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► **To cite this version:**

C. Pezon. Price-cap regulation of private water services for small towns in Burkina Faso based on solar energy. *International Journal for Sustainable Development*, 2017, 10.1504/IJSD.2017.089989 . hal-02012259

HAL Id: hal-02012259

<https://cnam.hal.science/hal-02012259>

Submitted on 8 Feb 2019

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Abstract

The Agenda for Sustainable Development adopted by the United Nations in September 2015 sets the ambitious goal of achieving universal access to safe water by 2030. This article explores the conditions for achieving this goal in Burkina Faso small towns under public-private partnerships (PPP). It results from an action-research project that adopted a price-based methodology, and involved a researcher, the author, and high level sector stakeholders, in a one-year participatory process, for defining a water policy that would be equitable for users and financially sustainable for private operators engaged in 10-year affermage contracts. The conditions to universalise in an equitable way the access to safely managed water services in Burkina are to switch to solar energy and to enforce a consistent price-cap regulation.



Key words

Water supply; Financial sustainability; Agenda 2030 for development; Equity; Water tariff; Service monitoring; PPP; Water demand; WASH; Action-research; Affermage

1. Introduction

The Sustainable Development Goals (SDGs) have succeeded the Millennium Development Goals (MDGs) on the international agenda for development. The MDG 7 which targeted to halve the population without access to safe water by 2015 has been achieved globally, and in Burkina Faso in particular, in 2011 (UN-Water, 2014).

In September 2015, heads of state from 140 countries representing 85 percent of the world's population gathered in New York to adopt the 2030 Agenda for Sustainable Development, an ambitious “plan of action for people, planet and prosperity”, with 17 Sustainable Development Goals (SDGs) and 169 targets. Drinking water, sanitation, and hygiene form a central part of the clean water and sanitation goal (SDG 6) and are reflected especially in targets 6.1 and 6.2. They are also recognized for their role in reducing health risks as part of the good health and well-being goal (SDG 3) in targets 3.3 and 3.9. SDG 6 sets out to “ensure availability and sustainable management of water and sanitation for all” (UN General Assembly, 2015):

- achieve universal access to basic drinking water, sanitation and hygiene for households, schools and health facilities;
- halve the proportion of the population without access at home to safely managed drinking water and sanitation services;
- progressively eliminate inequalities in access

Cost to achieve SDG 6 has been estimated by the World Bank based on a mix of technology options (Hutton and Varughese, 2016). Basic technologies include community wells for water supply, improved latrines for sanitation, and a basin with water and soap for practicing hand washing; while higher-cost options include piped water and sewerage. Safely managed water means an on-plot water supply for every household (high service), while a basic water supply includes an improved community water source within a 30-minute round-trip, including queuing.

The capital financing required to supply basic water services to all those unserved in the world would cost US\$ 7 billion per year, while the provision of high service to all the unserved in the world would cost US\$37 billion. To halve the population without access to high water service and provide basic service to the others worldwide would cost US\$ 21 billion per year, approximately three times the historical financing trend of extending access to the unserved (Hutton and Varughese, 2016).

Urban areas account for 70 percent of the capital expenditure requirements to achieve universal access to water. Interestingly, Hutton and Varughese find more cost-effective to invest straight in safely managed services than to offer first basic services then higher levels of service. “Additional investments can be well worth their cost if the appropriate hardware and software are chosen, and services sustainably operated.” [Hutton and Varughese, (2016), p.6]. In the case of Burkina Faso, the return on investment in higher service cannot be compared with basic service and the investment can well be worth if tariffs recover recurrent costs (Pezon, 2015a).

In November 2013, within the regular session of the National Assembly, members of parliament invited the Government of Burkina Faso, through the Minister in charge of water and sanitation, to develop a new water policy for semi-urban areas that envisions the

provision of an equitable service to all by 2030. The new water policy must comply with the existing institutional framework according which semi-urban services are privately operated through 10 years affermage contracts. Such a contract entails that public authorities are liable for capital investment while operators are liable for the operation, maintenance and capital maintenance (pumps and generator) expenditure¹. Semi-urban services must be equitable for users and financially sustainable for operators.

In September 2014, DGRE addressed the Assembly's request by appointing a researcher to develop a financial modelling and design a tariff policy that could meet political expectations. The scope of the modelling and policy covers 2047 small towns ranging from 2,000 to 10,000 inhabitants (Pezon, 2015a). In 2014, only 568 towns totalling 2.6 million people were equipped with embryonic piped schemes supplying in average 2000 people each versus an average population of 4880. In 2030, the 2047 small towns will account for 11.8 million people or 45% of the country's population (Comité National de Recensement, 2009).

The purpose of the article is to identify and analyse the conditions for meeting target 6.1 for water in Burkina Faso, more specifically in small towns. These conditions have emerged through an action-research project involving a researcher and high level stakeholders in Burkina for one year. Together they have designed a tariff policy that allows reducing by half the tariffs of safely managed water while providing a high level of service to 70% of the semi-urban population in Burkina by 2030, and granting a fair profit to private operators.

Next section explains the challenge of meeting SDG 6.1 in the context of Burkina Faso. Section 3 describes the action research process and methodology. Section 4 shows that the crucial condition for providing equitable access to water while ensuring profit margin to operators is to abandon fossil energy for solar energy. Section 5 compares the capital investment required under each energy option and concludes that the higher investment in capital for solar production is largely compensated by the operating loss of fossil run services over 10 years. Section 6 explains how a sound price-cap regulation would second the adoption of solar energy to deliver universal water services. Last section concludes on the process for adopting the proposed tariff policy in Burkinabè law.

2. The challenges of universal access to water in small towns in Burkina Faso

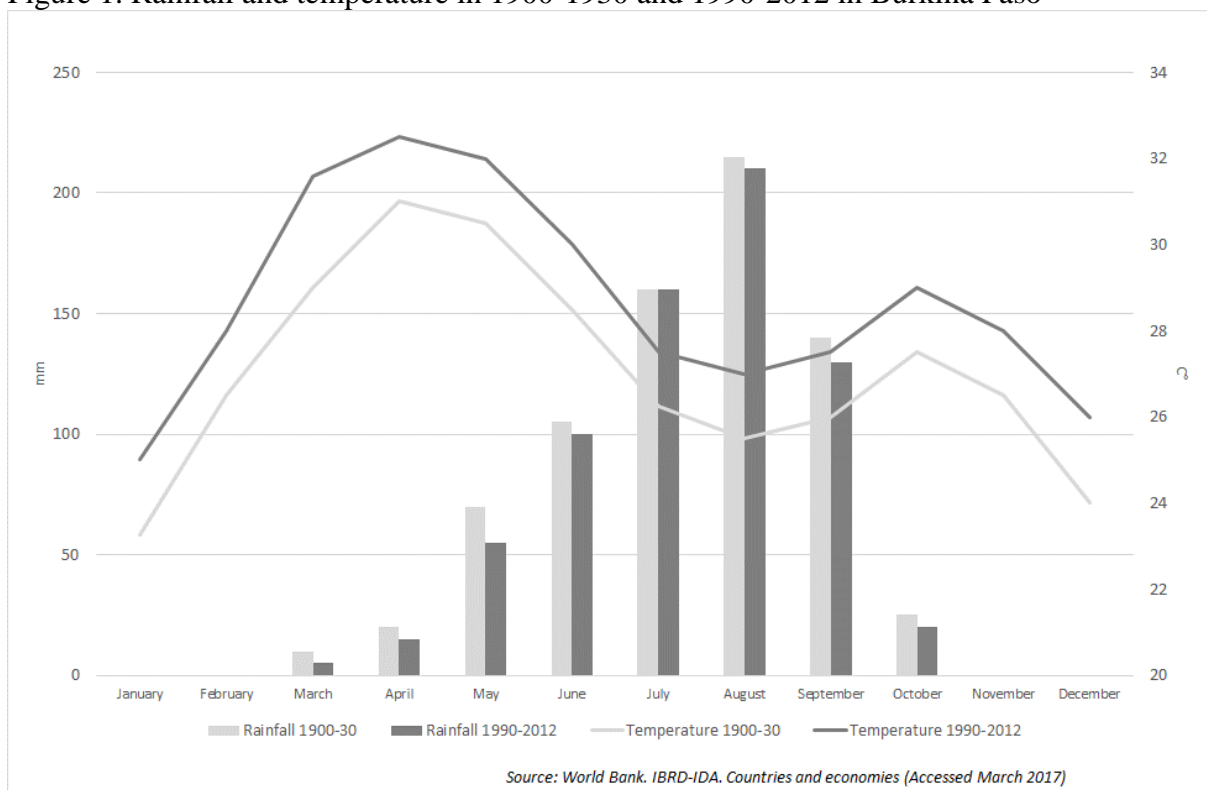
2.1. The demographic challenge

Burkina Faso is a landlocked country located in West Africa. It is ranked as the 7th most disadvantaged country in the world by the Human Development Index which combines wealth (GDP), Health (Life expectancy) and Education (UNDP, 2014). Half the population lives below the poverty level and the GDP per capita stands around US\$650 per year, i.e. half the average GDP per capita in Sub-Saharan Africa (World Bank, 2015). The mortality rate of under-five is 98 per 1000 and a Burkinabè dies in average at 57. Three quarters of adult population is illiterate (UNICEF, 2015).

¹ Under affermage, public authorities are in charge of capital investment: the State and development agencies finance the instalment and the extension of production and distribution capacities while private operators finance the operation and maintenance of services and the capital maintenance or replacement of short-term capital (pump and generators) on water revenues (tariff). The scope of capital maintenance to be recovered through tariff depends on the duration of the contract. A 10-year affermage entails that the operator is liable for the capital maintenance of all capital whose life expectancy is below or equal to 10 years.

Burkina Faso is a semi-arid water-stressed country characterised by a Sahelian-Soudanese climate with one short rainy season (June-September) and a dry season with average temperature over 30° Celsius (Figure 1). Annual rainfall tends to decrease and average temperature to increase over time. According to predictions for 2021-2050, the number of strong rainfall events (>50 mm/d) is expected to increase by 15 % and the lengthening of the dry season to spell at about 20 % (Ibrahim and al., 2014). Only 4 permanent rivers flow in the country (Niger, Volta, Comoé and Mouhoun), and ground water is the unique resource to supply rural and semi-urban areas with drinking water; dams were built close to the capital city, Ouagadougou, and other large towns (Ouahigouya), but only to secure the provision of water to the urban population (4 million people).

Figure 1. Rainfall and temperature in 1900-1930 and 1990-2012 in Burkina Faso



Burkina Faso has a total population of 17.5 million in 2015, growing at a rate of 3% per year. Ouagadougou, the capital city, concentrates 2 million inhabitants or half the urban population. 80% of the country is rural, with villages counting from few dozens to 10,000 inhabitants. According to population forecasts, the demographic growth should remain at 3% per year, leading to a total population of 25 million in 2030. Though rural population should stay constant, small towns (2,000 to 10,000 inhabitants) and larger towns, will increase by 7,5 million people in the coming 15 years (Comité National du Recensement, 2009).

The achievement of SDG 6.1 will depend on Burkina Faso's ability to develop safely managed water services in small towns. In 2014, only 568 small towns out of 2047 provided water through embryonic piped schemes to less than half their population. In total, more than 6 million semi-urban dwellers have today at best access to a basic service through community managed water points (boreholes equipped with hand-pumps), just as the rest of the rural population. Consequently, the challenge consists in developing safely managed water services to 12 million people with a large majority receiving water on premises. This ambitious objective is key to avoid a development where a metastasis capital city would be the only

economic attractive centre while the other towns would develop chaotically and fail to supply urban type of water (and other) services.

2.2. The tariff equity challenge

The organisation of water supply in Burkina Faso differentiates urban, semi-urban and rural areas. For urban areas, the public utility ONEA (Office National de l'Eau et de l'Assainissement) holds a monopoly through a concession contract with the State for the provision of drinking water to towns exceeding 10,000 inhabitants. For the provision of drinking water in semi-urban and rural areas, the National Department for Water (DGRE – Direction Générale des Ressources en Eau) remains the main stakeholder, despite the transfer of water and sanitation competencies and assets to local governments in 2009¹. As expected, the creation of local authorities (communes) in 2004² and the subsequent reform of public sector management has proved challenging (World Bank, 2002). Though legally in charge of providing water to their constituencies, local authorities are fully dependent on DGRE for financing capital investment. DGRE rules that:

- in villages (below 2000 inhabitants), population is supplied by boreholes equipped with hand pumps at a rate of 300 people per borehole. In each village, a benevolent community-based organisation is in charge for two years of collecting water fees from users and coordinating with a technician for regular maintenance and repair in case of break-down.
- semi-urban centres (2,000 to 10,000 inhabitants) should be equipped with small piped schemes supplying pressurised water to stand-pipes and a few private connections. These schemes are to be managed by professional operators contracted for 10 years under affermage. They collect water fees from users and maintain the infrastructure, including the capital maintenance of components such as pumps and generators.

Typology of access to water includes three different service levels depending on where one lives. In urban areas (outside Ouagadougou), the population considered as having access to water is less than 500 meters away from a stand-pipe providing through 3 taps 20 litres of safe water per person every day to 300 people. In semi-urban areas, one has access to water if located less than 500 meters away from a stand-pipe which supplies up to 500 people with four taps at a rate of 20 litres of safe water per capita per day. In rural areas, accessing water means walking up to 1 km to a safe water point that supplies 20 litres of water per capita to 300 people every day. The targeted level of service increases with density.

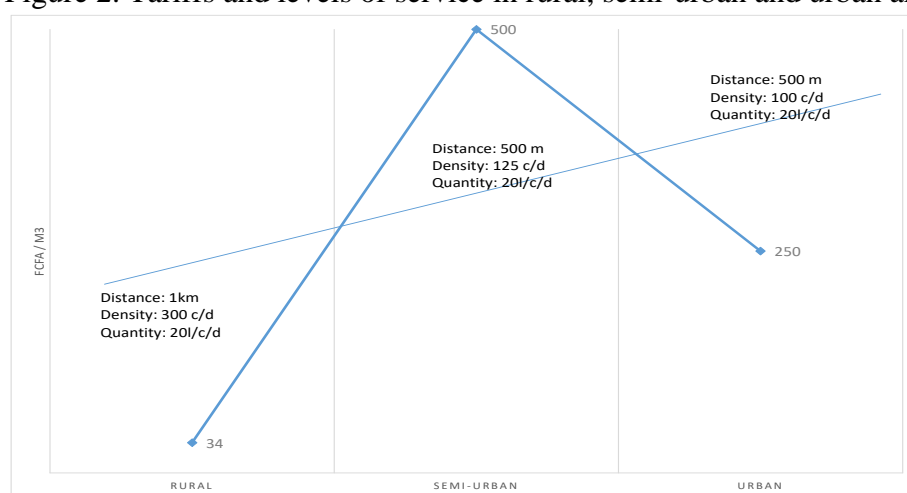
A separate tariff policy has been developed for each category. In urban areas, users pay a flat tariff of 250 FCFA/ m³ to access water at stand-pipes and an average tariff of 500 FCFA/ m³ when they receive water at home, on top of a monthly fee of 1000 FCFA. In semi-urban areas, users pay double at stand-pipe, 500 FCFA/ m³ (US\$1/m³), and for water at home (1000 FCFA/ m³) but a similar monthly fee of 1000 FCFA. While the instalment of a private connection is not charged to households in urban areas, in small towns, a family must pay 200,000 FCFA (US\$400) to get the best level of service. In other words, a small town dweller pays twice more than an urban one for a basic service (stand-pipe) of lower quality (higher crowding) and incomparably more to access an urban type of service e.g. water at home. In rural areas, families are expected to contribute an estimated lumpsum of 2,500 FCFA per year to access a safe water point (borehole).

¹ Décret 2009 N°2009- 107 IPRES/PM/MATD/MAHRH/MEF/MFPRE, March 3, 2009

² Loi n°055-2004/AN, December 21, 2004

The tariff structure is not aligned with the levels of service (Figure 2). It causes a major equity issue in a context where semi-urban population is notably poorer than urban (Institut National des Statistiques et de la Démographie, 2009). This equity issue is not specific to Burkina: frequently the poor tend to pay higher price to access lower quality water services in urban areas (Banerjee and Morella, 2011) and in rural Burkina poor pay as much as non-poor households, after considering both financial and economic expenditure (Schweitzer and al., 2013).

Figure 2. Tariffs and levels of service in rural, semi-urban and urban areas



Source: the author

2.3. The regulation challenge

The economic regulation of natural monopolies pursues two objectives: make sure that operators deliver agreed services in a cost-effective way and adjust tariffs to cost (Laffont and Tirole, 1997). Natural monopolies (such as network industries) are capital-intensive businesses. Cost efficiency cannot be obtained through competition, per definition, though it matters to ensure costs are the lowest possible considering the nature of the service provided (a public service recognised as a human right). However, natural monopolies benefit economies of scale that show through decreasing marginal cost with volume: for a given (production and distribution) capacity, the higher the volume of water the higher the profit margin per cubic meter of water. This is what economists call the monopoly rent, and regulation seeks to allocate this rent in favour of users through tariff adjustments to costs.

Today in Burkina Faso, the regulation framework is poorly designed, and the monitoring mechanisms fail to capture operators' performance in service delivery and cost-effectiveness (Pezon, 2013). Though Burkina opted for a price-cap type of regulation by setting a fixed and national tariff for water piped schemes, the regulation frameworks does not include a mechanism to monitor operators' performance in service delivery. The monitoring of services is limited to one indicator, the functionality of the piped schemes, and is collected only once a year by DGRE. For years, it stands at 67% meaning that one third of piped schemes are broken down. The other major service indicators (the quantity of water delivered, the number of users, the quality of the water and the time spent to fetch water) remain out of reach of the national Department. However, the compliance of the service delivered should be a central piece of the price-cap regulation according to economic theory, as lowering the quality of the service delivered is a tempting way for operators to increase profits (Pezon, 1999).

The regulatory framework includes no mechanism to report on operators' performance on cost-effectiveness. In particular, there is no mechanism to ensure that the annual provisions made by operators to finance capital renewal are properly disbursed during their contracts to replace pumps and generators. When this equipment breaks down, operators explain that they cannot replace it because the provisions are insufficient to meet the replacement cost. However, at the end of the contract, operators retain the net provisions cumulated over their contracts while, according to DGRE, these provisions should be transferred to the next service providers to finance future capital replacement. While each operator is contracted for the management of a portfolio of 10 piped schemes (combining fossil and solar schemes), DGRE suspects operators to make high profit on solar piped schemes but to stop running the fossil's as soon as capital investment is required to replace generators, instead of mutualising the cost and benefit of the two types of systems.

In this context, the challenge is to design regulatory mechanisms consistent with a price-cap type of regulation and assign clear financing responsibilities to contractors engaged in affermage contracts (Marty and al., 2005). These mechanisms should be within the reach of capacities available at local and national levels and in compliance with the institutional framework (local authorities being local regulators and national level overseeing the regulation).

3. Action-research: process and methodology

The action-research adopted a one-year participatory process with main sector stakeholders, and developed a reverse methodology to the cost-based approach that previously failed to address the National Parliament's request.

3.1. A participatory process to build on sector knowledge and ensure policy ownership

A participatory process was set up with the support of the World Bank. Parliamentarians, local authorities, DGRE senior staff, professionals from public and private sectors, and NGOs were involved into this action-research as active participants to a learning process (Sutherland and al., 2012).

Two important context elements encouraged the active collaboration of public and private stakeholders towards this achievement.

First, there is no more debate on the potential contribution of public-private partnerships to the water sector. Time has passed since the World Bank promoted the privatisation of water services of large cities in various developing countries, in the late 1980s (Fall and al., 2009), and lessons have been learnt on the limits of contracts such as concessions for the provision of water (Pezon and Breuil, 2012). In Burkina, the public utility, ONEA, resisted the privatisation and is today recognised as one of the most performing water operator in Africa (Bertrand and Géli, 2015). However, the private sector has developed successfully in the suburbs of Ouagadougou (Hydroconseil, 2013), and the potential of private sector to contribute to the sector's development and capacities in semi-urban areas is not contested (Van Dijk, 2008).

Secondly, two attempts had been made since the request of the Parliament in November 2013, to propose a new tariff policy for water provision in small towns, one by an independent consultant and the other by a Consultancy firm. Both studies were funded by the World Bank and rejected by DGRE as none considered a lower water tariff than the 500 FCFA per cubic

meter already enforced at stand-pipe. The researcher appointed for the third attempt, drawing lessons from the previous failures, proposed a participatory setting to develop a water policy benefiting from stakeholders' knowledge and meeting their expectations.

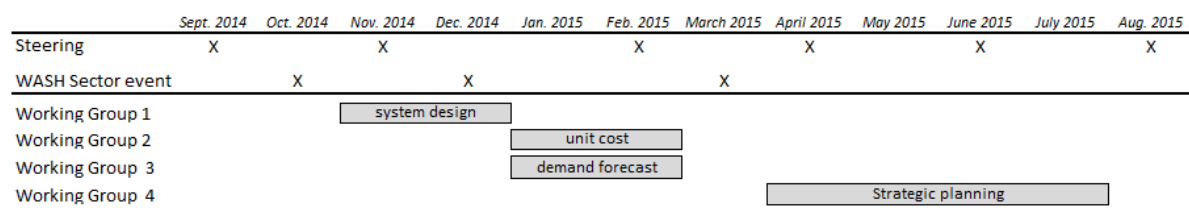
In parallel to the research steering committee, national sector workshops and forum created space for stakeholders to make critical decisions on the pillars of the water policy and discuss options on the ground of transparent, reviewed and sound cost and benefit data. Stakeholders community broke into four working groups which met on a regular basis over 10 months altogether, and addressed each one building block of the financial model (Table 1 and Figure 3).

Table 1. Action-research Stakeholders

WG	Building block	Participant	Objective
WG 1	Infrastructure design and lifespan	DGRE, Infrastructure Department ONEA (Urban WASH public utility) Engineering Companies (Burgeap, Antéa) Senior consultants Implementers (NGOs, public work Cies) Private operators (PPI, FasoHydro, Vergnet) World Bank, Wash advisor Researcher	Identify and quantify all the supplies and works required to install a pipe scheme with production and distribution capacities ranging from X m3 per day to X m3 per day Quantify in years or number of functioning hours the lifespan of all capital investment Identify the capital components whose lifespan is 10 years or below Coordinator and facilitator ; collect and process data and information
		DGRE, Investment & Procurement Department ONEA Private operators Consulting firms (IGIP, Royal Haskoning, Burgeap) World Bank, Wash advisor Researcher	Consolidate sector knowledge on unit cost for capital investment (production and distribution) Quantify the capital maintenance expenditure for less than 10-year equipment Consolidate sector knowledge on the value and cost drivers of operation and maintenance expenditures of piped schemes (fossil and solar) Coordinator and facilitator ; collect and process data and information; develop and test the financial model with collected data
WG 3	Demand for water	DGRE, regional directorates ONEA Private operators (PPI, FasoHydro, Vergnet) NGOs (Eau Vive, WaterAid, IRC, CRS) Consultants World Bank, Wash advisor Researcher	Consolidate sector knowledge on the access to and use of improved sources in urban, small towns and rural areas Consolidate sector knowledge on the ability and willingness to pay for basic and improved levels of service Demand forecasts for basic and improved water services Coordinator and facilitator; collect and process data and information; test the financial model with demand forecasts
		DGRE, Director & deputy Director for water supply Ministry of Economy and Finance, Direction Générale des Finances Publiques Consultancy firms World Bank Researcher	Define an investment plan for 2016-2030 and detail three 5-year investment programmes to universalise the access to water in 2047 small towns, including 568 equipped with embryonic pipe schemes. Define regulatory mechanisms to enforce private operators and public authorities' duties and rights Coordinator and facilitator; collect and process data and information; test the financial model under various investment scenarios; provide guidance on regulatory frameworks and mechanisms
Steering committee		DGRE World Bank Conseil National de l'Eau Researcher	Review model variables and hypothesis, validate research preliminary findings Reflect on working groups outputs Prepare and debrief sector events present and discuss methodology, financial model, findings and scenarios
WASH Sector events	National workshops	2-day workshops attended by 80 people in October 2014, representing all sector towns mayors and parliamentarians One-day workshop in December 2014 attended by the same stakeholders	Review current policies and limitations in the provision of water services in small towns ; define an equitable tariff and access to water in small towns; validate the research methodology and process Review the financial model and first building block; break into working groups to address other building blocks
	Annual sector Forum	3-day Sector annual meeting in March 2015 to review sector results and adjust planning ; attended by 250 people every year ; in 2015, one day dedicated to the strategy and policy for achieving universal access by 2030	Presentation of the financial model and results factoring system design, unit costs and demand forecasts under different scenarios ; sharing and learning session about preliminary tariff policy

Source: author

Figure 3. Action-research process



Source: author

3.2. A research methodology to design an equitable and sustainable tariff policy

The previous attempts to design an equitable tariff policy adopted a cost-based approach. They consider the recurrent costs for running an embryonic pipe scheme (supplying water to few stand pipes and private connections) that meet a demand of about 5 litres per capita per day, and conclude that the financial sustainability of the service cannot be met with a tariff below 500 FCFA/m³. The researcher proposed a tariff-based approach where the tariff does not stand as the outcome of the research but its starting point. Subsequently, the research question becomes: under which conditions the targeted tariff is compatible with the financial sustainability of the service? The methodology then consisted in developing a financial modelling that gives, for a set tariff, the profit margin of the operators over 10-year contracts, based on variables such as demand (demographic growth, consumption, type of service, density), investment (production and distribution of water) and operating cost. The modelling also factors macroeconomics variables such as inflation rate and tax rate. Finally, it allows for combining different sources of energy and consolidates the costs (investment and recurrent), revenues and profit or loss of 2047 small piped schemes over 15 years.

To define an equitable tariff and access to water in small town was the main objective of the first national meeting in October 2014. At the end of the 3-day workshop, sector stakeholders agreed that the same services should be provided in small towns and at the same prices as in urban areas.

In terms of tariffs, it means:

- the same payment per volume, 250 FCFA/m³ at stand-pipe (basic service) and 500 FCFA/ m³ at home (high service).
- the same condition to access water at home e.g. free private connection, as this major component of ONEA's tariff policy proved to be an effective pro-poor instrument (Komives & al, 2005)

However, and considering the higher poverty level of semi-urban populations, the monthly fee charged for the high service should be half the one charged to urban's (500 FCFA vs 1000 FCFA per month).

In terms of services, stakeholders agreed that the same proportion of semi-urban dwellers should benefit a high level of service as in urban areas by 2030: 70%. This could be phased in three 5-year periods. In phase 1 (2016-2020), the population of the 568 small towns that are already equipped with embryonic piped schemes would be targeted. In 2020, 70% would have access to a basic service and 30% to a high service. Phase 2 (2021-2025) targets 68% of the semi-urban population, located in 1308 small towns. Half receive a basic service and half a high service. In phase 3 (2026-2030), the remaining 739 small towns are equipped with piped schemes and supply a high level of service to 70% of the population -and a basic service to 30%- similarly as the other 1308 towns (Table 2).

Table 2. Targeted population with basic and high water services per investment phase

	Total population	568 small towns		1479 small towns		Targeted population			
		Total population	Average population	Total population	Average population	Total	%	Basic service	High service
2016	7 810 379	2 770 542	4 878	5 039 836	3 408				
2020	8 790 650	3 118 270	5 490	5 672 380	3 835	3 118 270	35%	70%	30%
2025	10 190 773	3 614 930	6 364	6 575 843	4 570	6 902 851	68%	50%	50%
2030	11 813 899	4 190 694	7 378	7 623 204	5 298	11 813 899	100%	30%	70%

Source: author, based on output from WG 3

The design and cost for providing water were tackled by the working groups 1 and 2 (annexes 1 and 2). Demand forecast was the third building block and entailed abundant discussion within the working group 3. While the Burkina Faso regulation clearly targets a demand of 20 litres per capita per day, professionals argue that this level of demand was nowhere to be seen in the 568 towns equipped with embryonic piped schemes. Private operators report an average consumption of 5 litres per capita per day. However, this average is obtained by dividing the volume of water distributed in a town by its total population. This demand does not reflect the demand of effective users: a scheme with 4 stand-pipes is designed to supply water to 2000 people not 4880 (average population of the 568 towns).

Previous research demonstrated that indeed the demand of users varies from 10 to 15 litres per capita per day, depending on season, and that the quantity per capita increases with the proximity of the family to the stand-pipes (Pezon, 2013). In Burkina, as in other countries, people's willingness to pay increases with the level of service provided (Mahendra, 2011). In the working group, a consensus emerged, according which the target of 20 l/c/d will be reached progressively and at different paces depending on the type of service (basic or high), with an initial demand of 5 l/c/d in 2016 for the basic service (Table 3).

Table 3. Demand forecast per level of service 2016-2030

	2016	2020	2025	2030
Daily consumption of water at stand-pipe	8 l/c	10 l/c	12 l/c	15 l/c
Daily consumption of water at private connection	10 l/c	15 l/c	20 l/c	20 l/c
Daily consumption of water by school, health center and others through private connection	500 l/o	500 l/o	500 l/o	500 l/o

l/c: litre per capita l/o: litre per organisation

Source: author, based on output from WG 3

The targeted tariffs, demand forecasts and unit costs for operating water services fed the financial modelling. The researcher draws various scenarios combining energy sources and phasing that were presented and discussed at the national sector Forum in March 2015. The last working group was formed to develop a strategic planning, and used the financial model as a decision-making tool.

4. Sustainable water services at half price with solar energy

Is it financially sustainable for operators to provide access to water to 11.8 million people at half price? Under what conditions the targeted tariffs can cover the operation, maintenance

and capital maintenance expenditure for pumps and generators, and spare a decent profit to the private sector?

The financial sustainability of water services depends on the type of energy used to pump ground water.

With carbon energy (fuel), it costs from 1,957 FCFA/m³ to 528 FCFA/m³ (US\$3.3 to US\$0.9/m³) to provide volumes of water ranging from 10 m³ per day to 200 m³ per day – covering respectively a demand of 5 l/c/d by 2000 people and a demand of 20 l/c/d by 10000 people (Figure 4).

For similar volumes of water, the unit costs of a solar type of system ranges from 1,754 FCFA/m³ to 177 FCFA/m³ (US\$3 to US\$0.3/m³) (Figure 5).

Figure 4. Operation and maintenance expenditure on a carbon system

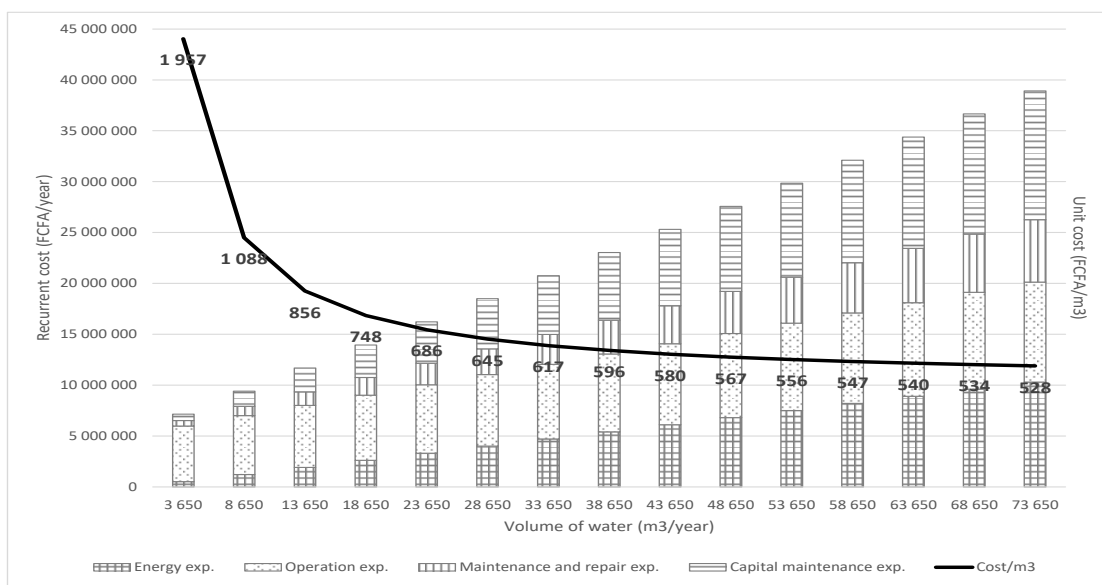
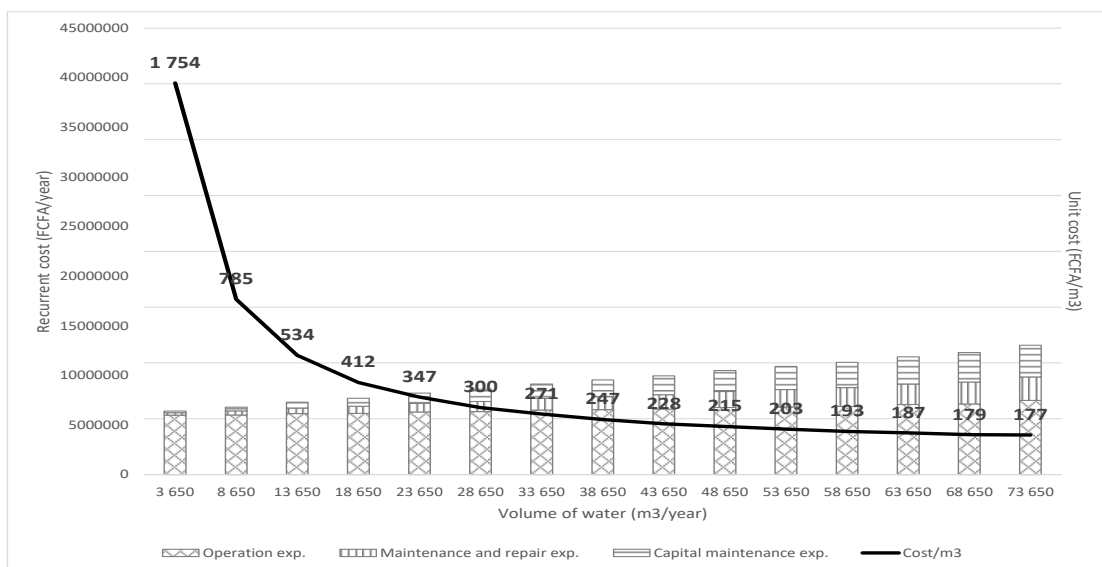


Figure 5. Operation and maintenance expenditure on a solar system



At the targeted tariff and forecast demand, never is a carbon energy system financially sustainable (Table 4). For instance, for a town with a population of 2000 inhabitants in 2016, an operator would accumulate an operating loss of 19,5 M FCFA under a 10-year contract. The larger the town, the bigger the loss with a cumulated operating loss of 91,2 M FCFA for a town of 10000 inhabitants at the beginning of the contract. In the former case, the loss equals 21% of the cumulated revenue in 10 years. For the latter, the operating loss margin culminates at 50%.

Table 4. Operating profit and operating profit margin of thermic and solar systems in 10 years

Population in 2016	Carbon type of system		Solar type of system	
	Operating profit in 10 years (FCFA)	Operating profit margin* in 10 years	Operating profit in 10 years (FCFA)	Operating profit margin* in 10 years
2000	-19 465 098	-21%	-25 101 512	-63%
2500	-23 945 912	-24%	-18 753 224	-39%
3000	-28 426 727	-27%	-12 404 936	-21%
3500	-32 907 541	-30%	-6 056 648	-9%
4000	-37 388 356	-32%	291 640	0%
4500	-41 869 170	-34%	6 639 928	8%
5000	-46 349 984	-36%	12 988 216	14%
5500	-50 830 799	-38%	19 336 504	19%
6000	-55 311 613	-40%	25 684 792	23%
6500	-59 792 428	-41%	32 033 080	26%
7000	-64 273 242	-43%	38 381 368	29%
7500	-68 754 057	-44%	44 729 656	32%
8000	-73 234 871	-45%	51 077 943	34%
8500	-77 715 686	-47%	57 426 231	36%
9000	-82 196 500	-48%	63 774 519	38%
9500	-86 677 314	-49%	70 122 807	40%
10000	-91 158 129	-50%	76 471 095	41%

* operating profit in 10 years / water sales revenue in 10 years
 Source: author based on financial modelling

A solar type of system becomes financially sustainable when the initial population is above 4000 people (Table 4). For instance, an operator supplying water in towns with population ranging from 5000 to 10000 inhabitants in 2016 cumulates, in 10 years, an operating profit ranging from 13 M to 76,5 M FCFA. The profit margin increases with the size of the service and culminates at 41%.

Looking at the 2047 small towns from 2016 to 2030, the cumulated operating result of the 2047 water services would amount to a loss of 110.9 billion FCFA (US\$ 190 million) with fossil energy versus an operating profit of 83,4 billion FCFA (US\$ 144 million) with solar energy (Table 5).

From a contract perspective, the 568 first systems are operated under 10-year affermage contracts from 2016 to 2025. With solar energy, these services hold a cumulated operating profit of 6,5 billion FCFA (US\$ 11 M) in 10 years, representing 12% of the cumulated water sales revenue. It means that the operation of the services is financially sustainable even with a phase 1 type of demand standing at low levels (from 9 l/c/d in 2016 to 12 l/c/d in 2020).

Table 5. Operating profit (loss) and operating profit margin of the 2047 services

		2016	2020	2025	2030
Fossil energy	568 towns	(40,5 billion FCFA) - 78%		(12,7 billion FCFA) -22%	
	740 towns	(40,4 billion FCFA) -48%			
	739 towns			(17,4 billion FCFA) -33%	
	2047 towns	(110,9 billion FCFA) - 45%			
Solar energy	568 towns	6,5 billion FCFA 12%		29,5 billion FCFA 52%	
	740 towns	25,2 billion FCFA 30%			
	739 towns			22,3 billion FCFA 42%	
	2047 towns	83,4 billion FCFA 32%			

Source: author based on financial modelling

Under similar conditions but with fossil energy, the 568 systems would lose 40.5 billion FCFA (US\$ 69 M) or 78% of the cumulated revenue in 10 years.

Similarly, the 740 systems developed in the second phase of the investment plan are operated under 10-year contracts from 2021 to 2030. With solar energy, they hold a cumulated operating profit of 25.2 billion FCFA (US\$ 43 M) in 10 years, or a margin of 30% of the total revenue. With fossil energy, the 740 systems would lose the equivalent of 48% of their revenue in 10 years.

For the 739 systems developed in phase 3, as well as for the 568 systems whose 10-year contracts expire in 2025, we have considered operating profits and margins over 5 years, from 2026 to 2030. In both cases, the operating profits reach outrageous levels, respectively 42% and 52%. According to demand forecasts, the majority of semi-urban population receives a high level of service (private connection) from 2025 and consumes a minimum of 17 l/c/d. Under such conditions, the provision of service becomes a cash cow type of activity. Conversely, the same services ran with fossil energy lose a fifth or a third of their revenue in 5 years.

At this stage of the analysis (National sector Forum), sector stakeholders share a common vision on the following points:

- A major energy shift is needed. There will be no universal access to water without a major shift towards renewable energy. The level of subsidy required to compensate the losses of fuel type of systems disqualifies this source of energy, regardless the fact that no private operator would enter a business where 50 to 80% of his expenditures are not covered by tariffs, suspending the financing of everyday business to the timely transfer of public money.
- With solar energy, it is financially sustainable to universalise the access to water in small towns by 2030 at equitable rates. A tariff reduction might even be considered before 2030. After 50% of the population has accessed to high water service, the tariff of both basic and high services may be reduced substantially while still offering fair profits to operators (Table 6).

Table 6. Operating profit margin of the 2047 water services (2026-2030) under 3 tariff scenario

Tariffs from 2026 to 2030	Unchanged tariffs	Revised tariffs: -20%	Revised tariffs: -30%
Stand-pipe (FCFA/m3)	250	200	175
Private connection FCFA/m3	500	400	350
Private connection (FCFA/month)	500	400	350
Operating profit margin (cumulated operating profit / cumulated water revenue)	45%	32%	22,5%

Source: author based on financial modelling

5. Capital investment does not invalidate solar despite being superior to fossil energy

Important capital investments are required to provide 18.5 litres of water per capita per day to 11,8 million people in 2030. Our estimation includes the capital investment in extension, be it to increase the production capacity (pump, generator or solar panel) or the distribution capacity (network, stand-pipes and private connections) over 15 years. The cost to replace short-life equipment (pump and generator) is part of the recurrent cost that operators recover through tariff.

The cost drivers of capital investment are twofold. The level of service drives the investment in water distribution, and the source of energy drives the investment in water production.

In distribution, a capital investment of 445 billion FCFA (US\$ 768 million) or 37,700 FCFA per capita (US\$ 65) is estimated to distribute safely managed water to 11.8 million people by 2030, after factoring the demographic growth and an inflation rate of 2.5% per year (Table 7). It includes the extension of the 568 existing distribution systems and the development and extension of the 1479 new schemes over 15 years. The capital investment in distribution is divided almost equally in networks and the instalment of stand-pipes and private connections.

Table 7. Capital investment in distribution and production per source of energy (2016 - 2030)

	Distribution			Production		TOTAL Solar systems	TOTAL Thermic systems
	Network	SP & PC	Total	Solar	Thermic		
Phase 1 (2016-2020)	48 294 007 937	23 516 460 875	71 810 468 812	21 079 142 409	3 494 683 413	92 889 611 221	75 305 152 225
Phase 2 (2021-2025)	66 739 912 422	66 456 697 625	133 196 610 047	138 600 623 639	75 636 479 095	271 797 233 686	208 833 089 141
Phase 3 (2026-2030)	100 397 475 555	139 872 679 934	240 270 155 489	186 224 650 503	95 978 848 676	426 494 805 992	336 249 004 164
TOTAL FCFA	215 431 395 913	229 845 838 434	445 277 234 347	345 904 416 552	175 110 011 183	791 181 650 899	620 387 245 530
TOTAL US\$	371 433 441	396 285 928	767 719 370	596 386 925	301 913 812	1 364 106 295	1 069 633 182

Source: author based on financial modelling

In production, the source of energy is the driver of the capital investment: it costs twice more to invest in the production of water with solar panels than with generators (346 billion FCFA vs 175 billion FCFA).

Consolidating capital investments in both distribution and production, it costs 27,5% more to establish water systems running on solar energy than on fossil fuels (791 billion FCFA vs 620 billion FCFA). This additional investment amounts for 14,500 FCFA per capita, i.e. roughly a supplement of 1000 FCFA per capita per year during 15 years (US\$ 1,6/c/y).

This additional investment is justified financially and from a risk perspective. Financially, investment must be compared with the wealth they generate. 2047 fossil type of systems require both capital investment and permanent subsidy for the recovery of most operational expenditure. In 15 years, the combination of capital investment and operational expenditure to be subsidised amounts to 731 billion FCFA. With solar energy, a capital investment of 791 billion FCFA generates a wealth of 83 billion FCFA: the net investment after 15 years is 708 billion FCFA, hence below the one with the fossil option.

A risk perspective favours the solar option too. We have already mentioned the fact that private operators are unlikely to enter a business that relies on subsidy more than on water sales revenues. Besides, donors are reluctant to finance operational costs, even against interest: they reserve development aid (grant and loans) to capital investment and sector strengthening (policy and strategy) (UN Water, 2014). It would thus leave the sole State of Burkina with the responsibility to contribute each year as much as users to the operation and maintenance of *de facto* no profit water services. Which donor would take the risk of investing massively in services the delivery of which is suspended to annual contributions of the ministry of finance for 15 years? Debates around tariff levels would sooner than later arise, and increased tariffs would again appear as the way to solve the lack of financing. The fossil option is simply not sustainable considering the equitable and universal access to water that stakeholders have defined.

The solar option, on the other side, turns the provision of the water service into a wealthy activity that benefits users, and the development of a bankable private sector. By 2025 / 2030, a technical and political reflexion can be engaged to discuss the allocation of the financial rent of water services between stakeholders (operators, users, public authorities). As suggested previously, solar services would become extremely profitable after 10 years and the threshold of half population with high service reached. This profit is a collective surplus, and though operators should take their share, they cannot be granted the full return on investments that have been financed by others (donors and the State) to deliver a public service listed as a human right. The economic surplus of water services can be partially allocated to users through a reduction of tariffs or to the service authorities to finance further investment or develop their capacities.

The capital investment to universalise the access to water at an equitable tariff to 11,8 million people by 2030, costs 791,2 billion FCFA or 67,000 FCFA per capita (resp. US\$ 1,36 billion and US\$ 115). These figures stand within the range of investments reported in Africa to supply higher level service (US\$ 80 to 130 per capita, WASHCost, 2012) and are coherent with the estimated investment required to provide safely managed water by 2030 (Hutton and al., 2016).

6. Sound regulation of solar water services

Universal and equitable access to safe water requires the development of regulatory capacities to enforce contracts, monitor operators' performance and service delivery, including to the poor (Marson and Van Dijk, 2016; Nyarko and al., 2016). Development of capacities come at

a cost, and development projects usually include a budget for capacity building equal to 3% of the investment in capital. The financial model factors this ratio and allows for an average budget of 1,5 billion FCFA per year over 15 years to finance local and national authorities' capacities.

Regulatory mechanisms and capacities must be coherent with the regulatory regime adopted for the water services. In Burkina Faso, the regulation of water services falls under the price-cap regulation regime, when the tariff is fixed for the duration of the contract and cannot be modified whatever cost changing during the contract. This regulation provides a high level of incentives for performance to operators: a cost reduction means an additional profit for operators (a kind of bonus for their out-performance) but an uncontrolled cost increase turns into a loss for which operators are liable. For the regulator, the downside of price-cap regulation is that operators may be tempted to deliver a sub-standard service in order to reduce their costs and increase their profits. Hence, the regulator should focus its attention to the conformity of the service delivered, and build on regulatory mechanisms to capture service level indicators.

Compared to fossil energy, the solar option facilitates the design and the enforcement of a sound regulation, adapted to capacities at local and national levels. First-of-all, it is possible to define fixed tariffs under the solar option, while the fossil option does not allow enforcing a simple price-cap regulation. With solar systems, the operators have control over all recurrent costs. The change in cost during their contract is attributable to their relative performance in delivering water services. Fossil systems introduce a recurrent cost on energy, the price of which is beyond the scope of operators' control.

This risk is usually handled by indexing the tariff of water on energy price. However, indexed tariffs would annihilate the equity of tariff. As there is neither a national price nor an index for fuel, tariffs would differ from place to place, and in semi-urban areas compared with urban areas. In the case of Burkina Faso, where equality of tariffs in all urban areas is considered as the first criteria in search for equity, the indexation of tariffs to energy is particularly irrelevant (Calder and Schmitt, 2015). From a capacity perspective, the adjustment of tariff on energy expenditure implies financial reporting and validation processes that are unlikely to develop soon in the 2047 small towns and are too heavy to handle at national level.

Under the solar option, local authorities can focus on the monitoring of service delivery, which is both the heart of price-cap regulatory functions, and within reach of their capabilities. Indicators such as the number of stand-pipes, the number of private connections, the volume of water supplied to basic and high services are easy to monitor since water is metered at each distribution point (stand-pipes, private connections). It is thus possible to compare the development of each service with annual objectives, and to use local indicators to trigger new investment in capital (extension of production and/or distribution) to support further development and reach full access by 2030.

In order to improve the accountability of operators with regard to provisioning for capital maintenance and avoiding litigation on the allocation of these provisions at the end of the contracts, the researcher proposed to pool them into a regional or national fund. All operators would have to transfer the provisions made every year to renew short-term capital to this fund. By mutualising the financing of capital maintenance, the pooling mechanism also helps

mitigate the risk that operators face in case of premature break-down, when the replacement cost exceeds the accumulated provision.

Governmental stakeholders agree that such a regulatory mechanism would uplift the level of trust among partners and secure the financing of capital maintenance. Private stakeholders will also adhere to the mechanism if the solar option is retained. Under this option, water services are profitable and there is no reason for holding on provisions in lieu of profit. Conversely, under the fossil energy option, operators would be dependent on subsidies to balance their recurrent expenditure. They would hold on the transfer of provisions until the subsidies expected to compensate operating loss are released. By retaining provisions, operators would mitigate the risk of late or dismissed subsidies by the State.

A price-cap regulation does not exclude the monitoring of costs. The researcher recommends a national monitoring of these costs in order to:

- benchmark operators against each other
- analyse the impact of contract size on performance
- update the unit costs that serve as sector references to adjust tariff for next generation contracts.

Therefore, operators would report their income statements to DGRE whose capacities allow for the development and the management of a national database. This database would not only be accessible by local authorities and operators but more broadly to everyone interested in operators' relative performances. This "sunshine" regulatory mechanism reinforces the incentives for a good and performing provision of water services (Murungi and Blokland, 2016). This digital benchmarking is today achievable at low cost (Melhem and Rifon Perez, 2015).

7. Conclusion

Sustainability of water services is often seen as pursuing conflicting goals as far as equity and cost recovery are concerned: equity calls for lowest possible tariff while recurrent expenditures are best recovered through water sales revenue. In Burkina Faso, sector stakeholders considered that the water tariff policy for small towns should align on larger towns' policy to be equitable for users. This requires to halve current tariffs for basic service (stand-pipe) and high service (on-plot) and to subsidy fully the instalment of private connections.

The financial sustainability of water services depends on the type of energy used to pump ground water. At the targeted tariffs, never is a carbon energy system financially sustainable no matter the population and demand. At the scale of the 2047 small towns and in 15 years, the carbon option turns into an operating loss of 110.9 billion FCFA (US\$ 190 million) versus an operating profit of 83,4 billion FCFA (US\$ 144 million) with solar energy. The sustainable development of an equitable access to water relies on the paradigm shift in energy (Omri and al., 2015).

A tariff policy is embedded in a regulatory framework whose objective is to make sure that services are delivered cost-effectively and to adjust tariffs to cost. In Burkina Faso, a sound price-cap regulation can be designed and enforced with solar energy while fossil energy requires adjustment of water tariff to energy price altering equity and exceeding by far monitoring capacities.

Renewable energy is the corner stone for equity, financial sustainability and regulation of water services. The contribution of solar energy to sustainable economy is a long pending question (King and Slesser, 1995) and the capital investment still one of the limiting factors. In our study, it costs 1000 FCFA more per person per year to invest in solar than in carbon systems (US\$1.6). However, in 15 years the operating loss of fossil systems fully compensate this supplemental investment, disqualifying the carbon option even from an investment perspective.

Since the end of the research action in October 2015, Burkina Faso has elected new head of State and parliamentarians in November 2015, and mayors in May 2016. The water tariff policy has been presented to the new ministry of water and incorporated in the 2016-2030 WASH strategy in view of submission to the council of ministers.

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Annex 1. Capital investment: unit cost and lifetime

In bold the values considered in the financial modelling

All values are in FCFA 2015

Capital investment in water production

	FCFA	Lifetime
Drilling 100m	17 500 000	30 years

	Power	FCFA	Lifetime
Thermic pump (16h/d)	0.75 kW	2 800 000	18,000 hours
	1.5 kW	3 100 000	
	2.2 kW	3 900 000	
	3.7 kW	5 000 000	
	5.5 kW	6 500 000	
	15 kW	9 000 000	
Solar pump (8h/d)	0.75 kW	2 800 000	18,000 hours
	1.5 kW	3 100 000	
	2.2 kW	3 900 000	
	3.7 kW	5 000 000	
	5.5 kW	6 500 000	
	15 kW	9 000 000	
Generator	5 kVA	6 500 000	14,000 hours
	8 kVA	8 000 000	
	10 kVA	9 000 000	
	12 kVA	10 500 000	
	17 kVA	12 000 000	
Solar panel	2000 WC	12 500 000	30 years
	3000 WC	17 490 471	
	4000 WC	22 361 379	
	5000 WC	25 000 000	
	6500 WC	30 000 000	

Water tanks

Volume (m3)	Height (m)	Steel	Concrete	Lifetime
		FCFA	FCFA	
20	6	16 199 734	22 000 000	30 years
20	9	17 399 734	23 500 000	
20	12	18 599 734	25 000 000	
30	6	19 589 979	24 000 000	
30	9	20 789 979	25 500 000	
30	12	21 989 979	27 000 000	
40	6	22 980 224	26 000 000	
40	9	24 180 224	27 500 000	
40	12	25 380 224	29 000 000	
60	6	29 760 714	30 000 000	
60	9	30 960 714	31 500 000	
60	12	32 160 714	33 000 000	

	FCFA	Lifetime
Technical area	10 000 000	30 years

IMPORTANT

For existing piped schemes (568)

There is no capital investment in drilling, storage (tank) and technical area.

Under the thermic option, capital investments in generators are different for the pipe schemes that already function on thermic energy (320) and those for which an energy conversion is required (248). For the former, generators are in place and must be complemented with additional capacities to meet the expected level of production. For the latter more investment is needed as there is no initial basic thermic capacity. Similarly, under the solar option, investments in solar panel differ according to the initial source of energy. The solar systems (184) benefit capital investment in complementary capacities while the non solar systems (384) need higher investment to build up the same capacity.

For all piped schemes (2047)

Same values are used for capital maintenance as for capital investment. When for instance a solar pump is replaced after 18,000 hours of service, the capital maintenance equals the investment cost of the pump (3,9 million FCFA) factoring the inflation rate.

Capital investment in water distribution

Forcemain pipes (PN 16)	FCFA / ml	Lifetime
DN > 63 mm	10 000	30 years
DN = 63 mm	8 000	

Distribution line (PN 10)	FCFA / ml	Lifetime
63 mm	7 000	30 years
75 mm	7 500	
90 mm	8 000	
110 mm	8 500	
125 mm	9 000	
140 mm	10 000	
160 mm	12 000	

Distribution system	FCFA	Lifetime
Stand-pipe	1 000 000	30 years
Private connection	200 000	30 years

IMPORTANT

Density: 1 km of distribution line for 1500 inhabitants

Forcemain pipes: 400 m

10 people serviced per private connection

500 people max serviced per stand-pipe

Meter on each stand-pipe and private connection

Annex 2. Expenditures on operation and maintenance

Fix cost per system

	FCFA / year
Staff	3 969 000
Water quality analysis	200 000
Administration	1 000 000

	<i>Thermic energy</i>	<i>Solar energy</i>
Repair (FCFA/ year)	235 000	150 000

23

Variable cost

Water disinfection	0,02	FCFA/m3
Stand-pipe care taker	62	FCFA/m3

	<i>Thermic energy</i>	<i>Solar energy</i>	<i>Unit</i>
Maintenance	80	30	FCFA/m3
Energy	140	0	FCFA/m3

Hypothesis

Non revenue water	5% of volume
Unpaid invoice (stand-pipe)	2% of sales
unpaid invoice (on-plot)	5% of sales