Annex to ICID Guidelines on Performance

CASE STUDY OF PERFORMANCE ASSESSMENT

Performance assessment in the management of "Canal de Provence" (France).

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This case study concerns the performance assessment of the network of canals and pressurised pipes of the public and private "Societé du Canal de Provence" (SCP).
According to State Concession decree, this society is due to provide a pre-established level of service to its customers, and be financially autonomous. Its technical and maintenance services have elaborated a network of measurements and data collection devices and specific performance indicators to achieve these two goals.

1 DESCRIPTION OF SCHEME

1.1 Genesis of the project

Provence region is located in the south-eastern part of France.

During the 1950's, considerable development problems arose in this region. These highlighted the need for a regular water supply. It was urgent to meet the water needs of towns, industry and rural world of eastern Provence, which was facing frequent droughts and could not easily use the River Durance water, which was already widely allocated.

In this context the Ministry of Agriculture encouraged local authorities (departments of the Bouches-du-Rhône and the Var, City of Marseille etc...) and regional agricultural extension services, to create a public and private capital company called the Société du Canal de Provence et d'Aménagement de la Région Provençale (SCP).

The mandate of SCP, (decree of the 15th of May 1963), includes:

a) construction and operation of a diversion canal of the River Verdon called the Canal de Provence, to supply the departments of Bouches-du-Rhône and Var and the City of Marseille with water for agricultural, domestic and industrial use. For this purpose SCP is allowed to divert up to 660 million m^3 (M m^3) per year at a maximum flow of 40 m^3/s.

b) construction and operation of reservoirs found necessary to perform an optimal use of the diverted resources. The additional necessary reserve storage capacity was estimated to 250 Mm^3 to be able to divert safely and reliably the allowed flows from rivers at any time. The decree mentioned that these reservoirs should be created and managed according to general interest in association with "Electricité de France"[1], responsible for the on-going hydropower scheme on the river.

c) construction and operation of any other hydraulic facilities necessary for the economic development of the region, especially dams, canals, irrigation networks insofar as local authorities, public bodies or Users' Associations, ask SCP to do it.

d) Management of pre-existing hydraulic structures that owners decide to hand over to SCP.

As underlined by the texts and the name of the company, construction of the Canal de Provence was the first priority. Other sections of the concession decree have also been applied in collaboration with local authorities to develop other hydraulic schemes.

According to law concerning Regional Development Agencies in France, SCP is entrusted, under government control, with assignments of public interest. These assignments object of the State Concession decree concern particularly the setting up and operation of water works necessary for regional development. Therefore as water resource manager, SCP assumes all the rights and obligations of project owner.

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[1] EDF : public electricity production and distribution

1.2 Actual scheme characteristics (see box 1 below)

Since 1975, the 250 Mm3 storage capacity has been created, shared between 3 reservoirs (Castillon :85M m^3, Bimont: 25Mm^3, and Sainte Croix: 140 Mm^3).

The main conveyors are canals or galleries supplying water to pressurised distribution systems for agricultural areas , industrial sites and urban resorts
This was innovative considering that until 1955 only surface irrigation was used, the water being distributed on a strict roster.
From this date it was decided that SCP should distribute pressurised water on instantaneous availability basis. The farmer takes all the water he needs with limited flow rate as contracted. The actual volumes consumed are recorded by water meter.

To ensure that the transport and distribution of water is properly controlled, at the beginning of the 70s the company developed its own control system called “Dynamic Regulation”. This system is fully automatic and has been described many times[2]. This process avoids any water wastes and enables the construction of optimally dimensioned facilities. It generates a very precious database for the scheme management.

The network actually includes more than 4 400 km of pipes with diameters comprised between 100 mm and 2 000 mm, supplying about one hundred towns and villages representing about 3 million inhabitants, their industries, and almost 73 000 hectares of farmland with 43 000 outlets.

BOX 1

Irrigable area	73 000 Ha.100 towns & villages (3 millions inhabitants);400 industries;43 000 outlets
Irrigated area	Not available.52000 Ha irrigable from subscribed outlets
Annual rainfall and reference ET	Rainfall: 600 mm/yr; dry season from May to September ETR: up to 7mm:day; 700 mm during dry season
Method of water supply	From storage reservoir, and transfer by a succession of lined canals and galleries.
Water delivery infrastructure	Multipurpose facility; Pressurised pipes, flow rate control at every outlet
Type of water distribution	Instantaneous availability
Predominant on-farm irrigation practice	Sprinkling irrigation , micro irrigation
Major crops	Vegetables, fruits, cereals and oil/protein producing crops (seeds or large scale farming)
Farm size	Intensive-oriented farms: up to 15 Ha Large scale farming: >50 Ha
Type of management	Public and private capital company held by local authorities in association with agricultural extension services; government controls

[2] cf for instance reports to 1981 ICID Symposium, R3; or to 1987 ASCI Symposium; or to 1995 ICID Congress

2 OBJECTIVES OF SCHEME

The objective of the scheme is to achieve balanced and sustainable management of water resources in order to provide every kind of users in Provence Region, with a guaranteed quality of service, with the best Quality/Cost ratio .

This objective, in the general interest policy, is the basis of SCP's organisation and action, according to the principles of public service management: continuity, equity, sustainability and transparency, to guarantee the quality of services at minimum cost.

- **Continuity:** continuous on-demand supply of water, under commonly agreed conditions of discharge and pressure.
- **Equity:** Water tariffs are established so as to orientate customer's decision towards collective economic equilibrium and optimal use of existing facilities. This enhances water user's responsibility. These prices account for the environmental or *in situ* value of water, investment and operating costs**.**
  Water tariffs are transparent and remain constant (in constant prices) over time. They help to establish costs equity between urban, industrial and irrigation water uses according to their specificity.
- **Sustainability**: SCP's is due to manage the facilities in order to guarantee their transfer back to the public sector at the term of its mandate (75 years) in perfect working conditions. SCP has to assure its financial balance: the water costs paid by the customers must cover full operational, maintenance and management costs, including the reimbursement of credits contracted to create the assets.
- **Transparency**: The compliance of SCP's activities to its assignments and to the orientations decided by its administrative boards is duly controlled by shareholders and by the State.

SCP has to be sure that its services are and will remain responding to customers needs, and that it uses efficiently the natural, technical and financial resources it has to manage.

Keeping all this in mind, SCP has conceived methods and procedures to monitor the behaviour and performance of facilities as described hereafter. It allows to ensure that the provided service is always adapted to user needs.

3 PERFORMANCE MEASURES AND INDICATORS USED

3.1 The purpose of SCP's performance assessment process

The performance assessment process on SCP scheme has been organised by and for SCP scheme managers, in order to:
- monitor and evaluate the performance of the enterprise;
- know how it works, identify problems and ways in which performance can usefully be enhanced;
- be able to make the evidence it fulfils its commitments with the users, with its shareholders and with the State.

This process focuses on measures and indicators directly related to the assignments of the company. For example SCP is fully responsible for design construction and management of the assets to provide water to its customers, but is not responsible for the way the water is used by its customers, nor for the agricultural development[3].

[3] So, SCP doesn't assess by its own any indicators about "***Field Application Ratio***", nor about ***Profitability of Irrigated Agriculture***", even if it is interested indeed to receive information on this topic from the stakeholders of agricultural development (see 3.6.1 hereafter)

The performance assessment process of SCP is integrated in the management process. It is carried out with its own means and data collection systems.
It applies to the whole assets SCP is responsible for.

There are indeed a few key performance indicators, used for strategic management of SCP. Considering that SCP is ISO 9001 and ISO 14001 certified, the staff at each level has its own performance indicators according to its responsibility on the quality of service.

It would indeed be too long to describe in detail the whole series of measures and indicators used at every level. The most significant, presented hereafter, are grouped under five major subjects: water balance, maintenance, environment, commercial, economic.

3.2 Water balance performance assessment

3.2.1 Measurements performed and data collected

The necessary measurements and data for performance assessment are issued from:
- technical characteristics of the assets as noted in the projects and checking files of works, equipment and apparatus, and controlled at their commissioning;
- data recorded by the real-time remote control system of SCP (see box 2);
- periodical checking of hydraulic performances of selected devices in real functioning conditions;
- recording of the volume supplied at every outlet from volumetric water-meter, on a yearly (individual customers) or monthly (cities and industries) basis;
- files of contracts with the customers.

BOX 2 : REAL TIME TECHNICAL MANAGEMENT
OF ALL THE COMPANY-MANAGED WATER CONVEYANCE FACILITIES

- **GENERAL REMOTE CONTROL CENTER (GRCT) REAL TIME DATA BASE**: actually (1999):
  1450 **telemetered items** (levels, flows, gate positions, pressures, water quality readings, etc.) including 520 computed remote measurements
  1100 **remote station signals** (equipment status or faults) including 350 reconstituted signals
  41 **remote station settings** (dispatch of flow or gate opening set points to local PLCs)
  375 **remote controls** (direct to safety gates, pumps, etc.)
- **DATA ACQUISITION SYSTEM/ REMOTE CONTROL NETWORK**
  2 Digital Alpha Station workstations poll 260 items of local equipment:
  . Remote transmission stations or PLCs directly (remote metered data, signals and controls)
  . Transmission network front ends (situated in the GRCT equipment rooms)
  . Supervisory system computers in 9 remote regional centres
  Transmission systems:
  . Private cables, hired dedicated links, switched telephone and GSM network, radio
  Protection through data backup and looping of certain links
- **INFORMATION PRESENTATION – SUPERVISION**
  General views, Zooms, Control dispatch by operator
- **ARCHIVING OF OPERATION DATA**
  Short term **trend curves** (functional analysis)
  Medium/long term statistics (updating of forecasts, degree of facility saturation, engineering ratio)
  Balances for hydraulic production and equipment operation
- **SAFETY: SELECTIVE MANAGEMENT OF ON-CALL STAFF**
  Alarm dispatch via STN, according to fault location and type
  Speech synthesis for alarm description
  Minitel or portable computer used for remote polling, modification or control of computers
- **DATA DECENTRALISATION: REMOTE TERMINALS FOR MAINTENANCE SERVICE**
  . Real time analysis of fault type and tripping
  . PC server for diagnostic aid application

3.2.2 Indicators:

Every measures and data listed ahead are used to monitor the evolution of two main types of indicators:

- **conveyance and distribution efficiency ratios**:
  the definition of these ratios is classical ("***measured outflow over measured inflow"***), even if it needs precise definitions of the contents and the way to evaluate every element of the water balances. SCP assesses annually these ratios in order to analyse, for each water resource, and each distribution system, the reasons of differences between inflows and outflows, and the rate of evolution of these differences.
  This assessment has shown the interest of improving accuracy and reliability of measurement devices, and helps to identify the losses which are worth while to reduce
- **water delivery performance**:
  considering the self service principle of water supply, the classical water delivery performance indicators ("***actually delivered volume/intended delivered volume"***, "***dependability of supply***", "***regularity of deliveries*** ") are normally **always equal to 1**, as the actual water flow is automatically commanded by the water consumption of the users. This is true as long as the conveyance and distribution system are able to provide the total instantaneous flow and pressure requested by the user.
  Indeed the design of the scheme takes into account the probability laws of every outlet to be used at any time. Moreover, generally it takes several years before the water use comes to its full development. It is thus necessary to measure the margin between actual demand and the capacity of the system: if, after years, at any time, even during the peak hour of the peak day of a very dry season, this margin remains very big, the company is sure the quality of service provided is better than requested by the contract, but it could be criticised to have over-invested. On the other hand, it also may occur that the real behaviour of the customers evolves, and does not correspond any more to the probability laws introduced in the models, which leads to suppress the security margin, or even to have insufficient pressure or flow in some places at some periods: then, the company can be criticised to have not respected its contracts.
  So, SCP has developed a new methodology [4]to assess these aspects of water delivery performance by means of two ratios:
  Line utilisation factor:
  This saturation ratio indicator is calculated annually to monitor the actual ability of the 70 main production lines (pumping stations, main feeders and associated reservoirs) to transfer the water resource necessary to feed the networks.
  "Network utilisation index":
  this saturation ratio indicator is used to monitor the actual ability of the networks to deliver water to every customer, with the contracted pressure and flow for each of the 170 networks of SCP scheme.

Line and network utilisation factors are used to know, at any moment, if (and to which extent), the works are able to satisfy new contracts and increasing water demands, and to prepare extension and reinforcement works which are found necessary.

3.3 Maintenance performance assessment

SCP' maintenance strategy aims at ensuring the continuity and sustainability of water service at minimum cost. The main concern for its managers is to be sure that available funds for maintenance and renewal are sufficient, and used in an optimal way. With this in mind, the first global indicators they look after are the evolution of corrective maintenance expenses, the ratio: ***total maintenance and renewal funds/actual value of the asset***, and the ratio:

[4] cf. presentation made at1993 ICID Congress

preventive/corrective maintenance expenses. Indeed, assessing the physical condition of the structures, their actual ageing and obsolescence, through auscultation and inventories methods must complete and detail this first global appraisal

3.3.1 measurements performed and data collected

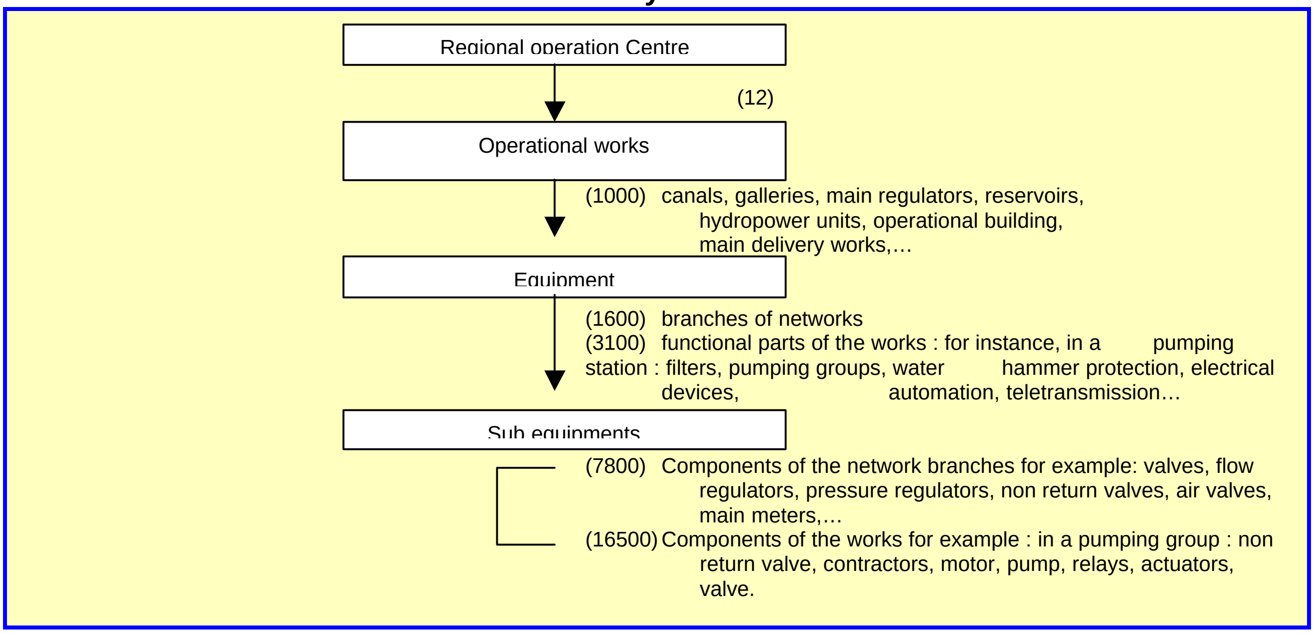
- Using GMAO software, the inventory of works, equipment and apparatus registers physical and technical characteristics of every device , their installation date, localisation, cost. This data basis is updated from reports on maintenance actions and diagnosis of failures. The main contents of this inventory are summarised in Box 3.
- The measurements and data used for water balance assessment are also used to define some of the maintenance actions necessary to keep hydraulic performances of the scheme (planning of pipe cleaning, for instance, according to "***discharge ratios"***). So, the corresponding indicators will not be repeated here.

3.3.2 indicators

Using the inventory data base every category of equipment are assessed: their "***effectivity"*** is evaluated through *failure rates*, *mean time before failure*, *standard duration of non-availability*, and *direct costs of maintenance*.
Every single equipment is compared to the standard, according to its age, obsolescence, rate of failure, and maintenance cost. These data are also used to evaluate indirect so called "non-maintenance costs", corresponding to the financial consequences of a failure for SCP (less water sold, commercial prejudice…).

The processing of all these results is made using reliability analysis methods ("AMDEC": analysis of the modes of failure, of their effects and criticality; "MBF»: maintenance based on reliability) which help to classify maintenance action priorities according to multi-criteria notations

BOX 3 : Asset inventory structure and contents



3.4 Environment performance assessment

SCP's responsibilities in this field are induced by its commitment of sustainable water resources management: from the quantitative point of view, the efficiency ratios from water balance give necessary data to control that there is no waste of water. Considering quality aspects, SCP must be sure its activities for conveyance and distribution comply with legal rules and standards. SCP is interested to keep the natural quality of the water it distributes and to prevent its works from pollution , and, more generally speaking, from any risk.

3.4.1 measurements performed and data collected

- **Water quality**: SCP collects regularly samples to monitor the chemical and biological parameters of waters in its main works. The natural high quality of this water remains quite steady. A few years ago, SCP decided to add continuous water quality sensors, which are now integrated in the real-time remote control process of SCP (see box 4)

BOX 4 : Real time remote control of water quality parameters

➢ **Natural rough waters**
4 Automatic biological stations
3 pH sensors
1 conductivity sensors
2 dissolved oxygen sensors
11 turbidity sensors
3 temperature sensors
➢ **Treated waters**
11 multiparameters settlements for drinkable water with turbidity, chlorometer and pH sensors
3 settlements for industries: turbidity sensors

- **Compliance with environmental regulations**: SCP has realised a detailed environmental audit of all its activities, and was labelled ISO 14001 after this assessment. This required collecting and reviewing a lot of data: for instance, every security or emptying outfall has been surveyed to precise operating instructions respectful to environment.
- **Safety**: conscious of an increasing public demand for safety, SCP decided to investigate what safety level is actually required for its works and operations, and to check if they are about to comply with these objectives. Thus, SCP is investing now in risk assessment. That means important enquiries to list potential cases of dangerous hazards, to analyse the reaction of works and people in such an event, and evaluate the probability of every factor.

3.4.2 indicators

- **water quality**: a service in charge of water quality control monitors the evolution of every ***relevant parameter, compared to standards values***.
- **compliance with environmental regulations**: objectives are defined for every aspect of SCP activities which can have negative impact, . The ***rate of achievement*** of these objectives is monitored by services concerned and controlled by internal audit
- **safety**: the main indicators are the combination of probability of risky events by evaluation of the potential gravity of the damages. These indicators refer to the conclusions of risk assessment already conducted mainly for industry (nuclear, chemistry, transport) and water storage.

3.5 commercial performance assessment

As long as water resources managed by SCP are able to face water needs in the region , and it seems to be the case even on very long simulations , the use of these resources in water regional market can usefully increase, to get the best return of the assets. So SCP must carefully monitor evolution of subscriptions and try to know how its customers are satisfied with its services.

3.5.1 data collected

- files of contracts with the customers considering category of use of the water, area of the plot where water can be used, historic series of subscribed flow rate, volumes consumed and payments.
- complaints reports (either received by letters, phone calls or on-field discussions)
- specific enquiries (subscription enquiries to prepare extension projects, opinion enquiries with panels of customers,…)

3.5.2 indicators

The problem to define a single main commercial indicator is not simple for SCP, as its scheme is multipurpose, and its services and tariffs are differentiated according to water use. Some users, such as big factories, need a continuous flow all year long; sea-side resorts, will use it mainly during summer time; farmers will use their outlet during a few hundreds hours mainly during July and August; and it is hoped that the fire-protection outlets will not be used at all except for exercises !
Thus the subscribed flows cannot be simply added to get a meaningful global evaluation of the subscriptions, which could be the main commercial indicator. It is necessary to use weighted indexes considering the types of contracts.
Other global indicators, such as total delivered volumes, or total fees collected, must also be considered cautiously because of the variability of climatic conditions inducing a large variability of volumes consumed.
It is easier to analyse commercial statistics and to get indicators by category of water uses (or contracts). It is then possible to analyse the behaviour of the population of customers. A very meaningful indicator , for this analysis, is the duration of use of the subscribed flow (not only average value, but also statistical distribution).

Satisfaction of customers: no global indicator could be found on this topic to be representative and meaningful[5]. "*Regularity*" is indeed a very interesting indicator (evaluated by the mean duration of subscriptions), but it is not evolving significantly from one year to the other. So, specific and punctual aspects are monitored, such as the *rate of complaints*, or the *quickness of payments*, as well as indicators on the quality of actions of SCP services in their relationship with the customers: *quickness of answering*, *efficiency of phone welcome*, *rate of mistakes in the billing process*, and so on.

3.6 Economic performance assessment

The concern of SCP, on this topic, is to control the financial viability of the scheme, to maintain its financial autonomy
SCP is also interested (but it is not part of its commitments) to collect information about the profitability of water delivered, for its customers, in order to appreciate the possible trends of evolution of the water use

3.6.1 data collected

-**financial viability** of the scheme: from accounting documents. The actual accounting tools allow to get control of these information almost in real time, knowing that the information system is well structured, with one responsible for each data.
-**profitability of water delivered**: information on that subject comes from multiple external sources with various accuracy (official statistics, , media, researchers, interviews or discussions with the customers or with colleagues in other regions…SCP tries to be aware of available data, collects and classifies them, in order to make them operational when required.

[5] As explained before, customers get water by "self service" from SCP works, whenever they decide, and as long they need it: so ratios of ***Dependability*** (***Duration*** , or ***Irrigation Interval***), are meaningless (always equal to 1)

3.6.2 indicators

As expressed before, the main concern for a company such as SCP is to be sure it will get, every year and until the end of its mandate, enough funds to make the asset financially autonomous and technically sustainable.
Besides the classical economical indicators of a private company (rate and evolution of total margin, added value, productivity), SCP pays a careful attention to provisions available for corrective maintenance and renewal, as compared to the ratios which seem to be necessary according to maintenance performance assessment.

3.7 Cost-effectiveness of performance assessment:

All these indicators come from processing information and data which are systematically collected and registered during the normal OM&M procedures of SCP water management : so, they do not induce significant over-costs, additional work and constraints for the staff, who is aware of the interest of efficiency improvement generated by his own action as well as SCP's one.

4 RESULTS AND ANALYSIS

4.1 Water balance indicators

4.1.1 conveyance and distribution efficiency ratios :

We distinguish:

- $Rough\ efficiency = \dfrac{measured\ outflow}{measured\ inflow}$
- $Net\ efficiency = \dfrac{measured\ outflow + controlled\ differences}{measured\ inflow}$

For conveyance efficiency, it appears that the difference between inflows and outflows is lower than the inaccuracy of the evaluations of flows by classical measuring devices.

This gives evidences of the urgent need to assess carefully the accuracy of every information and data and to perform calculation errors in the process of performance assessment in order to be aware of the reliability of the results.
That is why one of the first results of efficiency assessment is to identify, year after year, what improvements are worth while in the data acquisition system.

Thus, at the beginning of assessments processes in 1990, one thousand water meters have been verified to define statistic laws of accuracy (systematic errors and dispersion ratios) . The main on-line meters are periodically controlled.
Specific enquiries or studies are performed to appreciate the magnitude of identified losses or water utilities, in the conveyance system as well as in the distribution systems. Uncertainty of measurements can be reduced, by “reconciliation process”: based on redundancy of continuous measuring devices, and consistency control of these measures.

The software used is now integrated in the real time remote control system determine what sensors are suspected to divert, and evaluate the corrected values. If the suspected sensors are controlled accurate, the software can point other possible problems (such as uncontrolled opening of a gate, for instance).

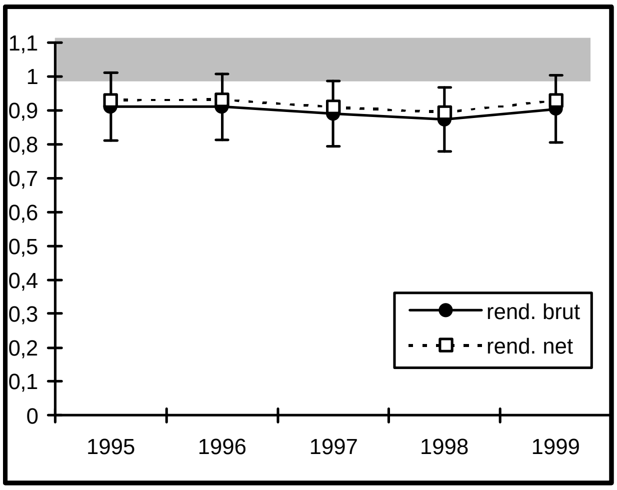
A synthetic presentation of annual efficiency assessment is made for every of the 15 SCP systems (one system: one intake from the water resources) and, inside the main system (Canal de Provence) for each one of the sub-systems. An example is shown in box 5 below.

BOX 5 : Efficiency assessment

Etang de Berre System example

	METERING Type	Frequency	ACCURACY (70% conf)
Water resources			**4%**
. EDF canal intake	US flowmet.	continuous	2%
. MRS canal intake	US sensor	continuous	5%
Water uses			**6%**
. Agricultural Irr.	meters	yearly	16%
. Non A. irrigation	meters	yearly	4%
. Private uses	meters	yearly	4%
. Cities	meters	monthly	4%
. Industries	US sensor	monthly	5%

Global accuracy (70%confidence) of efficiency : 11%



	1995	1996	1997	1998	1999
h net :	**0,93**	**0,93**	**0,91**	**0,89**	**0,93**
h brut :	**0,91**	**0,91**	**0,89**	**0,87**	**0,90**
Delivered (Mm^3)	21,2	21,3	22,1	21,9	20,7
Introduced (Mm^3)	23,2	23,4	24,8	25,1	22,9

Globally, the overall efficiency of Canal de Provence conveyance system appears to remain equal or greater than 95% (with 2 or 3% standard deviation), and close to 85% on the whole, for the conveyance plus distribution systems.

These annuals values and their evolution for each sub-system assessed, point the devices where additional investigation or action have to be performed.
In several sectors where the efficiency indicator appeared abnormally low investigations led to identify failures of the sensors at the headwork, in other, under-measuring problems of the meters at customers outlet, due to inadequacy of the meters as regards to the quality of the water, in others to find losses undetected up to now.

So, year after year, the unidentified part of the difference between inlet and outlet decreases; actions are decided in reference to their cost effectiveness; and performance is improved

4.1.2 Water delivery performance

Line utilisation factor (named "FUL"):

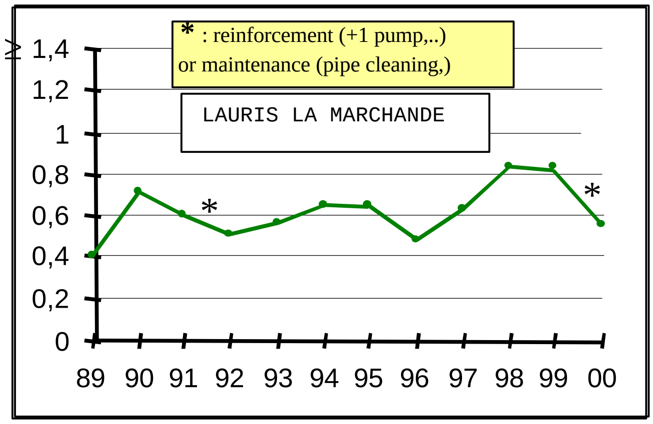
Considering its value is x, the line is able to stand an increase of the water demand up to 1/x without reinforcement needs . If the demand reaches 1/x, the security margin is closed to 0. If it overpass 1/x, there is a risk of emptying reservoirs, or limiting the service level and consequently a need for reinforcement .
The advantage of this approach appears when observing the FUL evolution over time. The trend revealed by annual index distribution curve allows short term analysis of the consequences of interventions independently of the variation of demand. .
In addition the FUL approach can be calculated for other simulated configurations such as:

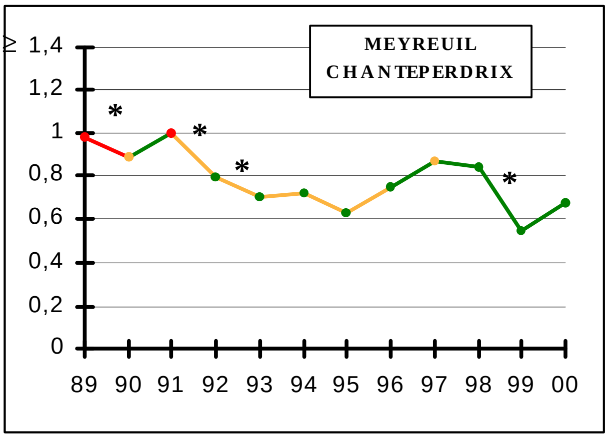
- with a production line at its maximum projected flow,
- stopping one of the pumps (lower electricity bill, eventual failure),
- using a reservoir with several days' capacity.

Each year SCP carries out on-site performance assessments in order to ensure that the critical values are effective.

Thus, the analysis of the critical FUL trend allows to design maintenance and verification programs (verification of accuracy of flow-meters, roughness of the conveyor, pump curves…

BOX 6 : Example of FUL trend analysis





The line utilisation factor for all SCP scheme is close to 0,6. The security margin is greater for the head conveyance lines, which have been dimensioned at the beginning, for the maximum project flow (due to the nature of the works which can hardly be increased afterwards). This security margin gives a great safety of water disposal, even in case of failure of one of the resources. As long as the flow required is not at its maximum, the head charge can be used to produce energy by on-line hydropower units, helping to optimise maintenance costs

On the other hand, the security margin is lower for smaller structures. They are generally dimensioned to stand medium term (10 years) provisional demand. When required by the evolution of demand we increase the capacity the sector considered (doubling of pipes, adding of reservoirs, connecting with other lines).

We have been able to decrease progressively the global FUL on long term, thanks to the result of investments made by SCP, to prevent the risks of lack of water resources in any sector

Network utilisation index

The method consists in determining on existing networks the effective water demand for each connection and consequently on the entire network, whatever is the available pressure margin. Then calculating the multiplication coefficient K to be applied uniformly to all the effective flows consumed of the to cancel out this margin.

The calculation is applied to each connection and then the most unfavourable Kmin value obtained is kept for all the network connections. The "Degree of Network Use" (DUR) is:

$$DUR = \frac{1}{Kmin}$$

We can see that:

- if DUR > 1, the network may face saturation problems since there are points where the required service pressure is not guaranteed. It is then necessary to fine-tune the analysis in order to characterise these problems: locate the critical points, assess their number, the importance of the pressure deficit, etc.
  On site checking, and adaptation of supplying conditions can be decided : (for instance using of schedulers to encourage non-peak consumption, eventually carrying out reinforcing work).
- if DUR < 1, the network will not be facing saturation problems. Therefore, at all points on the network there is an available pressure margin and an immediate capacity to supply additional flow to existing or new customers.

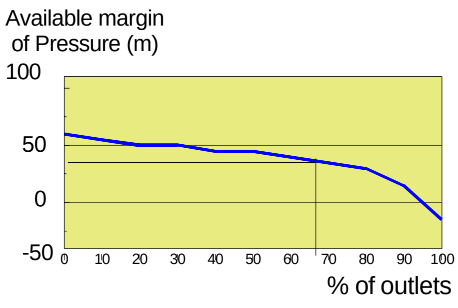
Today, 170 pressurised water supply networks are assessed by continuous monitoring routine following.

As with the previous index, the DUR calculation can be applied for simulation of:

- proposed new distribution systems,
- available flow margin at a given point,
- possible extensions, etc..

Once again, periodic site inspections are essential for the credibility of the method
All the measurements necessary to calculate the FUL also give information for adjusting the DUR calculation models, especially in terms of the effective flows to be reached at the head works.
Pressure recordings are also performed at significant points on the networks. These are used to check the accuracy of the calculation models specially for roughness coefficient adjustments
Below (in box 7) is an example of the results presentation.

BOX 7 : Diagram for analysis of "DUR" (network saturation index)



On SCP networks, the result of the assessment is that less than 3% of the points supplied (essentially on the irrigation supplies) have a DUR > 1, i.e. a risk of insufficient available pressure during peak consumption periods.

4.2 Maintenance indicators

Below is a table (box 8) recapitulating the results of the *reliability* evaluation prepared for the SCP on the basis of five-year records.
It is obvious that the validity of the results is improved progressively with time as the data base is enlarged.

BOX 8

Equipment		Reliability after t=				
		1 month	100 days	6 months	1 year	5 years
Apparatus	Pumping unit	0.95	0.72	0.56	0.39	
Apparatus	Automatic filters	0.80	0.63	0.5		
Apparatus	Treatment plants	0.99	0.95	0.89	0.78	
Apparatus	Remote control units	0.82	0.55	0.45		
Pipes & Apparatus	Branch of networks	=1	0.89	0.7	0.6	0.1
Civil works	Reservoirs	*0.98*	0.9	0.81	0.67	
Civil works	Canals	*0.75*	0.42			
Buildings	Pumping stations	=1	0.99	0.98	0.89	0.65
Buildings	Operation Centres	0.86	0.71	0.57	0.4	

Reliability is (according to standard NFX 60-500) the capacity of an entity to execute a required function in given conditions for a given period of time without any incident or failure.
The reliability curves show that the buildings of pumping stations, or the reservoirs, have a non-failure probability of up to t = 365 days (i.e. extremely high since it is almost equal to 1).
On the other hand, pumping units, or operating centres, have a reliability less than 0.5 based on t = 1 year (that means on average two corrective maintenance interventions every year).

The equipment reliability is extremely variable: it can be close to 1 for sludge treatment equipment, medium voltage, hammer protection systems, etc., up to t = 180 days and can be more reliable for trash rack type equipment, oxygen measurement, injection treatment, etc..

The applied research on pipes carried out these last four years by SCP with CEMAGREF is worth to be noted: it has led to the development of incident analysis methods which identify the most significant parameters to estimate the probability of failures. The data collected allow to operate a simulation model of failure prevision related to operating conditions.

4.3 Environmental indicators

- No particular comments are needed for water quality indicators, as the natural quality of the resource remains excellent and very steady, from intake to delivery out of the conveyance system

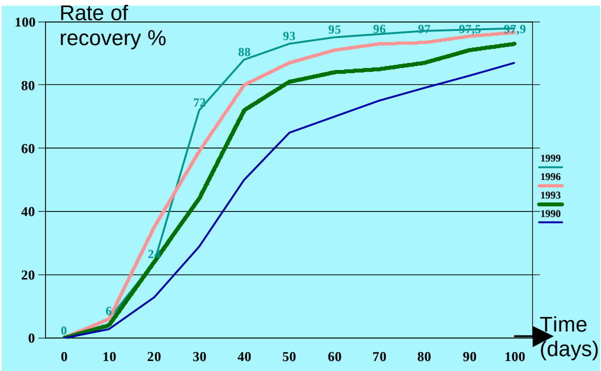
Risk assessment results need more analysis. The definition of safety levels is delicate and relative to the activity concerned.
In water industry, rainwater drainage systems are designed to face 10 to 100 years return rainfall (risk = 10^{-1} to 10^{-2}/year), and for dams 1000 to 5000 years flood flow return periods (10^{-3} to $2x10^{-4}$/year risk).
As to natural phenomena, the risks are 10^{-1} to 10^{-3}/year for earthquakes, 10^{-1} to 10^{-2}/year for floods, 10^{-2} to 10^{-3}/year for tornadoes, 10^{-7}/year for meteorites.

If we compare these figures with safety level for accident risks on SCP works (10^{-3}/year for canal pollution,10^{-4}/year for peak period network polluted water back flows,10^{-6}/year for off-peak period back flows), we observe that they are perfectly compatible with those usually adopted for projects such as dams, and comparable with the air transport risks .

4.4 Commercial indicators

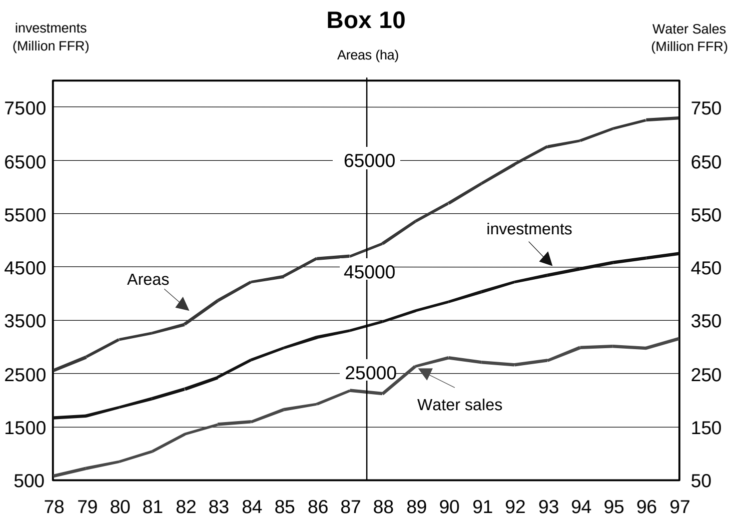
As an average on the last past 10 years , the *rate of recovery* of water charges is about 99.75%. The purpose of SCP is to keep this level of performance on this aspect, and to focus on the *quickness of payment*: thanks to the analysis and the monitoring of this ratio, it could be possible to increase continuously, year after year, the performance on this point, as shown in box 9 hereafter

BOX 9 : Quickness of recovery



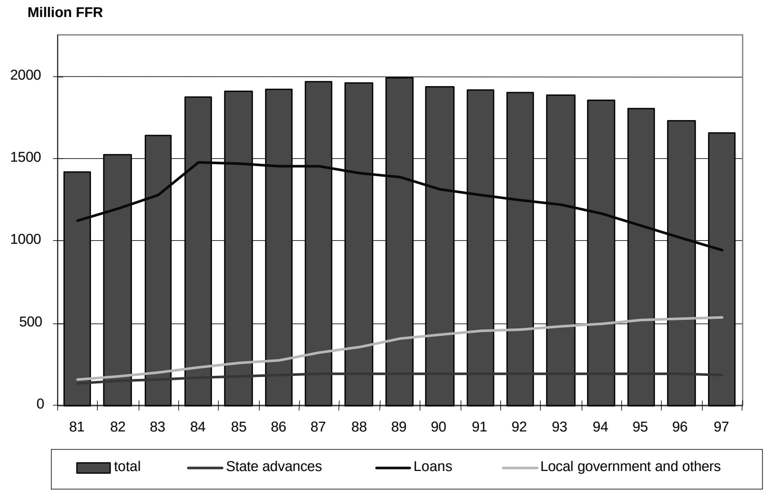
4.5 Financial indicators

The box 10 shows the time required to develop main structures, and distribution networks, with the weight of investments, and the very progressive evolution of income recovered from the users. Actually, 40 years after the beginning of the scheme, the annual water charges represent less than 3% of the actual value of the assets.
Cumulated asset value, annual water sales



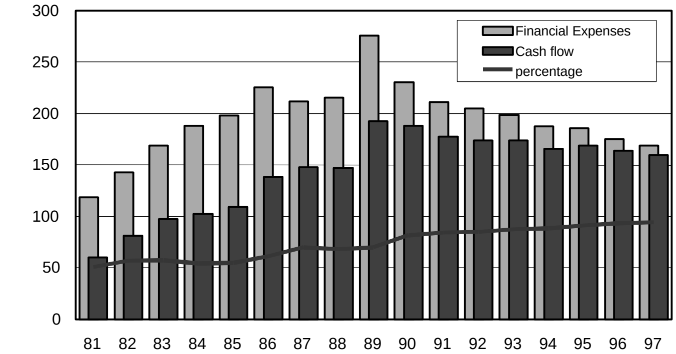
The Box 11 shows the importance of the credits contracted with the banks to achieve the investments : the maximum was in 1989, when the loans for construction of the first main structures came to the end.

BOX 11 : SCP indebtedness



Then, up to 1996, incomes from the users were not sufficient to cover the whole financial costs, and the public share-holders of SCP provided advance funds to get the accounts balanced : this appears on Box 12.

Box 12 - Financial expenses and cash flow

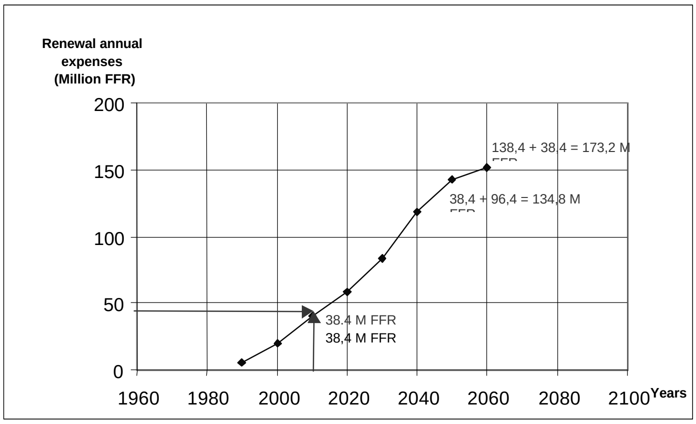


Now the Company has reached the financial equilibrium . That means ***“Financial Self-Sufficiency***” ratio is, and must remain, equal to 1. If the OM&M expenses could remain steady , if the users could go on increasing their demands, it could be thought that, as long as credits are reimbursed , the funds advanced by the shareholders could be reimbursed, or reinvested to develop new schemes, or even lower the tariffs.

Unfortunately, SCP has to face now increasing expenses for renewing and modernising its schemes.

According to theoretical ratios of life duration of every components of its schemes, SCP evaluates the trends of evolution of these expenses, as shown in Box 13

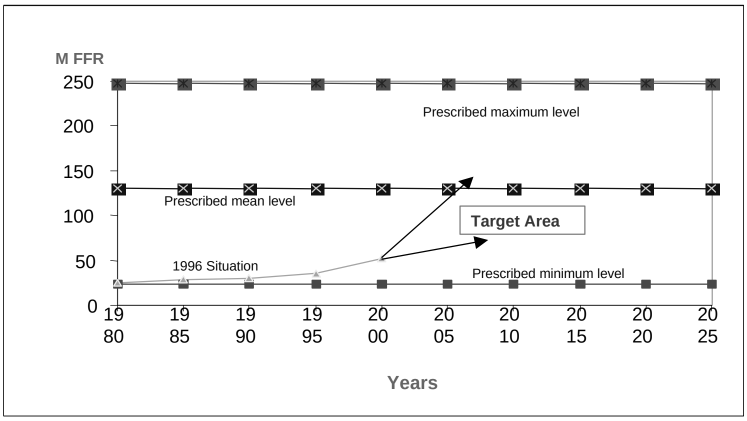
BOX 13 : Renewal annual expenses for all assets of categories 2, 3, 4 and 5



What is encouraging is that the ultimate level of these expenses is of the same magnitude as the actual reimbursement of credits : it is so possible to consider the system to be sustainable even if the expenses will increase strongly in the next years.

These elements have led SCP board in 1995 to decide that the priority was to increase the budget for assets renewing . Objectives were established for the next five years. It was decided to monitor the evolution of the needs, in order to adapt periodically the policy on this topic. This decision making process is illustrated by Box 14.

BOX 14 : Corrective maintenance and renewal



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