Development and Reconstruction (CDR): The CDR is responsible for the planning and programming of reconstruction/rehabilitation projects in all sectors across Lebanon. It is also mandated to develop a masterplan for urban planning. The CDR developed the NPMPLT, which was approved by the DGUP and the CoM and mandated through a Decree in 2009.

V. Higher Council for Privatization (HCP)

- Ensure environmental requirements are integrated in project documents and tenders related to RE projects; and
- Mainstream environmental requirements into private sector's agenda.

11.3 EIA Requirements

The most important recommendation is mandating the preparation of project specific EIAs prior to the development of any RE project. EIAs should cover the siting, design, construction, operation and decommissioning stages of any project.

The identified impacts and mitigation measures in the SEA report should be communicated to any EIA developer and be reflected in the EIA's Environmental Management Plans (EMP).

The EIA should be developed by a third party to avoid any conflicts of interest.

EIAs should be developed at the project's conceptual design stage in order to mainstream environmental considerations at an early stage and amend design accordingly.

Ensuring a participatory approach in EIA involving the local authorities, entities, and communities is crucial to account for stakeholders' and communities' concerns and recommendations.

Specific EIA requirements detailed in the SEA should be included in the tender documents of RE developments to allow the bidders to prepare adequate scopes and associated prices and integrate these requirements in the project's timeframes. These measures are in line with the mitigation measures detailed in section 10.1 and presented in Table 11-1.

Table 11-1 EIA Requirements

RE Technology	Requirements to be included in project specific EIA studies (where applicable)
Wind Farms	▪ An ornithological study over at least one year; ▪ Results of a scientific study evaluating avian and bat use (including the locations of active nest sites, colonies, roosts, and migration corridors) of the project area and the likely impacts of the project; ▪ Analysis of alternatives should consider various configurations for the siting of the turbines and demonstrate that the selected configuration has the least impact on avifauna; analysis of alternatives should also consider different sites within the intended development area and demonstrate that selected site has least impacts on avifauna; ▪ Means to be utilized for the detection, assessment and monitoring of the effects of wind farms on birds; ▪ Preventive measures following detection of birds and during migratory seasons (such as selective turbine shut down or reduction of speed rotation); ▪ Acoustic study with noise modeling; ▪ A visual modeling and a statistical approach taking into account the sunlight fraction, local features of wind and of the wind farm to quantitatively assess the probability of a perception of the flickering effect and possible disturbance to local residents; ▪ Details of the software configuration allowing the shutdown of the blades during the flickering times if one to three housing units are affected; ▪ Means to mitigate reflection and glare; ▪ Socio-Economic study demonstrating how existing land-uses can be integrated within the project and possible co-use of land; ▪ Land expropriation and compensation process; and ▪ Evidence of early consultation with affected communities and their participation in the design process throughout the EIA study.
Solar PV Farms	▪ Land-use compatibility analysis to demonstrate that the project does not affect any restricted land or protected area; ▪ CBA analysis for large PV installation to justify change in land use; ▪ Visual modeling showing adopted means to ensure integration of the project in the surrounding landscape; and ▪ Waste management/recycling practices and end disposal of various generated waste streams; namely hazardous waste containing parts such as CdTe; and ▪ Land expropriation and compensation process.
Hydro Power Plant	▪ Baseline wildlife and vegetation monitoring upstream and downstream the facility's site to document changes in aquatic flora and fauna that could be caused by the project; documented biodiversity (flora and fauna) should span at least one year to consider 4 seasons; ▪ Analysis of alternatives should consider different sites for the project and demonstrate that selected site has least impacts on ecology and local communities;

	▪ Projections of future water availability and use demonstrating that significant conflicts for water are not likely to occur among different water uses; the analysis should consider the projected impacts from climate change; ▪ Contingency plan in case of dam failure including risk assessment; ▪ Dam management plan; ▪ River basin management plan; ▪ Flow monitoring methods and plan; ▪ Water quality monitoring methods and plan; ▪ Detailed analysis of impacts on land-use and communities, including land expropriation and compensation process; ▪ Evidence of early consultation with affected communities and their participation in the design process throughout the EIA study.

11.4 Legal, Institutional, and Financial Recommendations

The following recommendations are inspired by previous national plans and policies which addressed for the first time the development of Renewable Energies (REs) in Lebanon and which provide various tools for the restructuring of the energy sector in Lebanon.

I. Legal Framework

With respect to existing laws, the electricity sector Law No. 462 published in 2002 aiming to bring in the private sector as a partner with EDL was never implemented. This law focuses on implementing a structural change in the electricity sector in Lebanon and provides for the privatization of all or some of the distribution and production activities of the electricity sector (transmission to remain with the public sector). This proposed privatization model starts with the Council of Ministers creating joint stock companies (subject to the commercial law) by decree and these companies shall seek licenses for performing their operations. Two years following the establishment of the company, the government may offer up to 40% of the share of the privatized company, through public auction or tendering.

Therefore, it is important to stress on the importance of implementing Law No. 462 of 2002 after making a few amendments so that it can introduce, for instance, special renewable energy payment mechanisms such as feed-in tariffs. Afterwards, the Lebanese Government would issue decrees that would be in implementation of Law No.462 to set for example the procedures for obtaining a license or authorization to produce energy by private companies and individuals.

It is also important to enact the Public Private Partnership (PPP) law, which meets law 462 in bringing in the private sector as a partner to public entities and help fill the infrastructures gaps in most of sectors (namely energy).

On the other hand, the energy conservation draft law needs to be amended/ revised, issued, and implemented for setting norms and standards for the provision of electricity services that are safe, equitable, and fair with the best quality and lowest cost. The law needs to be amended in order to establish a specific framework which covers all renewable energy sources such as wind, hydro, solar, and eventually biomass and geothermal at later stages (through amendments). Application decrees should follow the enactment of the law.

Therefore, it may be recommended to make several amendments to the draft law before its approval and implementation.

It is also essential to raise public awareness in terms of renewable energy and enable the involvement of stakeholders by bringing valuable suggestions and comments in order to promote a sustainable and independent energy sector in Lebanon, especially that the target of energy conservation and efficiency obligations falls on the industrial/commercial sector, and any success and compliance needs to have their buy-in.

Moreover, there are several environmental and economic aspects relating to renewable energy which need to be addressed either under the future amendments to Law No. 462 of 2002, or in the Energy Conservation Law (currently a draft), or through new laws or decrees. These issues include

but are not limited to feed-in tariffs, the Green Buildings Code and the Lebanese Thermal Standards, and need to be adopted as mandatory regulations.

II. Institutional Framework

The electricity sector is governed by EDL, which needs to be restructured and corporatized in order to enhance its resources and capabilities through the amendment of Law No. 462 of 2002. Such reform will enable EDL to grant permits and to mobilize private investments. Additionally, Law No. 462 provides for the establishment of the National Electricity Regulatory Body (NERB) in charge of issuing licenses to the companies established pursuant to the law, to regulate the system for Independent Power Producers, and to also monitor the various operations and activities of the sector. However, the lack of political consensus has prevented the establishment of this Commission, and the implementation of Law No. 462.

Once the NERB is institutionalized, it must set out binding mechanisms for the implementation of its regulations and standards. It is also important to regulate its expansion with respect to human resources, budget and mandates and to create regional branches around Lebanon in order to ensure that all projects are being covered and monitored.

From an institutional point of view and based on the above, a National Energy Authority should be responsible for all energy-related issues (renewables and non-renewables).

III. Financial Frameworks

Among the gaps of Law No. 462, it is worth mentioning that it does not introduce feed-in tariffs which are policy mechanisms designed to accelerate investment in RE technologies. A feed-in tariff achieves this by offering long-term contracts to renewable energy producers, typically based on the cost of generation of each technology. Therefore, the amendments to Law No. 462 of 2002 or to the Energy Conservation draft law need to include a regime for feed-in tariffs and energy audits.

Energy audits are usually conducted by an energy audit firm or an Energy Service Company (ESCO). ESCOs constitute the most advanced form of financing energy efficiency and reconstructing energy systems to maximize energy savings. It is important to regulate the framework pertaining to the licensing procedures pertaining to Energy Services Companies (ESCOs).

Additionally, investment aid mechanisms, such as tax alleviations, would be beneficial to promote innovation by the private sector, especially land and real estate owners in terms of relatively small renewable energy projects. These mechanisms need to be favorable not only to commercial establishments but also to households in order to encourage individuals to become more involved in energy sufficiency and efficiency.

Finally, as part of social measures, the Lebanese Government and the relevant institutions should promote public involvement and awareness in order to engage the private sector, users and investors into the reform of the energy sector in Lebanon. Currently, the Lebanese energy consumers, large institutions, land and real estate owners are progressively recognizing the economic, environmental and security potential of renewable energy. Nevertheless, renewable energy projects remain on the level of initiatives financed individually and built on a case by case

basis, rather than implementing a strong legal and regulatory framework for the renewable energy sector.

This legal and regulatory framework needs to be favorable to investors by offering financial incentives (exemption from taxes and duties, etc.) in order to attract small-scale renewable energy enterprises and encourage the involvement of the local and private sector.

REFERENCES

Ahmed, Z., Kazem, H., & Sopian, K. (n.d.). Effect of Dust on Photovoltaic Performance.

Bergmann, E., Colombo, S., & Hanley, N. (2007, April 1). The Social-Environmental Impacts of Renewable Energy Expansion in Scotland.

Brown, P., & Whitney, G. (2011, August 5). U.S. Renewable Electricity Generation: Resources and Challenges.

Environmental Impact Assessment of the Installation of a Photovoltaic Solar Powered Salt Water Reverse Osmosis Plant at Paget Farm Bequia. (2012, January 1). Retrieved from http://www.caribbeanclimate.bz

Environmental Impacts of Wind-Energy Projects. (2007, January 1). Retrieved from http://www.nap.edu

Fritsche, U. (2010, January 1). Bioenergy Environmental Impact Analysis (BIAS).

Gonzalez-Avila, M., Beltran-Morales, L., Braker, E., & Ortega-Rubio, A. (2005, September 1). Environmental Impact Assessment for Alternative-Energy Power Plants in Mexico.

Hung, C. (2010, July 1). Environmental Impacts of Renewable Energy.

ICEM, 2010, MRC Strategic Environmental Assessment (SEA) of hydropower on the Mekong Main Stream, Hanoi, Viet Nam.

Larsen, S. (2012, January 1). Climate Change in Environmental Impact Assessment of Renewable Energy Projects.

Lieberman, E., Lyons, J., & Tucker, D. (n.d.). Making Renewable Energy Wildlife Friendly.

Macknick, J., Newmark, R., & Turchi, C. (2011, April 1). Water Consumption Impacts of Renewable Technologies: The Case of CSP.

Newman, P., & Salequzzman. (n.d.). Environmental Impacts of Renewable Energy: Case Study of Tidal Power.

SGS, E., & Environmental Resources, M. (2007, January 1). Environmental and Social Impact Assessment Study of the Bui Hydroelectric Power Project. Retrieved from www.erm.com

Thomas, J. (2011, October 4). Socio-Economic Impacts of Renewable Energy.

Tsoutsos, T., Frantzeskaki, N., & Gekas, V. (n.d.). Environmental Impacts from the Solar Energy Technologies.

Turney, D., & Fthenakis, V. (2011, April 11). Environmental Impacts from the Installation and Operation of Large-Scale Solar Power Plants. Retrieved from http://www.elsevier.com/locate/rser

Partidário, M.R. (1998). Significance and the Future of Strategic Environmental Assessment. Paper presented at an International Workshop on Strategic Environmental Assessment, Tokyo.

Wind Energy and the Environment. (n.d.). Retrieved from www.ewea.org

APPENDICES

APPENDIX 1: OPTIMAL RENEWABLE ENERGY MIX OF THE POWER SECTOR BY 2020: INVESTMENT COST IMPLICATIONS FOR LEBANON

HTTP://CLIMATECHANGE.MOE.GOV.LB/VIEWFILE.ASPX?ID=214

APPENDIX 2: SCOPING WORKSHOP REPORT

APPENDIX 3: SEA REVIEW WORKSHOP REPORT

APPENDIX 4: LOW POTENTIAL SCENARIO

A. *ALLOCATION OF WIND AND PV INSTALLATIONS*

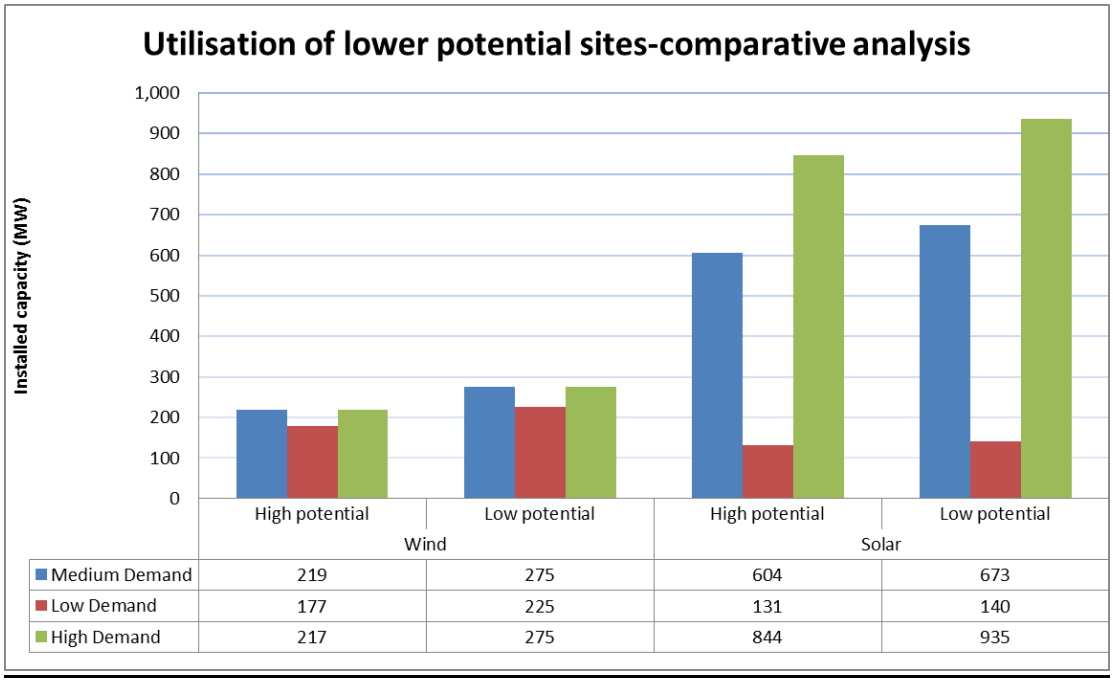
Wind energy

		Medium Demand		Low Demand		High Demand	
	Category	**Capacity**	**Electricity**	**Capacity**	**Electricity**	**Capacity**	**Electricity**
Avreage wind speed	UF	MW	GWh	MW	GWh	MW	GWh
>9.5 m/s	42.1%	0	0	0	0	0	0
9-9.5 m/s	38.4%	0	0	0	0	0	0
8.5-9 m/s	34.8%	120	366	120	368	120	366
8-8.5 m/s	31.4%	75	206	55	149	70	190
7.5-9 m/s	28.2%	80	198	50	123	85	208
TOTAL		**275**	**770**	**225**	**640**	**275**	**764**

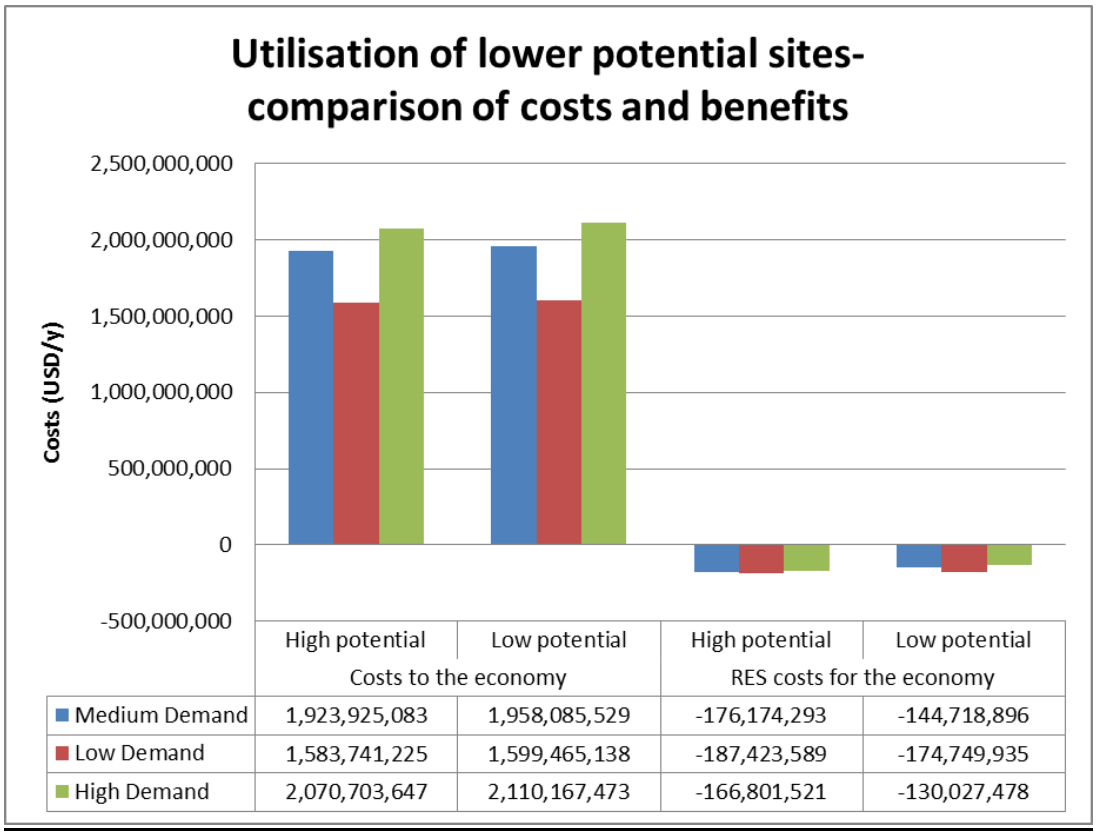
Solar PV

		Medium Demand		Low Demand		High Demand	
GHI	**Category**	**Capacity**	**Electricity**	**Capacity**	**Electricity**	**Capacity**	**Electricity**
2200-2300	20.8%	0	0	0	0	0	0
2100-2200	20.1%	0	0	0	0	0	0
2000-2100	19.5%	200	342	140	239	250	427
1900-2000	18.0%	308	486	0	0	450	710
1800-1900	17.3%	165	250	0	0	235	356
TOTAL		**673**	**1,077**	**140**	**239**	**935**	**1,493**

B. COMPARISON WITH MAIN DEMAND SCENARIOS



	Wind		Solar	
	High potential	Low potential	High potential	Low potential
Medium Demand	219	275	604	673
Low Demand	177	225	131	140
High Demand	217	275	844	935



	Costs to the economy		RES costs for the economy	
	High potential	Low potential	High potential	Low potential
Medium Demand	1,923,925,083	1,958,085,529	-176,174,293	-144,718,896
Low Demand	1,583,741,225	1,599,465,138	-187,423,589	-174,749,935
High Demand	2,070,703,647	2,110,167,473	-166,801,521	-130,027,478

APPENDIX 5: RECOMMENDATIONS CHECKLISTS

WIND ENERGY DEVELOPMENTS

Recommendation / Mitigation Measure	Yes/No	Comments
Wind farms are located outside Nature Reserves and their 500 m buffer zones		
Wind farms are located outside Important Birds Areas		
Wind farms are located in areas with a low incidence of fog and mist		
Wind farms are installed at a minimum distance from residential areas/sensitive receptors (e.g. 500- 700 m depending on the size of the turbines)		
Wind farms are at a minimum distance of 200 m from roads		
Analysis of alternatives considers different sites within the intended development area and demonstrates that selected site has least impacts on avifauna		
When Wind Farms Are Located in Agricultural Areas:		
Justifications for the installation of wind farms in agricultural areas and promotion of social cohesion and integration are provided		
Wind farms are located in agricultural areas where developers pay rent in exchange for the used amount of surface areas to the land owners		
Wind farms are installed in areas that have been earmarked for potential wind farm development - *when applicable*		
Ornithological study over at least one year is provided		
Evaluation of avian and bat use (including the locations of active nest sites, colonies, roosts, and migration corridors) of the project area is provided		
Means to be utilized for the detection, assessment and monitoring of the effects of wind farms on birds are provided		
Means to avoid impacts on birds when detected and during migratory seasons (spring and fall seasons) are provided		
Consideration of various configurations for the siting of the turbines and demonstrating that the selected configuration has the least impact on avifauna		
Acoustic study with noise modeling is provided		
Software configuration alleviating flickering problems is provided		

Statistical approach taking into account the sunlight fraction, local features of wind and of the wind farm to quantitatively assess the probability of a perception of the flickering effect and possible disturbance to local residents are provided		
Visual modelling showing how the project is integrated into the surrounding landscape is provided		
Proof that power cables or lines will be installed underground is provided		
Proof that flashing lights on the turbines is synchronized to flash at the same time is provided		
Management plan for all waste streams is provided		
Employee training plan is provided		
Public engagement plan is provided with evidence of early consultation with affected communities and their participation in the design process throughout the EIA study		
Socio-economic study demonstrating how existing land-uses can be integrated within the project and possible co-use of the land		
Proof that the cost of assessment of land devaluation as a result of the proposed wind energy project are covered by the developer is provided		
Proof that land expropriation and compensation will be conducted in accordance with relevant legislations (Expropriation Law No. 58/1991 and its amendment No. 8/2006) is provided		

SOLAR PV DEVELOPMENTS

Recommendation / Mitigation Measure	Yes/No	Comments
Land-use compatibility analysis to demonstrate that the project does not affect any restricted land or protected area		
PV farms are installed in areas that have been earmarked for potential solar energy development - *when applicable*		
PV farms are located outside highly productive agricultural area and those classified as agricultural domain of national interest		
PV farms are located outside Nature Reserves and their 500 m buffer zones		
PV farms are located outside forests and dense vegetation areas		
Details of how the amount of land disturbance and project footprint are minimized		
Ecologically sensitive areas and archeological sites have been identified and avoided		
Buffer zones around raptor nests, bat roosts, and other biota and habitats of concern such as rare plants are identified and respected		
CBA analysis for large PV installations is provided		
Public engagement plan is provided		
Visual modelling showing how the project is integrated into the surrounding landscape is provided		
Proof that power cables or lines will be installed underground is provided		
Management plan for all waste streams (including a recycling chain for PV cells) is provided		
Employee training plan is provided		
Proof that the cost of assessment of land devaluation as a result of the project are covered by the developer is provided		
Proof that land expropriation and compensation will be conducted in accordance with relevant legislations (Expropriation Law No. 58/1991 and its amendment No. 8/2006) is provided		

HYDROPOWER DEVELOPMENTS

Recommendation / Mitigation Measure	Yes/No	Comments
HPPs are located in areas that have been earmarked for potential solar energy development - when applicable		
HPPs are located outside Nature Reserves and their 500 m buffer zones		
HPPs are not located in areas with known seismic risk		
Details of how the amount of land disturbance and project footprint are minimized		
Justifications that the operational regime for the hydro-electric plant mimics, as far as possible, the seasonal variations in the hydrological cycle are provided		
Justifications that the operational regime for the hydro-electric plant ensures a minimum flow is maintained at all times are provided		
Proofs that the reservoir drawdown optimizes native and flood tolerant vegetative growth in littoral zones of the reservoir are provided		
Proofs that the reservoir drawdown minimizes the growth of non-native (and potentially invasive) species are provided		
Means for baseline wildlife and vegetation monitoring and management programme are provided		
Projections of future water availability and use demonstrating that significant conflicts for water are not likely to occur among different water uses are provided		
Monitoring plan for downstream flow is provided		
Monitoring plan for groundwater quantity and quality is provided		
Dam management plan is provided		
River basin management plan is provided		
Resettlement and compensation policy frameworks are provided		
Evidence of early consultation with affected communities and their participation in the design process throughout the EIA study		
Contingency plan for reservoir projects (including means of diversion of natural river bed / flow) is provided		

Emergency preparedness plan is provided		
Risk assessment and early warning systems are provided		
Visual modelling showing how the project is integrated into the surrounding landscape is provided		
Proof that power cables or lines will be installed underground is provided		
Management plan for all waste streams is provided		
Employee training plan is provided		
Proof that the cost of assessment of land devaluation as a result of the project are covered by the developer is provided		
Proof that land expropriation and compensation will be conducted in accordance with relevant legislations (Expropriation Law No. 58/1991 and its amendment No. 8/2006) is provided		