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UNEP **Finance Initiative**
Innovative financing for sustainability

Chief Liquidity Series

Water-related materiality briefings for financial institutions

Issue 2 • September 2010

Power Sector

Geographies
Australia
Brazil
India
South Africa
Mediterranean Basin
(Morocco, Italy, Greece)

Local guidance on a global issue
A briefing series by the Water & Finance Work Stream of the United Nations Environment Programme Finance Initiative

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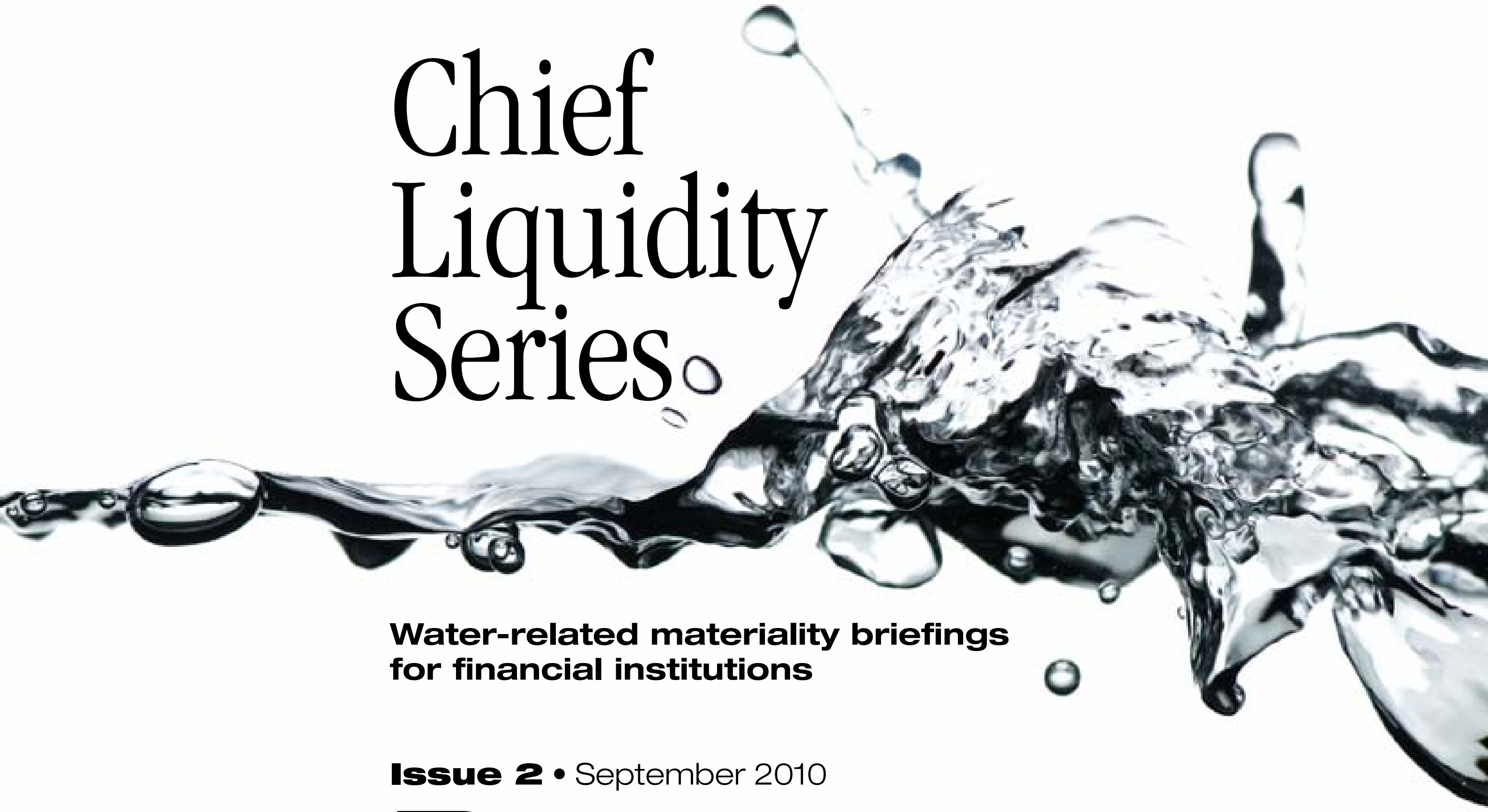

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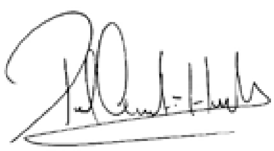
Foreword from the United Nations Environment Programme (UNEP) Finance Initiative

The journey of water into the mainstream agenda for practitioners, policy makers and finance institutions continues, and must accelerate as water stress mounts globally, exacerbated by development trends and climate change. Water related risks arising from water access and quality problems are confronting major companies from India to Australia to the Americas. These issues are prominent in the power sector, however, financial institutions should not only be aware of the water risks integral to the sector, but also the financial and investment solutions to the global water crisis, and its local issues.

Since the first edition of the Chief Liquidity Series, the eyes of the world have primarily been on the outcome of the climate change negotiations in Copenhagen. It is important to continue to reinforce the link between climate change and water, primarily in regards to its central role in adaptation. The Circle of Blue-Globescan global water survey found that freshwater pollution and scarcity topped climate change as a global environmental priority. Consequently, water issues present financial institutions not only with a rising potential for reputational risk or loss of shareholder value, but also with a considerable amount of opportunity.

The role water plays in the power sector is a formidable one, whether as a primary source of energy, for hydropower production, or as a vital resource for thermal power production and cooling for fossil fuel based solar thermal energy. How can the growing water risks and opportunities in the power sector affect investments and finance? Members of the UNEP FI Water & Finance Work Stream have once again collaborated to develop this briefing on the power sector with a focus on a number of water-constraint regions. The aim of this second briefing is to build on the expertise offered within first Chief Liquidity Series, for financial institutions to comprehensively understand the global water challenge, and effectively manage local water risks through a number of tailored Performance Indicators (PIs). Water is food, water is life, and water is energy.



Paul Clements Hunt
Head of Secretariat UNEP Finance Initiative

Foreword from the UNEP FI Water & Finance Workstream (WFWS)

Man's oldest source of power is from flowing water. Ancient civilizations used rivers to drive numerous mechanisms such as mills.

Water availability is critical to power generation: Without access to adequate amounts of water for cooling, thermoelectric plants, including coal, nuclear, solar and gas-fired facilities that rely on heat energy to generate electricity, cannot operate. Rapid population growth and increasing incidents of drought, however, are challenging the sustainability of water supplies needed for power generation.

Globally, hydropower contributes to 24 percent of the world's electricity, supplying over 1 billion people with power. Micro hydropower is probably the least common of the three readily used renewable energy sources, but it has the potential to produce the most power, more reliably than solar or wind power if you have the right site.

Ensuring water sustainability for power generation requires a broad-based research program to increase water use efficiency and conservation in a cost-efficient manner, while supporting watershed and community planning and management needs.

In this publication, second in the Chief Liquidity Series, we hope that the reader – foremost investors and bankers - find useful information on water challenges for electricity production globally, as well as in representative jurisdictions, and use the Performance Indicators (PIs) to mitigate these water-related financial risks through engagement or other processes.

Sasja Beslik
Director of ESG Analysis, Nordea
Co-Chair of the UNEP FI WFWS

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Sustainability Manager, Nedbank
Co-Chair of the UNEP FI WFWS

1

Why this series of briefings?

This is the second issue of a series of Water Materiality Briefings with which the Water & Finance Workstream (WFWS) of the United Nations Environment Programme Finance Initiative (UNEP FI) aims to assist UNEP FI Signatories and the broader financial services community in understanding the financial risks and emerging opportunities associated with water challenges across a range of particularly exposed sectors and hydrologically diverse geographies.

The idea of providing guidance on a level of sectoral and geographic specificity builds on a set of universal but indicative guidelines for water-related risks and opportunities for financial institutions, published by the UNEP FI WFWS in October 2007.[1] As a logical continuation, this new Briefing Series provides greater detail for an easier integration of water-related considerations into financial due diligence and stock picking processes. The underlying reason is that water pressures and their implications for business and finance generally manifest locally and vary considerably from sector to sector and geography to geography. Both this issue and the previous one on the agribusiness sector focus on the following geographies:

- Australia
- Brazil
- India
- South Africa
- Mediterranean Basin (Morocco, Italy, Greece)

1.1 Second Issue on Power Generation

The aims of this briefing on the electrical power generation sector are:

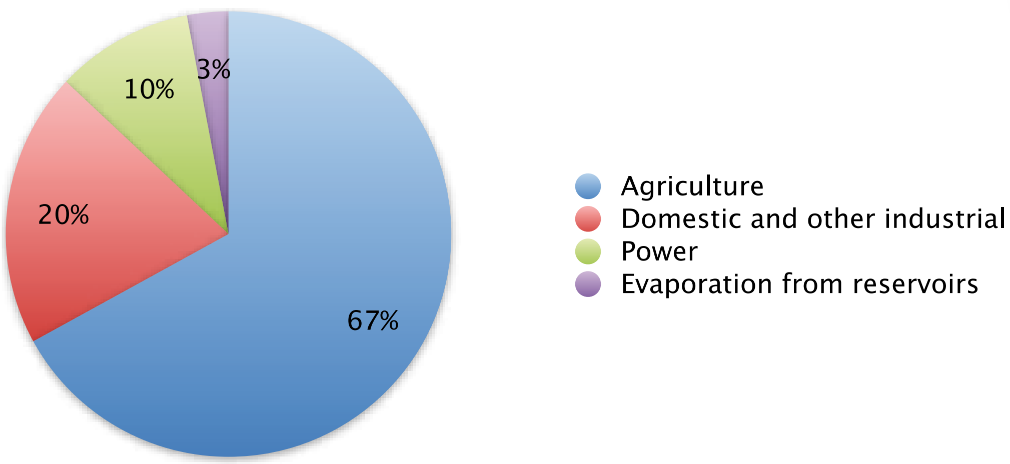
- To deliver to financial decision makers – particularly in credit institutions (but potentially also to asset managers and financial analysts) – an overview of water sustainability issues specific to corporate power generation operations. This is done across a set of geographies around the world where, from the perspective of the finance sector, water-related problems are clashing with economic growth and financial performance most strongly. These areas include: **Australia, Brazil, India, South Africa and the Mediterranean Basin**. The focus on specific geographic locations should not exclude businesses and financial institutions in other regions from making use of these Briefings. Rather, they should feel encouraged to use these guidelines as "proxies" for the management of water issues in all regions that have similar hydrological conditions to those addressed here.
- To provide an initial framework of water-related indicators for financial institutions to assess the strategic and operational water performance of power generation. A number of indicative Performance Indicators (PIs) have therefore been developed and tailored to the technologies and regions which are most prevalent.
- To raise awareness within financial institutions on the complexities of the topic and in particular **the levels of water used by technologies.**

2
How to use/read this Briefing?

Each issue of the *Chief Liquidity Series* looks at a different sector across a set of regions identified as being particularly exposed. Issue 2 looks at activities in the power generation sector. While the agricultural sector is by far the biggest water user in the world, the power sector is the biggest industrial water-using sector (**Figure 1**).

Figure 1

Water use per sector



Source: World Bank: Development Report 2010 [2]

An assessment of the water sustainability issues of thermal and hydropower generation is given in this Briefing together with the Performance Indicators (PIs) related to both of these technologies.

Each subsequent chapter addresses a different region and begins with an overview of the local hydrology and the water-related problems of the area. The use of the WaterGAP (Water - a Global Assessment and Prognosis) model allows a comparison of the volume of water available and the volume of water required for anthropogenic uses. The latter includes withdrawals for electricity generation. Outputs of the model are shown as regional maps, enabling water stress 'hotspots' to be easily identified..

The power generation sector in each region is reviewed and readers are directed throughout this briefing to relevant PIs. These PIs either address thermal power (TP) or hydropower (HP). For example, when a reference is given to PI-TP 3, it refers to performance indicator 3 for thermal power. The impact of water stress on power generating activities and their financial performance is analysed and, vice versa, the impact of power generating activities on local water resources discussed. This is done by examining water issues as they relate to the method used to generate power. Frequently within the text a link will be provided to a listing of performance indicators for thermal power and hydropower. These links are presented in the following format e.g. These links refer to the listing given in chapter 14, which provides a comprehensive explanation of each of the PIs..

See PI-TP 2

Throughout the text, boxed case studies present insights, best practices and innovative concepts in the sustainable management of water resources in power generating activities. This was done with the view to inspire financial practitioners to promote such practice within their respective spheres of influence.

3
The materiality of a water and risk framework

Water-related risks for the financial performance of water-dependent businesses, including the power generation sector, can be categorized under two key headings:

- **Water Dependency:** A power plant's water requirements are primarily influenced by fuel type, cooling system water source and technology. [3]
- **Water Security:** Future risks to water supplies, including shortages and/or declining quality, must be assessed at the local level with consideration to changes in climate and hydrological patterns as well as trends affecting competing uses. The relative strength and timeframe of water allocations and contracts must also be considered. [4]

Additionally, there is a risk of negative impacts on business activities arising from the impact on water quantity and/or deteriorating water quality, other than those directly related to minimal production levels.

If such risks materialize they can immediately affect investors, lenders and other types of financial institutions in one or more of the following ways:

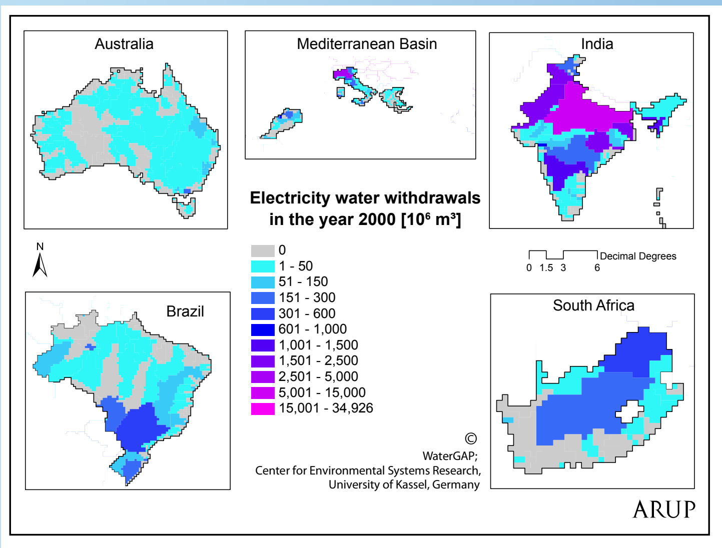
- **Debt-servicing ability -** resource bottlenecks can have immediate adverse effects on company turn-over, factor costs, and ultimately profitability and solvency. Financial institutions of all types will be affected by such resource shocks and developments either through clients' inability to service loans or by insufficient dividend yields from investee companies. Water bottlenecks are expected to become the resource constraints of greatest concern in the 21st century.
- **Creditworthiness of clients -** water-dependent companies and/or companies with a large water impact may become less creditworthy as water constraints sharpen over time. This will increase the overall risk exposure of finance providers, which in turn will increase the return expectations of shareholders and equity capital requirements of regulators (where applicable: Basel 2).
- **Reputation / brand value damage -** if reputation or litigation damage occurs on the borrower company level, it can rebound and hit banks, investors and other financial institutions that are involved, both through resulting profitability and solvency problems on the company level, as well as directly through reputation damage of the lenders involved. This may ultimately lead to bad bank ratings by the plethora of new SRI rating agencies.

Intuitively, corporate water sustainability performance in production processes can usually be addressed by improving water use efficiency. While better water efficiency is undoubtedly a significant factor in corporate water performance, other factors also require attention. These depend on the particular power technology under consideration (thermal power, hydropower, etc) and the location of operations. **It is this spatial and sectoral complexity of water as a source of financial risk that this briefing provides guidance on. This is done by looking at how water-dependent businesses, and the financial institutions that service them, are confronted with water challenges at a *local* level.**

Figure 2 Regional water consumption for electricity generation

The figure below low shows water withdrawals for electricity generation in the year 2000 in million m³.

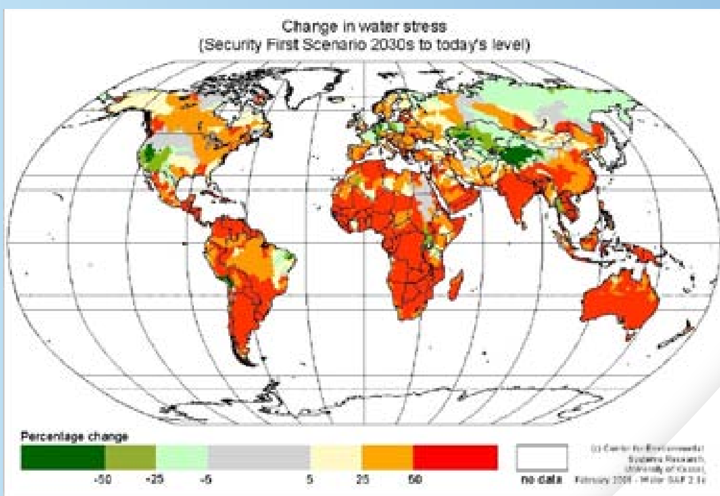
The maps indicate how different withdrawals impact on various river basins across the geographies considered in this Briefing. (**Figure 2**)



From a water sustainability point of view, it is important to ensure that the withdrawal does not compromise the availability of water for drinking water sources, personal hygiene, agriculture, recreation, other community needs and ecology.

Figure 3 Climate change and global water availability

As climate change progresses it is likely to have dramatic affects on the global hydrological szstem, which will have major impacts on water supply. Although in some areas, for example at higher latitudes, water availability may increase, already water-stressed areas in the mid-latitudes are expected to face a reduction in available water (Global Environment Outlook).[5] A global WaterGAP is provided below showcasing likely changes in water stress between 2006 and 2030 (**Figure 3**).



The maps indicate how different withdrawals impact on various river basins across the geographies considered in this Briefing.

3.1 Existing reporting and assessment frameworks

A range of existing reporting, analysis and risk frameworks are available for the power sector, and for power and sustainability analysts within financial institutions:

	Organisation	Initiative	Target audience
1	UNEP FI	"Half full-Half empty" - Practitioners Checklist	Banks, investors
2	Global Reporting Initiative (GRI) [6]	The Electric Utilities Sector Supplement (EUSS) [7]	Power sector / other private sectors including financial institutions
3		The Equator Principles [8]	Financial institutions
4	International Finance Corporation (IFC)	The Environmental, Health, and Safety (EHS) Guidelines on Thermal Power [9]	Power sector / other businesses including financial institutions
5	International Hydropower Association	Sustainability Assessment Protocol [10]	Private sector
6	International Standards Organisation (ISO)	ISO 14001 and ISO 14044	Private sector
7	Carbon Disclosure Project	Water questionnaire	Water-relevant private sectors and investors
8	World Business Council for Sustainable Development (WBCSD)	Global Water Tool	Private sector
9	Water Footprint Network	Water Footprint Manual	Private sector
10	UN Global Compact CEO Water Mandate	"State of play" corporate water disclosure practices / guidance quality water reporting / convene for endorsing companies	Private sector
11	World Economic Forum (WEF)	Water disclosure methodology and universal indicators of water management	Private sector
12	World Resources Institute (WRI)	Sector-specific water risks and opportunities for investors, particularly the publication "Overheating" [11]	Banks, investors
13	Interfaith Centre on Corporate Responsibility	Accountability measures for monitoring and reporting corporate water use	Private sector
14	Pacific Institute	Research on "state of play" and emerging practice on corporate water reporting	Private sector
15	UN Water	Water sector monitoring & reporting	Private sector

4 Thermal power

This section is derived from the Environment, Health and Safety Guidelines (EHS Guidelines) for thermal power plants issued by the International Finance Corporation (IFC).[12]

In order to reduce the complexity of analysis, many indirect aspects have not been included here, for example water use related to mining and extraction of fuels and coal washing. Rather, the briefing has been tailored towards issues directly associated with water use, water availably and water quality at the point where water is withdrawn or discharged by thermal power plants. A concise version of performance indicators that are relevant for financial institutions in dealing with thermal power is presented in section 14.1.

4.1 General technical description of thermal power

There are three common types of thermal power plant: steam turbines, combustion turbines and combined cycled plants.

4.1.1 Boilers (Steam Turbines)

Conventional steam-producing thermal power plants can be designed as either a once-through system or a closed system. In a once-through system, warm water is released back to the source water body.[13] In a closed system, water is cooled by recirculation through cooling towers, lakes, or ponds.

If a re-circulating cooling system is used, only a small amount of water is required to offset the evaporative losses and cooling tower blow down. A re-circulating system uses about one twentieth the water of a once-through system.

4.1.2 Combustion turbines

Gas turbine systems operate in a manner similar to steam turbine systems except that combustion gases are used to turn the turbine blades instead of steam. This greatly reduces the water volumes required.

4.1.3 Combined cycle

Combined-cycle generation uses both gas turbines and conventional steam generators. In a combined-cycle gas turbine the hot exhaust gases of a gas turbine are used to provide all, or a portion of, the heat source for the boiler. This produces steam for the steam generator turbine. An emerging technology is integrated coal gasification combined-cycle units.

It should be noted that some of the new combined-cycle plants use air-cooled condensers for their steam cycles, creating plants that use virtually no cooling water.

4.1.4 Cooling systems

Steam turbines used with boilers and heat recovery steam generators in combined cycle gas turbine units require cooling systems. These condense the steam used to generate electricity. Typical cooling systems used in thermal power plants include:

(i) once-through cooling systems;
(ii) closed circuit wet cooling systems;
(iii) closed circuit dry cooling systems such as air cooled condensers.

Combustion facilities using once-through cooling systems require large quantities of water which are discharged back to receiving surface waters with elevated temperature. Water is also required for boiler makeup, auxiliary station equipment, ash handling, and flue gas desulfurization (FGD) systems.[14]

4.2 Water consumption

Boiler units require large amounts of cooling water, often as much as 98% of the total water used in the whole unit. For once-through cooling water systems, water is usually abstracted from surface waters, however, occasionally, groundwater or even municipal supplies are used.

Dry cooling plants can save large quantities of water. However, these are usually more capital intensive than wet cooling systems, and the power generation process is less efficient. Despite this, research from South Africa has shown that the benefits are higher than associated costs. Significant water savings, with accompanying monetary savings, can be achieved[15].

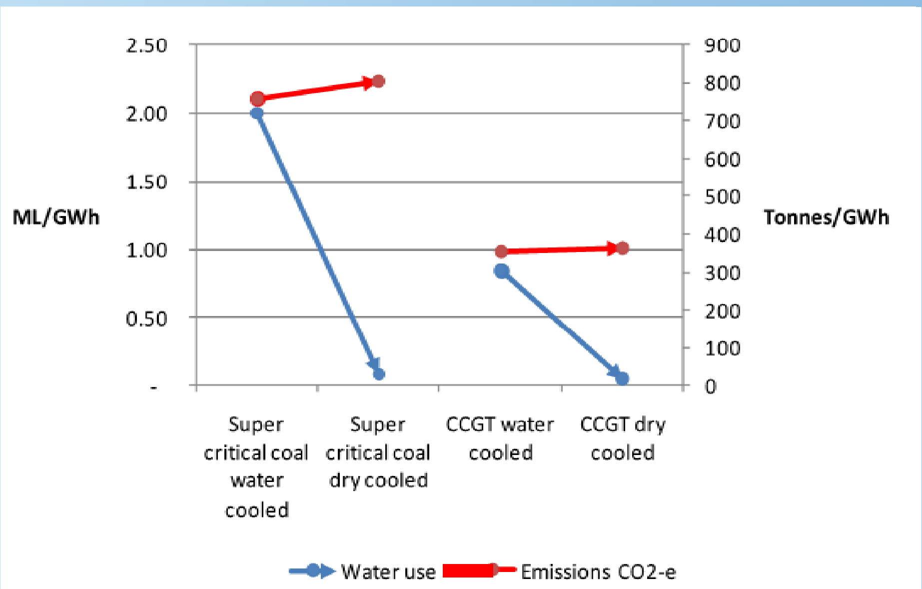
See PI-TP 2

Financial institutions should ensure that the cooling technology is appropriate to the given water availability.

Figure 4 Implications of shifting cooling technology towards dry cooling.

There are two primary types of coal-fired plant—the more traditional sub-critical and the newer super-critical plants. The difference is in their operating pressure. There are also gas-fired plants such as combined cycle gas turbine (CCGT).

Shifting cooling technology towards dry cooling has implications on water consumption. However, there are also implications for emission intensity. The following graph illustrates this concept. (**Figure 4**)



Source: Alan Smart, Adam Aspinall (2009): Water and the electricity generation industry. Waterlines report No 18 - August 2009, National Water Commission, Canberra. Copyrights granted by the Commonwealth Copyright Administration, Attorney General's Department[16].

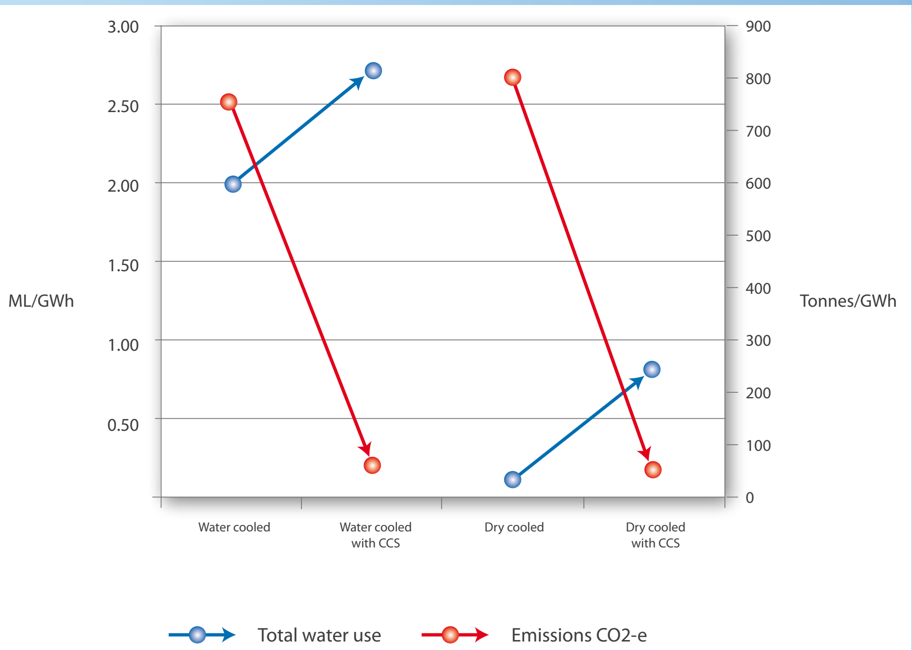
Further reading about unshackling carbon from water in global energy is provided here.[17]

Water consumption also changes if coal-fired power plants incorporate carbon capture and storage (CCS) and technologies to reduce sulphur emission using processes such as Flue Gas Desulphurisation (FGD). These can be as much as one-quarter to one-third more water intensive than conventional systems (see box below).[18]

Figure 5 Relationship between carbon emissions and water use.

FGD water requirements are a fraction of those required for cooling purposes, yet they still require significant quantities of water which is used, for example, to make up the limestone slurry.[19]

Implementing carbon capture and storage technology also increases water consumption. The relationship between carbon emissions and water is illustrated below showing that as carbon emission decrease, water used by the process increases (**Figure 5**).



Source: Alan Smart, Adam Aspinall (2009): Water and the electricity generation industry. Waterlines report No 18 - August 2009, National Water Commission, Canberra. Copyrights granted by the Commonwealth Copyright Administration, Attorney General's Department.[20]

4.3 Global recommendations

In areas with limited water resources, the following technologies and systems should be considered: [21]

See PI-TP 1

- The quantities of water used for power generation vary significantly according to fuel source. The average volume of water used per GWh is lowest for gas-fired power stations. **/See table below**

Table 1:

Withdrawal and water consumption benchmark values for different fuels and technologies. Source: Data from 2006.[22]

		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

See PI-TP 2

- Use of a closed-cycle, re-circulating cooling water system or closed circuit dry cooling systems. Cooling ponds or cooling towers are often used for re-circulating cooling water systems. **See table 2**

Table 2:

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[23]	
	High	Once-through		

- Once-through cooling water systems are strongly discouraged. They may be acceptable if water resources are not constrained and the impact on the receiving body is negligible. They may be the preferred alternative for certain pollution control technologies for example where flue gases are washed by contact with seawater (also known as seawater scrubbing).
- Recycling of wastewater (e.g. by membrane technology) in coal-fired plants. The recovered water will be available for plant use such as cooling tower water makeup or FGD makeup.

See PI-TP 7

- Water consumption and carbon emissions intensity are interlinked. Considerations associated with the water-carbon nexus were presented above (box).

4.4 A brief note on solar power

In recent years, the global energy challenge and climate change mitigation has heightened the focus on renewable technologies such as solar power. Concentrating Solar Thermal (CST) and integrated solar combined cycle power plants are promising technologies on the verge of commercial application in various countries, including Morocco and India. While the large scale implementation of CST could have a significant impact on global greenhouse gas emissions, they can also represent large scale water requirements. This is especially pertinent since areas most suited for solar farms tend to experience less water availability (e.g. Morocco, India, and Australia).

CST technology uses materials to concentrate solar rays which heat up a liquid in order to power steam turbines or engines. Just as with fossil fuel driven thermal power plants, that steam needs to be condensed back to water, and cooled down for reuse. Currently, the conventional method for CST plants is to use wet cooling. Wet cooling towers are used to cool the exhaust steam for recirculation, which is a very water intensive process utilising about 750-920 gallons/MWh. Additionally, CST plants require about 8-37 gallons/MWh to clean the collector mirrors. Technologies do exist for alternative cooling systems which could reduce water consumption, however they are currently expensive and reduce plant efficiency.[24]

5

Hydropower

As a result of the need for a low carbon economy, hydropower has received considerable interest. According to the International Energy Agency, electricity generation from hydropower and other renewable energy sources is projected to increase at an average annual rate of 1.7% from 2004 to 2030, for an overall increase of 60% through 2030.[25] Whilst in many developed countries – including Australia, the United States and most of Western Europe – most of the suitable sites for hydropower installations have already been developed, there is modest spatial and geophysical potential for new hydropower installations in other parts of the world. However, limiting factors include the social and environmental impacts of large dams and the controversy surrounding them, which collectively explain why so little hydroelectric potential has been tapped in developing countries. Many of these impacts can be mitigated to acceptable levels if a full assessment is carried out when new dams are proposed and an appropriate sites are selected.

There have been considerable contributions towards understanding and guiding sustainability performance in the dams sector generally and hydropower particularly, the most notable being the World Commission on Dams (WCD) assessment in 1998-2000 but also the Strategic Environmental Assessment of Hydropower provided by SEI in 2009. Despite prior efforts, there is presently an absence of a broadly agreed upon hydropower sustainability assessment tool and standard; and disparate approaches continue to be used at local, national and regional levels. The International Hydropower Association (IHA) in close collaboration with a range of partners launched the Hydropower Sustainability Assessment Forum in March 2008 to address this gap. Their Hydropower Sustainability Assessment Protocol has not been developed for a single purpose, but for a broad range of potential applications all in the interests of lifting sustainability performance for hydropower developments and operations. Potential users and uses include governments, potential financiers and other decision-makers to ensure that new hydropower developments are an appropriate solution for the context in which they are proposed.

The briefing in hand is aimed to be a concise water-related materiality briefing for financial institutions. It is admittedly challenging to be brief, since there are a substantial number of environmental, social and economic factors that should be addressed at the preparation stage of any new hydro plant. For example, appropriate site selection is key to minimising the impact of both water resources and the wider social and environmental landscape. A concise version of performance indicators relevant for financial institutions in dealing with hydropower is presented in section **14.2**. One should note, however, that for a thorough 360° assessment, financial institutions are advised to apply a thorough environmental and social impact assessment.

6

Water Sustainability and Power Generation in AUSTRALIA

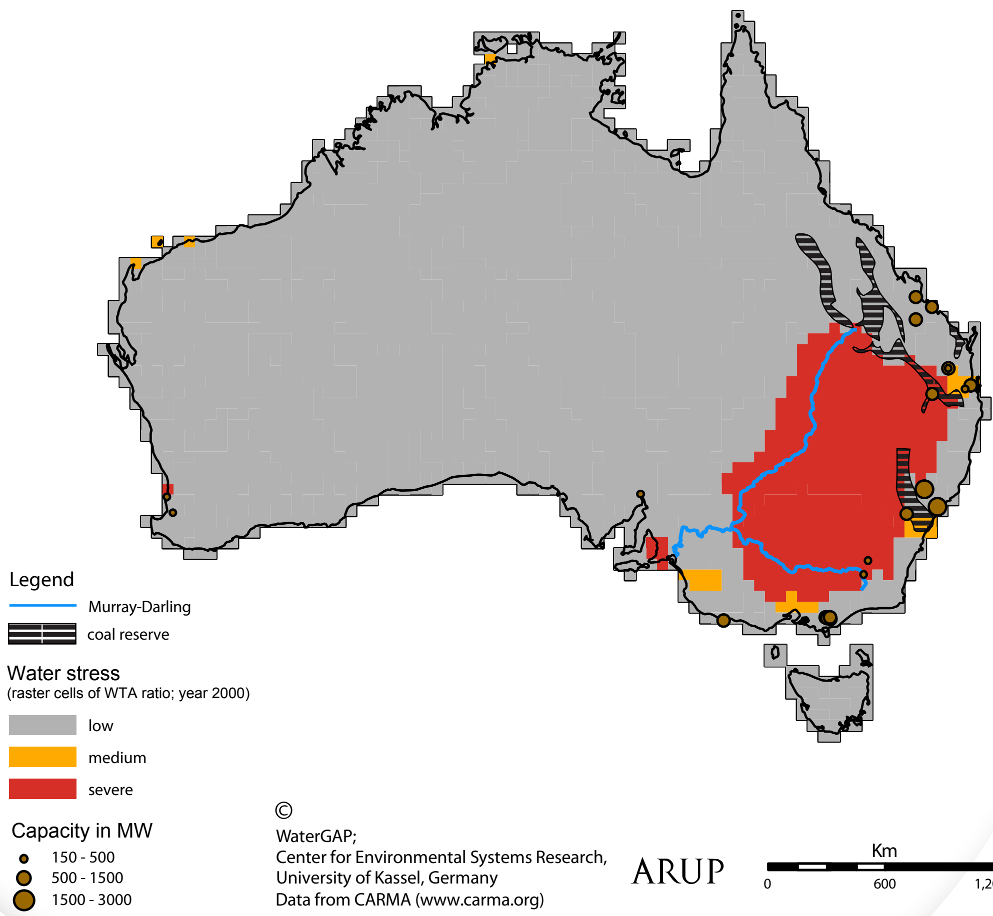
6.1 Local water challenges

Water challenges are experienced all across Australia's fresh water system, particularly in the Murray-Darling Basin (MDB). The MDB is an inter-jurisdictional area which is managed by the Australian Government, Australian Capital Territory and the States of Queensland, Victoria, South Australia and New South Wales (**Figure 6**). The Australian Capital Territory and the States are dependent upon these shared water resources.

The River Murray system of the MDB supplies, on average, more than two-thirds of the Basin's water resources for irrigation, industrial, stock and domestic and environmental purposes. Within the State of South Australia, around 75% of the water taken from the River Murray is used for primary production, such as water for stock and irrigating crops. Overall, agriculture accounts for about 96% of the water consumption in the MDB.

Figure 6:

Location of the Murray-Darling rivers and overview of the water withdrawal-to-availability ratio calculated by WaterGAP. This shows low, medium and severe water stress in river basins across Australia. The location of selected power stations (>150 MW) is also indicated.



6.1.1 Water availability

Overall, consumptive water use in the MDB and climate change induced changes in rainfall patterns (see below) have reduced average annual stream flow at the Murray River mouth by 61%. Over the 1895 to 2006 period, the average annual flow to the sea has declined by almost 40%.[26] The MDB is considered to be an acutely water stressed basin, **Figure 6**.

See PI-TP 4

6.1.2 Climate change impacts

Recently, water resources have been severely been affected by exceptionally hot, dry years.[27] In 2007, a 117-year low of water flowing in to the MDB river system together with historic low storage levels resulted in drought throughout the basin.

Surface water availability across the entire MDB is expected to decline further due to climate change. The average of likely climate scenarios suggests an 11% reduction in average surface water availability by 2030.[28] The reduction would be greatest in the south where the majority of the runoff is generated and where, therefore, the impacts of climate change are expected to be greatest. An outlook on how water availability (shown in **Figure 3**) is expected to change is provided by the University of Kassel.[29]

Financial institutions should, therefore, take into consideration the risks arising from the regional impacts of climate change on water availability.

See PI-TP 6

6.1.3 Institutional/regulatory context

Surface water diversions from the MDB have been capped since 1997 to prevent further growth in water withdrawals. Whilst this "cap" does not necessarily ensure a sustainable Basin ecosystem, it has been considered as an essential first step towards more sustainable water management. Compliance to the terms of the 'cap' by each of the states sharing the water in the basin is monitored annually.[30]

In response to the ongoing drought, the Australian Government has initiated policy changes to the management of water resources in the MDB as part of its *National Water Initiative*, *Water for the Future* program. New legislation, such as the *Water Act 2007* has also been introduced.[31] **In light of sharpening environmental regulation in the MDB and beyond, financial institutions should encourage clients to show their preparedness for compliance to increasingly stringent regulations and standards.**[32]

See PI-TP 3 & 8

There is also the "Restoring the Balance in the Murray-Darling Basin" Program for which the government has committed $3.1 billion to purchase water in the MDB over a 10 year period to restore environmental flows.[33] In May 2009 the Murray-Darling Basin Authority started to buy back water from licence holders on the open market. This water will help restore environmental flows to drought-affected wetlands in South Australia and improve environmental services.[34] Additionally, the Northern Victorian Irrigation Renewal Project is a major project identifying possibilities for structural change in the irrigation system, including the modernisation of channels and infrastructure and the closing down unviable channels.

See PI-TP 10

Freshwater supply is generally provided to inland power generators under licence arrangements. The mechanisms for accessing water include:

- Special purpose licences such as the major utilities licences in New South Wales.
- Access entitlements providing a share of the available capacity in the water system.
- Specific purpose agreements such as the Snowy Hydro Water Agreement.
- Contracts with water authorities.

6.2 The electricity power sector in Australia

Australia's energy consumption is dominated by coal, which fuels most of the country's power generating plants. In May 2009, Australia had approximately 47 gigawatts (GW) of installed electric generating capacity.[35] This was powered by fuels from the following sources: Coal (76%; with a majority coming from black coal), gas (15%), hydro (6%) and wind and biomass (1% each).[36]

The large coal fired thermal power stations are dominantly located outside the MDB. Selective information on their cooling technologies and plant locations is provided in **Figure 6** and **Table 3**. This shows the reduced water use of dry-cooled stations. In various locations seawater is used for cooling. In total, sea water provided around 9% of total water use and increases are expected.[37]

Table 3:

Overview of selected power stations in Australia and their absolute water use.[38]

Generator	Fuel and cooling technology	Water use
Millmerran (852 MW)	Super critical thermal coal -air cooled condenser	0.7 – 0.8 GL/year for boiler and auxiliaries
Kogan Creek (781 MW)	Super critical thermal coal – air cooled condenser	1.2 GL/year for boiler and auxiliaries
Stanwell (1,400 MW)	Thermal coal – water cooled natural draft cooling tower	15 GL/year
Gladstone (1680 MW)	Thermal coal – once through saline water cooling	0.9 GL/year for boiler and auxiliaries 0.7 GL/year treated recycled sewage for ash disposal
Mt Piper Power Station (1320 MW)	Coal-fired– water cooled natural draft cooling tower	15.6 GL/year for cooling, ash plant, makeup water and auxiliaries
Wallerawang 'C' Power Station (1000 MW)	Coal-fired– water cooled - natural draft cooling tower + Forced draft cooling tower	10 GL/year for cooling, make up water and ash plant.
Yallourn Power Station (1450 MW)	Coal - natural draft cooling tower	Low quality water 36.5 GL/year with around 15 GL/year returned to the river system – a net consumption of 21.5 GL/year.
Loy Yang Power Station (2200 MW)	Coal-fired – natural draft cooling tower	High quality water around 1 GL/year; Low quality water – around 25 GL/year ; Ground water – around 10 GL/year.
Loy Yang B Power Station (1000 MW)	Coal-fired – natural draft cooling tower	1 GL/year high quality water 17 GL/year low quality water.
Hazelwood Power Station (1600 MW)	Coal-fired – cooling pond	Total water use around 27 GL/year

6.2.1 Expansion

Projections of growth in electricity requirements for the National Electricity Market and the West Interconnected System suggest an additional total requirement of 27453 GWh up to 2020. This will require an additional generating capacity of around 2000 MW in New South Wales and around 3000 MW in Queensland by 2020.[39]

The types of investments needed to meet the growth in demand for additional generating capacity depend on a number of considerations. An important factor will be the ultimate price of emission permits. Other issues relate to progress in meeting renewable energy targets and the load patterns that emerge across the electricity supply grids.

In a study completed for the Electricity Supply Association of Australia in 2007, ACIL Tasman modelled different scenarios for a 10% emissions reduction target by 2020. Indicative results show that an additional 1304 MW of coal or gas-fired steam turbine generation, 6520 MW of combined cycle gas turbine and 1500 MW of geothermal capacity is scheduled. These technologies require cooling, either wet or dry.[40]

With respect to the coal/gas-fired steam turbine technologies, 208 MW are projected to be in the Upper Collie catchment in Western Australia and 375 MW in south east Queensland. For new combined cycle gas turbine, 2790 MW is projected to be in Queensland and 3250 MW in Victoria over the next ten years. However, a recent Waterlines Report does not provide further details on the MDB.[41]

6.2.2 Renewable energy

In 2004, Australia generated 2.5 GWh of electricity from renewable sources (excluding hydropower). Biomass and wind power are the most significant sources of this energy and in 2006 they respectively contributed 0.8% and 0.7% of the national energy mix. Hydropower is dominated by the Snowy Mountains scheme which is located within the MDB, **Figure 6**. Therefore, release of water in the scheme is in many cases determined by the water need for irrigation rather than electricity.

Australia's Mandatory Renewable Energy Target (MRET) is currently set at 9.5 GWh of total electricity generation and it is hoped that this target will be achieved by 2010. In line with this target, there are a number of investments being made in the renewable energy sector across the country. The government has, however, proposed changes to this from January 2011.

6.2.3 Water sustainability in practice

Given the water stress pressures on parts of Australia, the energy sector has been active in looking at technologies and systems that respond to water scarcity risk. A survey further revealed that (shorter term) water use efficiency measures delivered savings of up to 15 per cent in existing coal-fired power stations across Australia.[42]

The Millmerran station in Queensland (super critical thermal coal, air cooled), for example, uses recycled sewage treated with ultrafiltration and osmosis. Also, the wet-cooled Swanbank B and E stations within the MDB use in part recycled water.[43]

At a strategic level the power sector has entered into collaboration with the mining sector to share benefits. Frequently, waste water from mine dewatering activities is delivered to cooling towers. Examples include the Wallerawang C Power Station in New South Wales, the Bluewaters and Muja stations in Western Australia and the Loy Yang Power Station in the Latrobe Valley.

See PI-TP 10

In another cross-sector initiative the Kwinana combined cycle gas station, which uses saline water cooling, has entered into a contract with an oil refinery to use recycled water.[44]

Some operators also undertake retention of run-off water (drainage) which can be used for dust suppression within their systems.

6.2.4 Other

Energy commodities are an important source of export earnings for Australia and the development of these resources in a sustainable manner is a primary goal for the government. Improving end-use efficiency in various economic sectors remains a key element of Australia's sustainable energy policy, as does the utilization of renewable energy resources.

7
Water Sustainability and Power Generation in INDIA

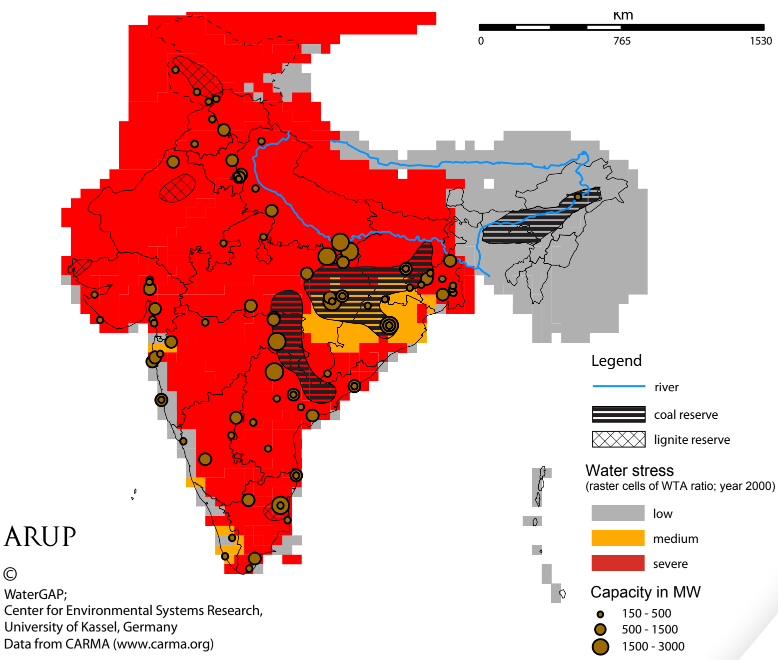
7.1 Local water challenges

7.1.1 Water availability

Growing water scarcity is evident in India due to falling groundwater tables and declining river discharge. This is despite annual utilisable resources of 1,122,000 gigalitres (GL).[45] Seasonal and regional precipitation patterns, such as the South West Monsoon, compound water management challenges. For example, many areas experience localised severe water shortages before the summer rains and are then subject to flooding during the monsoon period. Water resource development across India is also highly variable due to climatic and social factors. Experiences in the semi-arid west are, for instance, very different to those in the wetter eastern areas. **Figure 7** shows that across India, all river basins are water stressed with the exception of areas of eastern India and isolated pockets in the South West.

Figure 7:

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

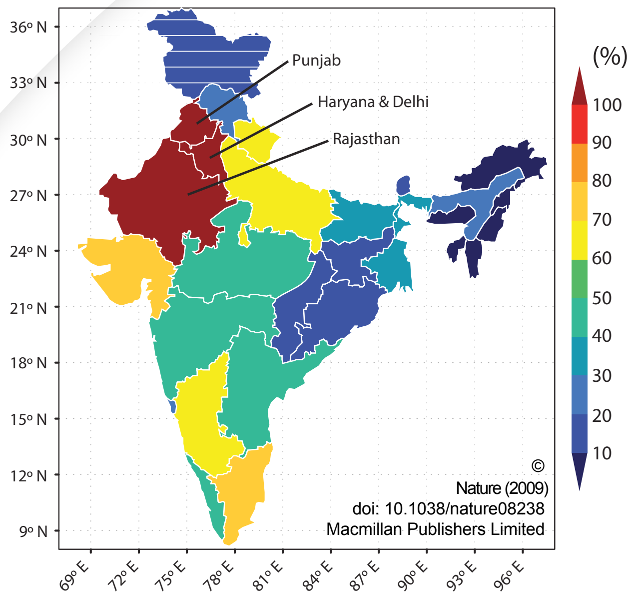


Water use in India is often unsustainable; the most significant cause is the overexploitation of groundwater, which is clearly illustrated in **Figure 8**. These groundwater resources underpin irrigated agriculture across India and occasionally conflicts arise with the power sector using groundwater resources for boilers and associated processes. **It is vital for financial institutions to understand that limited water availability and potential conflicts with competing users may affect the business operations of (newly planned) power utilities.**

See PI-TP 5 & 10

Figure 8:

Groundwater withdrawals as a percentage of recharge. The map is based on state-level estimates of annual withdrawals and recharge as reported by the Indian Ministry of Water Resources.[46,47]



Water stresses in the country are already having a significant impact on power generation. For example, in 2008, the National Thermal Power Corporation's Sipat plant was shut down due to lack of water supply from the Chattisgarh state, and thermal plants currently under construction in Orissa state are undergoing delays due to water allocation issues.[48] Furthermore, in June 2009, country widehydropower output dropped by over 9% due to the low availability of water.[49]

7.1.2 Climate change impacts

By 2050, freshwater availability, particularly in large river basins, is projected to decrease. In part, this will occur as a result of the continued shrinking of Himalayan glaciers and the discontinuation of their critical function: the storage of water and its gradual and uniform release over long and potentially dry periods of time. Studies also indicate that India will reach a state of water stress before 2025 when the availability is projected to fall below 1'000 m^3 per capita.[50] Additionally, increased temperatures alone will have an impact on electricity sector, as can be seen by the 2007 heat wave in Maharashtra which led to power shortages of 20% in the state and 9% across the country.[51] An outlook on how water availability (shown in **Figure 3**) is expected to change is provided by the University of Kassel.[52]

7.1.3 Water quality

Deteriorating water quality from untreated industrial and domestic effluent and municipal pollution limits available water supplies. Naturally occurring water quality problems can also impact on availability; high fluorine in Rajasthan and arsenic content in West Bengal are cases in point.

7.1.4 Institutional/regulatory context

Water resources are traditionally managed at the state level; however, the Ministry of Water Resources is responsible for policy guidelines and regulation of water at the federal level. In India, the use, management and ownership of water is often linked to land or irrigation structures, rather than the resource itself; hence property rights to water are poorly defined.[53] This lack of clarity contributes to the complexity and high cost of legal disputes over water. There is growing recognition that these laws need to be amended and international attention is beginning to focus on this issue.

Given the pressing need to manage demand, and re-allocate water in closed basins, uncertainty with regards to institutional responsibility, water policies, environmental regulation and property rights requires attention.

7.1.5 Transboundary water management

See PI-TP 10

India has a number of transboundary rivers and shares water with Pakistan, Bangladesh and Nepal. The water-sharing agreements between these countries, particularly with Pakistan, can be a source of tension. Inter-state water conflicts are also prevalent due to the federal system in India and are exacerbated by uncertain rights to water at the State level. A notable example is the dispute between Tamil Nadu and Karnataka over the Cauvery River.

7.2 The electricity power sector in India

With a population in excess of 1.1 billion, rapid economic growth and rising per capita power consumption, the demand for energy resources in India is increasing markedly. Whilst power generating capacity is growing, it is outstripped by demand. Some 40% of households particularly in rural areas are without access to electricity.[54]

India's power sector is dominated by thermal power plants with an installed capacity of 93 GW, this accounts for over 80% of electricity provision[55] (with hydropower, natural gas and nuclear sharing the remaining 20%).[56] Coal fuels the majority of these plants (53%). Associated thermal power plants are often located close to coal deposits in central areas, **Figure 8** (above).[57,58]

Significant fuels sources other than coal are oil, which provides 30% of energy for electricity production followed by gas (8%), hydropower (6%), nuclear (2%) and other renewables such as solar power generation provide less than 1%.

7.2.1 Expansion

According to a recent WRI report, 79% of new generating capacity will be built in already water stressed areas,[59] implying numerous financial impacts. Future trends will include greater reliance on gas technology, and the development of a wider nuclear programme given recent agreements on nuclear cooperation with the United States and France. A further trend is the development of India's substantial hydropower capacity, of which only 20% has been developed to date.[60] Government policies and targets are set out in 5 year plans. For the current plan (2007-2012), the government has set a thermal capacity expansion target of 60 GW of new capacity, which represents an increase of approximately 60%. This will be achieved through the development of Ultra Mega Power Projects or large thermal power projects producing about 400 MW each.[61] However, any expansion is constrained by limited water resources. The location of current thermal power plants is dictated by available water resources with many power plants being built in coastal locations in order to use seawater for cooling purposes (see also case study on following page). **By asking the right questions, financial institutions can play a role in carefully identifying and therefore minimising risk exposure due to water availability. Financial institutions should ensure that company's are using climate and hydrological information to assess not only present day risk, but also take into account future risk from climate change on sensitive water resources.**

See PI-TP 4 & 6

7.2.2 Renewable energy (hydro)

India has great capacity to increase the levels of hydro-electricity produced and is ranked 5th in the world for usable potential for hydropower development. These sites are predominantly situated in the mountainous regions in the north and north east of the country (states such as Himachal Pradesh, Sikkim and Uttaranchal).[62]

See PI-TP 1 to 22

In addition neighbouring Nepal has the potential to generate hydroelectric power and export electricity to India. Implementation and development of these schemes has been hindered by concerns about the environmental and social damage caused by large dams, the possibility of seismic risk in earthquake zones and the long gestation and capital intensive nature of these projects.

There is also renewed interest in small scale hydro-power generation as this is associated with fewer environmental risks and will contribute to the Indian Government's goal of increasing rural electrification. As with large-scale projects, there are a number of recognised barriers to implement these schemes, including technical challenges and costs. [63]

7.2.3 Other

India's power sector is dominated by state companies and characterised by a lack of foreign investment. This limits the ability to source capital investment to improve basic infrastructure. In recent years, the government has attempted to revitalise the sector by introducing a number of policy measures aimed at encouraging private sector participation.[64] The most significant move to reform is the Electricity Act of 2003, an incremental piece of legislation aimed at liberalising the power generation sector. The reforms have hadmixed success, in part due to the sheer size and complexity of the sector and also the reluctance of the State Electricity Boards to accede to the new framework.[65] In addition to these reforms are the ambitious targets of the 11th and 12th Five Year plans, the latter calling for more than 100,000 MW of additional power generation between 2012-2017. There is optimism that these targets may be achieved, in part because the effects of policy reform and the expected increase in private sector participation by the 12th Five Year Plan (*ibid*).

A further issue is that efficiency within the grid is low, with transmission and distribution losses averaging 26% of total electricity production. When non-technical losses such as energy theft are included in the total, average losses are as high as 50%; according to the Ministry of Power.[66]

Case study: Competing demands at the Hirakud reservoir

The Hirakud Reservoir is situated in the central zone of the Mahanadi river basin in the Eastern Indian State of Orissa. Completed in 1957, the dam has a multi-purpose function for flood control, irrigation and hydro-power generation. Recent increases in the allocation of water for industrial purposes and thermal power plants have resulted in a series of protests by farmers who are concerned about water shortages. The largest of these protests in November 2007 involved over 20,000 farmers and resulted in political turmoil at the State level.

See PI-TP 10

The government promised that 'not a drop of water for irrigation would be given to industry and water deficits would be met by reducing the water available for hydro-power generation.

This competition over water between different sectors of the economy has continued and in 2009, the State Government was forced to defer Mega-Power projects in the region due to farmer opposition. Those plants which have been given conditional permission have been asked to use seawater for cooling purposes rather than river water to avoid placing further pressure on the Mahanadi river basin.

Source: [67, 68]

8
Water Sustainability and Power Generation in BRAZIL

8.1 Water challenges

Brazil is a prime example of a region where water pressures and resulting financial risks are not solely a consequence of chronic water shortages or prolonged droughts, but also unsustainable water management and agricultural or industrial pollution of water resources.

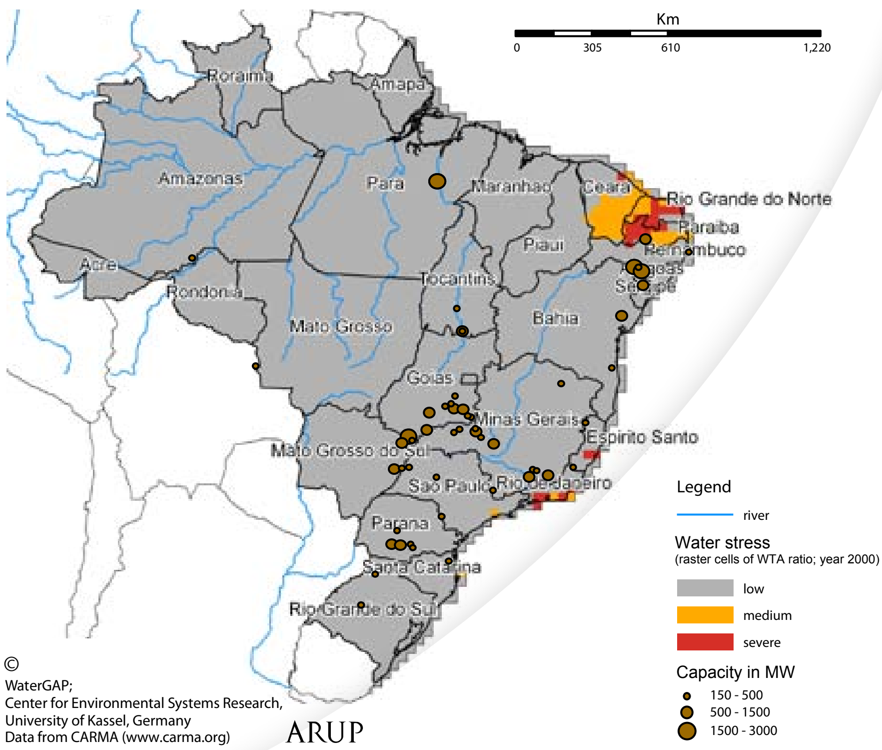
8.1.1 Water availability

Brazil has abundant water resources with approximately 12% of the world's available freshwater resources. Important sources of water include the Amazon River basin, Tocantins-Araguaia river basin and the São Francisco river basin.

While the average availability of water across the country is high, the North-eastern region has an arid climate with only 3% of the country's water resources, but almost 30% of the population. In this area river basins that are classified as water stressed are illustrated in **Figure 9**. Water stressed regions also exist in the south where much of Brazil's urban population is found. Competing uses in the area, further enforced by poorly maintained and managed water supply systems, have led to water conflicts.

Figure 9:

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



8.1.2 Climate change impacts

A detailed assessment of different climate change scenarios and their impact on water resources and agriculture is beyond the scope of this briefing, however key issues are worth highlighting. For example, the potential consequence of changing rainfall patterns which may cause decreases in water availability and erratic rainfall patterns. In the semi arid north-eastern region, model simulations suggest that by the middle of the 21st century, annual average river runoff and water availability will decrease. An outlook on how water availability is expected to change (shown in **Figure 3**) is provided by the University of Kassel.[69] These changes to water availability will have direct consequences for the electricity power sector.

See PI-TP 6

8.1.3 Institutional/regulatory context

The *National Water Resources Policy* (Law 9.433/97) provides guidance on water sustainability issues. It introduced the following fundamental premises for water management in Brazil: (i) water as a public good; (ii) water as a limited resource, with economic value; (iii) priority for human consumption and watering livestock; (iv) use of water by several sectors (challenge of preventing conflicts on water use); (v) river basins should be the planning and management unit; and (vi) participative management.

The regulation of water use in Brazil is based on a framework that promotes the "user pays" and "polluter pays" principle. For São Paulo state for example, law n°12.183/05 entitled "Disposition on charges for water use in São Paulo State" and its implementation decree n°50.667 of March 2006 provides regulation. **In light of sharpening federal regulation on water, financial institutions should encourage clients to comply with emerging regulation in Brazil before it becomes mandatory.**

See PI-TP 7 & 8

Watershed and basin committees have recently formed and have introduced voluntary water-user fees. In general, fees are collected by the local water management agency to redistribute a proportion to local watershed management committees. Similar schemes, based on payments for ecosystems services are increasingly common.[70]

See PI-TP 10

8.2 The electricity power sector in Brazil

Brazil's energy mix is characterised by renewable sources.[71] Hydropower plants represented the vast majority (77%) of Brazil's internal electricity production in 2007. The reminder of the national electricity mix consisted of thermal power (14.5%) and imported energy (8.5%).[72]

The largest hydropower station in operation is Itaipu, on the border with Paraguay at the Parana River. Itaipu, although not the world's largest hydropower plant, does generate the most electricity and has an installed capacity of 14 GW, with 20 generating units of 700 MW each. Other hydropower plants are concentrated in central-southern Brazil which is the most developed part of the country.

With regard to thermal power plants, their contribution to the electricity mix has increased over recent years. Thermal power stations have played an important role in providing electricity during peak demand periods and droughts when water levels in reservoirs are low. They also supply towns and communities that are not connected to the national electrical grid.[73] Thermal power plants are fired by biomass, natural gas, petrol derivates, nuclear and mineral coal. These sources of energy accounted for 4.1%, 3.3%, 2.8%, 2.6% and 1.6% respectively within the Brazilian electricity mix of 2007.[74]

8.2.1 Expansion

Brazil's hydroelectric potential is immense (more than 100,000 MW), yet estimates vary.[75] This potential includes small, medium, and large size dams. Brazilian's regulations define small dams as less than 30 MW, medium dams as less than 500 MW, and large above this limit. Approximately, 40% of the potential is located in the north of the country.[76]

Various dams are currently being assessed, funded or built and there are prospects for many others to be realised in near future.[77] However, a key requirement for new reservoirs and schemes under Brazilian Legislation is an Environmental and Social Impact Assessment.

See PI-TP 1 to 22

Financial institutions have the ability to influence the approaches used to realise the country's electricity generation capacity. Besides requirements of the statutory process, wider sustainability frameworks can help to assess the sustainability issues at stake.

Expansion of gas-fired thermal electric power is hampered by the limited pipeline network (availability of gas), in addition to the high cost of this fuel source.[78]

8.2.2 Renewable energy (biomass)

The use of biomass as a source of electrical energy has increased in Brazil, notably in co-generation systems belonging to the industrial and agricultural sectors. The term "biomass" includes many types of industrial and agricultural residues, such as sugar cane bagasse, black liquor (cellulosic pulp residue), wood waste, rice husk and biogas. Generally, few power plants with installed power capacity up to 60 MW use biomass as a fuel. . These are located close to industrial users, and are scattered across the agricultural hotspots.[79]

8.2.3 Other

Petrol derivates such as diesel, residual fuel oil, ultra-viscous oils or refinery gas are used to fuel thermal power stations.

Water permitting and water sustainability of a new Thermal Power Plant in Brazil

The coal-fired plant President Medici (UTPM) in the State of Rio Grande do Sul is looking at an expansion scheme (Candiota III, new phase C) to deliver an additional capacity of 335 MW. The Brazilian environmental agencies have granted a Water Usage Permit (outorga) and the Installation License. On the basis of studies on water availability and water demand the outorga was granted for the Arroio Candiota River Basin. It outlines a maximum withdrawal rate of 292 L/s, operating 24 h/day, 365 days per year. According to the National Water Agency this rate will ensure a minimum flow of 187 L/s downstream of the dam supplying water to the power plant.

See PI-TP 10

No water user fee is established in the river basin where UTPM operates and the region is not classified as water stressed according to the WaterGAP analysis. (see Figure 4). The project plans the adoption of a semi-dry desulphurization system for coal, which is characterized by low water consumption and does not generate liquid effluent. The cooling system of the thermal engines is semi-open (evaporative cooling tower).

See PI-TP 2 & 7

Sources: [80,81]

9
Water Sustainability and Power Generation in SOUTH AFRICA

9.1 Water challenges

9.1.1 Water availability

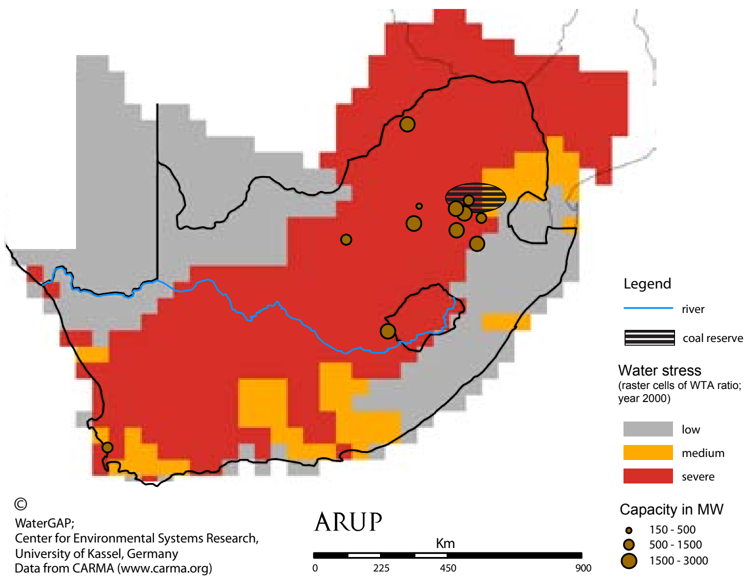
South Africa is a water-scarce country in which the demand in several river basins is in excess of the natural availability of water. The effects of variable rainfall patterns and different climatic regimes are compounded by high evaporation rates across the country. For example, the Cape Town region experiences a "Mediterranean" type climate with rainfall throughout the year and maximum precipitation during the winter. In contrast, the inland climate of Johannesburg has a rainy season in the summer months (October - April) but is dry throughout rest of the year.

Surface water is the most significant resource as groundwater availability is limited by the predominant geology of less permeable formations. In areas where groundwater is available the reserves are frequently over-exploited, for example, the Dendron, Springbok Flats and Coetzersdam.[82] Social and demographic factors also contribute to relative water scarcity; for example, the distribution of significant settlements and industry adjacent to notable mineral deposits rather than water resources.

Water availability in South Africa has been assessed using WaterGAP and the following map (**Figure 10**) shows that many areas of South Africa are experiencing severe water stress.

Figure 10:

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



9.1.2 Climate change impacts

Climate change will have two key effects: (i) increasing temperature and, (ii) reduced and more erratic rainfall. A recent estimate[83] of the effects on water resources suggests that a likely gross reduction of 10% in average rainfall would reduce surface runoff in South Africa by 50-75%. An outlook on how water availability (shown in **Figure 3**) is expected to change on a global level due to climate change is provided by the University of Kassel.[84] **As in other water-scarce countries and regions financial institutions need to take into account that changing weather patterns due to climate change may have severe impacts on power utilities.**

See PI-TP 6

9.1.3 Water quality

Water pollution is a growing problem and can be attributed to a range of sources including: municipal pollution, industrial effluent, returns from irrigation and acid mine drainage. Water quality can further be impacted by high levels of water re-use from returns of treated effluent to rivers despite strict regulations imposed to combat pollution.

In the power sector, water quality concerns often influence the construction of proposed power plants. For example, the feasibility of proposed power stations on the Waterberg coalfields required an investigation of the impact on water supplies of the effluents emanating from urban and industrial areas in Gauteng. A similar problem has been encountered for the proposed extension of Sasol's operations with regards to the development of additional coal-to-liquid plants. Feasibility studies on the treatment of effluents are being undertaken.[85]

See PI-TP 5

9.1.4 Institutional/regulatory context

South Africa's progressive water policy is underpinned by the *National Water Act of 1998*. This legislation has a strong emphasis on social equity, environmental sustainability – using the concept of the "Ecological Reserve" - and on South Africa's responsibility to neighbouring states through the sharing of transboundary river basins. In 2004, the *National Water Resource Strategy* reported that 98% of the available water resources are already allocated, which is why the strategy focused on increasing stakeholder participation. It also provides the framework within which water is managed at the regional or catchment level in defined water management areas. The Department of Water Affairs is responsible for water management decisions in conjunction with River Basin Catchment Organisations and Water Users Associations. The recently announced *Water Growth and Development Framework* is outlined in the box below.

Energy, fuel supplies and water availability

The Department of Water Affairs (DWEA) is negotiating with Eskom to pump water from the Steelpoort River valley to the top of the Nebo Plateau, a height of 700 m, at a reduced energy cost for the benefit of communities in the Nebo area. Given the link between energy, fuel supplies and water availability, the Department has considered factoring in the water needs of the energy sector in its reconciliation strategies and accompanying feasibility studies. In so doing, concepts and principles that underpin this scheme include those of water efficiency, conjunctive uses of water, linkages between water for growth and water for development, and the utilization of alternative sources of energy. There is a close working relationship between the large water users within the energy sector to ensure that current expansion plans for the national energy grid are supported by water resource planning initiatives.

Source: [86]

9.1.5 Transboundary water management and water transfers

South Africa has entered into a number of bi- and tri-lateral transboundary water agreements with neighbouring states regarding shared watercourses such as the Orange and Limpopo River systems.

Nationally, a series of "inter-basin" transfers link the water resources of the country. Large volumes of water are transferred from the relatively water-rich Eastern areas to the water scarce areas in the West by means of man-made infrastructure. As a result of this strategy and despite limited water availability, the South African Government has managed to provide water for agriculture and industry at the required levels.[87]

An example is the Vaal River Eastern Sub-system Augmentation Pipeline (VRESAP). A total of 160 million m^3 of water per annum will be transferred to augment the water supply to the Eskom and Sasol power stations which is currently met from the Vaal River system.

9.2 The electricity power sector in South Africa

South Africa has large coal deposits and is one of the cheapest electricity suppliers in the world. Strong economic growth, rapid industrialization and a mass electrification program led to demand for power outstripping supply in early 2008. In 2006 coal accounted for 93% of the electricity generated followed by nuclear (4.6%) and hydropower (2.2%).[88] Almost all of the electricity produced is generated by the South Africa company Eskom which is one of the largest power producers in the world.[89] Eskom recognises the importance of effective stakeholder engagement for its long-term business success (e.g. expansion; see 7.2.1) and engagement is one of their top ten business priorities.[90]

See PI-TP 11

9.2.1 Expansion

The growth in coal use by Eskom and Sasol is expected to accelerate over the coming years. In April 2008 Eskom began construction of the new Medupi power station in Limpopo, located next to the Waterberg Coalfield that contains vast resources of coal. In the event that coal-fired power stations are built on the Waterberg coalfields, the Department of Water Affairs (DWEA) stated that Eskom would be obliged to intensify its water efficiency practices.[91] **Power providers and the financial institutions financing their activities should have a great interest in the development of water regulation in South Africa.**

See PI-TP 3

See PI-TP 2

Escom is investing in dry-cooled systems. It operates Matimba power station near Lephalale, in Limpopo, which is the largest direct drycooled station in the world.[92] In South Africa there are few installed sulphur removal systems. In 2008, Eskom began construction of a coal-fired power plant, named Kusile Power Station (previously called Project Bravo) which will be completed in 2017. It will be the first power station in South Africa to have flue gas desulphurization (FGD) installed.[93]

See PI-TP 7

The building of the first of a new generation of high-temperature helium gas-cooled nuclear reactors (Pebble Bed Modular Reactor, PBMR) has seen challenges to secure funding arrangements. If successful, the South African project would become the first commercial-scale high-temperature reactor in the world. **Financial institutions can influence decisions on the implementation of new technologies that have a reduced impact on local water availability.**

See PI-TP 1 & 2

9.2.2 Renewable energy

The Department of Minerals and Energy (DME) issued a White Paper on Renewable Energy in 2003. The government set a target to increase the development of renewable energy by 10,000 GWh by 2012. However, South Africa does not have adequate water supplies to meet the needs of large conventional hydropower stations and so far, large scale hydropower is available only in the Mozambique corridor.

See PI-HP 2

Small scale hydropower plants enable CO2 emission reductions and may replace coal fired electricity generated under certain circumstances. These schemes can help to overcome the electricity shortages currently experienced in South Africa. A critical factor is often the option for conjunctive use with irrigation or other storage releases,Small scale hydro schemes have received increasing levels of attention as the following case study illustrates.

There is a further proposal on the De Hoop Dam for the operation of Eskom's proposed hydropower pumped storage scheme in the Limpopo Province.

Case study: Bethlehem mini-hydro power plant, Free State province

Bethlehem Hydro (Pty) Ltd (BH) is an independent power producer. BH commenced construction of a mini-hydro power plant in December 2006 which will contribute towards the government's objective of increasing renewable energy development in addition to its environmental objective of reducing greenhouse gas emissions.

The increase in power production (from 3.9 MW in the feasibility study to the final level of 7 MW), together with the improved greenhouse gas emission reductions and "the recent increase in Eskom's electricity tariffs" [94] has markedly improved the project's financial viability.

Innovative nature of the project

The project is unique in the sense that it is one of the first commercially independent power producers in South Africa to construct a new plant. It is also the first hydro power project to be licensed under the new Water Act (Act 36 of 1998) and one of the first Clean Development Mechanism (carbon credit) projects in South Africa. From an environmental point of view, the provision of green electricity in place of coal-fired power is significant. It also assists South Africa in reaching Kyoto Protocol targets.

Hydropower projects are not common in South Africa due to the seasonal nature of water resources. This project was feasible due to a unique set of circumstances that transformed a seasonal river, the As, in the Free State, into a perennial river as a result of the Lesotho Highlands Water Scheme. Environmental mitigation was also used to offset the Merino wetland which was drained for the project.

See PI-HP 16 & 20

Community involvement

The local community was engaged through the Dihlabeng Local Municipality's Exco, whose members emphasised the use of local labour and local participation during the project. After completion, local contractors will be used for the operation and maintenance, albeit minimal for a hydro power project.

See PI-HP 12 & 13

The project also provided the opportunity for a Free State-Based women's group to obtain an 11% equity stake in a hydro power project. This arrangement was negotiated upfront with the developer to demonstrate their goodwill towards the local community.

Source: [95]

Komati water scheme augmentation project: Options for managing Water Scarcity

Additional demands will be placed on the on the Komati System due to increased power generation, return to service of the Komati Power Station and an upgrade of capacity at the Arnot Power Station.

Eskom investigated a number of options to alleviate the pressure on the Komati System and concluded that the following two alternatives had to be investigated in more detail:

- Install a 35 Ml/d desalination plant at Duvha Power Station, or
- Construct a pipeline and pumping station to transfer water. The two main options were evaluated at a feasibility stage, addressing environmental considerations, capital cost and life cycle cost.

See PI-TP 5

Source:[96, 97]

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]

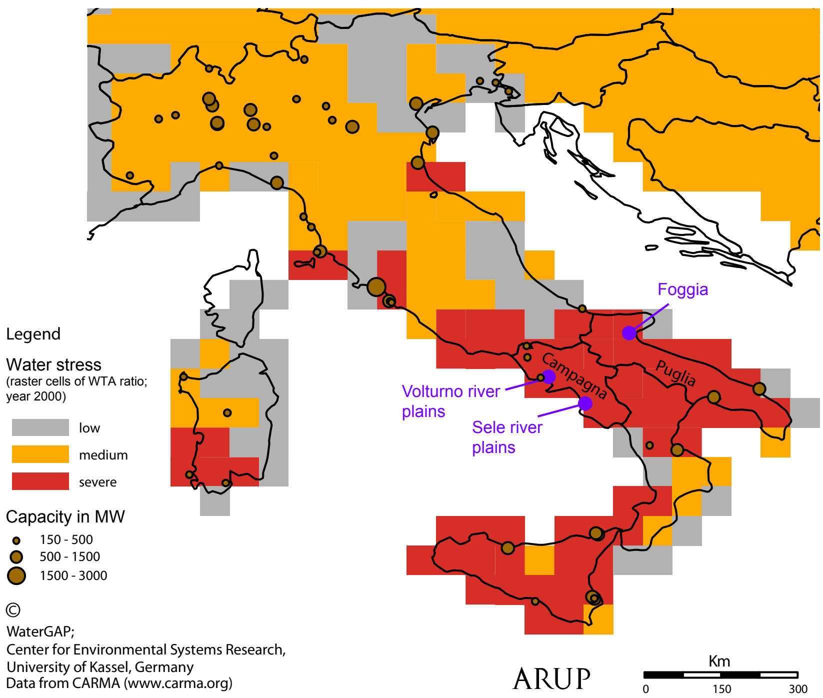
The established practice of withdrawing groundwater (principally for irrigation) throughout Italy, and particularly in the south, has led to overexploitation of potentially renewable resources. This has put considerable pressure on many groundwater reserves.[99] As a result, public water supply increasingly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

See PI-TP 6

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.

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.

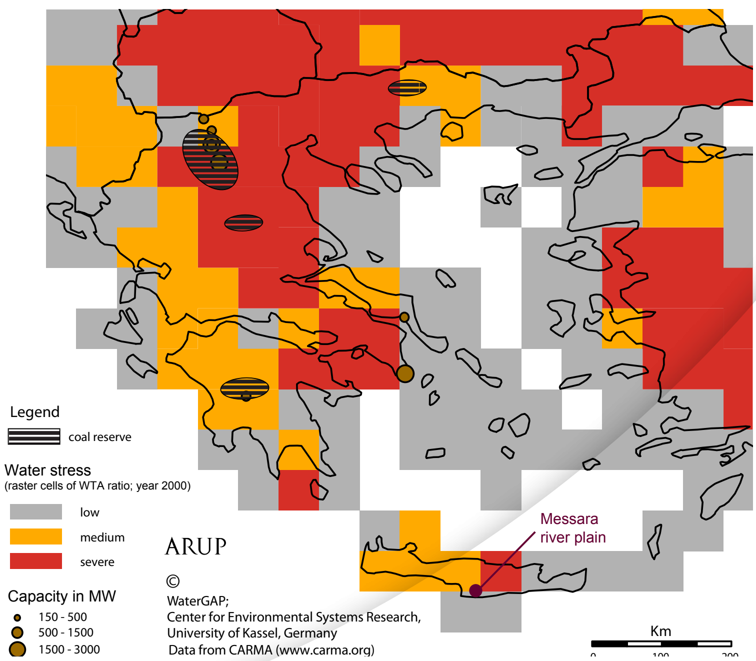
See PI-TP 11 & 10

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.**

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

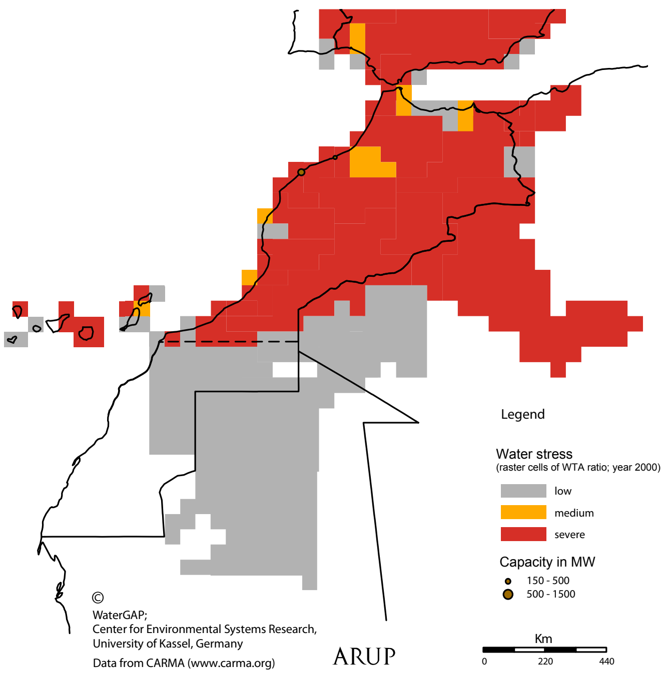
12.1 Local water challenges in Morocco

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 healthy for fish, wildlife, and water quality, including seasonal flow fluctuations.
- Dam construction on shared rivers, where the other riparian States raise an objection that is upheld by an independent panel.

As a final note, banks, investors and lenders tend to get involved late on in the project development process, when the loan requires approval. However, many of the key design decisions happen much earlier on in the process. At such a late stage, the power to refuse a loan is the only real option for a bank to meet its own sustainability criteria. A more productive approach may be for banks and lenders to become engaged in the design process earlier on.

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Appendix on Methodology

A1.1 Global modelling of water resources, water use and water scarcity

The WaterGAP (Water - a Global Assessment and Prognosis) model has been developed by the University of Kassel in Germany to investigate current world-wide water availability, water use and water scarcity by means of a standardised framework. WaterGAP computes both the terrestrial components of water flow and storage (surface runoff, groundwater recharge, river discharge, water storage in soil, groundwater and surface water bodies) and water use (for irrigation, livestock, households, thermal power plant and manufacturing) at a spatial resolution of 0.5 degree (55 x 55 km at the equator). WaterGAP has contributed to various global and continental freshwater resources assessments such as the Global Environment Outlook (GEO -Towards 2015 and Beyond) of UNEP.

WaterGAP compares modelled amount of water available and water required for anthropogenic uses and identifies areas where the need cannot be satisfied. The indicator used to identify areas under water stress is the withdrawal-to-availability ratio (WTA), i.e. the sum of water withdrawn in the domestic, industrial and agricultural sectors divided by the total annual renewable water resource of a basin. The indicator is a measure of the amount of pressure put on water resources and aquatic ecosystems. Categories of water stress are as follows:

- low for WTA < 0.2,
- medium for WTA between 0.2-0.4
- and severe for WTA > 0.4.

This classification is based on a publication by Alcamo, Flörke, and Märker in 2007 entitled "Future long-term changes in global water resources driven by socio-economic and climatic changes". (Hydrological Sciences Journal-Journal Des Sciences Hydrologiques 52:247275). It is recognized here, that there is different approaches to water stress indicators. Others e.g. represent the ratio of total withdrawals to utilizable water less the minimum amount of water used by the ecosystem.

Further, Water-GAP is concerned with the various impacts of global change on water availability and water demand, and to determine the development of water stress conditions. However, a slightly different indicator baseline is used for this new work. See http://news.bbc.co.uk/1/hi/sci/tech/7821082.stm

A1.2 Power plant data

Plant data are from CARMA (www.carma.org). Capacity refers to approximate 2007 output. The maps presented merely display plats greater 150 MW. No further detailed screening of plants has been undertaken.

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146 An example model is CORMIX (Cornell Mixing Zone Expert System) hydrodynamic mixing zone computer simulation, which has been developed by the U.S. Environmental Protection Agency. This model emphasizes predicting the site- and discharge-specific geometry and dilution characteristics to assess the environmental effects of a proposed discharge.

147 Suitable wastewater streams for reuse include gypsum wash water, which is a different wastewater stream than the FGD wastewater. In plants that produce marketable gypsum, the gypsum is rinsed to remove chloride and other undesirable trace elements.

148 If coal pile runoff will be used as makeup to the FGD system, anionic detergents may increase or create foaming within the scrubber system. Therefore, use of anionic surfactants on coal piles should be evaluated on a case-by-case basis. For example, a 500 MWe plant using coal with 2.5% sulfur (S), 16% ash, and 30,000 kilojoules per kilogram (kJ/kg) heat content will generate about 500 tons of solid waste per day.

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17
Acknowledgements

About the UNEP FI

The United Nations Environment Programme Finance Initiative (UNEP FI) is a global partnership between the United Nations Environment Programme and the private financial sector. UNEP FI works closely with the nearly 200 financial institutions that are Signatories to the UNEP FI Statements, and a range of partner organisations, to develop and promote linkages between the environment, sustainability and financial performance. Through regional activities, a comprehensive work programme, training activities and research, UNEP FI Carries out its mission to identify, promote, and realise the adoption of best environmental and sustainability practice at all levels of financial institution operations.

About the UNEP FI's Work Stream on Water & Finance

The UNEP FI Water & Finance Work Stream to create awareness and capacity among financial institutions in order to promote their proactive approach towards water issues, both in the area of water-supply and sanitation as well as with regards to water as a production factor in businesses downstream.

This is done by identifying and addressing the common grounds between the commercial objectives of financial institutions and the water sustainability of society at large.

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About Arup

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