EXPERT SERVICES FOR SOLAR PV PROJECTS
CAPABILITY STATEMENT
RAMBOLL POWER GENERATION
SOLAR PV – THE INTEGRATIVE PART OF FUTURE POWER SYSTEMS

The investment costs of Photovoltaic (PV) Systems have dropped significantly in the recent years. Utilities, investors and major electricity consumers have discovered Solar PV in multi-MW sizes as the KEY driver for their purposes and future business. PV is a reliable, predictable and economic way of generating power from renewable sources on a long term perspective. It is the quickest way to set up utility scale power generation and it is also modular & easily extendable. In addition, it can be installed nearly everywhere. By end of 2017, more than 400 GW$_p$ of Solar PV plant capacity is in operation worldwide and the number of new plants is increasing fast. Ramboll has pushed this development over the past 15 years with consultancy services for small to utility scale PV projects mainly in Europe, Africa and the Middle East.
WHY RAMBOLL?

Ramboll is a leading engineering, design and consultancy company founded in Denmark in 1945. We employ more than 13,000 experts and have a significant presence in Europe, India, North America and the Middle East. With 300 offices spread over 35 countries around the world, we combine global knowledge with local experience.

Ramboll has more than 45 years of experience in the planning, design and implementation of energy solutions. Our 1,500 specialists working internationally provide expertise in the full range of energy strategies, engineering and master planning, including high efficient power plants based on gas, waste, biomass and renewable resources, as well as energy transmission, distribution and storage.

Ramboll contributes with its services to:

- Ensure project finance by provision of a strong independent opinion and support regulatory approvals with minimum delay.
- Identify solutions and recommend designs that avoid or reduce environmental and social impacts in a cost-effective manner.
- Evaluate solar resources, estimate energy yields and losses as well as minimize risks for a bankable basis.
- Deliver value throughout the project lifecycle.
- Assess community health, technical risks, safety and security.
- Enhance national & international reputation of our clients and their projects.

Ramboll is a one-stop-shop for smart and efficient energy solutions, combining power, cooling and heat generation for societies' future demand and supply of energy. We take responsibility to create a sustainable society where life is built on decarbonised energy systems that are based on renewable resources.
Solar PV Projects

Solar PV as substantial part of Hybrid Energy Systems
- Optimised systems to secure reliable power supply
- Solar PV combined with other renewable & conventional generators, storage facilities and flexible consumers
- Resilient and Smart Grid infrastructure (e.g. communication)
- Island, Micro, Off-Grids or embedded Smart Cities
- Holistic approach - sector coupling of energy systems (e.g. electricity, heating/cooling, Power-to-X, eMobility)
- Producer, consumer & prosumer – NEW business models

Solar PV Power Plants for IPPs and Utilities
- Multi Mega Watt projects
- Grid connected within existing or new power supply systems
- Locally managed and remotely supervised
- Long term reliability with high performance
- Competitive and proven system design and operation
- Rural, industrial or urban applications - globally
- Free field ground mounted installations in the desert, in open planes and on complex mountains or floating on water

Solar PV for commercial Clients with self consumption
- Rooftop, canopy or open space installation
- Net Metering or/and wheeling business models
- Designed and optimized to cover/fit with individual demand
- Cross-technology integration (e.g. Battery, Power2Heat)
- Demand Side Management (e.g. peak shaving, savings)
- Integration into Micro Grids & Smart Grid Systems
- Future energy systems standards (e.g. IEC TR 63097:2017)
- Decarbonisation of business (e.g. CSR, Green Footprint)
EXPERTISE IN EACH SERVICE AREA FOR YOUR SOLAR PV PROJECT

Our many local offices and multidisciplinary structure enable us to offer holistic services covering every aspect of a Solar PV project worldwide. Specialised teams are established from across the entire Ramboll group to ensure that the strongest expertise is applied to each individual project locally.

As a One-Stop-Shop service provider for all kinds of Solar PV projects we are able to offer singular, modular and tailor-made solutions depending on individual project requirements, composed of the following services:

- **Expert planning, engineering and Project Management** services throughout the entire project life cycle of a Solar PV project.
- **State-of-the-art Solar Resource Assessments**, measurements, energy yield & soiling studies as well as topographical surveys.
- **Full range of services** for comprehensive advice from one of the world’s leading Environmental Consultants and auditors.
- **Services covering all engineering disciplines** within power transmission needed for Grid Connection of Solar PV plants.
- **Innovative structure design**, world class Civil Expertise and specialist geotechnical know-how for long lasting solutions.
- **Asset Management** for performance follow-up on your Solar PV plant or portfolio based on a KPI driven monitoring system.
- **High level in-depth investigations** revealing Risks & Chances for our clients prior to plant acquisition or financing.
- **Strategic Management Consulting** and special services for entering new markets and service portfolios on client side.
Ramboll offers a complete service by acting as trusted adviser to clients at every stage of the project’s life cycle: from strategy development and planning over detailed design and engineering to project execution and commissioning.

We take part in approximately 40,000 projects each year, including some of the world’s largest and most complex infrastructure, building and power projects. Such sophisticated projects require flexible and cost-effective solutions. To address these demands, Ramboll’s ‘Project Excellence’ programme is dedicated to provide clients with world class project management, certainty and high quality solutions.

**Services during Project Development (1/4)**
- Site identification and topographical studies
- Conceptual plant design and feasibility studies
- Grid Impact Studies (GIS) and load flow analyses
- Engineering, adapted plant & infrastructure design
- Energy yield assessments
- CAPEX/OPEX modelling and cost benchmarking
- Approval planning and permit management
- ESIA, glare assessment and expert reports for permitting
- Project PR and stakeholder management

**Service during Procurement and Tendering (2/4)**
- Procurement schedules
- RfP invitation and tender documents
- Employer’s Requirements (ER)
- Tender criteria and evaluation documents
- Review of agreements (e.g. EPC, PPA, CA, SPA)
- Contract negotiations and award
- Contract implementation

**Audits and Technology Assessment (3/4)**
- Sourcing of bankable equipment and supplier
- Factory visits and supplier assessment
In power projects Ramboll typically acts in the role of the Owner's Engineer (OE) or/and technical consultant/engineer in connection within specific EPC, EPC-M construction assignments, trouble shooting, strategic evaluation, due diligence and O&M support.

Our clients consist of utility companies, industrial players, IFIs, banks & asset funds, EPC contractors & supplier, governments, cities and local communities.

Services during Project Construction and Commissioning (4/4)

- Design review & Due Diligence
- Project Management
- Project specification and schedules (e.g. budget, timing)
- Risk management and master implementation planning
- Health, Safety and Environmental management (HSE)
- Quality inspection, audits and surveillance
- Factory Acceptance Tests (FAT)
- Site supervision or site management during implementation
- Performance tests and commissioning
- Punch list and claim management
- Operational support and Life Time Extension (LTE)
- Special technical support and expert opinion
- Documentation and Reporting

The different roles could differ in the form of Ramboll’s participation within the Solar PV project: Starting from lead management services during the entire project implementation down to regular reviews and project audits ending in particular statements for specific project phases or/and activities.

We keep client focused in every phase of a project

Our clients’ need and satisfaction are key in every phase of a project and are the prerequisite for Ramboll’s success. It’s only by putting clients first that we can deliver the very best service and solutions in our projects. It is about understanding our clients’ needs and success criteria so that we can develop solutions that cater to these needs.
SOLAR RESOURCE & SITE ASSESSMENT

Based on 15 years of experience in following procedures under a Quality Management System (QMS) our team of engineers and experts is well suited to provide qualified, state-of-the-art solar resource assessments, to render measurement campaigns and energy yield & loss simulations utilizing latest data, models and software tools as well as to comply with the most demanding standards (e.g. IEC 61724-1:2017). The bankable outcomes create a reliable basis for investment decisions and financial closing of projects.

The basis for the analysis and services are:

▪ Solar resource maps for site identification and selection.
▪ Initial landscape topographical assessments.
▪ Long term climate and environmental conditions.
▪ Solar measurement campaigns & soiling studies.
▪ Conceptual design of the Solar PV plant.
▪ Simulations of the expected annual energy yield & production.
▪ PV power plants output loss & uncertainty assessment.
▪ Site access and grid interconnection solutions.
▪ Glare assessments and expert statements.
▪ Performance reviews and audits as well as plant optimisation measures using SCADA data and actual measurements.
▪ Key environmental and potential planning constraints.

Lessons Learned:
Working for more than 15 years in the field of Solar PV developments we state that the conceptual design of a Solar PV plant is mandatory for the financial success of the project. Very often, minor changes in the initial setting of a project considering e.g. technical aspects, site’s topography, the layout of the PV array or simple observations during the on-site visit, may cause a significant change of resources (time & money) in the development or/and implementation phase later on.
The protection of nature and the biodiversity of the environment are the main objectives to be considered within a new development. A bankable Environmental and Social Impact Assessment (ESIA) following local applicable and international standards (e.g. EBRD’s and IFC’s Performance Standards & Requirements, Equator Principals) constitutes the basis for each power project.

Over more than 20 years, our multidisciplinary teams of scientists have gained deep expertise in landscape, wildlife, fauna, wetlands, hydrology, watersheds, ecology and geology. Therefore, we are intimately familiar with navigating the complex network of local, state and federal government regulations and stakeholders.

We offer the following EIA/ESIA technical assessment services:

- Scoping and preparation of EIA/ESIA for submission to the authorities, local or International Financing Institutions (IFI)
- Archaeological and cultural heritage surveys
- Ecological and ornithological surveys to determine the presence of sensitive habitats and species
- Landscape, visual and socioeconomic impacts, including impacts on tourism, businesses and communities
- Electromagnetic fields and aviation interference (EMF/EMI), glare assessments and specific requested hazard risks
- Hydrology, hydrogeology and geology impacts, including waterways and steep slopes.
- Traffic and transport implications, including impacts on roads, ports/harbors during the different phases of a project
- Environmental Management & Mitigation Plan (ESMMP) incl. waste management prior, during and post construction

Our International Finance Practice (IFP) team combines an extensive knowledge of lender standards and broad sector experience, with a practical approach to resolving issues, thereby facilitating project compliance in a robust and cost-effective manner. Ramboll has particular expertise in complex biodiversity and social issues. The IFP team works through Ramboll offices in 18 countries and maintains a roster of external consultants around the globe for support on projects.
The effective development of a Solar PV scheme requires connection to the electricity transmission or distribution network in a way that optimises the developer’s CAPEX and OPEX, while complying with the applicable grid code and local technical and planning standards. The grid connection needs to provide a solution that optimises the often-conflicting requirements of cost and export reliability.

In the field of power transmission and distribution, Ramboll offers the full range of electrical engineering services necessary to assess, engineer and manage the grid connections for Solar PV schemes.

Our Power Systems team has extensive international experience in the analysis, planning and engineering of transmission and distribution networks from 11kV to 400kV, with services ranging from specialist studies to feasibility studies, FEED, engineering design, commissioning and project management.

Ramboll offers the following technical services aligned to the grid connection of Solar PV schemes:

- Scoping & feasibility studies for grid connection
- Techno-economic and reliability analysis
- Grid Code compliance and Grid Impact Studies (GIS)
- Design review and verification
- Power systems analysis, including load flow, short circuit and reactive compensation studies, dynamic response studies, fast transient EMTP and harmonic studies, substation grounding studies
- Substation engineering, including layout optimisation, switchgear, transformers, reactors, harmonic filters and SVC/Statcoms
- Protection and control schemes, SCADA and metering systems
- Transmission line and cable engineering and routing studies

We are well placed to provide a complete package of services for the development of large transmission connected or smaller distribution connected Solar PV schemes.
Structural engineering is a key discipline in design work whether as free field plant on the ground on specific topographies, as floating Solar PV on water bodies, with a multifunctional use as Solar Carpark (stand alone system) with shading effects or as integrated solution on existing complex structures, buildings and facilities. The calculation of adequate structural capacity within the design frame is a necessary safety measures to prevent over-utilization and requires advanced software analysis tools and specialist structural engineering expertise.

Our civil and structural engineering work for e.g. ground based generation facilities includes the design of different types of foundations as well as materials depending on the sub-structures for a range of installations. The dimensions and the type (e.g. fixed, floating, tracker system) of the plant have to be considered in relation to the local weather conditions and their extreme values (e.g. wind, ice, snow, sand, water, temperature) to ensure long term operations and viable lifetime of power production.

Ramboll uses intelligent 3D CAD systems for integrated plant layouts, modelling of facilities and design tasks. Our structural and civil engineering services cover:

- Ground survey programs and execution
- Geotechnical calculations (e.g. stability, settlement, bearing capacity, etc.) and design review/verification
- Laboratory tests, load analysis and audits
- Geotechnical maps and section drawings
- Design of e.g. substructure, foundation, drainage system and roads – covering the general BoP scope for civil engineering
- Design of control building, warehouse and auxiliary space
- Fencing, security and protection measures
Ramboll is qualified within all parts of technical operation management and supervision of power plants necessary to achieve high availability, performance, profitability and safety. We use our experience with qualified and proven management procedures together with specific technical services to deliver solutions that support our clients' operations and enhance project’s economy.

We have extensive experience in supporting our clients with post-permitting and construction services including:

- Technical Operation Management (TOM) and KPI based monitoring of the power plant.
- Portfolio management of various assets.
- Performance analysis and regular audits.
- OPEX modelling and lifecycle cost analysis.
- Development of environmental and waste management plans for post construction.
- Discharge of permit and approval conditions.
- Sourcing of suitable TOM team & set-up of team organisation together with technical interfaces, stakeholders, project documentation and working procedures.
- Developing of project specific O&M concept (e.g. spare part management, resources, cleaning strategy).
- Forecast system, bankable documentation and reporting (e.g. energy trading).
- Drone and thermography assessments.

Through our holistic approach, we create smart information & communication systems to supervise KPI’s, show deviations, present alarms and errors for a fast follow-up and to identify trends in the overall performance of the plant (e.g. failures). A sustainable O&M concept will lead to minimal OPEX and a maximum optimisation of revenue over the lifetime of the plant for the owner.
A comprehensive risk assessment ensuring compliance with technical, permit/regulatory, ESIA and CSR requirements provides a solid basis for investment decisions and assures a robust business case for the solar project.

Our due diligence process focuses on the interaction between commercial and technical risks. We rely on the experience of our specialists from all disciplines within power plant engineering resulting in an integrated advisory team, providing our clients with the technical and strategic recommendations, market assessments, third party evaluations, and advice needed to optimise their investments.

We support banks, financial institutions and private equity firms reviewing solar power plants which are under development, being already constructed or in operation to ensure that there are no “fatal flaws” that would prevent a solar power plant from being constructed or continuing to operate. Our Technical Due Diligence (TDD) services include for example:

- Gap Analysis (quantity).
- Review of studies and assessments (quality).
- Review of design, engineering & technology (quality).
- “Fatal flaw” analyses, incl. review of permits and approvals, and environmental/social impacts to ensure compliance with regulatory guidelines.
- Review of contracts like EPC, O&M, PPA, CA and PSA
- Risk analysis and benchmarking with similar projects in the market (CAPEX, OPEX).

The review of the project specific documentation follows various phases and level of details (TDD 1.0 to 3.0) according to scope & resources of the client, for instance, at a conceptual level (for acquisition of project rights & shares, budgeting), ready-to-build level (for CAPEX/OPEX financing, equity participation) and operating level (repowering, asset deal, equity).
STRATEGY & SPECIFIC SERVICES

TRANSFERRING VISIONS INTO PLANS

With 600 experts in management consulting we provide our clients with precisely the knowledge and services they need. We deliver both stand-alone services as well as the complete transformational approach by multidisciplinary services. Whatever the challenge, our services rest on tried and tested methods.

We strive to be the consultancy that best equip our clients to address the most transformational megatrends in an increasingly global world; like digitalisation, mobility, liveability, climate change, and sustainability. Our mission is to create sustainable societies where people and nature flourish. This is our driving force and the reason why nearly 40% of our revenue stems from projects that in one way or the other help progress the UN Sustainable Development Goals. And we are pushing for more.

Strategy planning & individual consultancy services

- Energy master planning (e.g. resilience, carbon footprint, decarbonisation scenarios, forecasting).
- Business model analysis & market entry studies
- Energy sale & auction strategy within tender schemes
- Digitalisation & systems integration
- Training & coaching
- Peer review of existing studies and conducting new research
- Direct expert testimony in court proceedings or at inquiry
- Supporting negotiations with regulators, dispute resolution or third-party litigation

Project experience

The city of New York is inspired by the scale of Copenhagen’s blue-green infrastructure. The city’s department of environmental protection has selected Ramboll to analyse whether similar solutions can also pay off in the biggest city in the US.
SOLAR FOOTPRINT IN THE WORLD

>3 GW
15 YEARS EXPERIENCE
500+ PROJECTS
30+ COUNTRIES

NORWAY
470 kW Solar PV
Building Integrated

FINLAND
18 MW Solar PV
Layout Design

DENMARK
60 MW Solar PV
Expert Statement

ROMANIA
5 MW Solar PV
Feasibility Study

ITALY
120 MW Solar PV
ESIA for 10 plants

UK
30 MW Solar PV
Feasibility Study

CZECH REPUBLIC
10 MW Solar PV
Feasibility Study

BULGARIA
900 kW Solar PV
Planning & Design

SPAIN
200 MW CSP
Environmental Due Diligence

GERMANY
7 MW Solar PV
Glare Study

BELARUS
16 MW Solar PV
Conceptual Design

UKRAINE
10 MW Solar PV
Energy Yield
Assessment

MOROCCO
1,336 MW CSP
EIA Management

MONGOLIA
50 MW Solar PV
Gap Analysis

CANADA
12 MW Solar PV
Energy Yield
Assessment

FRANCE
3 MW Solar PV
Technical Due Diligence

BELGIUM
7 MW Solar PV
Conceptual Design

JAPAN
14 MW Solar PV
Environmental Review

UNITED STATES
Floating Solar
Evaluation of Potential
Environmental Impacts

CHINA
12 Solar PV Sites
Environmental Site
Assessment

ALBANIA
2 MW Solar PV
EPC tendering support

INDIA
5.5 MW Solar PV
Design Structure

MYANMAR
200 MW Solar PV
ESIA

EGYPT
50 MW Solar PV
Energy Yield
Assessment

JORDAN
10 MW Solar PV
Grid Impact Study

ARMENIA
50 MW Solar PV
Energy Yield Estimate

PERU
2x20 MW Solar PV
Pre-Investment Review

GHANA
25 MW Solar PV
Feasibility Study

MAURITIUS
780 kW Solar PV
Static Analysis

CHILE
160 MW Solar PV
Independent E&S
Consultant

EXCERPT OF SOLAR PROJECTS [BY 03.2018]