Established in 1922 and family-owned ever since

Project experience in more than 170 countries

Total turnover of €246 million in 2017

More than 1500 employees worldwide – over 500 of these in our home office

Long-standing employees from 66 nations

Certified systems for quality, workplace health, safety, compliance, environmental protection
22 companies | 60 countries

100+ locations

Home office in Stuttgart | 22 subsidiaries and affiliates
Over 100 branch and project offices | Present in 60 countries worldwide
Planning and consulting in all project phases - for technically and economically sound solutions
INDEPENDENT

We are an owner-managed family business that has maintained its independence in order to seek objective and customer-oriented solutions.

COMPETENT

Highly qualified employees, decades of experience and a comprehensive quality management ensure project success.

INTERNATIONAL

Thanks to the global nature of the Fichtner group with its worldwide network, projects can be handled close to the customer.
Energy

With technical and economic expertise, we advise on all current issues, from energy procurement to its efficient use.

- Energy economics
- Conventional power plants
- Power transmission and distribution
- Automation and telecommunications engineering
- E-Mobility
- Energy transportation and storage
- Energy Management
- Oil & Gas
Renewable Energies & Environment

With highly qualified engineers and consultants, we work on complex projects in the field of renewable energies and the environment.

- Renewable energies
- Environmental studies
- Permit engineering
- Environmental management
- Environmental protection technologies
- Waste management
Water & Infrastructure

With technical, ecological and economic know-how, we advise on the construction and operation of infrastructure facilities and ensure the responsible use of water resources.

- Integrated water resources management
- Water supply and sanitation
- Seawater desalination
- Architecture and building construction
- Civil engineering and structural planning
- Transportation
- Mining and minerals
- Geotechnics
Consulting & IT

With comprehensive consulting services and a high degree of IT expertise, we complement the engineering services in all our business areas.

▪ Strategy and organization consultancy
▪ Transaction advisory services
▪ Economic consultancy
▪ Project management
▪ Arbitration proceedings
▪ Asset management
▪ IT consultancy
▪ Smart IT solutions
▪ Smart energies
Energy Efficiency (EE)

Range of services

Fichtner is supporting clients all over the world in using their energy more efficiently and thereby saving costs and emitting less green house gases. Areas to improve energy efficiency are within conversion of energy such as generation of power or heat and the end-use of energy such as within industrial production, buildings or Small and Medium Enterprises (SME). Our services comprise:

▪ EE audits and specification/design of EE measures
▪ Implementation of Energy Management Systems (EnMS) and Energy Monitoring Systems (EMS)
▪ Design and execution of trainings on: EE audits, EE marketing, EnMS and EMS (e.g. Train-the-Trainer)

On behalf of Development Banks Fichtner is operating Sustainable Energy Loan Programs:
▪ Marketing of EE financing opportunities
▪ Collection and assessment of EE project proposals
▪ Development of energy audits
▪ Assessment and monitoring of EE improvements
Energy Efficiency (EE)

Overview of Fichtner services

**Fichtner's Energy Efficiency Services**

- **Energy Audits**
  - EE Measures
  - Savings: energy, costs
  - Investment needs
- **Implementation of EE-measures**
  - Specification
  - Supervision
  - Post construction audits
- **Energy Monitoring Systems (EMS)**
  - Visualization and monitoring of consumption of energy and costs
- **Energy Management Systems (EnMS)**
  - Specification
  - Implementation
  - Assistance of certification
- **Energy Efficiency Training**
  - Energy managers
  - Authorities
  - ESCOs
  - Train the Trainers

**Typical Vehicles to implement EE**

- Sustainable Energy Loan Programs
- ESCOs - Energy Service Companies

**BAT = Benchmark for EE**

**Reduction of Losses → Increase of Energy Efficiency**

**Overview of Fichtner Services**

- **Energy Conversion**
  - Fuel RE
  - Losses
  - Power
  - Heat
  - Cooling
  - Industry
  - Buildings
  - SM Es

**Sustainable Energy Loan Programs**

**ESCOs - Energy Service Companies**

**BAT - Best Available Technologies**

**EE - Energy Efficiency**

**RE - Renewable Energies**

**SM Es - Small and Medium Sized Enterprises**
Energy Efficiency (EE)

Experience - Overview

Fichtner has a broad international experience in the field of energy efficiency, such as:

- Handling more than 300 EE projects in industry, SMEs, municipalities and buildings
- Working on EE projects in more than 40 countries worldwide
- Operating 12 Sustainable Energy Loan Programs
## Energy Efficiency (EE)

### Selected References

<table>
<thead>
<tr>
<th>Reference</th>
<th>Description</th>
<th>Dates</th>
<th>Count/Details</th>
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<tr>
<td>1</td>
<td>Energy Efficiency and Resource Audits in the industry in Middle and South America</td>
<td>04/2010 - 11/2013</td>
<td>6 industrial energy audits</td>
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<td>2</td>
<td>Moldovan Sustainable Energy Financing Facility (MoSEFF) for Small and Medium Enterprises</td>
<td>09/2009 - 12/2017</td>
<td>577 EE applications, 271 EE audits</td>
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<td>3</td>
<td>Energy audits and of energy efficiency measures in public buildings in Montenegro</td>
<td>01/2012 - 12/2015</td>
<td>40 EE audits, 30 EE projects implemented</td>
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<tr>
<td>4</td>
<td>Energy management system, energy monitoring system, building inventory; Montenegro</td>
<td>10/2017 - 11/2021</td>
<td>Energy Management &amp; Monitoring tools</td>
</tr>
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</table>
Energy Efficiency

Energy efficiency and resource audits in the industry in Middle and South America

DEG is seeking financing opportunities and intends to finance measures for raising energy efficiency and conserving resources in industrial plants. To justify the financing decision Fichtner undertakes energy and resource audits.

Fichtner services:

▪ Site visits to review production processes and assess energy and resource efficiency

▪ Energy audits to review the suggested and identify further measures for upgrading energy efficiency and using renewable energies

▪ Audited plants:
  – Guatemala: sanitary paper factory; sugar factory
  – Brazil: wood processing facility
  – Uruguay: plywood and fiberboard factory
  – Mexico: sugar refinery; wood processing facility
Energy Efficiency

Moldovan Sustainable Energy Financing Facility (MoSEFF) for Small and Medium Enterprises

EBRD has established the Moldovan Sustainable Energy Financing Facility (MoSEFF) with the aim of financing energy efficiency (EE) and renewable energy (RE) projects in Small and Medium Enterprises (SMEs). Another aim was to familiarize local banks with appraising and financing EE and RE projects. As an anticipated outcome a self-financing market for investments in sustainable energy projects is established in Moldova. Fichtner acted as project consultant for managing and implementing the MoSEFF.

Fichtner services:
- Marketing campaigns to promote the financing facility
- Working with local banks in developing a project pipeline
- Assessment of 577 EE and RE project applications
- Site visits and identification of further opportunities to improve EE and use RE
- Energy Audits and approval of 271 EE and RE projects
- 104 public seminars, 24 workshops with local banks
- Monitoring and reporting of facility performance to EBRD

European Bank for Reconstruction and Development (EBRD), London

09/2009 – 12/2017

577 EE applications, 271 EE audits
Energy Efficiency

Energy audits and energy efficiency measures in public buildings in Montenegro

The Government of Montenegro has launched the “Energy Efficiency Program in Public Buildings I” (EEPPB I). The Ministry of Economy has taken the lead in implementing all energy efficiency projects under the Energy Efficiency Law. Fichtner acts as the Program Consultant to provide consultancy services to execute the EEPPB I.

Fichtner services:
- Assessment of 40 educational buildings by walkthrough audits and preparation of a shortlist of 30 eligible projects
- Conduction of 30 detailed energy audits
- Preparation of conceptual and final design
- Preparation of tender documents and guiding tender process
- Supervision of construction works
- Post-construction energy audits to confirm the target of 20% energy savings
- Support to set-up an energy efficiency training program

Ministry of Economy, Sector for Energy Efficiency, Podgorica

01/2012 – 12/2015

40 EE audits, 30 EE projects implemented
Energy Efficiency

Energy management system, energy monitoring system, building inventory; Montenegro

Fichtner supports the Government of Montenegro in the implementation of the "Energy Efficiency Program in Public Buildings II" (EEPPB II) funded by KfW. The program supports the implementation of the “European Public Building Directive” and provides the basis for the future issuing of “Energy Performance Certificates” for buildings. The activities of the project are related to all 5000 public buildings in Montenegro.

Fichtner services:

- Energy management system: concept development
- Energy monitoring system: concept development, support within tendering, bidder selection, supervision of implementation
- “Energy Performance Certificate” software: supervision of development
- Implementation of a building stock inventory, collection of structural building data
- Energy efficiency classification of buildings and definition of reference buildings
- “Cost optimal level” – analysis of reference buildings
- Support of the update of the national energy efficiency rules
- 59 Post construction audits of buildings refurbished in EEPPB I

Ministry of Economy, Sector for Energy Efficiency, Podgorica

10/2017 – 11/2021
Energy Efficiency

Training on energy efficiency and environmental compliance; Georgia, Montenegro, Republic of Moldavia, Romania, Serbia

In countries where EBRD is active, Small and Medium Enterprises report on low energy performance compared to international average. Reasons are obsolete technologies, lack of information on and awareness of energy efficient technologies, difficulty in accessing financing, no or a limited number of consultants being able to deliver Energy Efficiency (EE) services. The objective of the assignment is to design and deliver EE trainings to local consultants.

Fichtner services:
- Undertake local training needs assessments
- Prepare curriculum and training material for industrial and building EE courses for different knowledge levels
- Carry out training courses in different countries including presentations, exercises and on site audit demonstrations
- Train on how to sell energy efficiency consultancy services
- Provide a set of tools to assess EE measures
- Provide follow-up mentoring to local consultants

European Bank for Reconstruction and Development (EBRD), London

03/2013 – 11/2014

4 different EE training courses of 3-5 days
Posta Veche, solar system
“Hotel Dacia” in Ungheni was built in 1976 and has been out of order for the recent 8 years. The hotel is planned to be reopened in spring 2011 and will complete with all rehabilitation works in autumn 2011. The hotel will contain 3 conference rooms and 58 guest rooms; 30 of them with two single beds and 28 rooms with one big (double) bed. This leads to a total of 116 guests who could stay overnight as the maximum. With the aim to improve energy efficiency in the hotel, the company decided to enter the MoSEFF program. Due to this “Hotel Dacia” reached energy savings in an amount of 80% that greatly improved the company’s economical situation.

### SUCCESS STORIES

**“DACIA” – Hotel**

<table>
<thead>
<tr>
<th>Region</th>
<th>Ungheni, Moldova</th>
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<tr>
<td>Energy Consumption</td>
<td>830 MWh per year</td>
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<tr>
<td>Project Goals</td>
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<tr>
<td></td>
<td>Installation of solar collectors</td>
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<tr>
<td></td>
<td>Thermal insulation and replacement of windows</td>
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<tr>
<td></td>
<td>Gas grid connection</td>
</tr>
<tr>
<td></td>
<td>Installation of condensing boilers and rehabilitation of heat distribution system</td>
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</table>

<table>
<thead>
<tr>
<th>Main Investments</th>
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<tbody>
<tr>
<td>Solar collectors</td>
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<tr>
<td>Insulation of building shell</td>
</tr>
<tr>
<td>Windows replacement</td>
</tr>
<tr>
<td>Gas grid connection</td>
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<tr>
<td>Condensing boilers</td>
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<tr>
<td>Heating distribution system</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Investment volume</th>
<th>EUR 280,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payback period</td>
<td>8 years</td>
</tr>
<tr>
<td>Project Results</td>
<td></td>
</tr>
<tr>
<td>80% final energy savings</td>
<td></td>
</tr>
<tr>
<td>79% CO2 emissions reduction, what is equal with 133 tones of CO2 reductions per year.</td>
<td></td>
</tr>
</tbody>
</table>

MoSEFF was developed by: [European Bank for Reconstruction and Development](https://www.ebrd.com) and Technical Assistance financed by: [INOGATE](https://www.inogate.org) and the European Union.

For additional information please contact MoSEFF on [www.MoSEFF.org](http://www.MoSEFF.org) or call our hotline on +373 (0) 60 13 46 69.
Hotel Dacia, energy efficiency criteria

**Characteristic data:**

U-Value

**Criteria:**

External walls / temperature difference more than 10 K

Walls: $\Delta U < 0.60 \text{ W/m}^2\text{K}$

Roof: $\Delta U < 1.00 \text{ W/m}^2\text{K}$

Floors: $\Delta U < 0.40 \text{ W/m}^2\text{K}$

New windows: $U_{wo} \leq 2.1 \text{ W/m}^2\text{K}$;
Hotel Dacia, energy flow (water heating system)

**Baseline (old system)**

- **Natural Gas**: 93 MWh
- **Hot Water**: 67 MWh
- **Losses**: 25 MWh

**Project substitutes natural gas by solar heat**

- **Solar Thermal Energy**: 62 MWh
- **Natural Gas**: 19 MWh
- **Electricity***: 2 MWh
- **Losses**: 14 MWh

* auxiliary electricity for solar pumps
Feasibility Study – Hybrid Power Plants

Drawing up specifications and tender documents, Germany

In the Philippines as in other countries in the region and around the world PV-solar hybrid systems have become a cost effective alternative solution to provide electricity to off-grid areas. The Philippine government is preparing to tender out a number of off-grid generation systems in remote areas of the countries as well as on islands.

Fichtner is conducting feasibility studies and concept design considering the optimum system configuration of a generation power plant in off-grid area required for each of the projects and prepare Minimum Functional Specifications (MFS) for each of the projects.

For each off-grid hybrid system Fichtner will consider the existing Diesel generators in a combination with new PV, possibly wind and storage plants. Other technologies may be considered case by case. Using Fichtner’s own certified hybrid optimization software the best configuration will be determined. For the final selected solution a basic design will be elaborated. Levelized Cost of Electricity (LCOE) as well as CAPEX and OPEX will be calculated.

As a basis for future tendering of the hybrid power generation systems Minimum Functional Specifications as well as Hybrid Performance Guarantees will be prepared.

12 sites:
PV: 49 MW
Storage: 16 MW / 35 MWh
Diesel: 135 MW
I. Assessment of site conditions

- Existing and conventional power stations
- Grid and load analysis
- Resource assessment (solar, wind, geothermal, biomass, etc.)

II. Technical Simulation

- Yield simulations of renewable energies
- Hybrid power plant model incl. load and conventional power systems
- Simulation over operation period

III. Techno-Financial Optimization

- Calculation of financial parameters (NPV, IRR, LEC, Payback) with dynamic cash flow model
- Optimizing technologies, sizing and operation to achieve highest financial benefits
Design of Renewable Hybrid Plants

Fichtner Hybrid Configurator

- CSP Plant
- PV Plant
- Wind Turbines
- Fossil Plant
- Thermal Storage
- Electrical Storage
- Grid

Energy Flow
Cost Optimization

System Costs

CAPEX / OPEX
Exemplary Hybrid Project: Dairy farm in Saudi Arabia

Project Background

- 75,000 cows at 30-50°C in the Arabian desert
- Peak electrical demand between 75 – 100 MWe
- Heating and Cooling demand for milk processing
- Currently powered by multiple 4-8 MW diesel generators
- LFO price today at 12 USDct./liter

Challenge

- Increasing production and demand of energy
- Fuel price increase
- Fuel budget limitation
- Manure disposal

Hybrid Project Solution

- Save fuel
- Increase maximum power output
- Implementation in stages until 2022
Energy Concept

- **Existing Prime Power Supply**
  - ORC

- **Backup Diesel Generators**
  - Electrical Storage

- **PV**
  - Electrical demand

- **Biogas fermentation**
  - CHP
  - Adsorption chiller
  - Heat recovery
  - Heat demand of Processing Plants

- **Extension of Prime Power Supply**
  - Heat recovery

- **Boiler**
  - Mechanical Demand of Irrigation Pumps

- **Decentralized Diesel Engines**

- **Cooling demand dairy farms**

- **Chillers**

- **Electrical demand**

**Fuel Sources:**
- HFO
- LFO

**Fuel Supplies:**
- LFO supply
- HFO supply

**Energy Types:**
- Electrical energy
- Heat energy
- Refrigeration energy
- Mechanical energy

**Power Generators:**
- Diesel
- ORC
- CHP
- Adsorption chiller
Conventional Diesel generators

Diesel Generator specifications:
- 8 x 8 MW engines (Prime) running on HFO
- 48 MW Back-up generators distributed over Dairy farms running on LFO

Objective:
- Main power supply
- Active and reactive power control
- Ramp rate + frequency control
- Peak power supply
- Back-up power

Generation costs:
- HFO: 3.1 USDct./kWh
- LFO: 4.9 USDct./kWh
Organic Rankine Cycle Plant

**ORC specifications:**
- Heat recovery of diesel engine exhaust
- ORC Module (Turbine + Thermal oil circuit) 4.8 MWe (8 x 600 kWe)
- Air cooled condenser existing from diesel generators

**Objective:**
- Increasing electrical efficiency of main diesel engines (Reduce fuel consumption also at partial loads)
- Increase maximum power output

Generation costs: 4.5 USDct./kWh
Diesel engines for CHP

New diesel engines for CHP specifications:
- 8 MWe Diesel engines (For HFO + LFO) (2 engines Stage I + 3 engines Stage II)

Objective:
- Provision of Electricity
- Increase maximum power output
- Provision of ramp rate + frequency control
- Provision of Heat (Steam 200 °C, 8 bar)

Interfaces:
- Switchgear at Processing Power Plant
- Steam interface at Boiler Plant

Generation costs: 3.2 USDct./kWh (heat not included)
**PV Plant**

**Objective:**
- Provision of electricity (active + reactive)
- Increase maximum power output during day
- Save diesel fuel

**Specifications:**
- 40 MVA (Stage I) + 50 MVA (Stage II)
- DC/AC ratio: 1.1

**Interfaces:**
- Switchgear at Main Power Station

**Generation costs:**
- 1-axis tracked: 4.65 USDct./kWh
- fixed: 4.85 USDct./kWh
Biogas Plant

Objective:
- Provide electricity (Base load) and save diesel fuel
- Provision of Cooling energy
- Provision of Fertilizer
- Disposal of manure

Specifications of Biogas Plant:
- 6.3 MWe (split into 2 locations)
- Adsorption Chiller and circuit at Dairy farm
- Interconnection to 34.5 kV at Dairy farm

Interfaces:
- Power connection
- Cooling circuit at Dairy farm
- Fertilizer at Compost area

Generation costs: 14 USDct./kWh (cooling not included)
Electrical Storage

Objective:
- Increase of maximum power output
- Provision of reactive power
- Provision of spinning reserve (bridging the time the diesel generators need to start up to avoid inefficient reserve capacity)
- Firming of short-term fluctuations of PV (e.g. clouds, sand storms) until ramp rate capabilities of the diesel generators
- Load shifting of PV energy production to increase PV utilization
- Black-start capability

Specifications of Storage:
- Lithium-ion technology
- 50 MW / 25 MWh (Final Stage)

CAPEX assumption: 28 mio. USD (2016)
## Lessons learned in Hybrid Projects

<table>
<thead>
<tr>
<th>Hybrid Project Challenges</th>
<th>Project Risks</th>
<th>Solutions / Mitigations</th>
</tr>
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<tr>
<td>Off-taker has doubts of benefits</td>
<td>No management board decision on execution</td>
<td>Feasibility study certified to VDE-PB-0014:2015, Implementation in stages</td>
</tr>
<tr>
<td>High RE share desired</td>
<td>Supply reliability, low utilization</td>
<td>Conventional plants still required, Electrical storage</td>
</tr>
<tr>
<td>Developers with expertise in all technologies</td>
<td>Plant optimization difficult, low competition, technical difficulties</td>
<td>Strict MFS, separate EPC expertise requirements, dispatch experience requirements</td>
</tr>
<tr>
<td>Performance guarantees for off-taker (fuel provided by off-taker)</td>
<td>High operational costs / risk for developer depending on load and resource conditions</td>
<td>Separate performance tests of plants, dispatcher tests</td>
</tr>
<tr>
<td>Investor risks of feed-in interaction</td>
<td>No financing or high financing rates</td>
<td>Split of payments and deemed energy payments for curtailment</td>
</tr>
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