10

Water Sustainability and Power Generation in ITALY

10.1 Local water challenges in Italy

10.1.1 Water availability

Water availability in Italy varies substantially across the country. Areas of southern Italy where rainfall patterns are extremely uneven are considered as semi-arid. Water here is a limiting factor and severe droughts have occurred in recent times in this region, specifically between 1988 and 1990.[98]

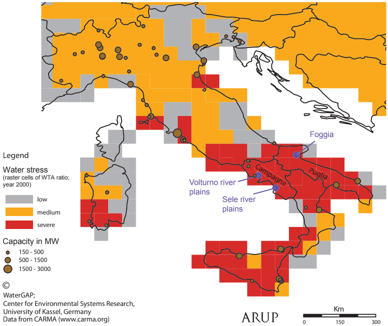
The established practice of withdrawing groundwater (principally for irrigation) throughout Italy, and particularly in the south, has led to overexploitation of potentially renewable resources. This has put considerable pressure on many groundwater reserves.[99] As a result, public water supply increasingly relies on desalinated water to supplement traditional resources.

See PI-TP 10 & 11

Additional pressures on water availability are attributed to increased consumption and increasing numbers of tourists in the period of May to September when water stress peaks. Consequently, water resource conflicts between different users (tourism, industry and agriculture) are likely. **In light of water competition between users, power companies and investors or other financial institutions servicing them may be exposed to reputational risk.** An overview of the water stress in river basins across Italy is shown in **Figure 11**.

Figure 11:

Overview of the water withdrawal-to-availability ratio calculated by WaterGAP that indicates low, medium and severe water stress in river basins across Italy. The location of selected power stations (>150 MW) is also indicated.



10.1.2 Climate change impacts

Several global studies have concluded that the Mediterranean will be significantly affected by future climate change. This will result in decreasing precipitation and increasing temperatures. In light of this, confident projections suggest that the area will suffer from water shortages in the future.[100] An outlook on how water availability is expected to change is provided by the University of Kassel.[101]

A thorough assessment of climate change impacts affecting current and future power sector operations is crucial. Financial institutions should emphasize this requirement during negotiations with their clients.

See PI-TP 6

10.1.3 Water quality

In coastal plains, groundwater abstraction has sometimes resulted in saltwater intrusion.[102] Where there are high levels of agricultural activity, with high levels of fertiliser use such as the Po River Basin, groundwater resources may contain high concentrations of nitrates.[103] The waste produced by agriculture,rearing livestock and the high level of regional development have negatively impacted water resources.

10.1.4 Institutional context

Italy has a long history of water legislation including the Consolidated Law of 1933. More recently, the *European Union Water Framework Directive* commits Italy to achieve good qualitative and quantitative status of all water bodies by 2015. At a regional level, the established *District Basin Authorities* are responsible for water resources management and the allocation of resources to different uses.[104]

10.2 The electricity power sector in Italy

The generation of electricity in Italy is mostly from thermal sources. In 2005 gas accounted for 50%, followed by coal (16%) and oil (15%). Over recent years, the mix of thermal power has gradually shifted away from oil and toward natural gas. Electricity generation from hydropower generated 14% of the electricity in 2006.[105]

10.2.1 Expansion

ENEL, the former state utility now partially privatised, is planning to convert several old large oil fired power stations to coal, in order to have a "better" energy mix. The first of these is a 2 GW power station in Civitavecchia, near Rome, which is expected to come online in 2011. A second 2 GW station is planned in Porto Tolle, in the River Po delta and will be completed in 2016.

Most new investment in electricity generating capacity in Italy has been in the form of gas-fired plants, specifically combined-cycle, gas-fired turbines.[106]

See PI-TP 1

10.2.2 Renewable energy

Italy's main national indicative objective is 22% of electricity from renewable energy sources in the gross electricity consumption in 2010 under the EU Directive 2001/77/CE. The 2005 renewable energy electricity gross production (almost 50 TWh) represented 16.4% of total gross production, 15.1% of total electricity demand (net consumption + network losses = 330,4 TWh) and 14.1% of gross inland consumption (352,8 TWh). The main tool to support renewables will remain the "Green Certificate" market-based mechanism. In parallel, the feed-in tariff scheme for photovoltaic and the recent legislation on energy efficiency in the building sector will contribute to accelerating the increase of renewables in the energy mix.[107]

Contributions from renewable sources in 2006 included biomass (1.2%), geothermal (1.8%) and wind (0.9%).

The 24 MW Montalto di Castro solar power plant, the largest solar photovoltaic (PV) facility in Italy, was completed in 2009 as the first phase of a planned 85-100 MW development that will be fully operational in 2010.[108]

10.2.3 Other

Italy banned nuclear power generation in a 1987 referendum but the Italian government is interested in reintroducing nuclear energy.[109]

In the summer and early fall of 2003, Italy experienced a significant power blackout when supply was unable to meet a surge in power demand as the result of increased air conditioning use during an extreme heat wave.[110]

11

Water Sustainability and Power Generation in GREECE

11.1 Local water challenges in Greece

11.1.1 Water availability

Water availability in Greece is limited due to its Mediterranean climate. Precipitation is spatially skewed with an average of 1500 mm in the West and 400 mm in the East. Water shortages are common particularly in the areas to the South-East where consumptive use is greatest and precipitation lowest.

Few rivers exist in peninsular Greece and many of the existing small rivers and streams dry up during the summer months. By contrast, rivers in the Balkan Peninsula (which flow through northern Greece) - for example, the Axios (*Vardar*) and Strymonas (*Struma*) - have significant summer discharge.[111] Over-exploitation of groundwater has resulted in low groundwater tables and there is limited effective control on the amount of water extracted.[112] Agriculture presently uses 84% of available resources whilst domestic supply and industry account for 13% and 1.7% respectively.

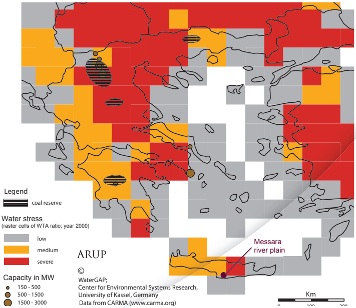
The tourism industry is a significant user of water in this region. The high season is concentrated in the period of May to September when water availability is at a minimum and water stress peaks. **In light of water competition between users, power companies and investors or other financial institutions servicing them may be exposed to reputational risk.**

See PI-TP 11 & 10

Levels of water stress in river basins across Greece are presented in Figure 12.

Figure 12:

Overview of the water withdrawal-to-availability ratio calculated by WaterGAP that indicates low, medium and severe water stress in river basins across Greece. The location of selected power stations (>150 MW) is also indicated.



11.1.2 Climate change impacts

Several global studies have concluded that the Mediterranean will be significantly affected by future climate change. This will result in decreasing precipitation and increasing temperatures. In light of this, confident projections suggest that the area will suffer from water shortages in the future.[113] A global outlook on how water availability is expected to change as a result of climate change is provided by the University of Kassel (**Figure 3**).[114]

See PI-TP 6

A thorough assessment of climate change impacts affecting current and future power sector operations is crucial. Financial institutions should emphasis this requirement during negotiations with their clients.

11.1.3 Water quality

A significant cause of water pollution in Greece is the increasing level of salinity in groundwater. This is caused by both seawater intrusion into aquifers and returns from irrigation water. Seawater intrusion is exacerbated by the long coast line of Greece, the karstic characteristics of the aquifer systems and the potential for sea-level rise in the future.

11.1.4 Institutional context

The transposition of the *European Water Framework Directive* (WFD) into Greek legislation has resulted in a new institutional framework to manage water.[115] The protection and management of river basins and the implementation of the WFD are the responsibility of thirteen Regional Water Directorates. In the case of shared river basins, the National Water Committee determines which regional authority is responsible.[116] To comply with WFD, increasing attention has been given to *minimum ecological flows*, which is the component of river flow necessary to maintain ecosystems.

See PI-TP 8

Financial institutions will have an increasing interest in ensuring the compliance of projects/clients in the power sector with existing and/or emerging environmental regulation on water such as the European Water Framework Directive.

11.1.5 Transboundary water management

Approximately 25% of the available water resources from rivers is derived from trans-boundary watercourses where Greece is the downstream country.[117] Increases in water development in upstream countries and subsequent reductions in river flow could impact on water availability in these regions.

11.2 The electricity power sector in Greece

Greece has a total installed capacity of approximately 13.7 GW. The electricity generation system is composed of the mainland system, the autonomous systems of Crete and Rhodes, as well as independent power stations on the numerous smaller islands. The most important source of fuel for electricity generation in Greece is brown coal (lignite), which accounts for 53% in the energy mix. Most of the thermal power plants are located in the North of the country where the lignite fields are located. The remaining energy sources are gas (18%), oil (16%), hydropower (11%) and wind (3%).[118]

11.2.1 Expansion

See PI-TP 1

Whilst domestic lignite is the most significant fuel for power generation, the use of natural gas is growing due to investment by the government into this area.

11.2.2 Renewable energy

Greece has significant renewable energy potential, particularly from wind, solar, biogas and hydropower resources, however the installed capacity remains very low (excluding large hydro units). Greece has an installed hydroelectric capacity of 3,135 MW and the annual hydroelectricity generation ranges between 3.5 and 6.0 TWh. Hydroelectric plants are located at reservoirs and are designed and operated to cover peak load.

The use of renewable sources is also expected to grow as an EU mandate stipulates that 20% of electricity must be generated by renewables by 2010.[119] According to a new EU Directive, Greece will have to generate 18% of its final energy consumption from renewables by 2020 (currently it is 6.9%). To reach this target, the installed capacity of renewable energy sources will have to be increased by expanding, among others, wind power from the current 1,000MW to almost 9,000-10,000 MW as well as PVs from 30 MW to almost 1,000 MW by 2020.

As yet, only a quarter of the hydropower potential has been exploited. However, the exploitation of only a very small portion of the remaining potential is technically and financially viable. The development of new large hydropower plants has stagnated due to the opposing claims of water users, a lack of interest from the Public Power Corporation, political opposition from agricultural cooperatives as well as technical and financial difficulties.[120] These issues are all exacerbated by the fact that most attractive sites have already been developed. By contrast, small hydropower plants are considered more attractive due to their lower environmental impact and attractive financial opportunities in this sector.

11.2.3 Other

Despite the liberalisation of the electricity sector, the sector is dominated by the previously state owned Public Power Corporation (PPC). Currently, PPC provides over 90% of generating capacity although competition is beginning to grow.

12 Water Sustainability and Power Generation in MOROCCO

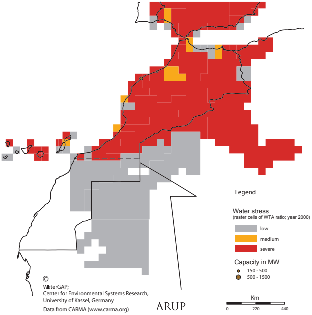
12.1 Local water challenges in Morocco

12.1.1 Water availability

In Morocco, three river basins (Loukkos, Sebou and the Umm Ribia) provide over 70% of national water resources. In 2000 only 3 of the 8 major river basins in Morocco were considered to be water stressed. Recently, however, a growing population, increased urbanisation, extended irrigated agriculture and highly water intensive crops in addition to the development of the industrial and tourism sectors have placed additional pressure on water resources. Today's water stressed basins include the Souss Massa, Bou Regreg, Tensift, Loukkos of Sebou and Umm Ribia. **Figure 13** shows that river basins are severely water stressed across much of the country. Predictions show that the Moulouya river basin in the North East of the country will be added to the list of severely stressed basins in the near future.[121] The map also shows the withdrawal to water availability ratio for the Western Sahara, however data for this particular region may not sufficiently describe the situation.[122] Morocco attenuates the effects of extreme hydrological phenomena (dryness and floods) through almost 120 dams and reservoirs.

Figure 13:

Overview of the water withdrawal-to-availability ratio calculated by WaterGAP that indicates severe water stress in river basins across Morocco. The location of the Jorf Lasfar and Mohammedia power stations (both >150 MW) is also indicated.



12.1.2 Climate change impacts

Several global studies have concluded that the Mediterranean will be significantly affected by future climate change. This will result in decreasing precipitation and increasing temperatures. In light of this, confident projections suggest that the area will suffer from water shortages in the future.[123] A global outlook on how water availability is expected to change as a result of changing climatic conditions is provided by the University of Kassel (**Figure 3**).[124]

Irrespective of predicted climate change, Morocco's water deficit is exacerbated by variable and irregular climatic conditions which include cycles of repeated drought. This effect is likely to increase in frequency and intensity (particularly the south and the east of the country). In addition, a preliminary analysis of available rainfall data suggests that future climate change impacts will also decrease precipitation in parts of the Atlas Mountains, the main source of water supply in western Morocco.[125] A first quantitative estimate of the possible impact of climate change on the water resources in 2020 suggests a reduction of 10% to 15%.[126] **A thorough assessment of climate change impacts affecting current and future power sector operations is crucial. Financial institutions should emphasize this requirement during negotiations with their clients.**

See PI-TP 6

12.1.3 Water quality

In Morocco, surface water quality is assessed on the basis of four parameters (organic pollution, nitrogen, phosphate and bacterial) which lead into five water quality grades. The 2007-2008 census on surface waters provided the following results: 6% excellent, 37% good, 18% medium, 18% bad and 21% very bad. The census on water quality of groundwater was subject to slightly more concern, as it revealed the following results: 0% excellent, 28% good, 28% medium, 23% bad and 21% very bad quality. It is concluded that 44% of the groundwater resources were either strongly mineral-bearing (saltwater intrusions in the coastal aquifers Chaouia, Béni Amir and Tafilalt due to excessive abstraction) or contained high levels of nitrates (Temara, Meskala-Kourimate, Berrechid and Chaouia). Maps of both assessments are available online.[127]

Overall, water quality problems in Morocco have been reduced by the improvement of the sanitary conditions of urban areas through the collection, treatment and reuse of wastewater. The preservation of water quality of surface waters is often associated with securing a minimum level of incoming and outgoing flow. Similarly, coastal aquifers require a finely tuned balance of abstraction to prevent saltwater contamination. It is these inter linkages of quality and quantity that will remain a challenge in Morocco.

12.1.4 Institutional context

A national charter of sustainable development was signed on April 24, 2010 which has a strong environmental approach.[128] It calls for strong and concerted action to integrate the protection of the natural resources and the environment in the evolutionary progress for human development and economic growth. Progress under this policy is monitored and the following indicators are mentioned with particular respect to water: quality of coastal sea waters, drinking water and sewage, annual rate of resource mobilization on water, water general quality index, rate of drainage systems for resource sanitation, treatment of sewage and finally siltation of dams rate. [129]

The legislative framework in the field of water resources includes Law n° 10-95 on water which mainly aims at setting up a coherent and flexible planning context. It also sets the rational for the management of all the resources, such as protecting and preserving, and it adopts the "polluter pays" principle. Law n° 12-03 relates to impact studies on the environment that facilitate the application of precautionary measures to ensure environmental protection.

12.2 The electricity power sector in Morocco

Morocco produces 21,000 GWh of electricity per year, and between 1996 and 2007, it doubled its capacity. By 2009, rural electrification[130] had reached 96.5%, up from 35% in 1995. This was a combined effect of rapid development, urban migration and a 1.2 billion USD rural electrification project from 2003-2007 (so called PERG). In 2009, the electricity energy mix of Morocco consisted of coal (42%), oil (14%), gas (12%), hydropower (10%) and wind (2%) (with the remaining 18% from import and 2% STEP, Station de Turbinage et Pompage d'eau).[131] The country's two largest electricity power stations at Mohammedia and Jorf Lasfar are both coal fired. Most of the coal is imported from South Africa.

Morocco's electrical sector was traditionally controlled by the state-owned Office National de l'Electricité (ONE). Due to a growing population and economic development, Morocco's electricity demand is increasing rapidly. Power shortages and a desire to control public spending have led the Moroccan government to make more use of the private sector to meet the country's power needs. The state's share of electricity generation is likely to decline by 40% by 2020. However, ONE will continue to be solely responsible for the distribution and transmission of electricity in Morocco.[132]

12.2.1 Expansion

See PI-TP 1

Morocco's campaign to increase generating capacity includes the expansion of the Jorf Lasfar plant and the development of a gas-fired power station in the Sidi Kacem Province, amongst others. ONE is also considering a further pumped storage plant in the Azilal region south of Rabat.[133] The capacity of the Jerada power station will also be extended.

In addition, growing attention has been paid in recent years to Morocco's reserves of oil shale which are estimated at 50 billion barrels of oil, the 6th largest globally.[134] Internationally, many have started to investigate the cost/benefit ratio of production from oil shale, and recently, the Moroccan government has begun to investigate the country's production strategy. Oil from shale can be used as fuel for thermal power plants, by burning it, as with coal, to drive steam turbines. Depending on technology, above-ground retorting uses between one and five barrels of water per barrel of produced shale. A programmatic environmental impact statement stated that surface mining and retort operations produce 8 to 38 litres of wastewater per tonne of processed oil shale,[136] in addition to the introduction of metals into surface- and groundwater into an already arid region. The government's new energy strategy also outlines the realization of solar potential by 2030: 1000 MW into solar with concentration; 400 MW into photovoltaic; 3.000.000 m² in solar thermals.

See PI-TP 2 to 7

As energy prices, demand and the pressure to establish new sources increase in Morocco, financial institutions should be encouraging thorough assessments of the implications of risky sources such as oil shale/tar sand mining. An extensive understanding of the consequences on water quantity and quality, as well as impact these decisions may have on climate change are critical to the successful implementation of future energy related projects.

12.2.2 Renewable energy

Historically, the share of hydropower in the energy mix was 90% in 1955, but the considerable impact of water availability led towards a change. The average production of Morocco's hydroelectric plants during the last twenty years varied between 450 and 1500 million kWh, which indicates the effect of the variable and irregular climatic conditions in the region. However, a trend analysis revealed that production resulted in only 50% of the discounted value during the last 30 years, which may be an indication of a changing climate.[136]

Renewable energy plays a key role in Morocco $11 billion energy development plan. The goal is to increase the share of renewable energy to 20% by 2020. Projects already operational in 2009 were a thermo-solar facility in d'Ain Beni Mathar (472 MW) (see case study below), a hydropower complex at Tanafit El Borj (40 MW), situated at the Oum Errabia source, and a wind installation at both Tanger (140 MW)[137] and Essaouira (60 MW).[138] These wind installations are in line with the governments target of a installed wind capacity of 1554 MW in 2012, 2200 MW in 2020, and 5500 MW in 2030. Further, the hydropower project at Tanafit El Borj is particularly interesting since it is a smaller scale project which ONE sees as having greater potential for replication. Projects that will be operational by 2012 include a large Greenfield wind installation (250 MW) in Tarfaya and a pumped storage hydropower plant at Abdelmoumen (400 MW).

Morocco has additional renewable resources that could be developed. There are four perennial rivers and many dams with hydroelectric potential. In May 2005, ONE selected Temasol for a project to supply solar power to 37,000 rural homes by 2007. In the non domestic market, Morocco also has the opportunity to supply concentrated solar thermal (CST) energy to neighbouring countries in both Africa and Europe. Water remains an important component in CST technology and advanced technologies to reduce water consumption also tend to escalate costs. Morocco has been identified as one of the prime locations for CST development, and currently has one CST plant.[139]

Case Study: The Moroccan Solar Combined Cycle Power Station

The Ain Beni Mathar is a 470 MW integrated solar combined cycle power plant in eastern Morocco. The project is currently under construction and is due to be completed in 2010. Accompanying the main hub of the plant is a concentrated solar thermal (CST) plant installed with parabolic trough technology. CST works through concentrating solar energy to generate steam to drive steam turbines to generate electricity.

To successfully utilise CST, a minimum level of solar energy must be present. The majority of Morocco falls beneath this value, however the west coast has a small number of very well suited sites. In North Africa, a 6000 square kilometre of desert has the capability to supply the thermal energy equivalent to the entire oil production of the Middle East (9 billion barrels a year).[140]

Solar thermal power plants are generally cooled by means of cooling towers which consume water. Some suppliers deliver plants which are cooled by means of air in order to save precious fresh water. These forms of technology are more expensive and reduce overall plant efficiency.

Although the interest in CST technology is growing, there is still a sense of technological risk on the part of utilities or investment decision makers who are unfamiliar with CST. This tends to reduce investment in comparison to better know established coal fired technologies. However, interest in this technology is growing, as can be seen by the increased focus from recent reports on CST as well as media interest in projects such as Desertec.[141]

Regions with the most promising solar resources are unfortunately often arid regions. However, the potential of CST projects, including region wide ones such as Desertec, are important responses to both energy demand and climate change mitigation. Additionally, the Mediterranean Solar Plan has been endorsed by a union of European, Middle Eastern and North African countries, and calls for developing 20 GW of energy from solar and other renewable energy resources in Middle Eastern and North African countries by 2020. The plan aims to allow electricity exports from mainly CST generated energy to be transmitted via high-voltage lines to Europe. .

Financial institutions can play a pivotal role in channelling investment flows into not only technology improvement (i.e. reducing water use) but also into improved transmission infrastructure. Lenders and investors should ensure that the cooling technology is appropriate to the given water availability.

See PI-TP 2 to 6

12.2.3 Other

Morocco has expressed interest in nuclear power for desalination and other purposes. In September 2001, the government signed an agreement with the United States establishing the legal basis for constructing a 2 MW research reactor. Morocco signed an agreement with the U.S. company, General Atomics, to construct the research reactor east of Rabat.

13

Water quality aspects associated with thermal power

This section is derived from the Environment, Health and Safety Guidelines for thermal power plants (EHS Guidelines) issued by the International Finance Corporation (IFC).[142]

13.1 Aquatic habitat alteration

Cooling water is often treated before use in the power plant to avoid corrosion, calcification and to fight the growth of bacteria and algae in the cooling system. Any products used to treat this water including biocides or other additives may affect aquatic organisms when this water is discharged. The temperature of the discharged water may also have an impact on the ecosystem.

Aquatic organisms can be drawn into cooling water intake structures and can either be caught on the intake structure or entrained in the cooling water system. Sea turtles, for example, can become trapped in the intake canals. The location of the cooling water intake structures is therefore a crucial factor in reducing the impact on habitat areas that support threatened, endangered, or other protected species or where local fisheries are active. Conventional intake structures can be particularly damaging if they include travelling screens with relative high through-screen velocities, no fish handling or return systems.[143]

Measures to prevent, minimize, and control environmental impacts associated with water withdrawal should be developed in accordance with an Environmental Impact Assessment (EIA). These should consider the availability and use of water resources locally and the ecological characteristics of the project affected area.

See PI-TP 7

13.1.1 Management measures[144]

Recommended management measures include:

- Reduction of maximum through-screen design intake velocity to 0.5 ft/s;
- Reduction of intake flow to the following levels:
  - For freshwater rivers or streams, the instream flows should be sufficient to maintain irrigation, fisheries and biodiversity during low flow conditions.[145]
  - For estuaries or tidal rivers, reduction of intake flow to 1% of the tidal excursion volume. For lakes or reservoirs, the intake flow must not disrupt the thermal stratification or turnover pattern of the source water.
- Where there are threatened, endangered, or other protected species or fisheries within influence of the intake then mitigative measures should be undertaken. These should include: the installation of barrier nets, fish handling and return systems, fine mesh screens, wedgewire screens, and aquatic filter barrier systems. Alternatively, operational measures such as seasonal shutdowns, reductions in flow or the continuous use of screens can be undertaken. Thorough research regarding the location and placement of the intake structure will also reduce the impact on aquatic biodiversity.

13.2 Effluents: thermal discharges

As described in Section 4.1 thermal power plants with steam-powered generators and once-through cooling systems use significant volumes of water to cool and condense steam. Heated water is discharged back to the source water (i.e., river, lake, estuary, or the ocean) or nearest surface water body. In circumstances where warm water is discharged from a plant, the system should be designed such that ambient water temperature standards are not exceeded (these are normally assessed outside an established mixing zone).

If a once-through cooling system is used for large projects, impacts of thermal discharges should be evaluated in the Environmental Impact Assessment with a mathematical model. This is an effective method for evaluating thermal discharges so they meet the environmental standards of the receiving water.[146]

Thermal discharges should be designed to prevent negative impacts to the receiving water by taking into account the following criteria:

- Elevated temperature areas caused by thermal discharge should not impair the integrity of the water body as a whole or endanger sensitive areas (such as recreational areas and breeding grounds);
- There should be no significant impact to organisms passing through the elevated temperature areas;
- There should be no significant risk to human health or the environment due to the elevated temperature or residual levels of water treatment chemicals.
- Use of heat recovery methods (also energy efficiency improvements) or other cooling methods to reduce the temperature prior to discharge.

See PI-TP 7

13.1.1 Effluents: liquid waste

There are many processes that produce wastewater in a thermal power plant including; cooling tower blow down; ash handling wastewater; wet FGD system discharges; material storage runoff; metal cleaning wastewater; and low-volume wastewater. All of these processes are found in plants burning coal or biomass; however, in oil or gas fired power stations, not all of these waste generating streams will be present.

The characteristics of the wastewater generated depend on the ways in which the water has been used. Contamination arises from demineralizers; lubricating and auxiliary fuel oils; trace contaminants in the fuel; and chlorine, biocides, and other chemicals used to manage the quality of water in cooling systems.

Recommended water management strategies for liquid waste include:

- Minimizing use of antifouling and corrosion inhibiting chemicals. Less hazardous alternatives should be used and the dose applied should be in accordance with local regulatory requirements and manufacturer recommendations
- Testing for residual biocides and other pollutants of concern should be conducted to determine the need for dose adjustments or treatment of cooling water prior to discharge.

See PI-TP 7

13.1.1 Water treatment and wastewater conservation methods

Recommended measures include the following:

- Recycling of wastewater in coal-fired plants. This conserves water and reduces the number of wastewater streams requiring treatment and discharge;[147]
- In coal-fired power plants without FGD systems, wastewater can be treated in conventional treatment systems. Depending on local regulations, these treatment systems can also be used to remove most heavy metals to part-per-billion (ppb) levels;
- Collection of fly ash and bottom ash in new coal-fired power plants;
- Use of soot blowers or other drying methods to remove waste from heat transfer surfaces. This minimizes the amount of water needed to wash these surfaces;
- Use of infiltration and runoff control measures such as compacted soils, protective liners, and

sedimentation controls for runoff from coal piles;

- Spraying of coal piles with anionic detergents to inhibit bacterial growth and minimize acidity of leachate;[148]
- Use of sulphur oxide (SOX) removal systems that generate less wastewater; however, the environmental and cost characteristics should be assessed on a case-by-case basis;
- Treatment of low-volume wastewater streams;
- Treatment of acidic low-volume wastewater streams, using chemical neutralization;
- Reduce chemical treatment requirements for cooling towers through pre-treatment of cooling tower water, installation of automated bleed/feed controllers, and use of inert construction materials;
- Elimination of metals such as chromium and zinc from chemical additives used to control scaling and corrosion in cooling towers;
- Manage biocide application and consider using chlorinated rather that brominated biocides.

See PI-TP 7

14
Performance Indicators

This briefing made clear that water is already a material issue for power plants in a number of water constrained areas. It is therefore also a material issue for banks or investors providing debt or equity capital to clients in this sector, or for insurers in relation to the premium they calculate for clients in the power sector. Three types of issues were recurring in all of the regions assessed:

- Water withdrawal-to-availability shows that every country that was analysed is already experiencing areas of severe water stress.
- Climate change will likely have negative effects in terms of water availability.
- Governments, which need to address the needs of many stakeholders, are stepping up to tighten regulation and legislation.

In addition, in certain countries such as India and South Africa, dwindling water quality will also directly impact water availability for thermal power plants. All these issues may lead to increased costs or reduced revenues for power plant operators, and hence affect the credit worthiness or debt-servicing ability of borrowers, or lead to loss of shareholder value. In addition, financial institutions may experience reputational risks when being associated with the financing of a power plant that has negative societal or environmental impacts. Negative environmental and social impacts should not only be associated with hydropower, but also with thermal power.

To help financial institutions to better understand and mitigate adverse water-related risks related to their clients in the power sector, we have provided a number of Performance Indicators (PIs) that can be used in relation to thermal power (section 14.1) and hydropower (section 14.2). Indicators outline the most relevant aspects and expand on the global recommendations that were given in section 4.3. These can be used as part of an engagement process with clients in the power sector, as part of due diligence, or other processes.

14.1 Performance Indicators on Thermal Power

Eleven performance indicators (PI) were identified for thermal power (TP).

		Description	Rationale and materiality	Attributes
PI-TP 1	Does the thermal plant use the cleanest fuel economically practical?	High-heat-content fuels are preferred and result in low ash production. The choice of fuel has also affects water consumption. The greater the shift from coal and nuclear to natural gas, the greater the decrease in water consumption for power generation.[149]	Natural gas is preferable to oil, which is preferable to coal.	YES / NO
PI-TP 2	What is the water consumption of the technology applied?	Water consumption is clearly a function of power generation by various thermal power plant types. New combined-cycle plants have been built which use air-cooled condensers for their steam cycles. These plants use virtually no cooling water. Evaporative recirculation cooling system use approximately 5% of the water volume required for once/through cooling systems.	Consumption of the plant can be optimized by new technologies.	See * for relative comparison. See ** for benchmark values

		Description	Rationale and materiality	Attributes
PI-TP 3	Did the provider meet the target specific water consumption?	Most companies communicate their target water consumption (liters per kWh sent out) within their annual report. See also the EN8 indicator if reporting is done under GRI "G3". Regulatory bodies often announce target values. Actual water consumption is often also dependant on the maintenance level. Further, numbers on water consumption provided by plant operators may sometimes include an increase of 50% to 90% if CO2 and compression is added.[150]	Efficiency improvements are anticipated.	YES / NO In South Africa for example, target values for water consumption are 2.02 liter per KWh.
PI-TP 4	Is the region characterized by water-stress?	WaterGAP enables quantification of water stress within the river basin.	In regions already facing severe water stress consideration must be given to water saving technologies.	See Figures 1,2 and 4-8. Low / medium / severe
PI-TP 5	Has the client conducted a localized assessment of security of sustainable water supply in terms of quantity and quality?	Localized assessments may allow for a refined understanding of the security of water supply. Often a combination of field testing and modelling techniques are applied. The assessment would also indentify alternative sources of supply such as re-use of internal or external wastewaters in the cooling system. (see the additional indicator EN10 if reporting is done according to GRI "G3"). The assessment may further evaluate wetland restorations to enhance cooling.	An assessment minimizes risks and may increase water sustainability.	YES / NO
PI-TP 6	Has the company assessed how their power production is at risk as water flow changes by climate change?	The effect of climate change should be properly assessed, accounting for seasonal variability and projected changes in demand. The assessment may also comment on the extent of usage of improved hydrological forecast systems.	An assessment minimizes risks and supports management on their decision making.	YES / NO

		Description	Rationale and materiality	Attributes
PI-TP 7	What is the extent of measures undertaken to prevent, minimize, and control thermal discharges and effluents within outflow?	Measures include: ¨ Is groundwater monitored and is appropriate management in place? ¨ Have multi-port diffusers been used? ¨ Adjustment of the discharge temperature, flow, outfall location, and outfall design to minimize impacts to acceptable level? ¨ Is water from boiler blow down, demineralizer backwash and wastewater recycled? ¨ Are pH, chemicals, ash content and temperature of water monitored continuously? ¨ Have sulphur dioxide (SO2) removal systems been implemented that generate less wastewater? The technology of SO2 removal systems has been more frequently applied over recent years, but is uncommon in old systems. An assessment of the environmental and cost characteristics of installing such systems should be made available? If monitoring is done according to GRI "G3" then the additional indicator EN25 "Water sources and related habitats significantly affected by discharges of water and runoff" may provide further information.	The measures help to increase environment quality and maintain essential ecological services.	YES / NO
PI-TP 8	Has the company been prosecuted to not comply with environmental standards respectively their subscription to a local "zero effluent" policy?	Environment standards are often set in regard to water use outflow. In most geographies the operators of power stations sign zero effluent policies to comply with the statutory energy authority.	Breaching environmental standards and subsequent prosecution can incur financial costs.	YES / NO
PI-TP 9	Has the client considered alternatives for solid waste deposition?	Ash and FGD sludges are commonly disposed of in landfill or coal ash waste impoundments. Caution should be taken to ensure that they do not impact upon water bodies. In some circumstances ash can be recycled for building materials.	Reduced volume of solid wastes created wider sustainability benefits.	YES / NO
PI-TP 10	Has the client assessed the competing uses and how water is shared?	Water resources continue to be in demand for many purposes, including securing environmental flows. Ideally a river basin committee serves as a platform for the assessment of the entire basin.	A robust sharing, rather than seniority system, is anticipated.	YES / NO
PI-TP 11	Were stakeholders consulted?	Stakeholder consultation is essential for larger thermal power projects. There is a variety of methods available for stakeholder consultation such as: one-on-one engagement, joint working groups, and managed consultation processes.	Stakeholder consultation may help to improve reduce negative impacts.	YES / NO

Notes:

* see next table on relative comparisons between different cooling technologies.

		Water consumption		
		Low	Moderate	High
Water withdrawal	Low	Dry cooling (e.g., air cooled condensers)		closed-circuit
	Moderate		Cooling pond[151]	
	High	Once-through		

** see table on water withdrawal and water consumption benchmark values for different fuels and technologies. Source: Data from 2006.[152]

		Coal	Natural Gas (Combined cycle)	Nuclear
Withdrawal [m³/ MWh]	Open circuit cooling	76-190	28 – 76	95 – 227
	Closed circuit cooling	1.1 - 2.3	0.8	1.8 – 4.1
Consumption [m³/ MWh]		1.1 – 2.3	0.4 – 0.6	1.5 – 2.7

14.2 Performance Indicators to new hydro power

Despite the importance of hydroelectricity in generating renewable energy, there are a number of negative environmental and social impacts, which are critical for FIs to take into account. A number of different sustainability assessment approaches have been developed over the past 10-15 years. The indicators provide a broad overview of the variety of issues to be aware of when engaging in project finance of hydropower projects. A large number of initiatives and institutions have developed sets of indicators for their own assessment frameworks, including:

- World Commission on Dams (WCD) assessment in 1998-2000
- Low Impact Hydropower Certification Criteria of the Low Impact Hydropower Institute, Portland, USA
- Various national level regulatory frameworks and political guidance (one example of many is the UK Environment Agency Guidelines on how to assess small scale plants)
- World Bank: Environmental criteria for site selection of hydroelectric projects

The WCD provides a broad and comprehensive set of guidelines for the planning and implementation of water and energy projects. A set of 26 guidelines for good practice lay out specific actions for complying with the strategic priorities at five key stages of the project development process. The European Commission and several private banks have adopted the WCD framework in its entirety. Many other financial institutions, governments and industry associations have endorsed the Commission's strategic priorities, but not the more specific guidelines. Additionally, member states of the EU have decided that carbon credits from large dams can only be sold on the European market if the projects comply with the WCD framework. In addition, many carbon exchanges have set their own rules on purchasing hydroelectric related carbon credits through the Clean Development Mechanism (CDM). Hydropower is now the most common technology in the CDM, with 25% of all projects in the pipeline. There is a certain amount of controversy over a number of hydropower projects in the CDM as being potentially 'non addition', in contravention of the mechanism's basic principle .

The Hydropower Sustainability Assessment Forum (HSAF) is a collaboration of representatives from different sectors who are close to finalizing enhanced sustainability assessment tool, to measure and guide performance in the hydropower sector, based on the Sustainability Guidelines and Assessment Protocol developed by the International Hydropower Association (IHA). Further information can be obtained at http://www.hydropower.org/sustainable_hydropower/HSAF.html. The HSAF included representatives from development and commercial finance institutions and considered existing bank safeguards, as well as the above mentioned assessment frameworks in their work.

The following section will give a broad overview of the key issues addressed in some of the assessment frameworks mentioned above. The list is not exhaustive, but instead aims to provide an overview of some of the more relevant issues for FIs. The points listed below refer to issues that should be taken into account when reviewing a hydropower project, and fall into three categories relating to broad, social or environmental impacts of large dams.

Broad Issues:

- Importance of good site selection (upper tributaries vs. main stems of rivers) as a mitigation measure to ensure that the proposed dam will cause relatively little damage.
- Social and environmental aspects are often not deemed as significant as technical, economic and financial factors.
- Compliance with social and environmental regulations.
- Budgetary and development requirements of negotiated settlements for affected stakeholders.
- Establishment and independent review of compliance mechanisms been established.
- Adequate dam safety for both employees and local population.
- Secondary impacts of access roads, power transmission lines, quarries and borrow pits, urban expansion etc.

Social Impact Issues:

- Open and participatory process requirements for the formulation of:
- Development needs and objectives
- Involuntary displacement and/or resettlement
- Informed participation in decision-making processes through stakeholder fora.
- Public acceptance of key decisions.
- Inappropriate impact on cultural resources.
- Free, prior and informed consultation for affected indigenous peoples.
- Ability for affected populations to negotiate mutually agreed and legally enforceable agreements to ensure the implementation of mitigation, resettlement and development entitlements.

Environmental Impact Issues:

- Basin-wide assessment of the river ecosystem
- Attempt to avoid significant impacts on:
  - Environmental conditions in the watershed
  - Flooding of natural habitats
  - Loss of terrestrial wildlife
  - Water quality
  - Threatened and endangered species
  - Erosion and sedimentation
  - Effective passage for migratory fish
- Impacts of sedimentation in reservoirs on hydropower output
- Provision of environmental flows [illegible] for fish, wildlife, and water quality, including seasonal flow fluctuations
- Dam construction [illegible]

As a final note, banks, investors and lenders tend to get involved late on in the project development process, however, [illegible] requires [illegible]. However, many of the key design decisions [illegible] in the process. At this late stage, the power to refuse a loan is the only real option for a bank to enforce its own sustainability criteria. A more proactive approach may be for banks and lenders to become engaged in the design process earlier on.