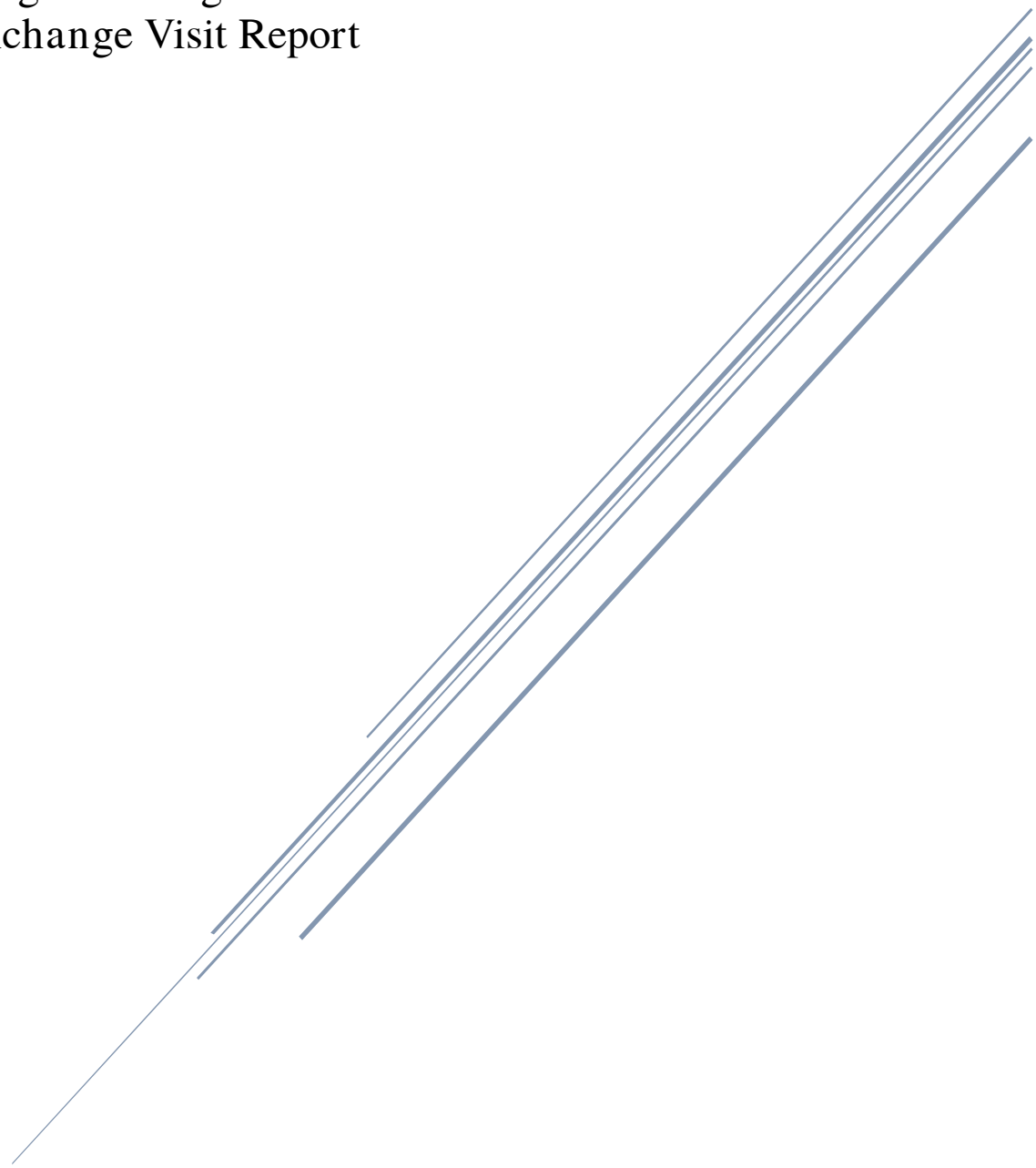
Mekong River Commission
Combodia • Lao PDR • Thailand • Viet Nam
For sustainable development

Mekong Learning from Rhone: An Exchange Visit Report



Vientiane, Lao PDR
June 2018

Background and objectives of the exchange visit to the Rhone:

The Mekong River Commission Council and JC Members, the CEO and senior Secretariat staff made an exchange visit to the Rhone river basin and the Compagnie National du Rhône (CNR), the French public company responsible for the development and management of the River Rhone in France, from 4 to 7 June 2018.

With more than 80 years of experience, the CNR has learnt from past developments in the second half of the 20th century to adapt to new trends, addressing environmental concerns and the energy transition in France. As a designer, owner and operator of multi-purpose assets, it combines electricity production with territorial development.

The exchange visit allowed the MRC to better understand CNR's approach in managing and operating its multi-purpose assets, most of which have to meet triple objectives – electricity generation, facilitating navigation, and irrigation.

Visiting CNR was also of interest to the Mekong as the consulting company had engaged in Mekong development for over 20 years, starting with the 1994 study that planned run-of-river hydropower projects in the Mekong mainstream, supporting hydrological monitoring (HYCOS) and assisting the Lao government in reviewing and designing its hydropower projects.

Outcomes

In general, the exchange visit was highly educational and successful. The following key lessons learned could be concluded.

Key lessons learned

1. The Rhone River Basin was gradually yet comprehensively developed using a run-of-river dam concept, an experience that formed the basis for the Mekong Master Plan for mainstream hydropower projects (1994), a shift from the 1970/1987 Indicative Basin Plans of large reservoirs. The run of river implementation has shown to cause less environmental and social adverse impacts.

2. Even in run-of-river projects, it is important not to only consider hydropower but also to optimize navigation and irrigation (using pumping).

3. Once the cascade dams were built on the whole Rhone (19 dams, including 14 locks), navigation was possible all year round. Without the cascade, the Rhone was not navigable for 3 months of the year due to fierce currents, shallows, floods in spring and early summer when the ice was melting, and droughts in late summer. A navigation coordination center, like CNR's CGN, is needed to operate a series of locks to optimize navigation, increase safety, and reduce human resources.

4. As more and more infrastructures are built, it is critical to put in a place a centralized monitoring, coordination and control center like the CNR's COCPIT – able to monitor, forecast and operate assets as well as sell energy on the markets. It is noted that CNR, with AFD funding, is conducting a feasibility study for the Lao Government in this regard.

5. It is possible to incorporate new fish pass facilities into existing dams as old as 50 years. After a year of monitoring, the new fish passes have found to pass some 35 fish species and between 40-70,000 individual fish. Monitoring data are only accessible by environmental association.

6. Effective transboundary sediment management requires close coordination between riparian states (France and Switzerland) and their dam agencies, consultation with different water users and stakeholders, and technical specifications (e.g. different elevations for sediment outlets) and operational principles (e.g. in terms of flushing and routing) as well as monitoring.

7. CNR has 85 years of river basin development and management experience – unique in terms of combining all aspects – design, construction, operation and maintenance. This experience and expertise have been put into use by countries and basins all over the world, including the Mekong. CNR has advised and reviewed Mekong mainstream projects for the Lao government.

Program in brief

The exchange visit was from 4 to 7 June 2018, whose technical program was as follows, with the list of participants and some pictures included in Annex 1 and 2, respectively:

Day 1 (4 June)

- Briefing and discussion at **CNR Headquarters** in Lyon on the differences and similarities of the Mekong and the Rhone and opportunities for mutual leaning. See highlights below and presentation in Annex 3.
- Visit to the **CNR COCPIT** – center in its HQ dedicated to remote coordination and control of all CNR assets (dams, hydropower plants) and flow and energy forecasting and selling on the market. See PPT in Annex 4.
- Visit to the **CNR CACOH** (Le Centre d'analyse comportementale des ouvrages hydrauliques) or laboratory used for hydraulic and sediment modelling and testing.

Day 2 (5 June)

- Visit of **Genissiat** dam – the oldest dam in the Rhone (started construction in 1937 and started generating power from 1948) with 420 MW installed capacity and generates the second most power in the Rhone (1,780 GWh/y)
- Briefing and discussion on **transboundary sediment management**. See PPT in Annex 5.

Day 3 (6 June)

- Visit of Rochemaure small hydropower project and **new fish pass facility**
- Visit to **Bollene** dam (Donzère-Mondragon) – a multipurpose project with 348 MW installed capacity and generates the most power in the Rhone (2,032 GWh/y)

Day 4 (7 June)

- Visit **CNR Remote control center for navigation** in Châteauneuf (controlling all 14 locks). See highlights below. See PPT in Annex 6.

- Visit of **Logis-Neuf** multipurpose project with 210 MW installed capacity and Pouzin small HPP with new fish pass facility

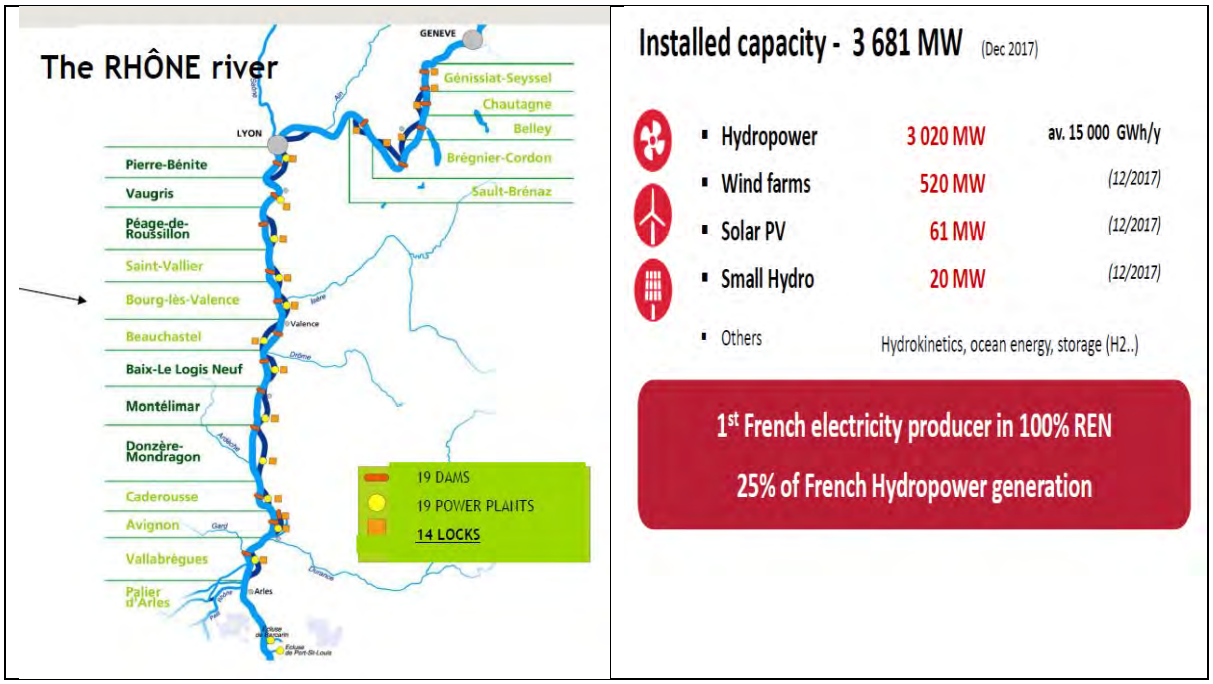
Highlights

The Rhone and Mekong river basins in comparative perspective

- The Rhone is a comparatively smaller river than the Mekong (about 10 times smaller) – 80,000 km2 in basin size, 500 km in length, and annual discharge of 1650 m3/s
- The Rhone hydrological profile is similar to the downstream stretch of the Upper Mekong (Lancang) – thus ideal for hydropower development
- The Compagnie du Rhone (CNR) was founded in 1933 as a state enterprise. Since its inception, the company was entrusted by the French government to develop and operate the Rhone (with a concession from 1934), with three equally important goals: power generation, navigation, and irrigation and other agricultural uses.
  - Thus, while a dam was built to generate power, CNR had to meet the objectives of navigation and irrigation even if it meant generating less power. In the Mekong, there are different developers and the primary objective is power generation.
  - From 1946 to 2001, CNR built the dams and Electricity du France (EDF) operated them. From 2001, CNR became independent and operated all dams on the mainstream Rhone (some dams in the tributaries are operated by EDF).
  - CNR currently has 1,372 staff and gross turnover of euro 1,056 million per year (2016).
  - CNR re-invests about 160 million euros (2014-2018) to the Rhone river for the benefits of local authorities, NGOs, environment, tourism, etc.
- There were debates in the 19th century in the Rhone what type of development (big reservoir dams or multiple run of river dams) would be best. It was decided for run-of-

river for the reasons of cost and mitigating risks. The same development strategy was the basis for CNR's recommendation for the Mekong in the 1994 study (master plan).

- The Rhone was developed early – starting in the postwar period and accelerating between 1950s to the 1980s. The lower Rhone was developed first and then the upper Rhone – 4 more dams. Total 19 schemes (including 14 locks), plus 20 small hydropower projects.
- Wind was first put in place in 2006 and solar in 2008. Both now are an integral part of many CNR assets.

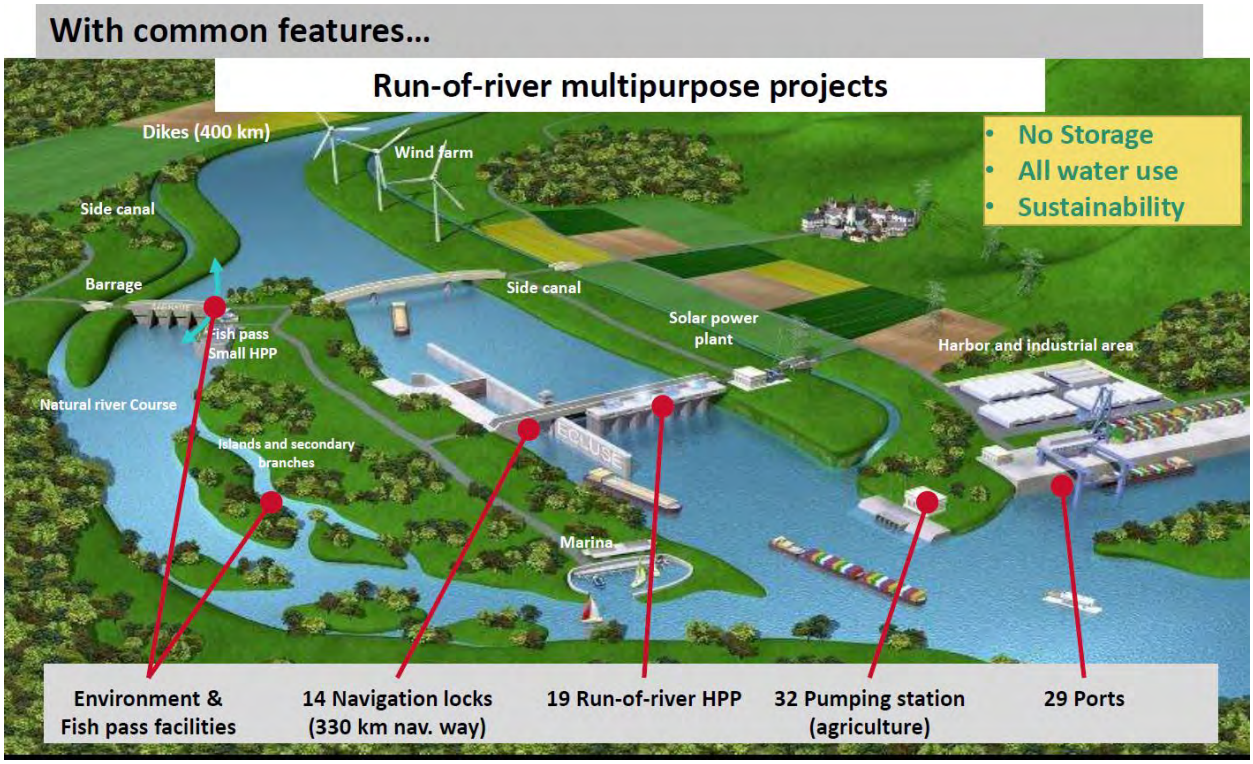


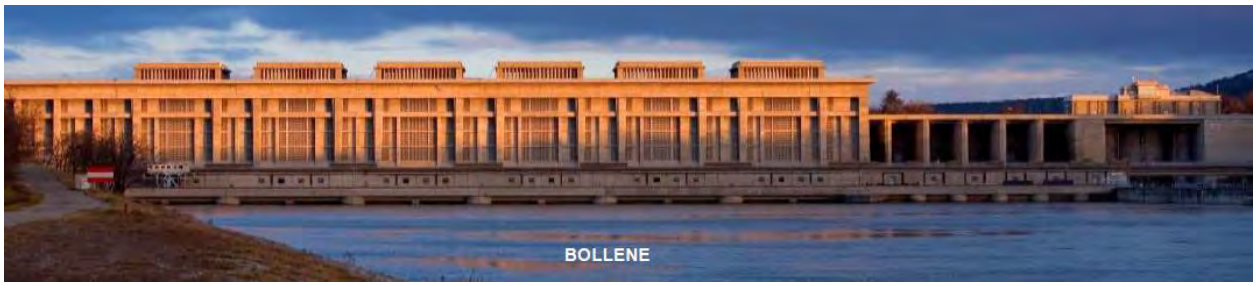
Integrated project development – hydropower, navigation, irrigation (plus territorial development, solar, wind, and tourism)

- The delegation visited three large dams – the oldest one (Genissiat) and two more (at Bollene and Logis Neuf) – that, especially the latter two, illustrated CNR's integrated model of run-of-river development
- Typically, there are HPP with generates electricity, sediment outlets, navigation locks, pumping stations (though not in the ones the delegation visited, they are mostly in the lower Rhone), wind turbines and solar panels, environment flow and fish pass facilities.
- Bollene is the only dam that was constructed with fish pass from the start
- We visited the small HPPs Rochemaure and Pouzin that after 50 something years of operation recently (last 5 years) incorporated new fish pass facilities (costing between 2 to 10 million euros). After 1 year of onsite monitoring, it was observed that about 35 something species and some 40,000 to 70,000 individual fish were found to have pass the fish ladders.
- Before the fish passes were built, there were no onsite monitoring for fish although some basin wide monitoring (like in the Mekong) was done (saw declining trends). The new

fish passes were attempts by CNR and the French government to meet the new environmental requirements of the EU Water Framework Directive.

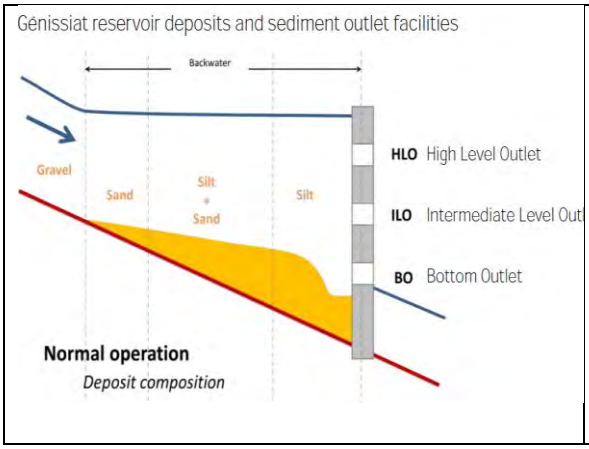
- CNR also grants land concessions to and supporting industries – about 27,000 ha – this generates additional revenues other than hydropower.

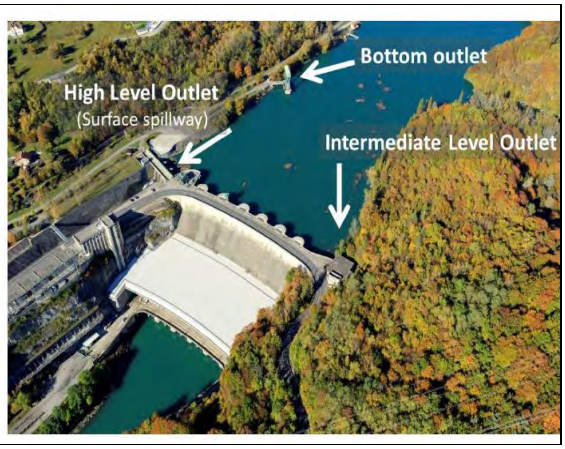




Transboundary sediment management

- The Rhone faces four sets of issues related to sediment
  - Human activities – flood hazards due to bed aggradation, drinking water quality, leisure activities like fishing and bathing
  - Agriculture – intakes and wellfields clogging
  - Environment – aquatic life, habitats quality and diversity, sediment continuity (disruption in reservoirs)
  - Industry – nuclear power plant cooling system clogging, water intake clogging and loss of storage capacity for dams, dam safety issues like spillways obstruction, and navigation safety like channel obstruction
- The Genissiat dam has three level sediment outlets: High Level Outlet (HLO), Intermediate Level Outlet (ILO), and Bottom Outlet (BO)

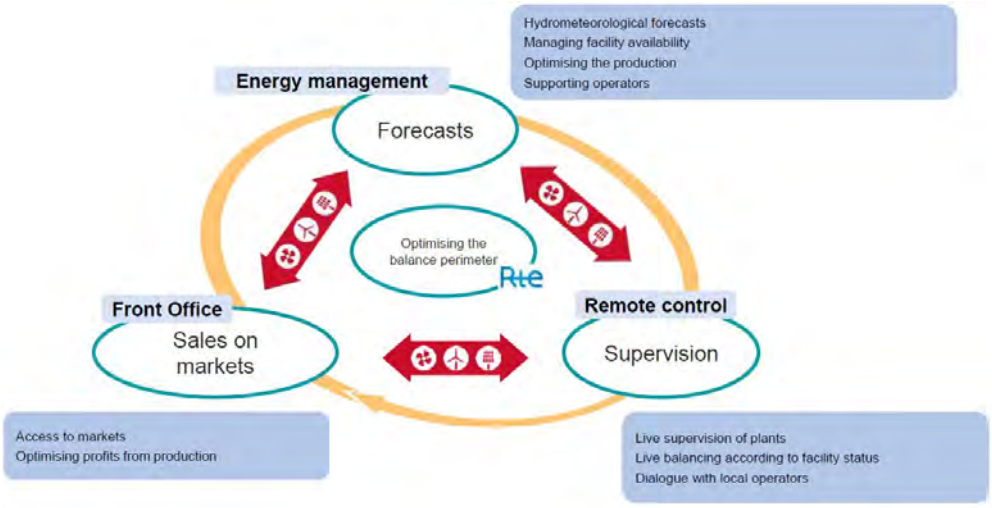




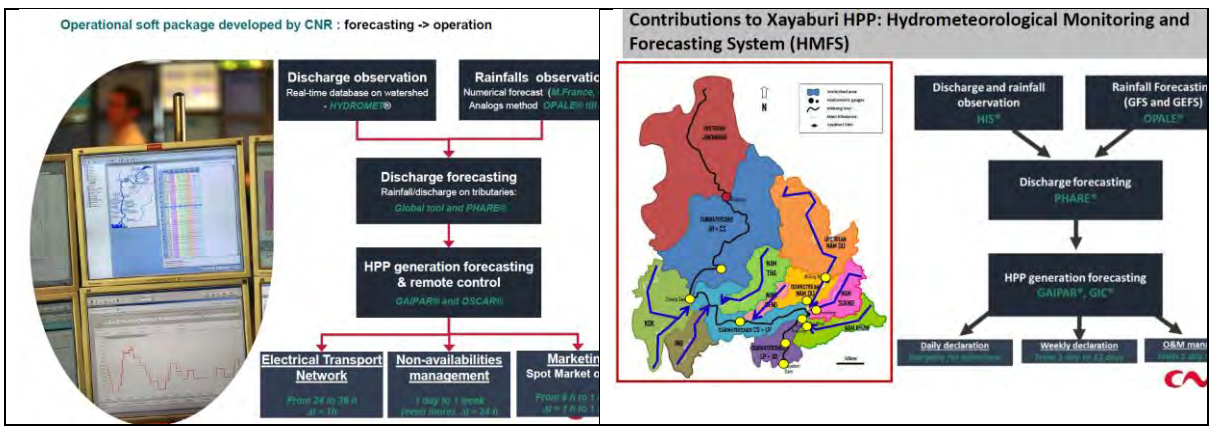
- Operation and monitoring: several sediment gauging stations providing real time 24/7 data; some stations are managed jointly by Swiss and French teams. The gates opening as well as the reservoir water level are then adjusted to obtain appropriate concentrations.
- During operation, ecological surveys are conducted to evaluate impact on aquatic life (fish)
- Coordination between Swiss operator (SIG) and French (CNR) and authorities – binational technical committee for the Upper Rhone River
- Consultation through public meetings with different stakeholders for most consensual sediment management scheme

- Currently studying to develop a masterplan for sediment management for the whole Rhone river from Lake Geneva to the Mediterranean sea, taking into account sediment, ecological and socio-economic issues
- Lessons from 85 years in the Rhone can help save time for other developing basins:
  - Flushing and routing of sediment through reservoirs can be conducted in an environmentally friendly way
  - Dams should be equipped with water and sediment release facilitates located at different elevations deepening on their height
  - To facilitate sediment routing, dam conception should allow recovering natural like flow conditions in the reservoir for a large panel of discharges
  - A close cooperation between operators of each dam on the cascade
  - Permanent and comprehensive field observations on hydraulics and sediment fluxes are required for decision making

CNR COCPIT

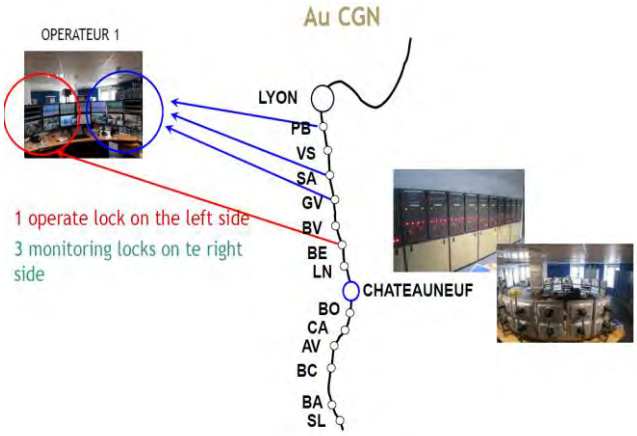


- Centre in CNR HQ to remote control and operate all CNR assets
- Hydrological and meteorological monitoring and forecasting, energy production forecasting, and access to energy market
- Real time control of hydropower generation and adjusting disparities
- Using power generation forecasting tool – developed by CNR and now will be used also by Xaiyaburi HPP.



Navigation

- 14 wide-gauge navigation locks
- 29 industrial and port sites (including the important Lyon Port)
- 5.4 million tons of transported goods per year
- 95,000 locks passages per year
- 195,000 passengers transported per year
- In 2016, 38,327 boats passed the locks, 13,587 cruise ships, and 14,821 pleasure ships

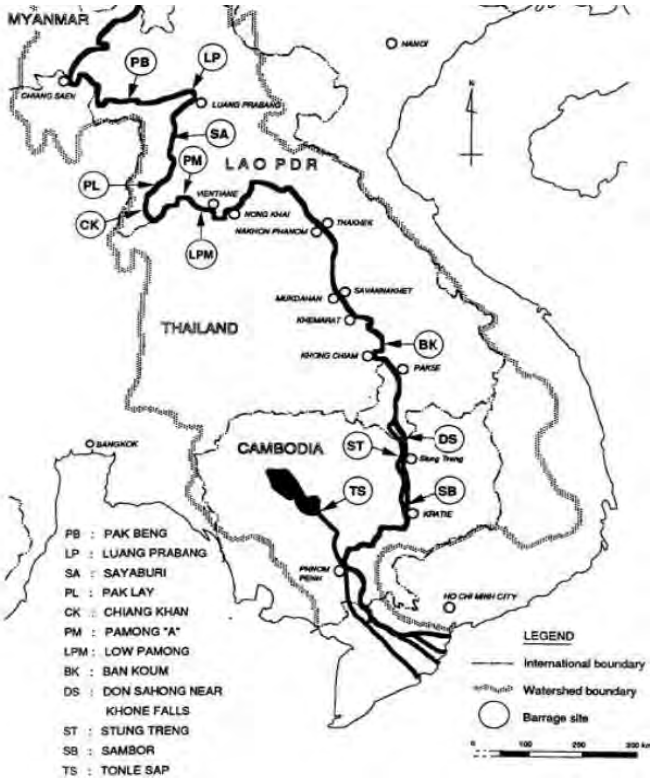


- Before the cascade dams were built, the Rhone was, like the Mekong, not navigable all year round (about three months not able to navigate) due to fierce currents, shallows, floods in spring and early summer when the ice was melting, and droughts in late summer. Now only 15-20 days of maintenance that cannot navigate per year.
- Remote Navigation Management Centre (CGN) in Châteauneuf, operating all 14 locks from one location. With the center, CNR needed less human resources to man every lock and can coordinate better the passage of ships. Also, the center operates 24/7, while before the locks were operated only between 5 am to 9 pm.

CNR's support of sustainable development of the Mekong River Basin

Regional:

- **1993-1994:** Commissioned by the Mekong Secretariat (predecessor of the MRCS) to review and develop master plan for Mekong mainstream hydropower (1993-1994)
  - Based on experience in the Rhone, CNR converted and recommended all planned mainstream projects to be run-of-river to minimize environmental and social impacts
  - CNR also recommended that before proceeding with individual projects, impact studies must be conducted



- **2007-2012:** Working with MRC and funded by AFD, implementation of the HYCOS network in the four MRC Member Countries.
- **2008-2009:** Working with MRC, recommended new locks for potential mainstream dams and navigation safety measures.
- **2016-2018:** Working with MRC, implementation of HYCOS follow up and trainings

National:

- Commissioned by Government of Laos (GOL) to provide peer-review of mainstream projects before PNPCA – Xaiyaburi, Don Sahong, Pak Beng, Pak Lay, as well as Sanakham and Phou Ngoy
  - CNR checked against three international standards (MRC PDG, WB, ICOLD), recommended on-site monitoring as a key for design improvement, request for documents to be provided by developer, and that design/construction/operation must be given same importance
- Conducted optimization study (2009) for the upstream of VTE dam cascade (5 projects)
- Conducted sediment study (2012) with 1-year field monitoring (1,000 km survey upstream and downstream of Xaiyaburi, 35 sampling sites) and recommended specific sediment outlet designs (low level outlets, flushing principles) and long-term monitoring
- Working with WB – Water-Energy Nexus - bringing the gap between IWMR and hydropower generation, with case studies of Nam Ou and Sekong (working / coordinating protocol between Lao MEM and MONRE)
- Feasibility Study for Coordination and Monitoring Center (CMC) for all multipurpose HPPs in Laos

4 Next steps / Follow up

- Organize a similar (perhaps three days) exchange for ministers only (ministers of water/natural resources/environment as well as ministers of energy)
- Organize a similar exchange for relevant technical specialists, especially those involved in PNPCA
- Share experience via Brown Bag Lunch with MRCS staff and others
- Document lessons and disseminate
- Prepare report (this report) for future reference in MRC work

Annex 1: List of Participants

MRC

Member Countries

- Madame Bounkham Vorachit, Vice Minister, Ministry of Natural Resources and Environment, Alternative Member of the MRC Council for Lao PDR
- Dr. Le Duc Trung, Director General of Viet Nam National Mekong Committee, Ministry of Natural Resources and Environment, Member of the MRC Joint Committee for Viet Nam
- Mr. Phonepaseuth Phouliphanh, Deputy Secretary General, Lao National Mekong Committee Secretariat, Ministry of Natural Resources and Environment, Alternate Member of the MRC Joint Committee for Lao PDR
- Mr. Suntiporn Nimkingrattana Deputy Director General, Department of Water Resources, Ministry of Natural Resources and Environment, Thailand
- Ms. Nuanlaor Wongpinitwarodom, Director, Bureau of International River Basin Management, Thai National Mekong Committee Secretariat, Department of Water Resources, Ministry of Natural Resources and Environment, Thailand

MRC Secretariat

- Dr. Pham Tuan Phan, Chief Executive Officer
- Dr. An Pich Hatda, Director of Planning Division
- Dr. Naruepon Sukumasavin, Director of Administration Division
- Mr. Bountieng Sanaxonh, Director of Technical Support Division
- Dr. Anoulak Kittikhoun Chief Strategy and Partnership Officer, Office of the CEO & MRC Exchange Visit Coordinator
- Dr. So Nam Chief Environmental Management Officer, Environmental Management Division
- Dr. Son Lam Hung, Head of Regional Flood Management and Mitigation Centre, Technical Support Division
- Dr. Thim Ly, Chief Basin Planner, Planning Division

CNR

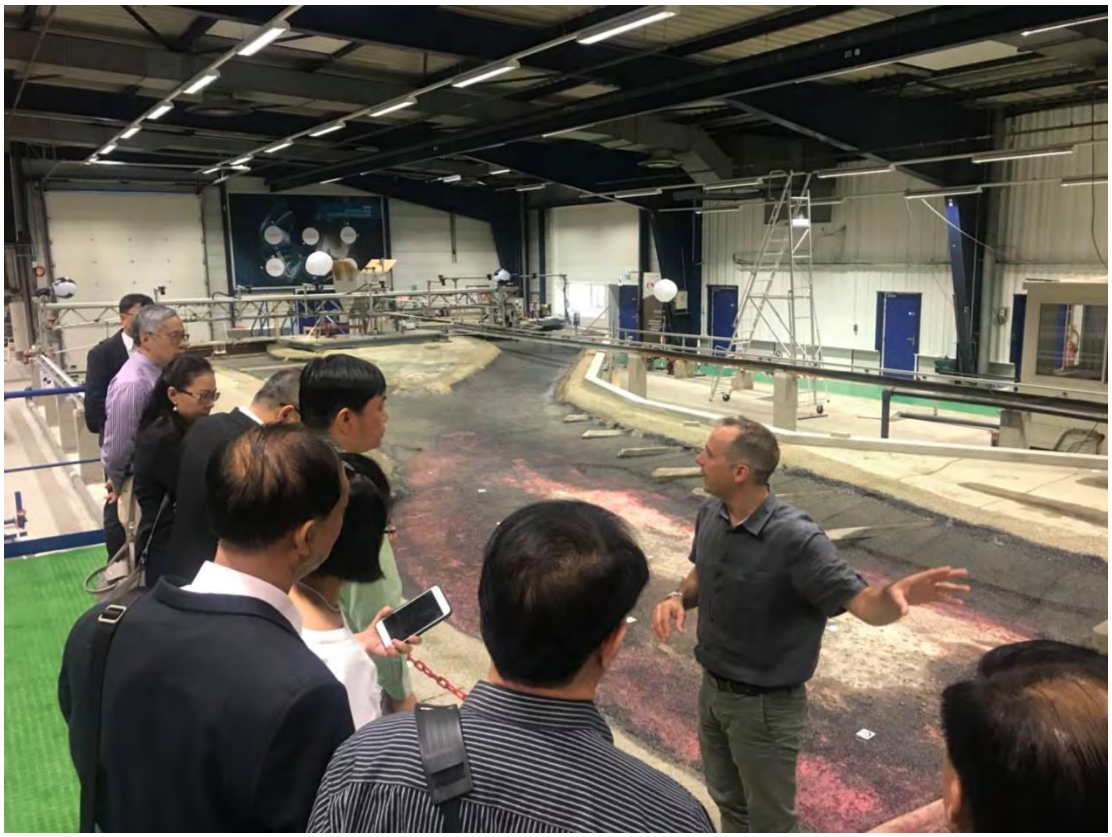
- Madame Elisabeth AYRAULT, Chairwoman of the Board and Chief Executive Officer
- Mr. Didier Lhuillier, Managing Director, Operations
- Mr. Daniel Jouve, Director of Engineering and Major Projects
- Dr. Benjamin Graff, Business Development Manager, CNR Engineering & CNR Exchange Visit Coordinator
- Mr. Christophe Peteuil, sediment expert
- Mr. Franck Pressiat, Team Leader for Environment, Engineering and Major Projects Department

Annex 2: Pictures

The MRC delegation at the start of the visit – posing with CNR Managing Director and staff

Exchanging lessons and experiences at the conference room of CNR HQ

Listening to briefing at the COCPIT (center for operation, forecasting and control of assets) @ CNR HQ



Observing the lab (CACOH) where CNR models and tests sediment transport

Visit to the Genissiat Dam – the oldest in the Rhone and the second most productive in power generation.

Discussing transboundary sediment management between Switzerland and France and sediment transport operation – *what kind of outlets are suitable for the Mekong dam?*

Hydropower project at Bollene (old pic without solar and wind)

Bollene now - Many CNR dams integrate wind and solar as well as territorial development

Visit the Rochemaure hydropower project where a new fish pass facility was installed recently. We asked CNR – *does this fish pass work?* After one year of monitoring, some 35 fish species and 40,000 individual fish are found to have passed.


Visit to Logis Neuf multipurpose project and the nearby Pouzin.


Pouzin fish pass facility – similar to Rochemaure – 70,000 fish found after one year monitoring. Monitoring station data is accessible only by an environmental association.

CNR's CGN – remote control center for navigation

Ship lock

Concluding group picture at the final meeting with CNR CEO and Lyon's Vice President.

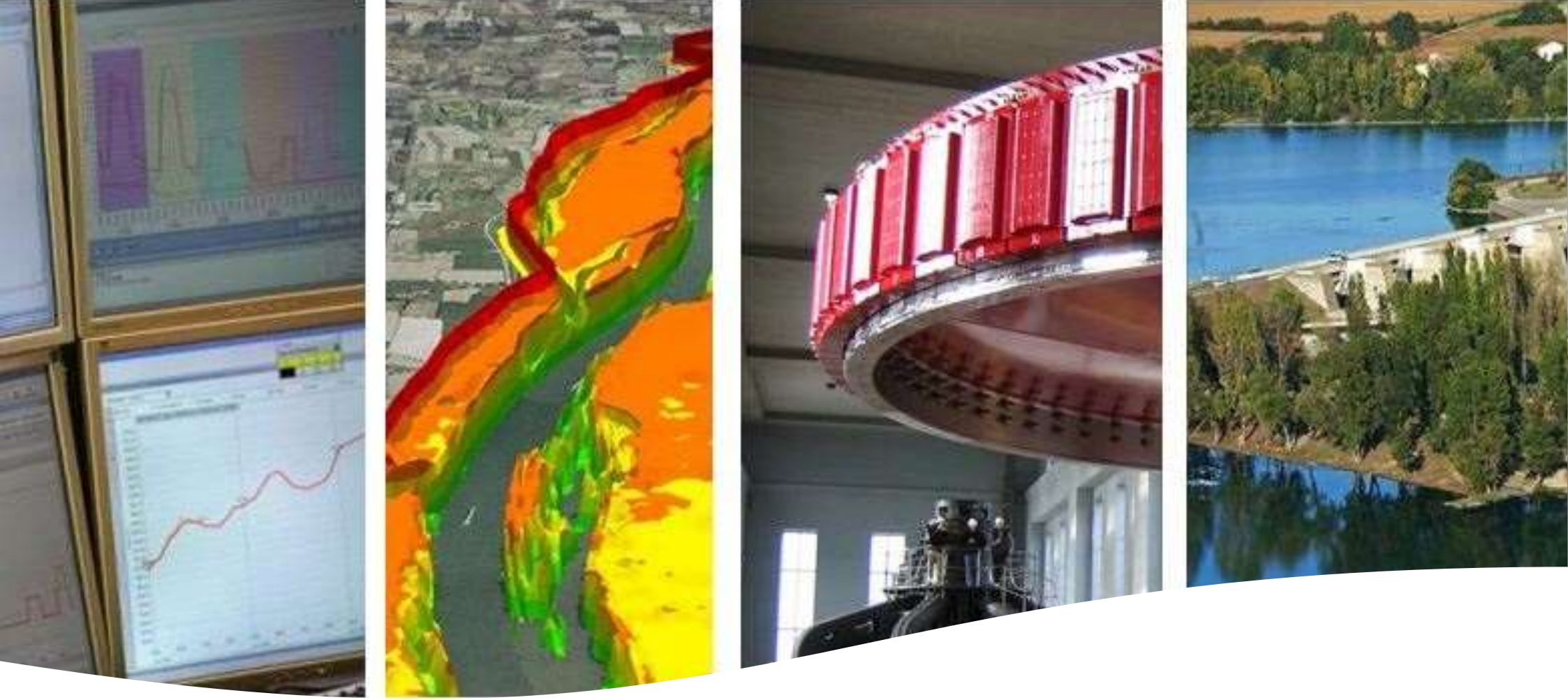
Annex 3

INTRODUCTION TO CNR
85 YEARS OF EXPERIENCE IN THE SUSTAINABLE DEVELOPMENT OF RIVERS AND RENEWABLE ENERGIES

MRC Visit
Lyon, June 4-7, 2018

MRC VISIT
AGENDA

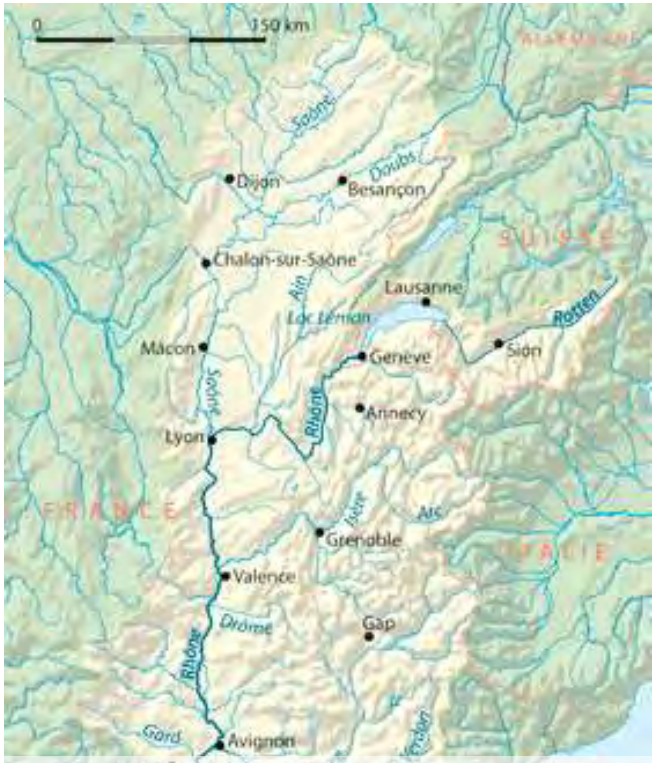
- **Welcome address**
- **Parallel Introduction to Mekong and Rhone Rivers**
- **CNR in brief**
- **CNR expertise in renewable energy management**
- **CNR Engineering : a specific know-how**
- **CNR experience on the Lower Mekong Basin**
- **Concluding remarks**
- **MRC visit programme**



PARALLEL INTRODUCTION TO MEKONG AND RHONE RIVERS

With common features…

2 international rivers under the influence of flow management upstream
Rhone operated by CNR is nearly 10% of Mekong Basin



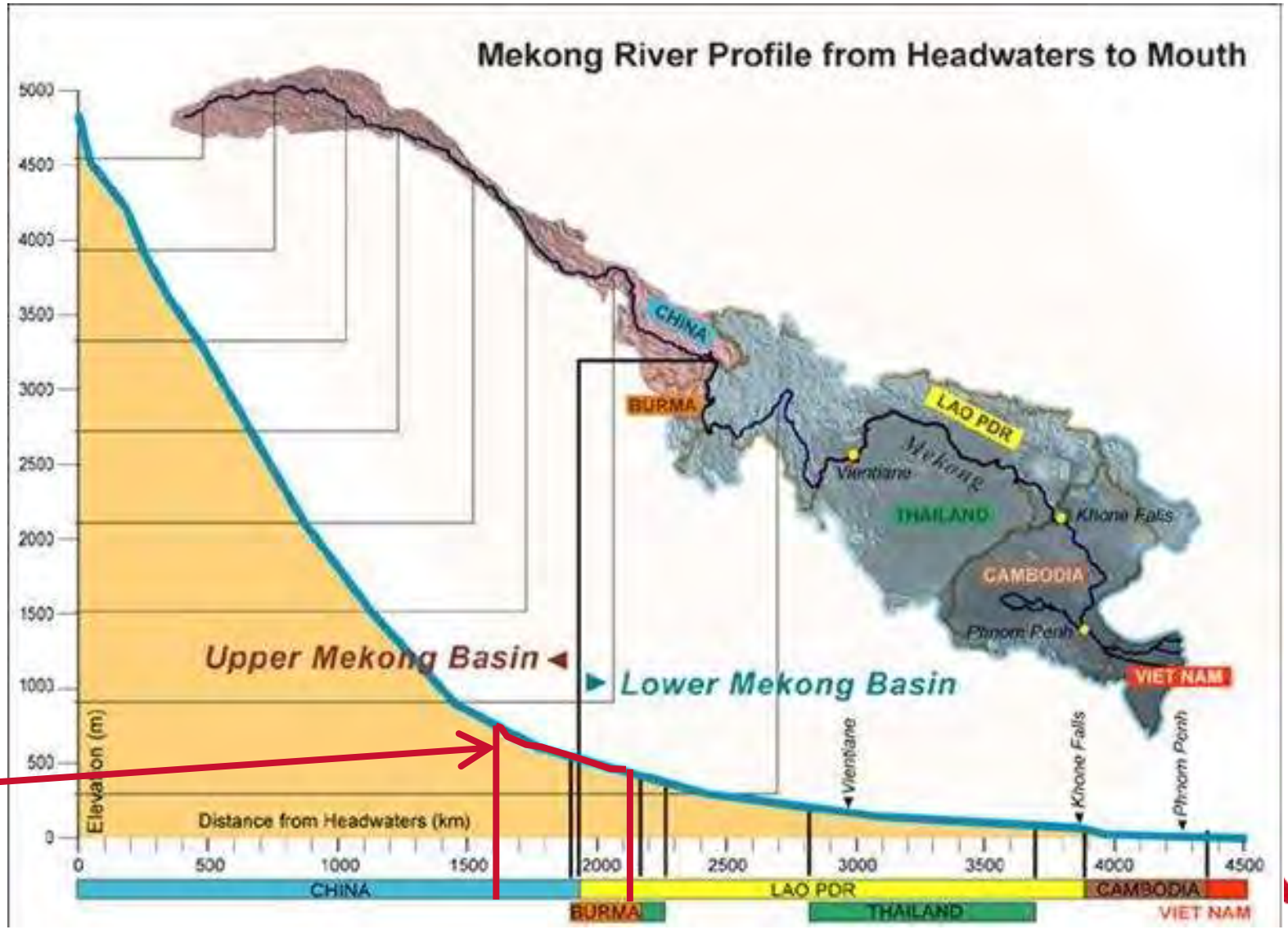
Rhône River by CNR (in total):
80 000 km² (95 600 km²)
500 km (810 km)
1500 m³/s (1 650 m³/s)

x10

Mekong River:
795 000 km²
4 500 km
15 000 m³/s

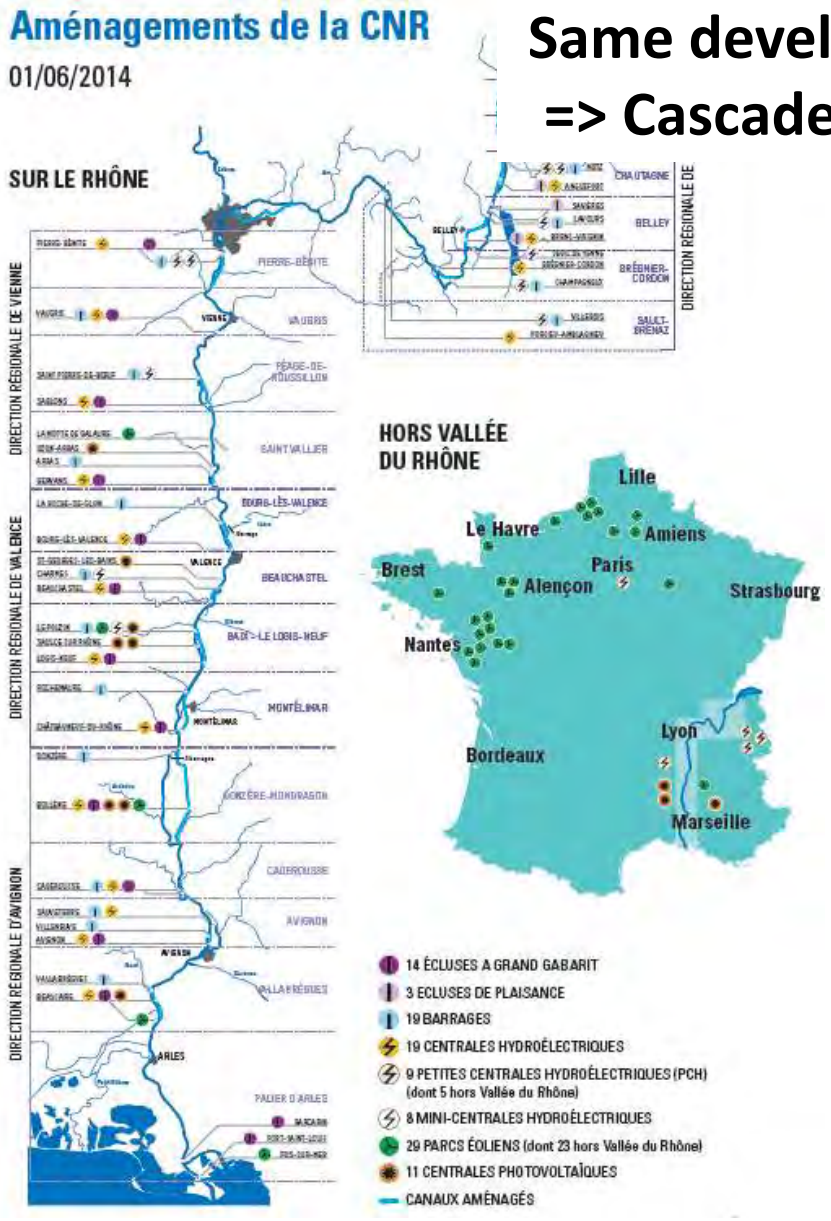
With common features…

High potential for the development of hydropower



Rhône River profile similar to d/s China stretch

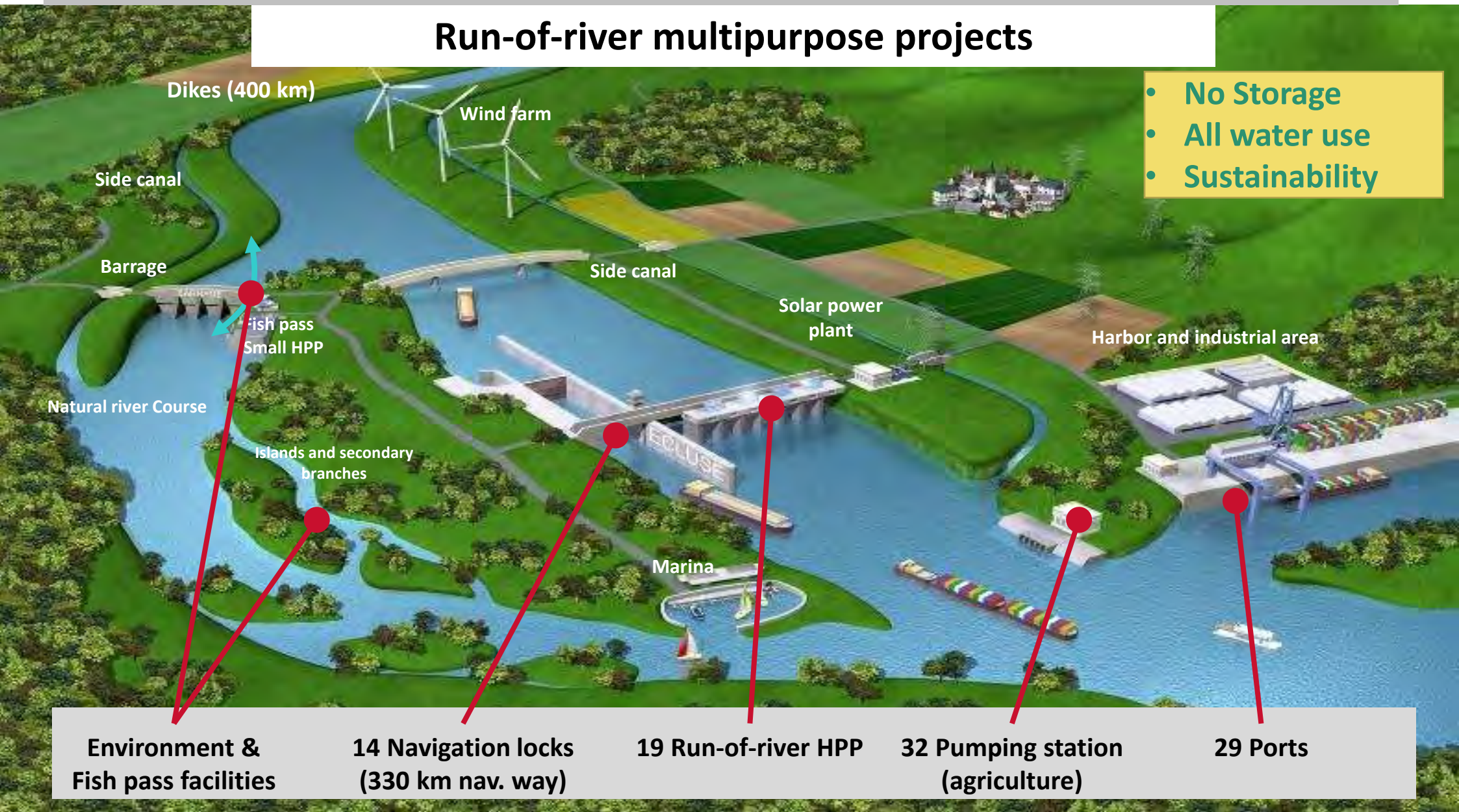
With common features…



Same development strategy in LMB
=> Cascades of multipurpose HPPs

With common features…

Run-of-river multipurpose projects



- No Storage
- All water use
- Sustainability

Environment & Fish pass facilities

14 Navigation locks (330 km nav. way)

19 Run-of-river HPP

32 Pumping station (agriculture)

29 Ports

With common features… and major differences!

	Rhône River	Mekong River
River development	• One developer: CNR • A multipurpose concession • Consistency of the cascade (design and operation)	• One IPP per project • Hydropower as first priority • Xayaburi as a benchmark but consistency still questionable
Non-Power Interests	• Hydropower as an opportunity to develop non-power interests • Final equalization among water uses	• Constraints from developers' perspective • Additional costs
International Organization	• No so-called "Rhone River Commission" • Agreement between CNR and other operators (Switzerland and main tributaries) • Exchange of information and data • Co-organization of specific operations (sediment flushing, flood management…)	• Mekong River Commission • China and Myanmar as observers • Room for water diplomacy and knowledge dissemination • Final decisions are up to Member Countries' Governments

CNR integrated vision of the Rhone River since 1934

Producing **hydroelectricity**

Developing inland **navigation**

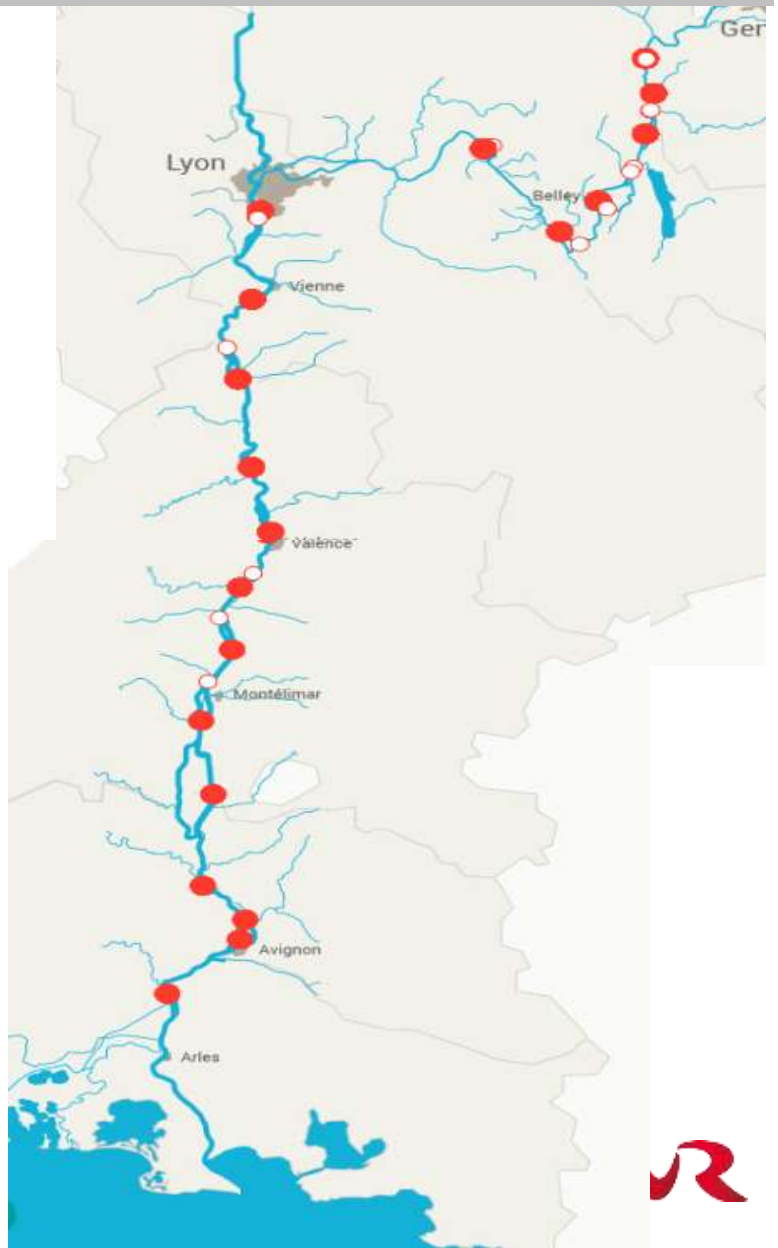
Facilitating **irrigation** for agriculture

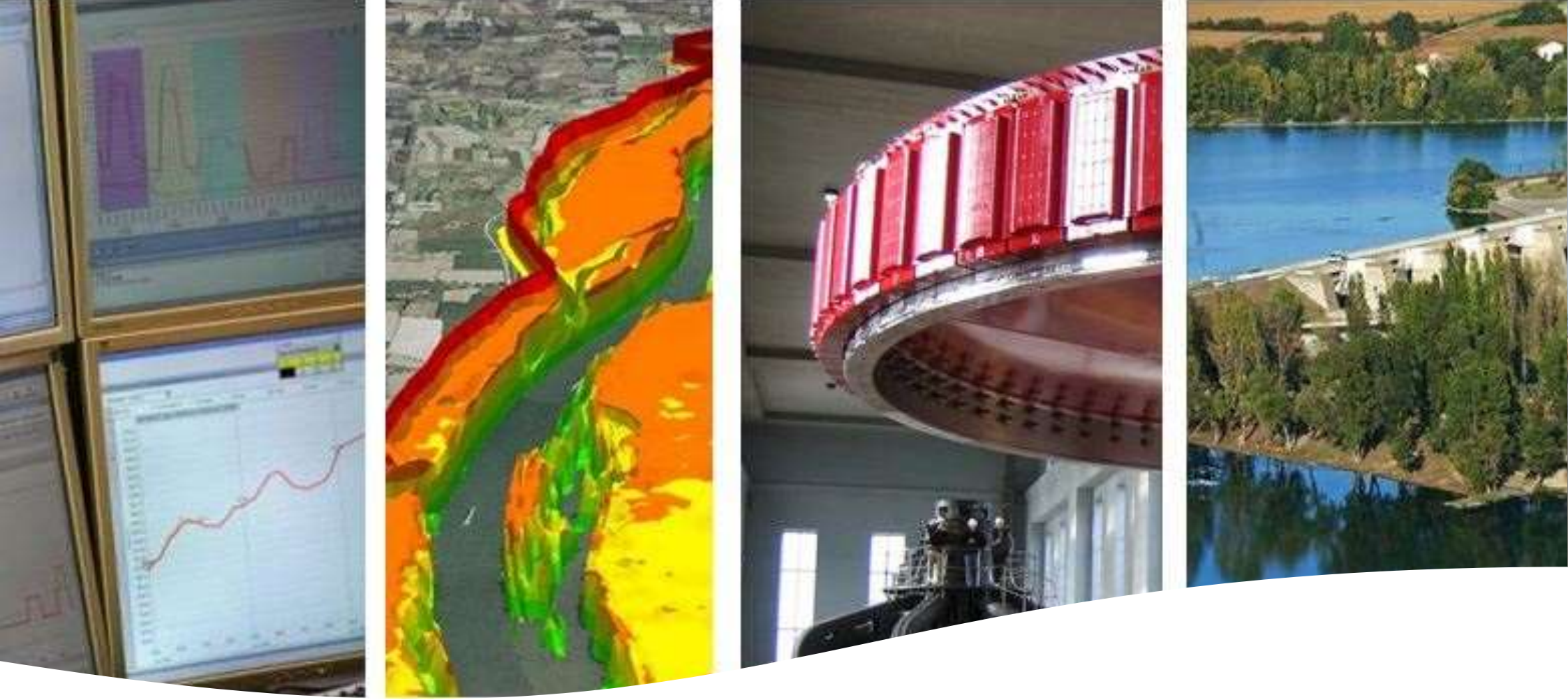
Unique "CNR model"

⇔

Financial equalization between 3 missions

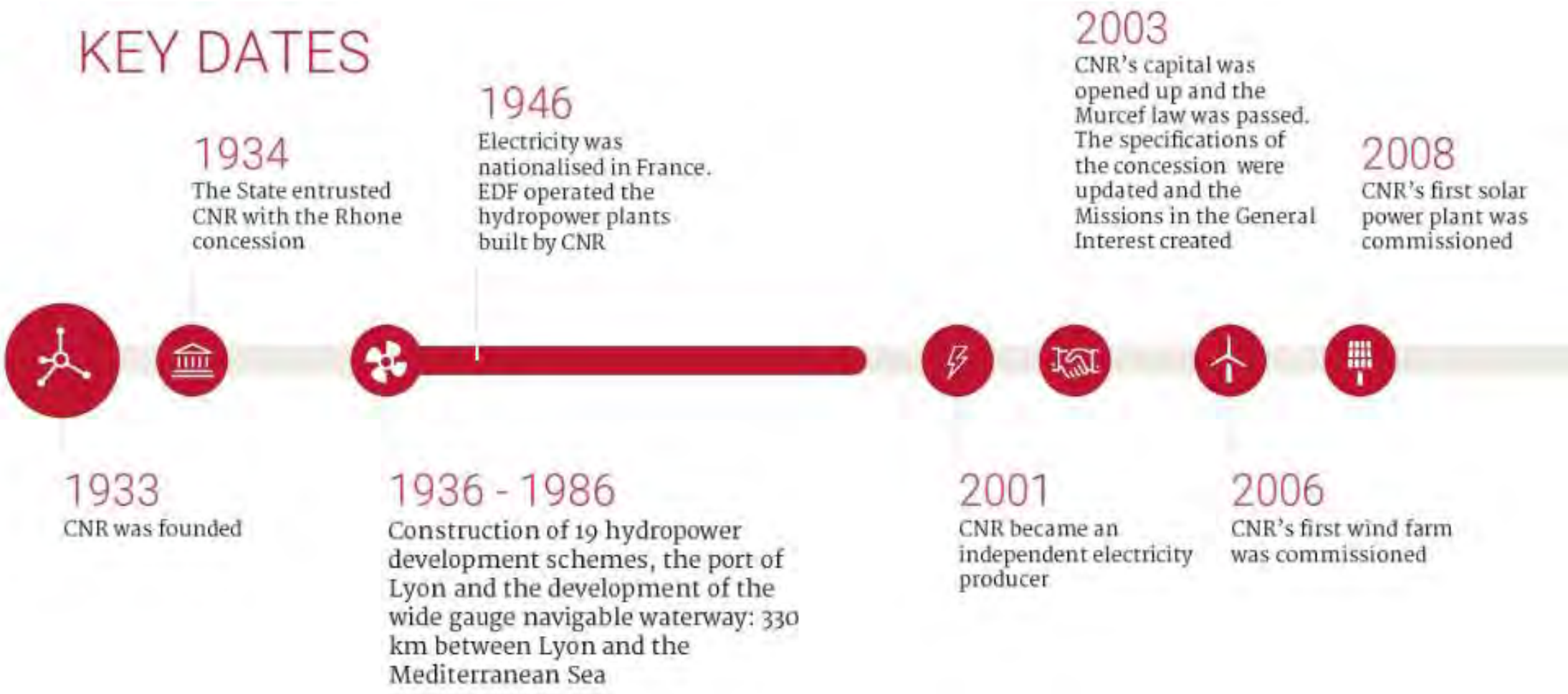
Design, construction, operation, maintenance, optimization and experience sharing





CNR: 85 YEARS OF SUSTAINABLE DEVELOPMENT OF THE RHONE RIVER

GENERAL OVERVIEW OF CNR
85-Y LONG HISTORY

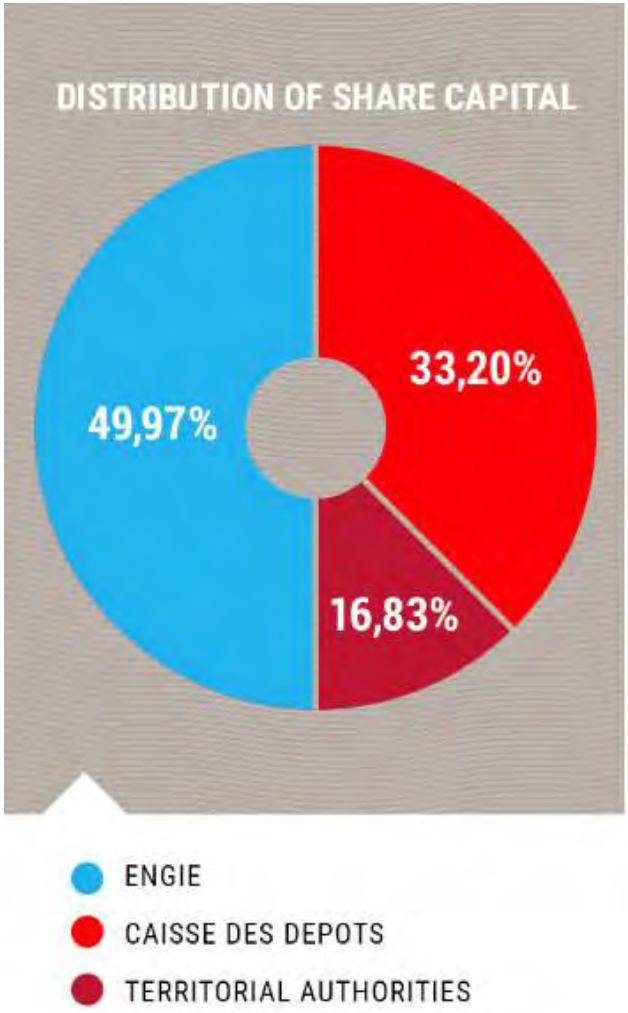


GENERAL OVERVIEW OF CNR
KEY FIGURES

- Staff 1372 permanent (12/2017)
- Gross Turnover 1 056 M€ (Y16)

ENERGY AT THE HEART OF THE TERRITORIES

- The concessionary of the Rhone and territorial developer with three missions for the community:
  - Producing hydroelectricity
  - Developing navigation
  - Facilitating irrigation for agricultural use
- No. 1 producer of 100% renewable energy generated from water, sun and wind
- A joint stock company in the general interest with a balance between public and private shareholders



Installed capacity - 3 681 MW (Dec 2017)

▪ **Hydropower**	**3 020 MW**	**av. 15 000 GWh/y**
▪ **Wind farms**	**520 MW**	*(12/2017)*
▪ **Solar PV**	**61 MW**	*(12/2017)*
▪ **Small Hydro**	**20 MW**	*(12/2017)*
▪ Others	Hydrokinetics, ocean energy, storage (H2..)	

1st French electricity producer in 100% REN

25% of French Hydropower generation

GENERAL OVERVIEW OF CNR MULTIPURPOSE ASSETS

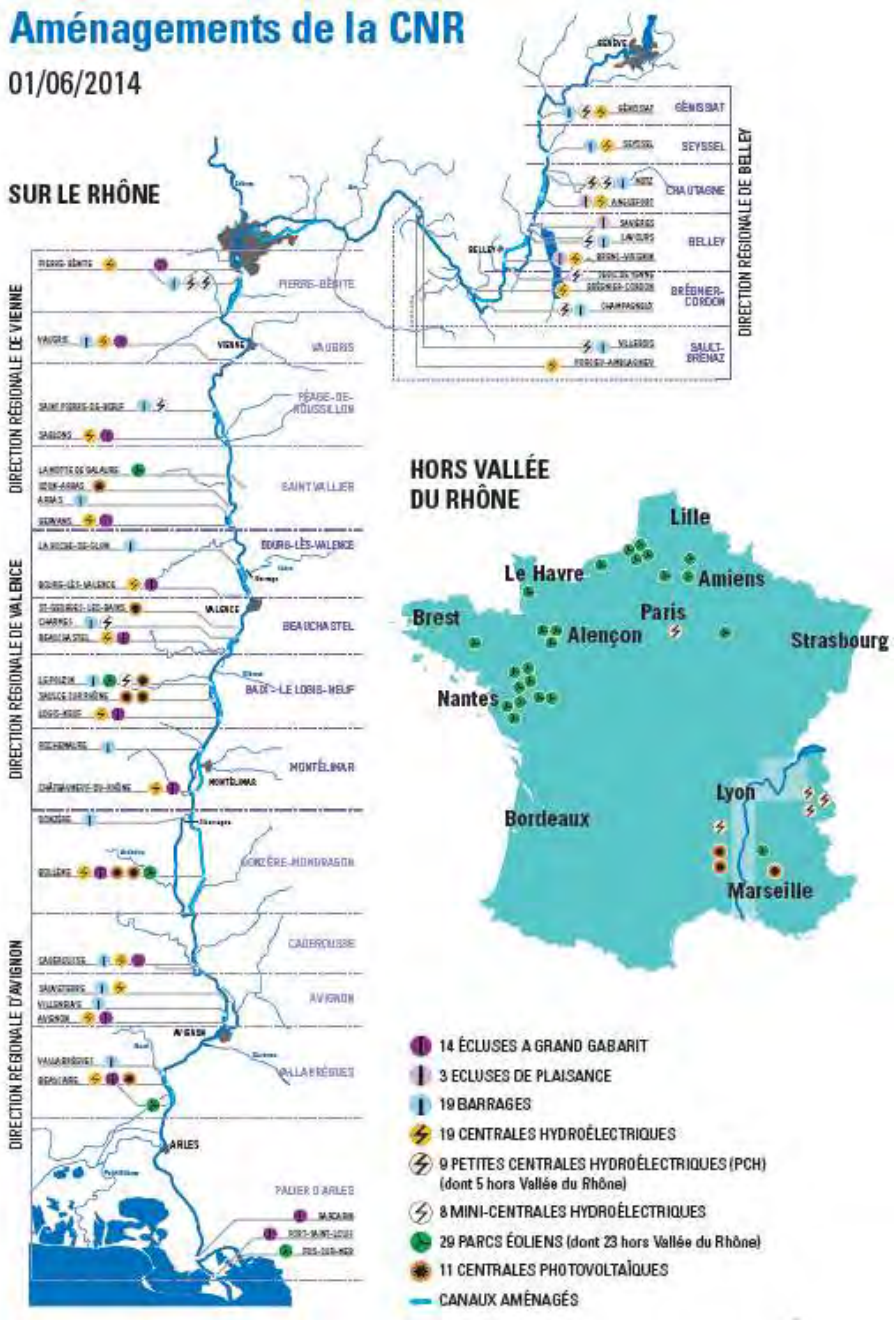
- **19** hydropower plants and dams
- **14** wide-gauge navigation locks
- **400** km of maintained dikes
- **330** km of wide gauge navigable waterway

And also

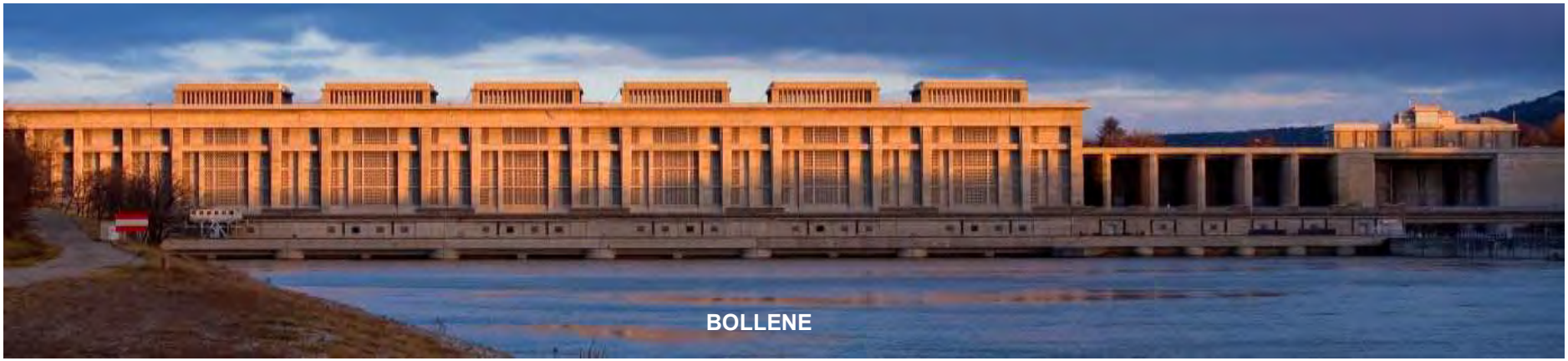
▪	42	Wind farms
▪	17	Solar PV power plants
▪	**29**	**Industrial and port sites incl. Lyon port**
▪	20	Small hydropower plants
▪	27,000 ha	Land under concession
▪	4	Leisure locks
▪	40	Water intakes for irrigation
▪	**120,000 ha**	**Irrigated land**
▪	4	Regional Directions, etc.

Navigation : 5,4 Mio tons transported (tons 1,2 bio x km)
: 95'000 locks passages per year
: 195'000 passengers transported
: Remote Navigation Management Centre (CGN)

*A push-tow convoy of 440 t (264 TEU) ⇔ 110 * 40 tons wagons (3-4 trains)*
*⇔ 220 * 20 tons trucks on the road*

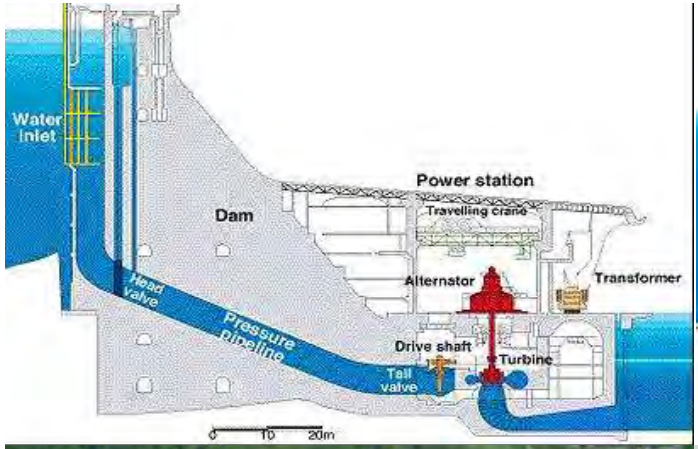


GENERAL OVERVIEW OF CNR
A CASCADE OF 19 MULTIPURPOSE SCHEMES

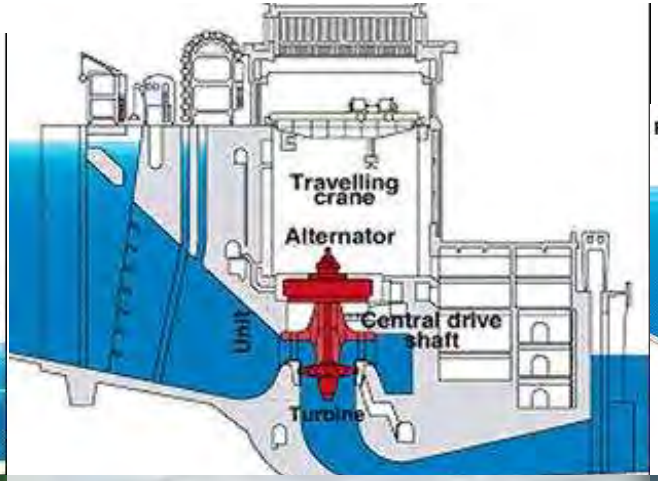


GENERAL OVERVIEW OF CNR
HYDROPOWER PLANTS OPERATED ON THE RHONE

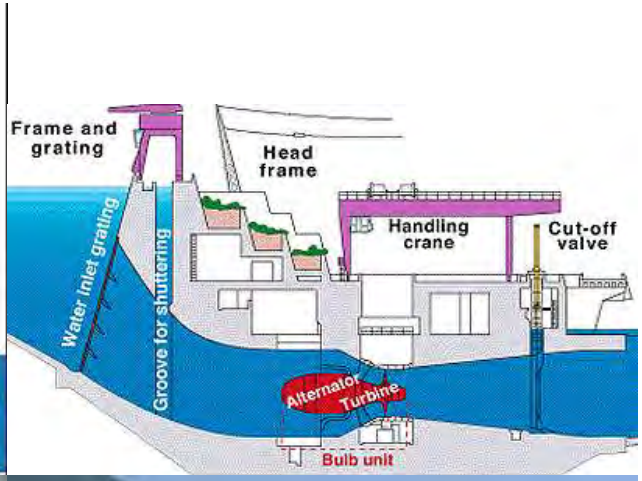
GENISSIAT – 420 MW
1,780 GWh/y
6 Francis units



BOLLENE - 348 MW
2,032 GWh/y
6 Kaplan units



CHAUTAGNE - 90 MW
450 GWh/y
2 Bulb units



GENERAL OVERVIEW OF CNR
MISSIONS IN THE GENERAL INTEREST (MGI)

Missions in the General Interest

Return to territories part of wealth created locally

Started in 2004, the MGI plans aim to strengthen links with Rhone river riparian people, participate in sustainable development of territories

Sustainable development

the founding values of CNR model

- A voluntary action plan developed by CNR
- A hundred of actions already performed with local authorities and NGOs
- Strategy of partnership with other stakeholders (state, national agencies, water agency, local authorities, …)
- Balance between private/public stakes
- Integrated valley development incl. economy
- Topics: Navigation, Environment, Economy, small hydropower, fish passes

Budget	1st plan- 2004-2008	127 MEUR
	2nd plan- 2009-2013	160 MEUR
	3rd plan- 2014-2018	160 MEUR

GENERAL OVERVIEW OF CNR
MISSIONS IN THE GENERAL INTEREST (MGI)

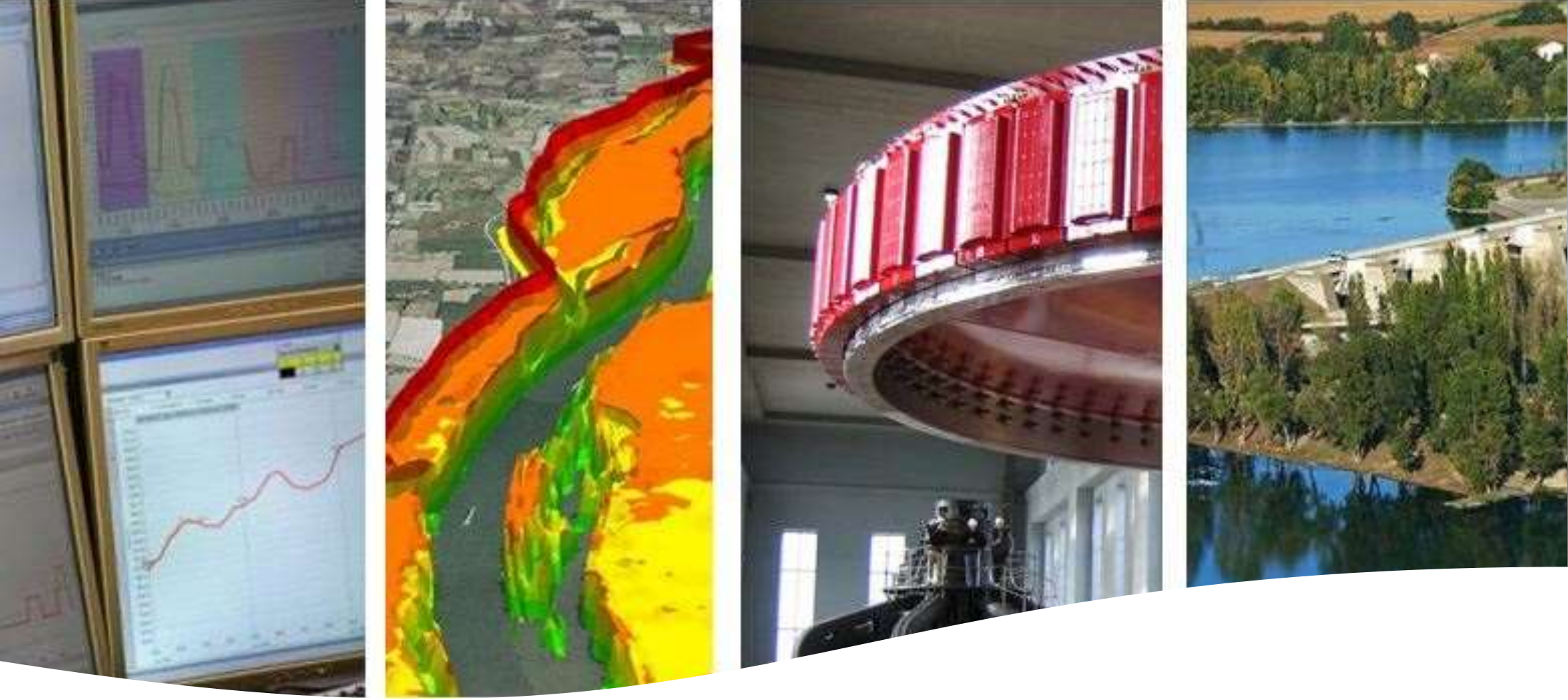
3rd Missions in the General Interest plan: typically € 160 M every 5 years

€47 M
for water and biodiversity resources

€45 M
for energy and sustainable mobility

€38 M
for economic development and tourism

€30 M
for river transport



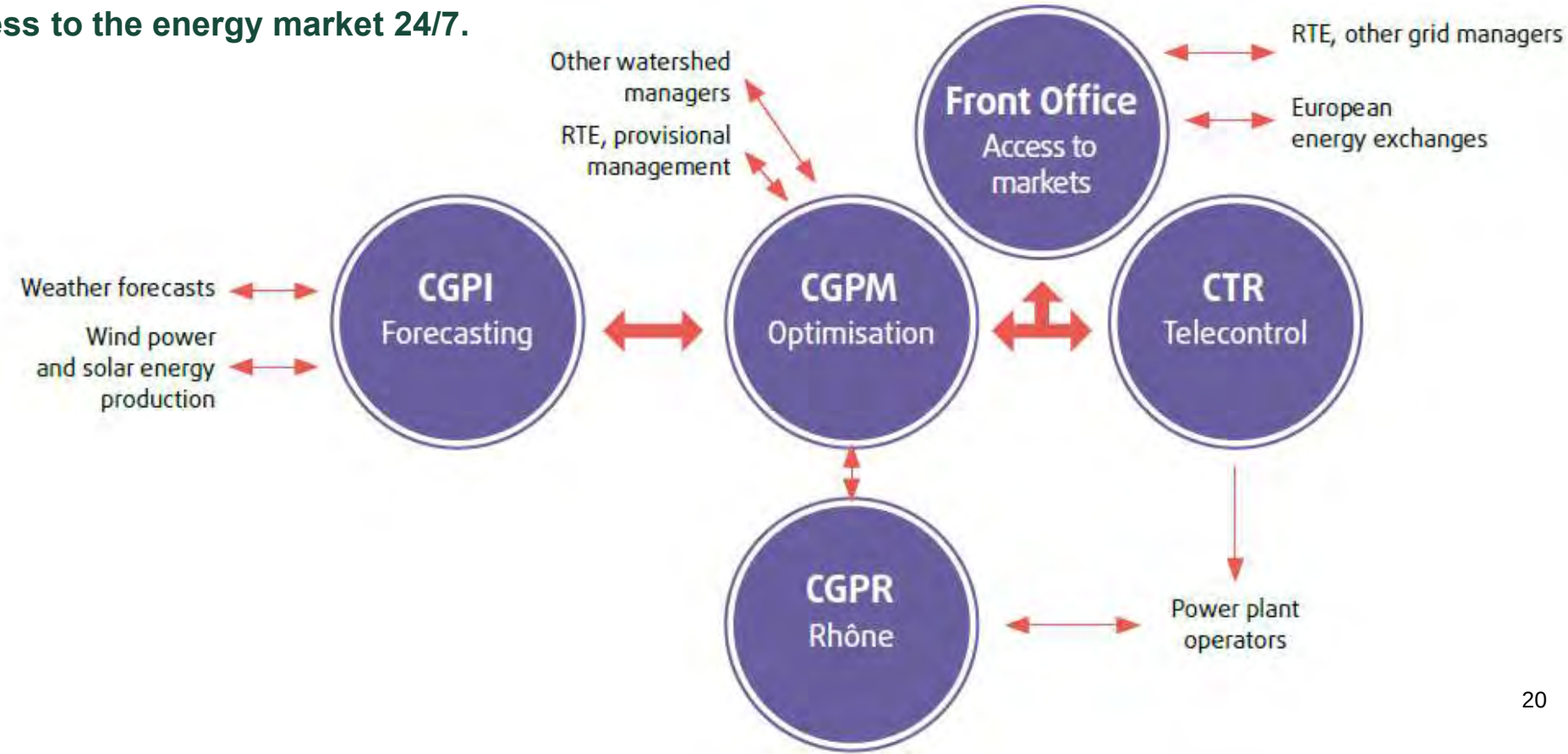
CNR: AN EXPERT IN RENEWABLE ENERGY MANAGEMENT

COCPIT
OPERATIONAL MANAGEMENT – THE COCPIT

To face the randomness nature of renewable generation (water, wind, sun), we specialized in **managing intermittent energies** to optimize the appreciation of our energies on the markets.

Modern dispatch center: COCPIT and a complete industrial environment able to:

- **Anticipate the conditions of production through weather forecasting;**
- **Optimize the placement of production in relation to the trading room;**
- **Real-time control of our generation and reduce disparities;**
- **Access to the energy market 24/7.**



COCPIT
OPERATIONAL MANAGEMENT – THE COCPIT

COCPIT – unique area covering **Sales, Forecasting, Planning and Remote-control**

COCPIT
POWER GENERATION FORECASTING

Operational soft package developed by CNR : forecasting -> operation

Discharge observation
Real-time database on watershed
- *HYDROMET®*

Rainfalls observation
Numerical forecast (*M.France, GFS*)
Analogs method *OPALE® till J+4*

Discharge forecasting
Rainfall/discharge on tributaries:
Global tool and PHARE®

HPP generation forecasting & remote control
GAIPAR® and OSCAR®

Electrical Transport Network
From 24 to 36 h
Δt ≈ 1h

Non-availabilities management
1 day to 1 week
(even more) Δt ≈ 24 h

Marketing
Spot Market or PPA
From 6 h to 1 week
Δt ≈ 1 h to 1 day

Forecasting time horizon – what for?

National grid operator

H+3 to D+1

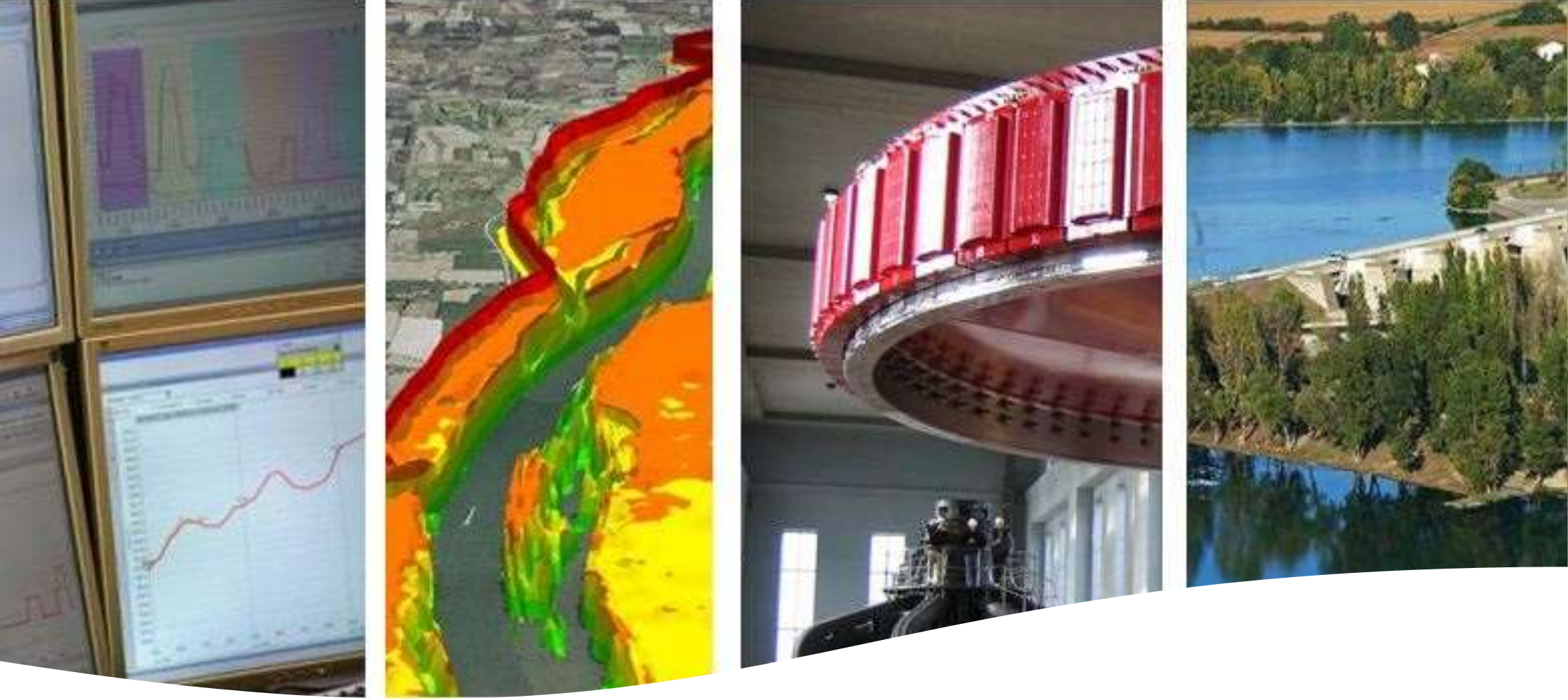
Market hedging /front-office

D to D+8

O&M operation optimization

Hydraulic safety

H+2 to D +4



CNR ENGINEERING : A SPECIFIC KNOW-HOW

CNR Engineering, differing from conventional consultants:

- ✓ **Shared experience of designer & operator of hydraulic structures**
- ✓ **Integrated company model : in-house engineering skills**
- ✓ **CACOH - Hydraulic laboratory** [physical models, surveillance, materials, metrology]

Capitalizing on its 85 years' experience on the Rhone river, CNR Engineering offers its clients a wide range of modular and turnkey services to satisfy the requirements of every project phase.

Our services during project life-cycles:

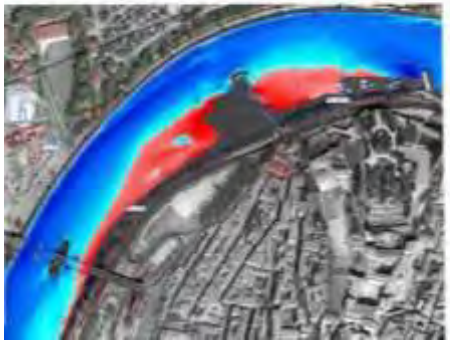
- analysis and diagnosis,
- masters plans, overall design,
- technical-economic studies,
- feasibility studies,
- institutional studies, ESIA studies,
- preliminary and detailed design,
- technical assistance to the owner,
- supervision of works,
- assistance for commissioning,
- assistance for operation & maintenance
- high added-value services in forecasting, sediments, etc

Internal & External provisions:

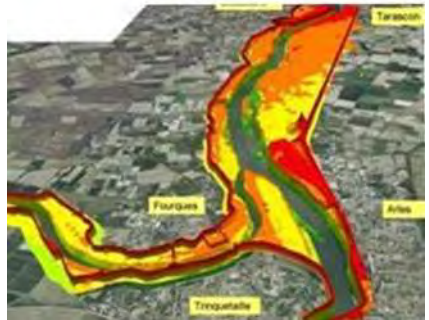
- Design office in assistance to the operation of CNR developments
- Design office in charge of studies & works supervision for general interest program on the Rhône river
- **Consulting engineer in hydropower & river engineering (France and Abroad)**

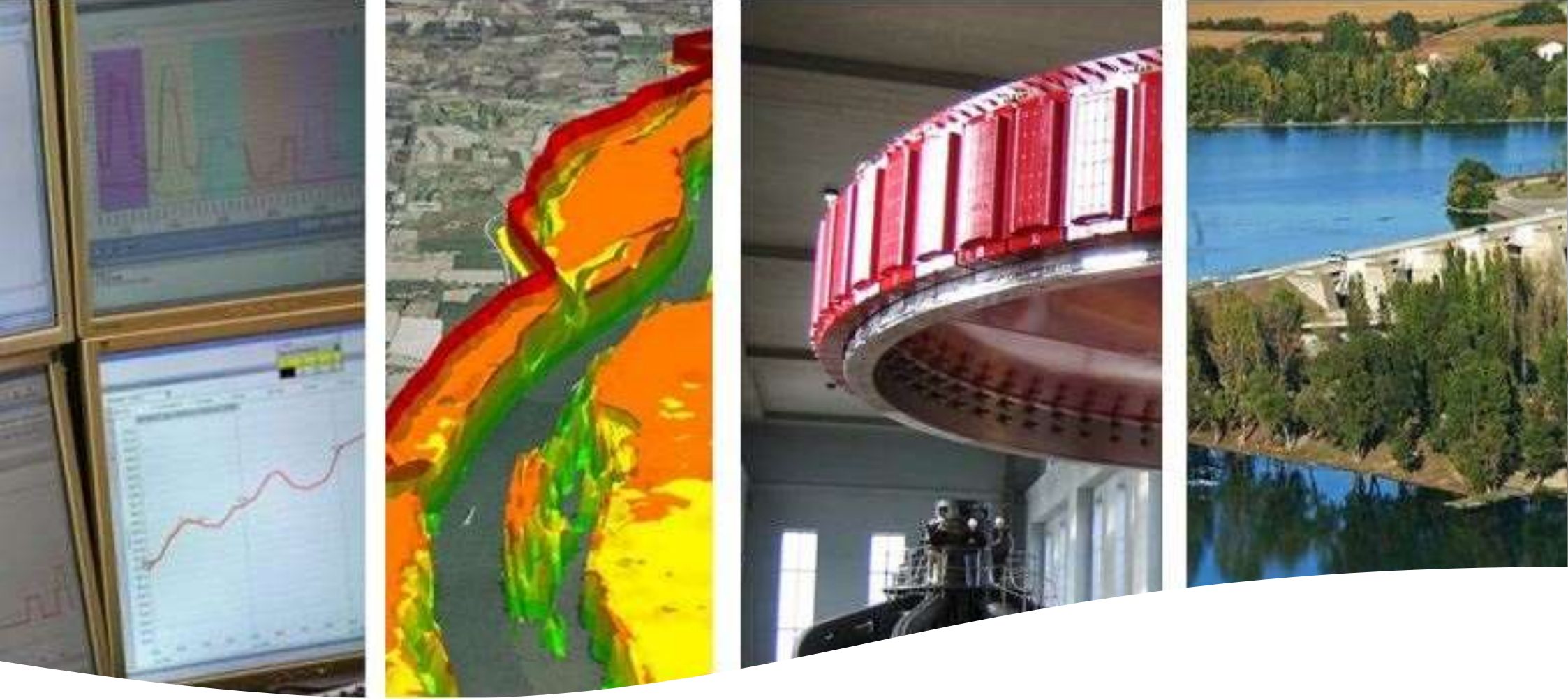
Areas of expertise and typical services

Areas of expertise		
	• **Hydropower**	Hydropower plants, dam, dikes, electromechanical, hydro-mechanical,
	• **Navigable waterways**	Locks, channels, ports, etc.
	• **River Engineering**	Dikes, canals, banks protection, ecological engineering.
	• **Hydraulic systems management & climate change**	Mathematical models, physical models, discharge forecasting, flood, etc.



Our services		
	Expertise and assessment	Operational support and maintenance Preliminary studies Expertise, Diagnosis, Masterplans Institutional and Impacts studies, Technical-economical
	Projects supervision	Preliminary studies Feasibility and Design studies Assistance to the owner Works supervision
	Operation and maintenance	New projects audit / Expertise of existing equipment Assistance to commissioning / Training for operators Assistance on operational management issues during O&M Monitoring on hydrology, forecasting and sediments issues





CNR: 25 YEARS OF CONTRIBUTION TO MEKONG RIVER SUSTAINABLE DEVELOPMENT

Mekong development based on CNR experience on the Rhone River

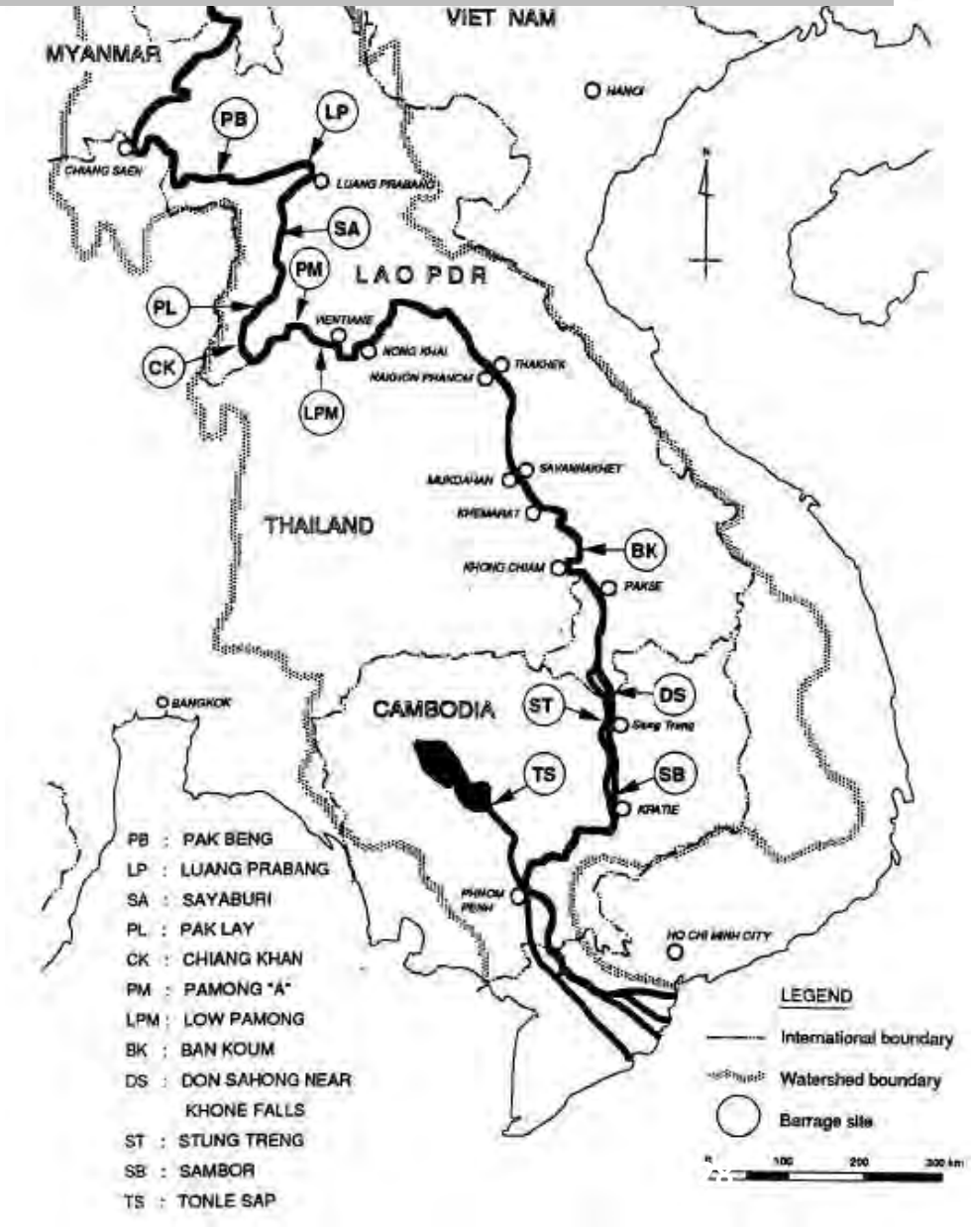
Evaluation of the hydropower potential of the Mekong River (1993-1994) on behalf of the Mekong Secretariat

Methodology based on CNR experience of the Rhône River

Recommendations for impact assessment studies

Run-of-river HPP to minimize environmental and social impacts compared to large reservoirs

To-date the reference study for development of the Mekong River



Lao, Vietnam, Cambodia, Thailand

Mekong-Hycos project for MRC

Technical Assistance for the implementation of a reliable and efficient system of collection and transmission of hydro-meteorological data in the Lower Mekong basin. Strengthening national and regional capacities.

Client: MRC - 2007-2012

Navigation on the Mekong-River

Recommendations for :

- new locks to be implemented in association with the hydro generation plan on the Mekong Main stream.
- Improvement of navigation safety through a set of preventive actions.

Client: MRC – 2008-2009

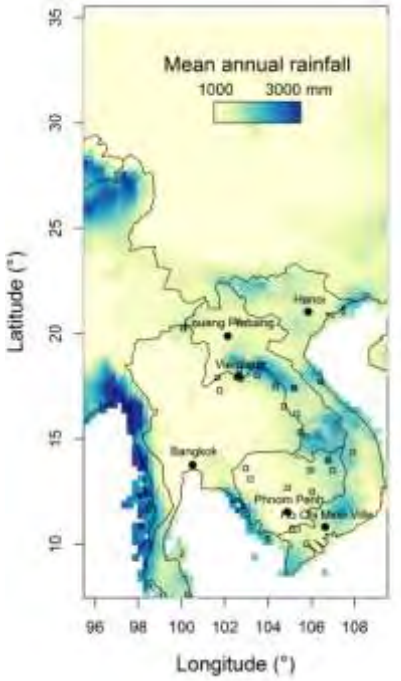
HYCOS Follow-up

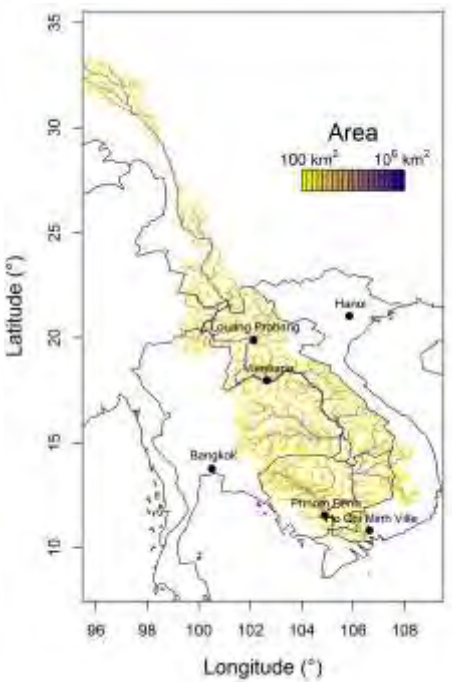
Improvement of data usage based on statistical analyses

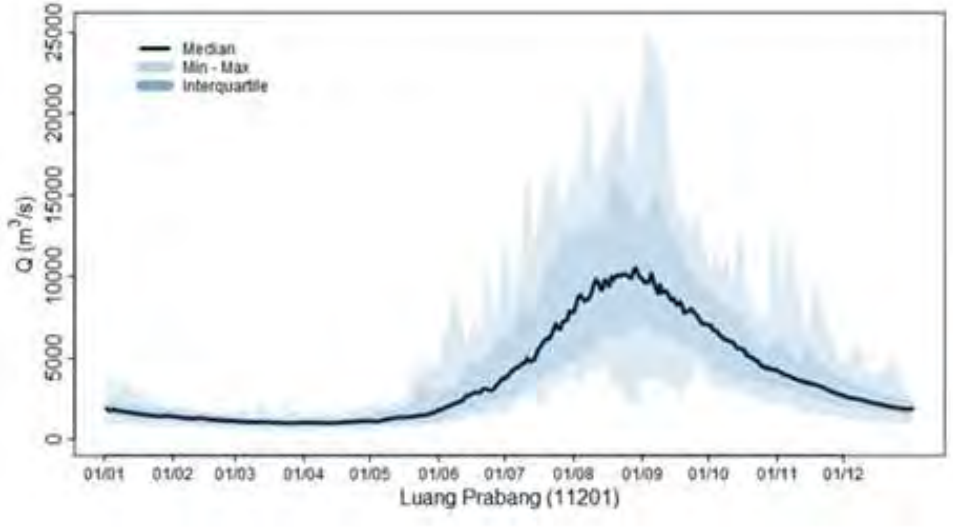
Methods and tools for discharge and sediment measurements
QA/QC
Regional analysis of river flow regime

Trainings for trainers at regional level from 2016 to 2018

CNR, Irstea, OIEau and IWMI
CNR as Team Leader







ENERGY AND MINES

Government of Lao PDR

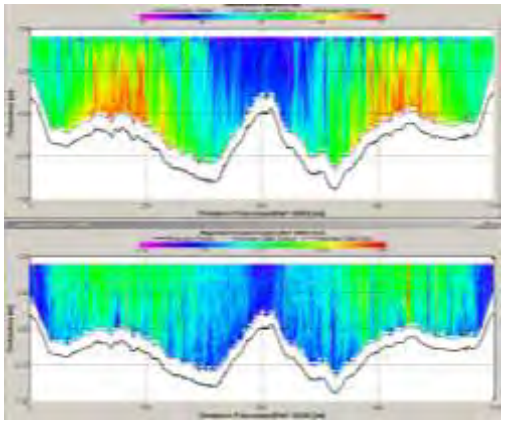
Peer Review : CNR contribution to design review and improvement

CNR called by GOL to bring expertise at the beginning of PNPCA ➔ peer-review

Expertise performed on Hydrology, Navigation and Sediments transport with benefits from experience on Rhône River Operation.

Suggesting improvements of the project regarding sediments transportation and navigation

➔GOL asked for more detailed study on Sediments to comply with MRC guidelines



Sediments issue – an unparalleled know-how on the Mekong with 1 year field campaign

./..

ENERGY AND MINES

Government of Lao PDR

Peer Review : CNR contribution to design review and improvement

Large feedback and technical knowledge developed in-house

(i.e. Swiss flushing backing)

Contributing to better knowledge of the Mekong river dynamics

- **1'000 km** of river surveyed - u/s and d/s XHPP
- Measurement in dry and monsoon seasons
- Quantifying fluxes by different means, Numerical models
- **Redesign proposals**: Low-level outlets, flushing principles
- **Long-term action plan**: "Model-Monitor-Mitigate" 3M

ENERGY AND MINES

Government of Lao PDR

Mekong Cascade Optimization based on CNR experience

Optimization Study on the flow regulation of 5 HPP Mekong projects northern of Laos on behalf of Government of Lao PDR

Cascade Optimization instead of a project by project optimization

Updating the 1993/94 study and performing additional studies: hydrology, hydraulics modeling, flood mapping, power generation, operating guidelines, ESIA screening…

Implementing environmental, social, technical and economical criteria in order to optimize and propose a manageable operation regime for all 5 projects upstream Vientiane

To-date the reference study for development of Lao upper stretch of the Mekong River

Characterization of grain-size distribution of Mekong River sediments (from Chiang Saen to Nong Khai)

Large scale field survey performed for GoL by CNR in 2012

Objective: evaluate the longitudinal and transverse evolutions of bed-material features

- 1000 km of river covered by boat
- 35 sampling sites surveyed
- 230 samples collected and sieved for determining the GSD curve of deposits
- 2000 kg of sediment collected
- Assessment of bed load, graded suspension and uniform suspension

- 10 sites on Mekong River (Nov. 2012)
- 10 sites on Mekong River (April – May 2012) + 3 on Nam Ou, Nam Xuang & Nam Khan
- 12 sites on Mekong River (Nov. 2012)

Characterization of grain-size distribution of Mekong River sediments (from Chiang Saen to Nong Khai)

From Chiang Saen to Vientiane, very diversified features and rapidly changing situations are observed in terms of valley shape, bed morphology, sediment supply, deposit nature and forms, and flow conditions

ENERGY AND MINES

Government of Lao PDR

FS review: CNR contribution to design review and improvement

4 issues to address

- Hydrology
- Sediment transportation and hydraulics
- Dam safety
- Navigation

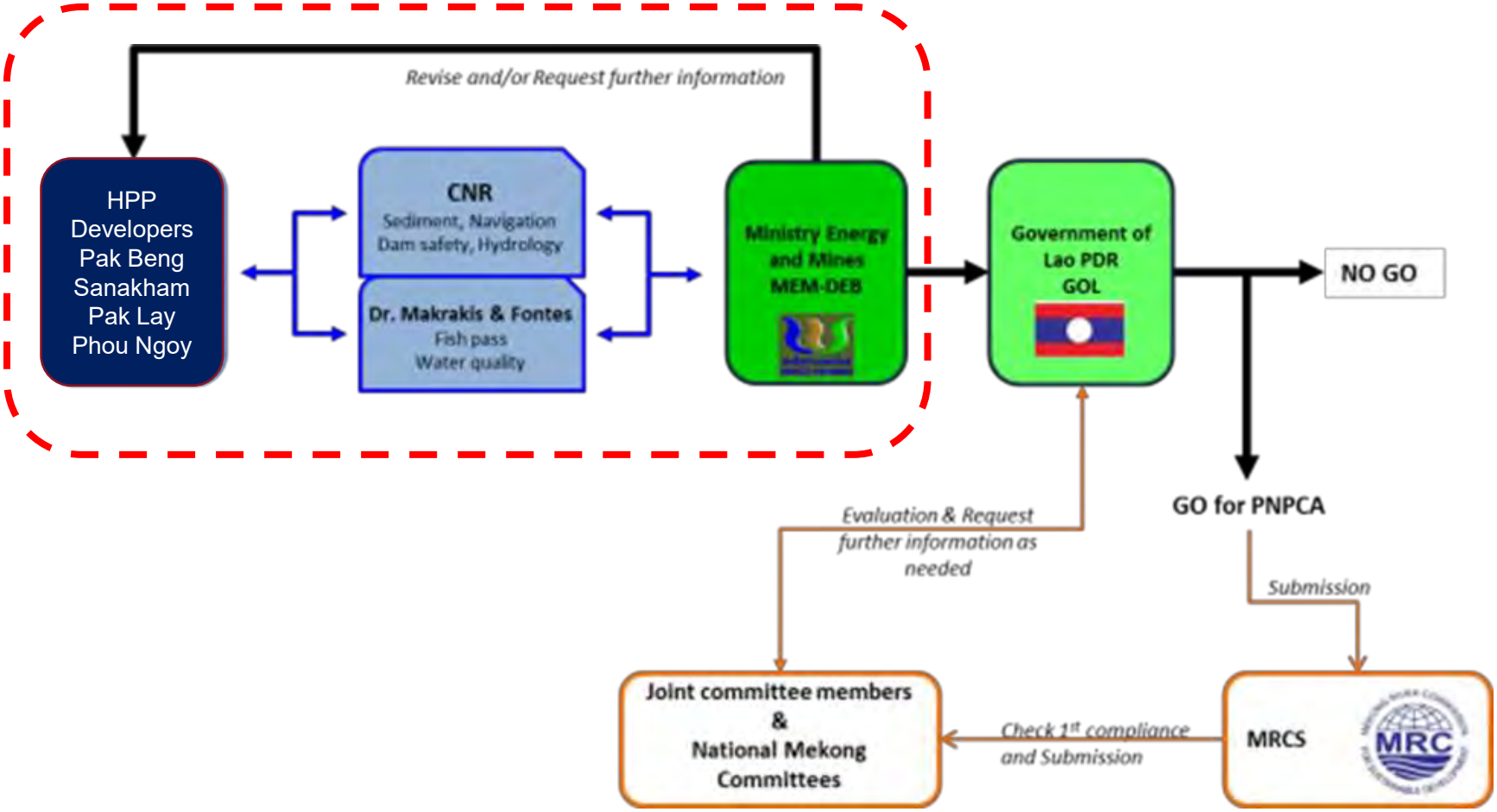
On 4 projects

- Pak Beng
- Pak Lay
- Sanakham
- Phou Ngoy

ENERGY AND MINES

Government of Lao PDR

Internal review at Lao PDR level before PNPCA



CNR as GoL Engineer on the Mekong mainstream

- Feasibility Study reviews of 4 Mekong mainstream HPP
- 4 issues: Hydrology, Dam safety, Navigation, Sediment transportation

ENERGY AND MINES

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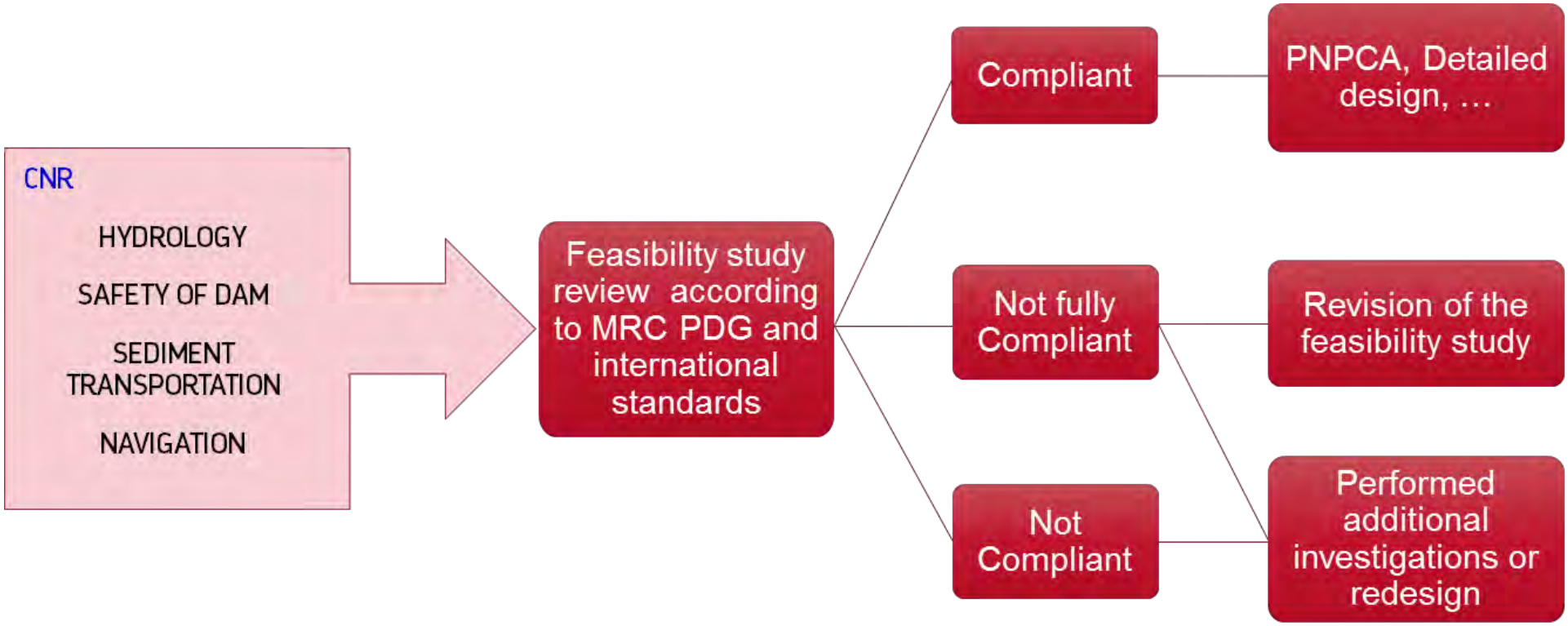
General Scope of Work



ENERGY AND MINES

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FS review: same driving principles as on the Rhone River

Reference to international standards

- MRC PDG (final version of August 31st, 2009)
- WB Operational Policy on safety of dams
- ICOLD Bulletins about safety of dams

On-site monitoring as a key for design improvement

- Generally a lack of data in the FS
- Need for accurate site specific data for design and demonstration of the efficiency of the technical solutions proposed by the developer
- Input data useful for both design phase and operation phase

Request of the documentation to be provided by the developer

- Reference to international standards (including PDG)
- Every management plan that is required must be delivered
- Consistent with existing regulation

Design, construction and operation must be given the same importance

- Developers and their design institutes are usually familiar with design and construction.
- Most of the time, there is a need to improve capacity regarding operation, operation preparation before COD and operation of run-of-river HPP in particular.

Sharing CNR extensive know-how about run-of-river HPP operation

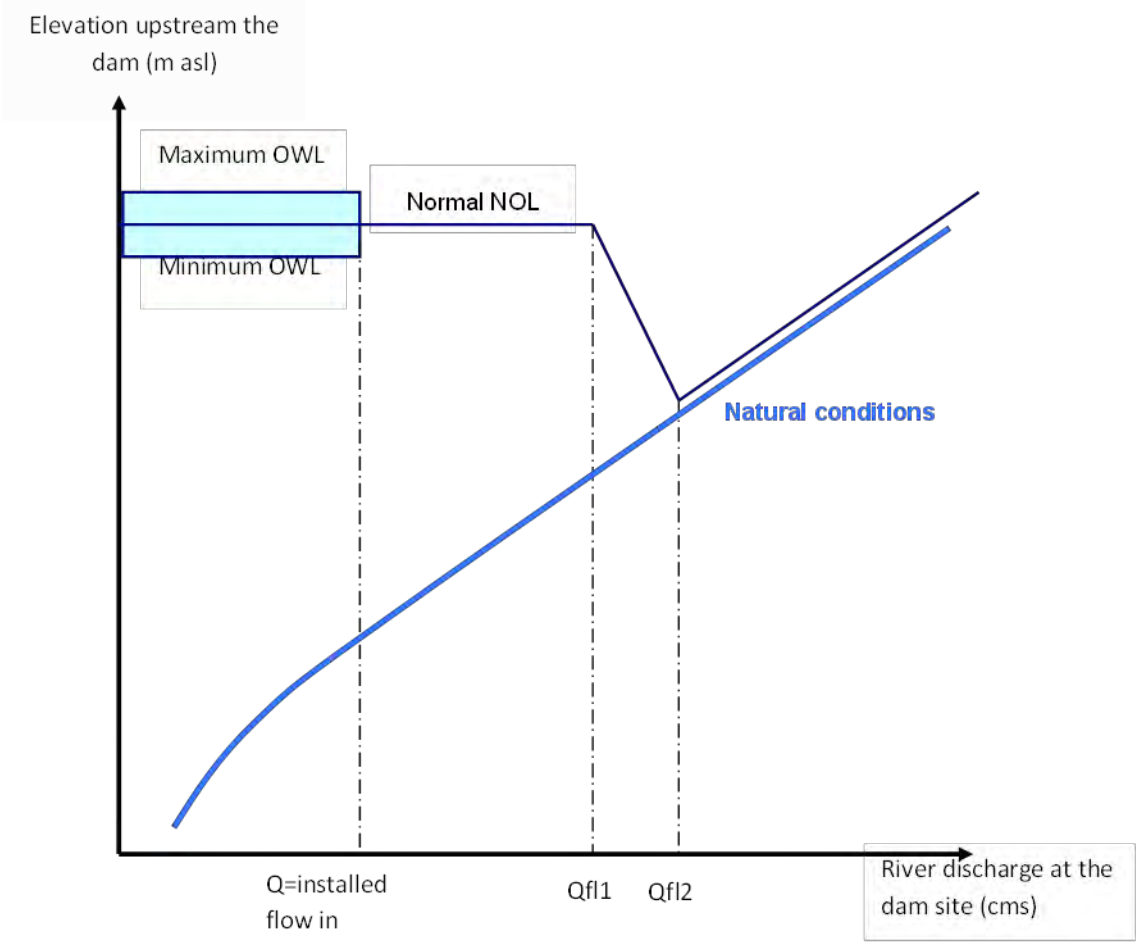
Run-of-river concept

- No storage
- No regulation capacity
- What is flowing in is flowing out

- Need to go back to natural flow conditions if all gates opened and power house turned off.
- In particular, need to go back to natural conditions in case of flood event.

- Operation pattern of the project is mandatory and must be consistent with run-of-river concept.

- Need for flow monitoring and forecasting



XAYABURI POWER
YOUR SENSE OF ENERGY

ENERGY AND MINES

Government of Lao PDR

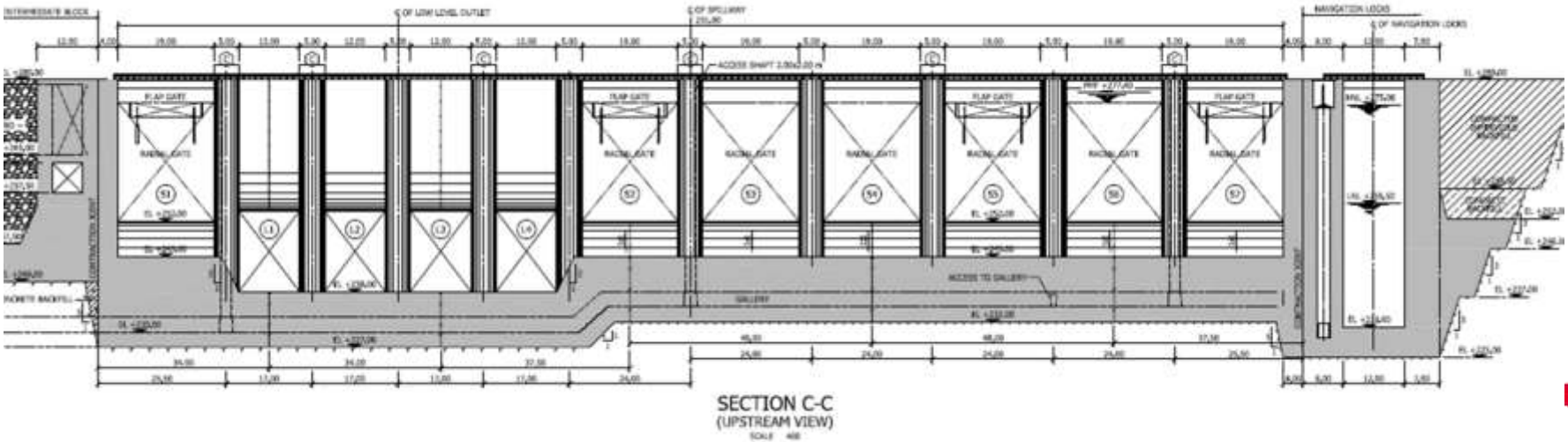
Contributions to Xayaburi HPP

Xayaburi as a benchmark

- Xayaburi design used as a reference
- Consistency of Mekong cascade design and operation

Main contributions to Xayaburi HPP

- Design improvement (LLO, navigation lock…)
- Sediment study from Chiang Saen to Vientiane
- O&M preparation
- Hydrometeorological Monitoring and Forecasting to optimize flow management and power production

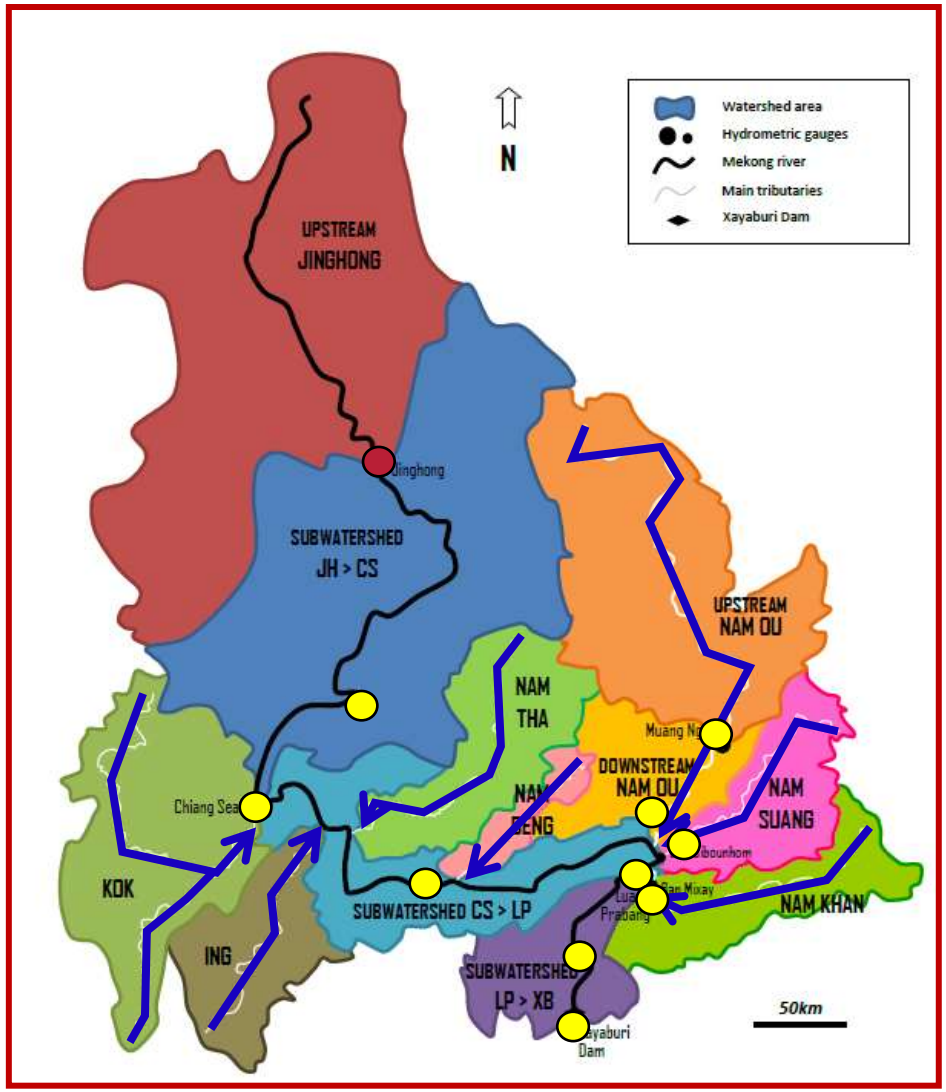


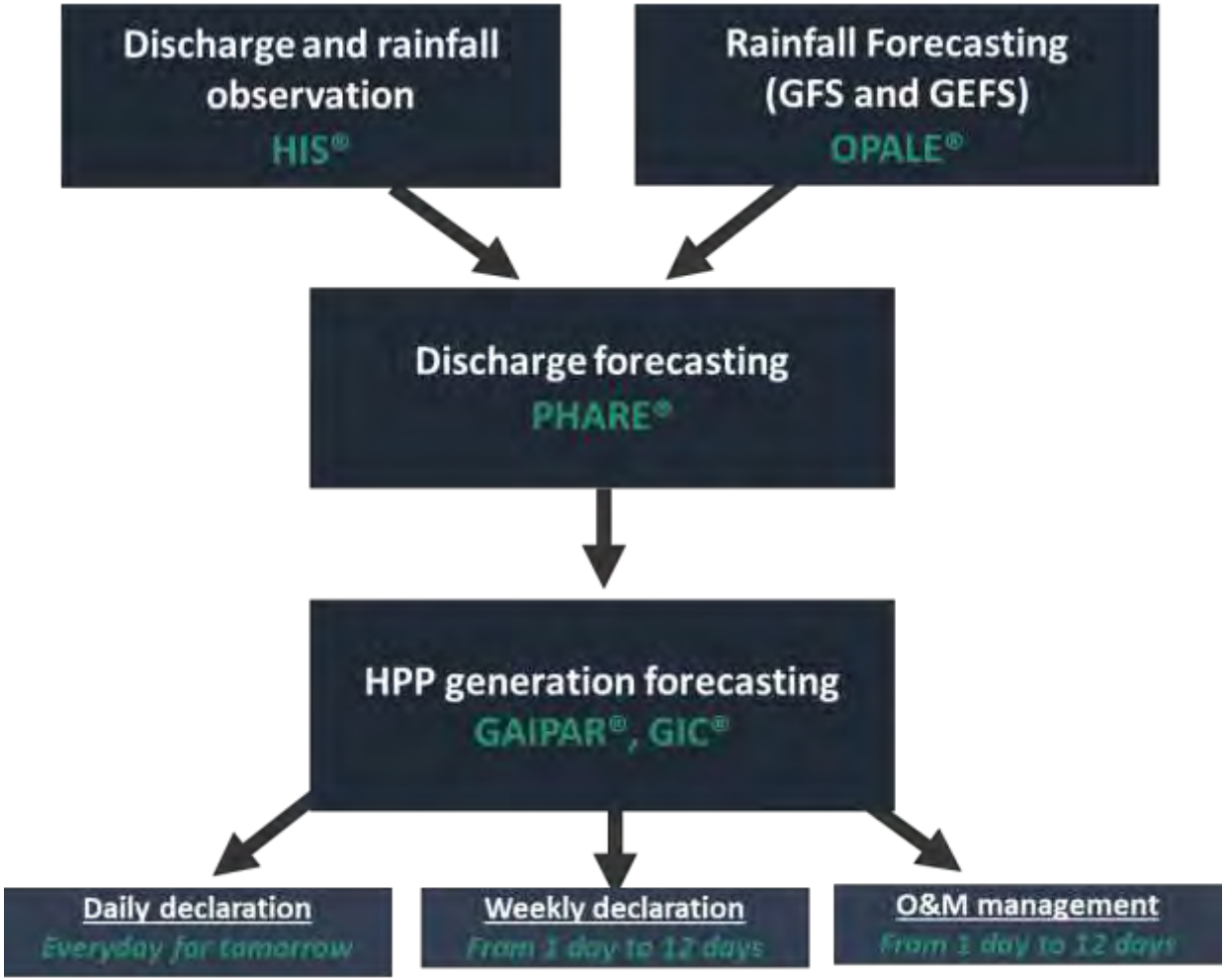
XAYABURI POWER
YOUR SENSE OF ENERGY

ENERGY AND MINES

Government of Lao PDR

Contributions to Xayaburi HPP: Hydrometeorological Monitoring and Forecasting System (HMFS)





Demonstrating Integrated Water Resources Management in the Hydropower Sector

Bridging the gap between IWRM and hydropower generation

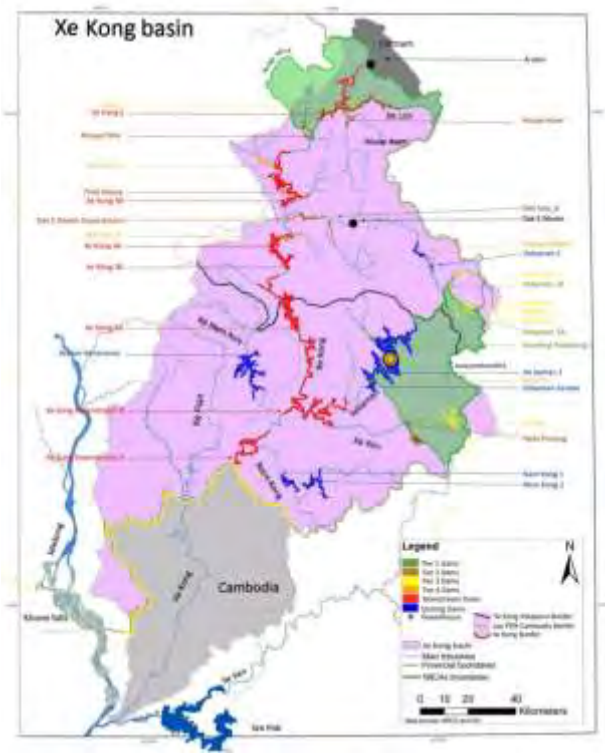
Optimization of Hydropower production integrating non power interests

Hydropower planning at the basin scale

Roadmaps for IWRM in the hydropower sector

2 demonstration basins: Nam Ou and Sekong

CNR, OIEau, IWMI and LJHC
CNR as Team Leader



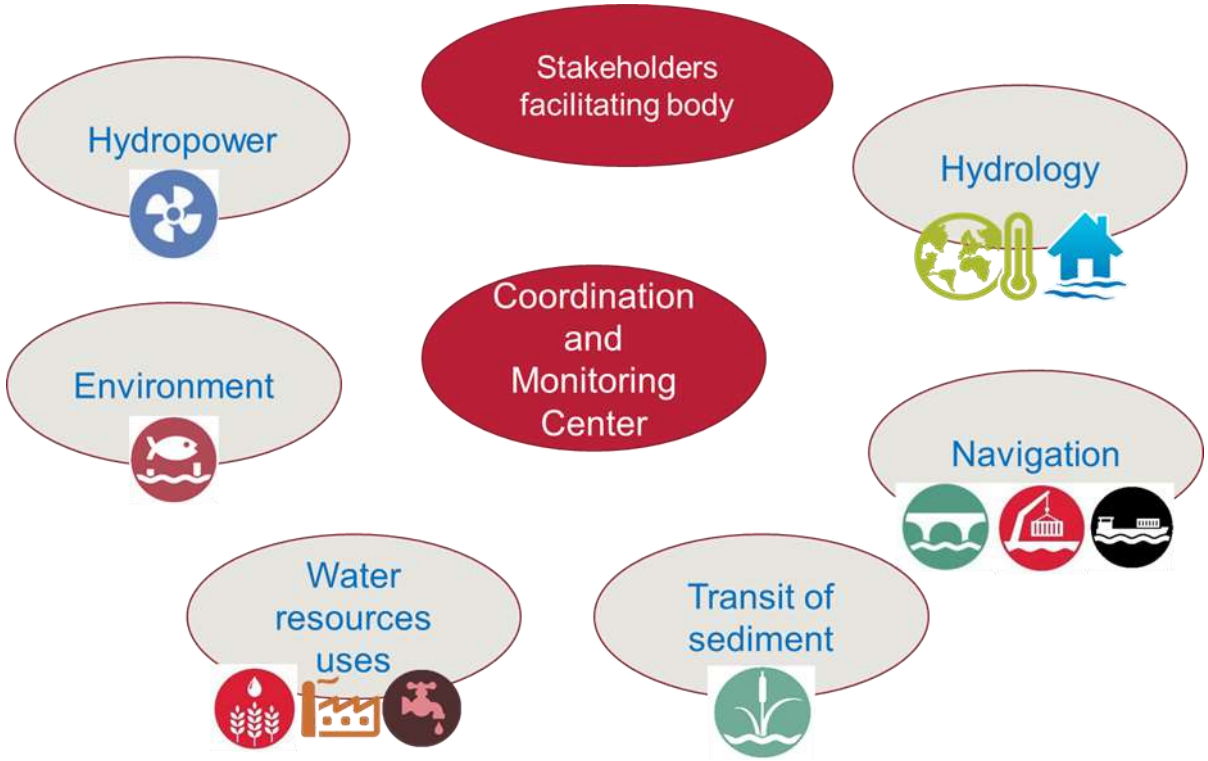
Need for operation coordination and control in Lao PDR

- FS for the development and implementation of a GoL state agency dedicated to the coordination and monitoring of the management of all the multipurpose HPPs implemented in Lao PDR
- Sub-objectives:

Coordination and Monitoring Center – CMC Sub-objectives	
# 1	Governance and capacity building
# 2	Dialogue and coordinated management
# 3	Water resources management and climate change
# 4	Environmental and social management
# 5	Dam management and safety

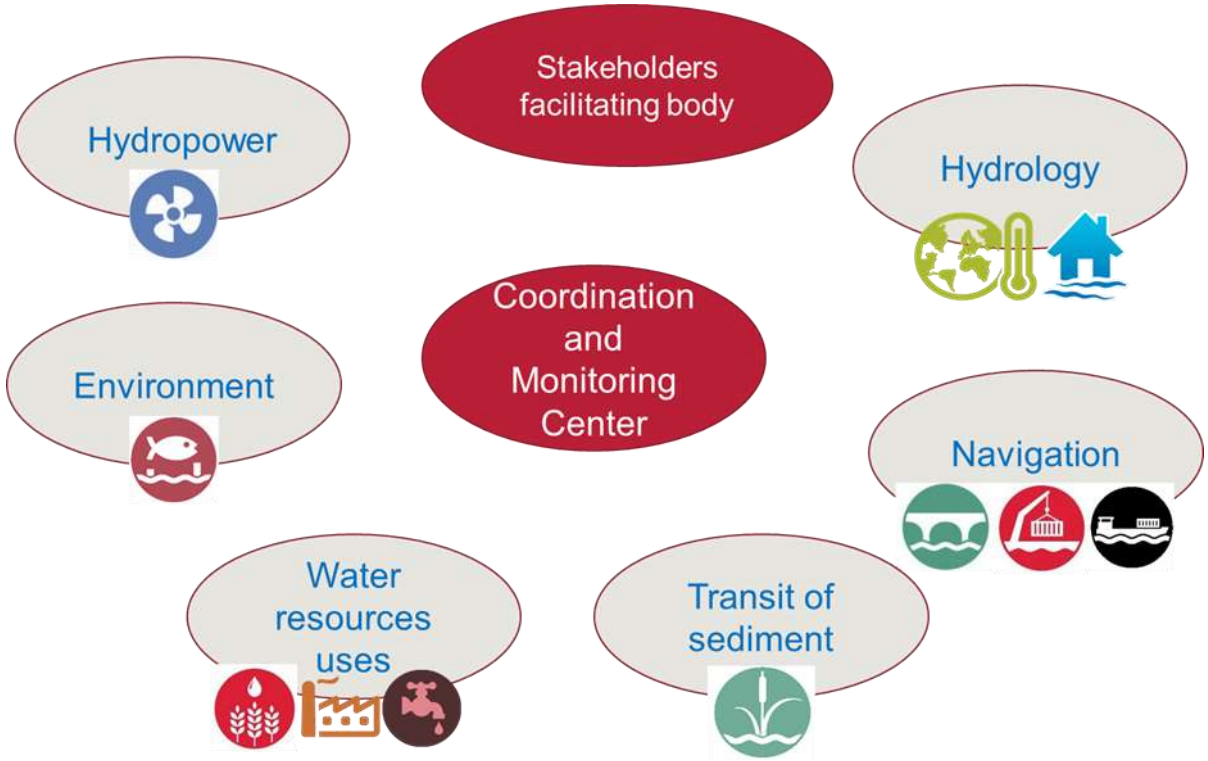
Need for operation coordination and control in Lao PDR

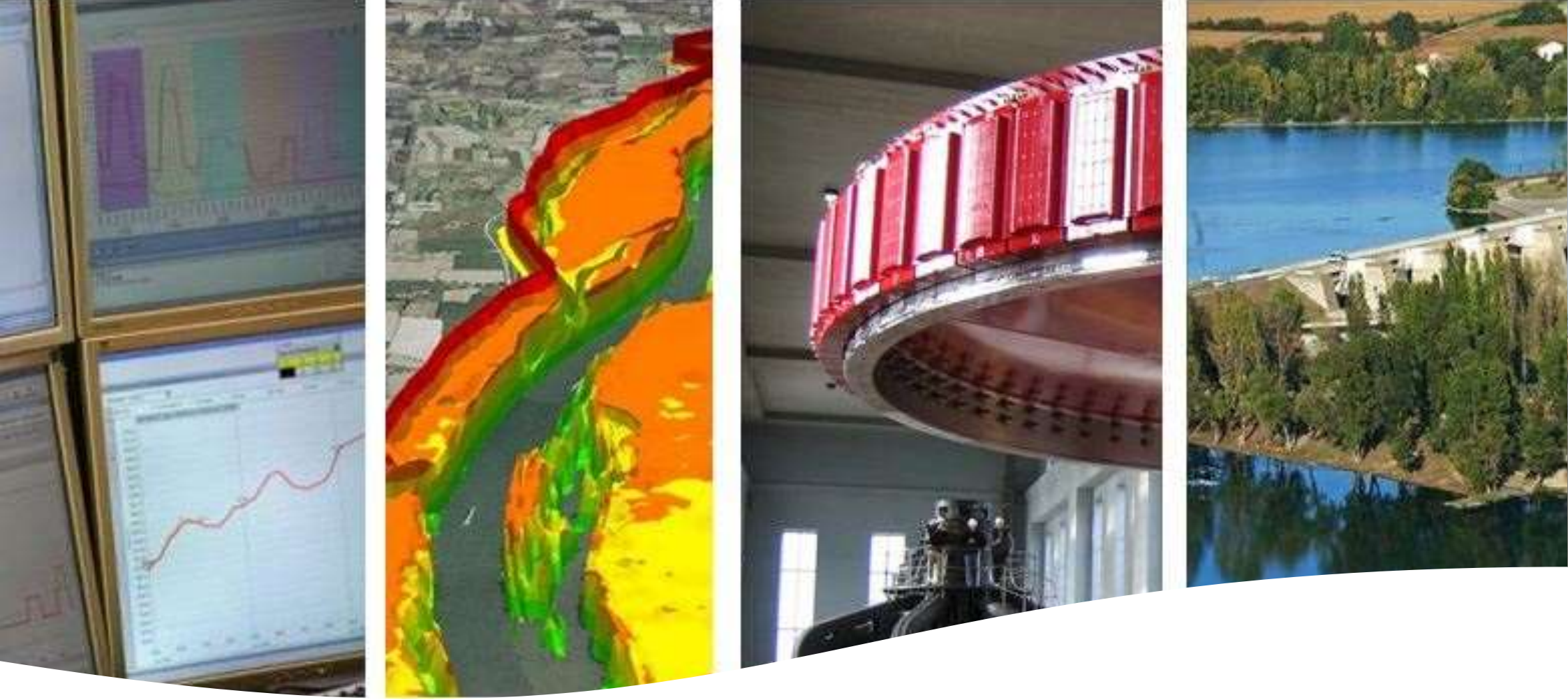
- FS for the development and implementation of a GoL state agency dedicated to the coordination and monitoring of the management of all the multipurpose HPPs implemented in Lao PDR
- Mekong River upstream Vientiane as a first step
- Core functions to address:
  - Integrated water resource management, incl. institutional issues, power and non-power water uses,
  - Safety: dam safety, coordination of flood management, early warning system, water quality, etc.
  - Continuity: sediment management, fish migration follow-up, inland navigation development, etc.



Need for operation coordination and control in Lao PDR

- FS for the development and implementation of a GoL state agency dedicated to the coordination and monitoring of the management of all the multipurpose HPPs implemented in Lao PDR
- Mekong River upstream Vientiane as a first step
- Key issues to deal with at FS stage:
  - Data sharing from upstream to downstream, including the main tributaries,
  - Coordination with operation in Lancang (all year long, every day, including daily flows and, if possible, flow programs…),
  - Coordination of O&M in the frame of existing Cascade from upstream to downstream,
  - …





CONCLUDING REMARKS

CONCLUDING REMARKS
CNR UNIQUE EXPERIENCE ABOUT MULTIPURPOSE BENEFITS OF RUN-OF-RIVER CASCADES

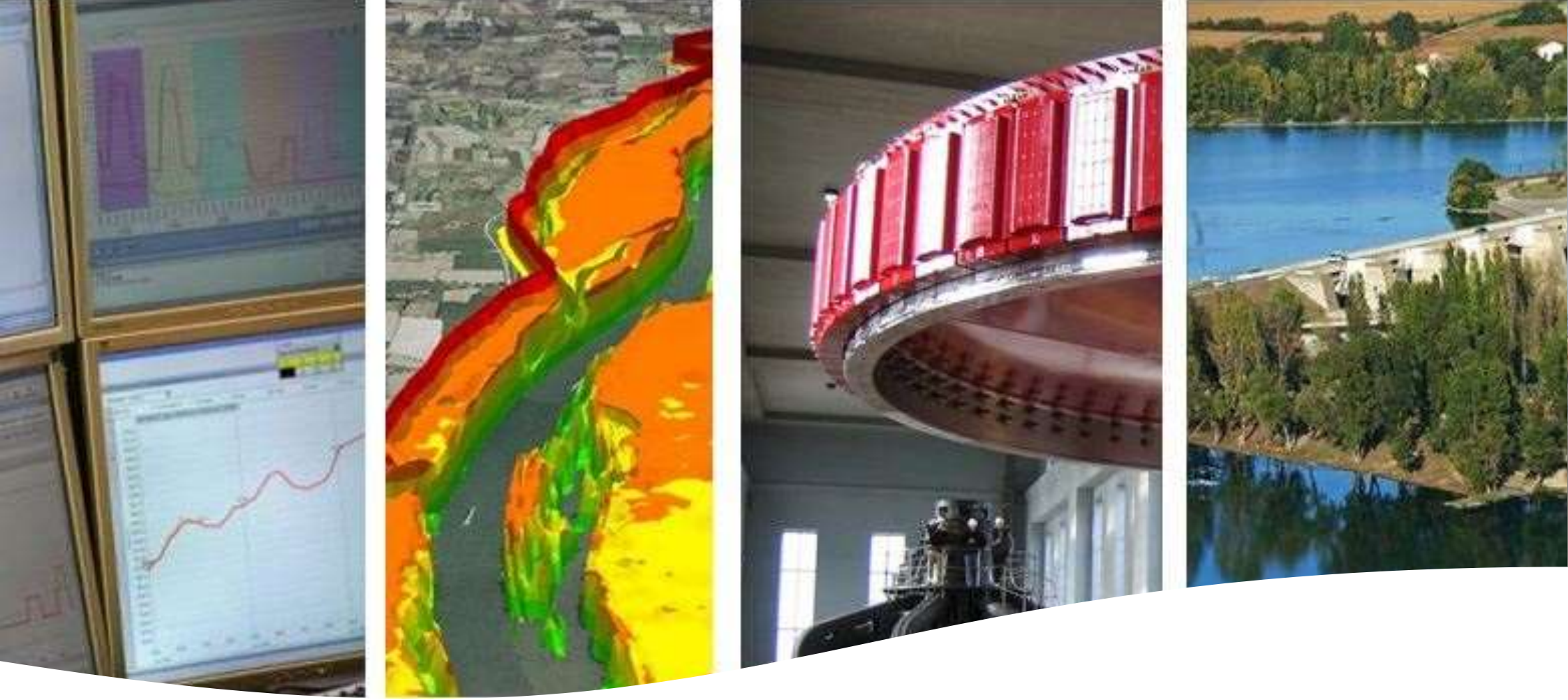
- **CNR, as designer, developer and operator of the multipurpose Rhone River cascade in France, has been supporting the Mekong sustainable development in the LMB for 25 years.**

- **Major issues at stakes while developing large rivers:**

  - Run-of-river production is a catalyst for development of large rivers (no storage and no regulation capacity) and an opportunity to develop non power water use:

  - River Cascade development needs consistency in the design from upstream to downstream and coordination of operation;

  - Integrated vision of a whole river is of paramount importance to implement best practices.



MRC VISIT PROGRAMME

MRC VISIT PROGRAMME
PRINCIPLES

- **Good balance between technical visits, presentations and social events**
- **Flexibility and adaptation**
- **Tight agenda but fruitful sharing**
- **Open discussions and visits**
- **Q&A any time**

MRC VISIT PROGRAMME
DAY 1 : JUNE 4TH

Date	Time	Activities	Location
04-juin	9h30	Hotel Pick-up	Bus
	10h00 - 10h30 10h30 – 10h45 10h45-11h45 11h45-12h	Welcome tea / coffee Welcome address and introduction of the delegation Presentation to CNR and relevant experience in the Mekong Basin Programme of the visit and expectation of the group	Salle du Conseil
	12h-13h30	Lunch (CNR)	Salle Nord-Sud
	13h30 – 14h30	Visit of CNR COCPIT (center dedicated to remote coordination, forecasting and control of CNR assets)	Salle du Conseil (15-20 min) puis COCPIT
	14h30 – 15h00	Transfer to CNR Laboratory	Bus
	15h – 16h	visit of CNR laboratory	CACOH
	16h	Back to hotel and free-time	Hotel
	18h	Welcome dinner by CEO for MRC delegation	To be recommended by CNR
	20h	Stay overnight in Lyon	Ibis Part Dieu

MRC VISIT PROGRAMME
DAY 2 : JUNE 5TH

Date	Time	Activities	Location
05-juin	8h	Departure to Genissiat dam	Bus
	10h – 12h30	Visit of Genissiat dam Introduction to sediment management : cross-boundary management of sediment between Switzerland and France	Genissiat
	12h30-14h	Lunch (CNR)	La table perdue
	14h-16h	Back to Lyon	Bus
	16h	Back to hotel and free-time	Hotel
	20h	Stay overnight in Lyon	Ibis Part Dieu

MRC VISIT PROGRAMME
DAY 3 : JUNE 6TH

Date	Time	Activities	Location
06-juin	8h	Departure	Bus
	10h – 11h	Visit of Rochemaure small HPP and fish pass	Rochemaure
	11h – 13h00	Transfer and visit of Bollene multipurpose HPP	Bollène
	13h – 14h30	Lunch (CNR)	Les Tourrelles Lamotte du Rhône
	PM	Visit of a Vineyard Appointment with Avignon Deputy Mayor Free-time to visit Avignon	Avignon City
	20h	Stay overnight in Avignon	Ibis and Mercure Hotel

MRC VISIT PROGRAMME
DAY 4 : JUNE 7TH

Date	Time	Activities	Location
07-juin	8h	Back to Lyon	Bus
	9h30-10h30	Visit of CNR remote control center for navigation	CGN
	10h30 – 12h	Visit of Logis-Neuf and Pouzin	Logis Neuf
	12h-15h	Lunch (CNR) and way back to Lyon	Mas de Bérianne
	15h-18h	Free time	Hotel
	18h	Lessons learnt, conluding remarks and cocktail (CNR)	Lyon Metropole
	21h	Stay overnight in Lyon	Ibis Part Dieu

ຂອບໃຈສຳລັບຄວາມສົນໃຈຂອງທ່ານ

ขอบคุณสำหรับความสนใจของคุณ

សូមអរគុណចំពោះការយកចិត្តទុកដាក់របស់អ្នក

Cám ơn vì sự quan tâm của bạn

Thank you for your attention

Merci pour votre attention

CNR ENGINEERING

Annex 4

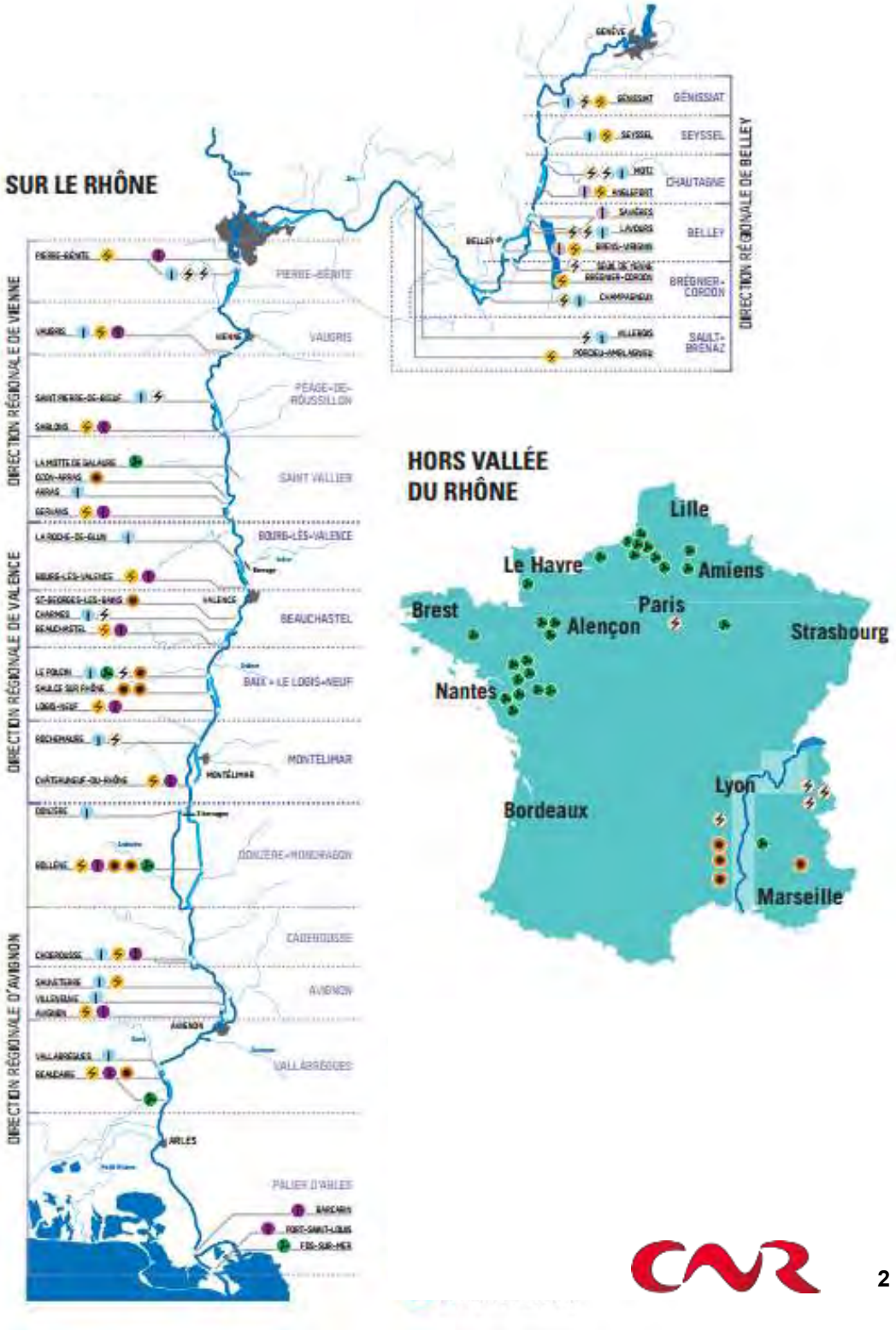
MRCS-CNR
ENERGY DEPARTMENT

JUNE 6TH 2018

INSTALLATIONS & ORGANISATION

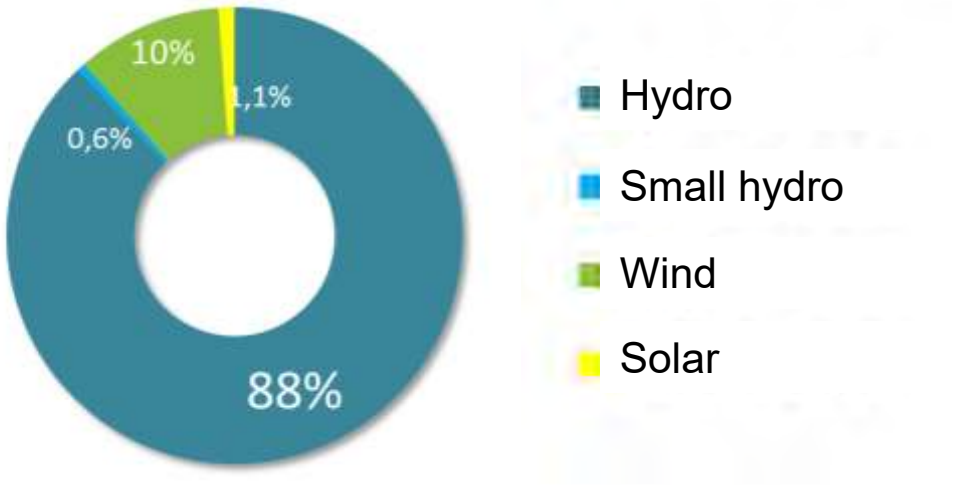
Patrimony

19	Hydropower plants
37	Wind farms
17	Solar energy stations
21	SHPP
14	Wide gauge locks
330 km	Wide gauge navigable waterway
29	Industrial and port sites



CNR INSTALLED CAPACITY

19+14	Hydropower plants + SHPP (Rhône)	3 016 MW → 15 TWh
37	Wind farms	557MW
17	Solar energy stations	61MWc
7	SHPP not on the Rhône	20 MW



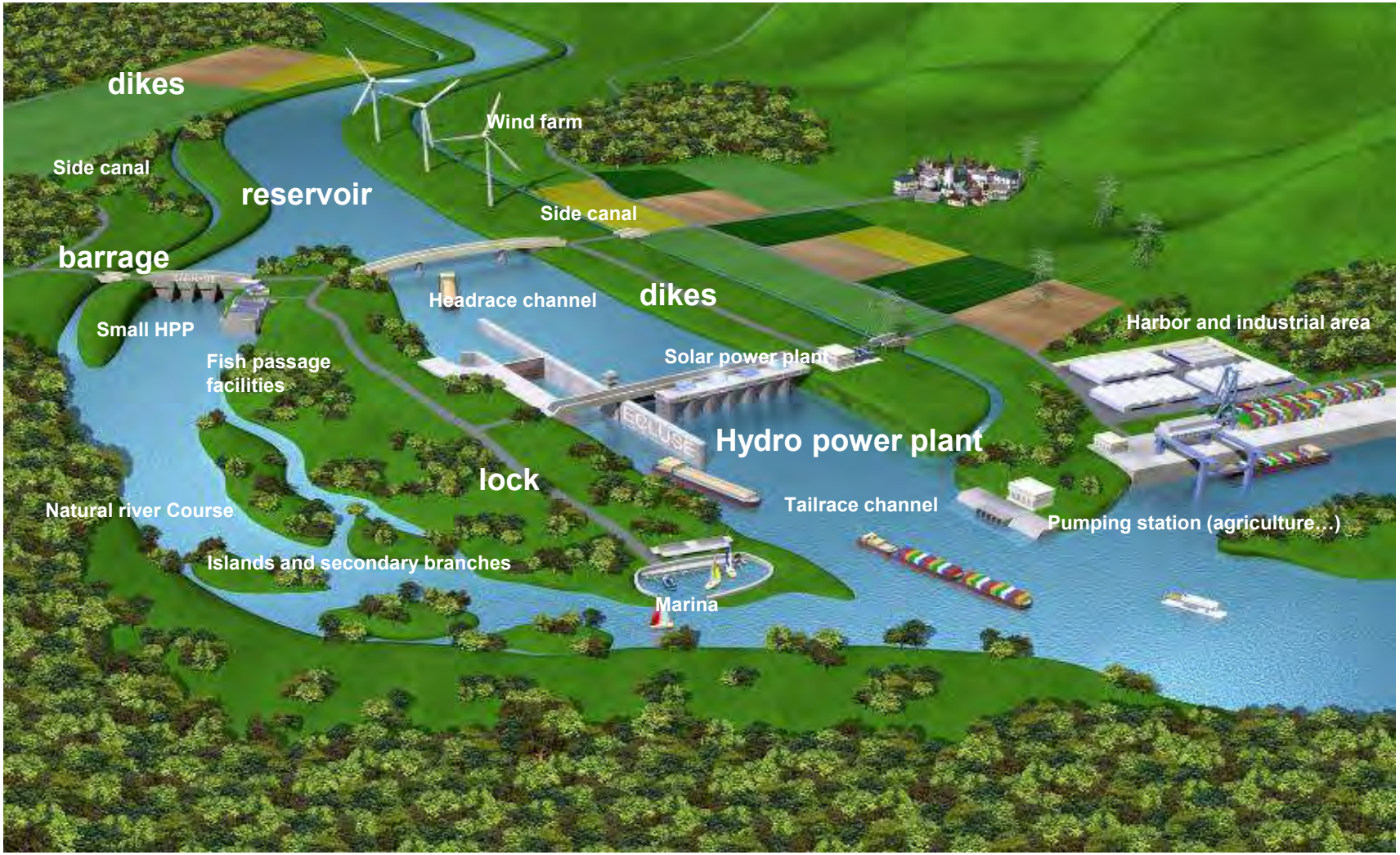
→ **THIS RES PORTFOLIO WILL REQUIRE, at CNR's scale:**

- Good quality forecasts
- Flexibility to match the grid demand
- Flexibility to balance intermittency

A STANDARD HYDROPOWER SCHEME

Hydropower

- **Hazards: hydrometeorological fluctuations and management of upstream development schemes :** Swiss Rhône, Fier, Ain, Isère
- **Storage capacity upstream**



Operation under severe constraints : no enclosure, navigation, irrigation, nuclear safety

→ **Very strict regulatory framework**

Energy management

Centralised management at the head office, in Lyon

Goal : Optimising production value, while controling hydraulic safety

Structures management

- Expertise in **hydraulic safety and security**
- Expertise in **floods management**
- **Awareness campaign about risks** linked to a rise in waterlevels
- Expertise in **maintenance** : **100 M€ / y** dedicated to maintenance of structures
- Local management in **Regional Divisions**

AN EXPERT IN FLUCTUATING ENERGY MANAGEMENT

Production with low storage capacity…

Expertise in managing the fluctuations of intermittent renewable energie

Adressing 2 main **hazards**

Prices

Hedging with long-term contracts

Aim : Ensure predictability of turnover

Production

Short term management of the open position of production

- Intra-day management of variations
- Optimization

EXPERTISE IN INTERMITTENT RENEWABLE ENERGIES MANAGEMENT – HEDGING LONG TERM

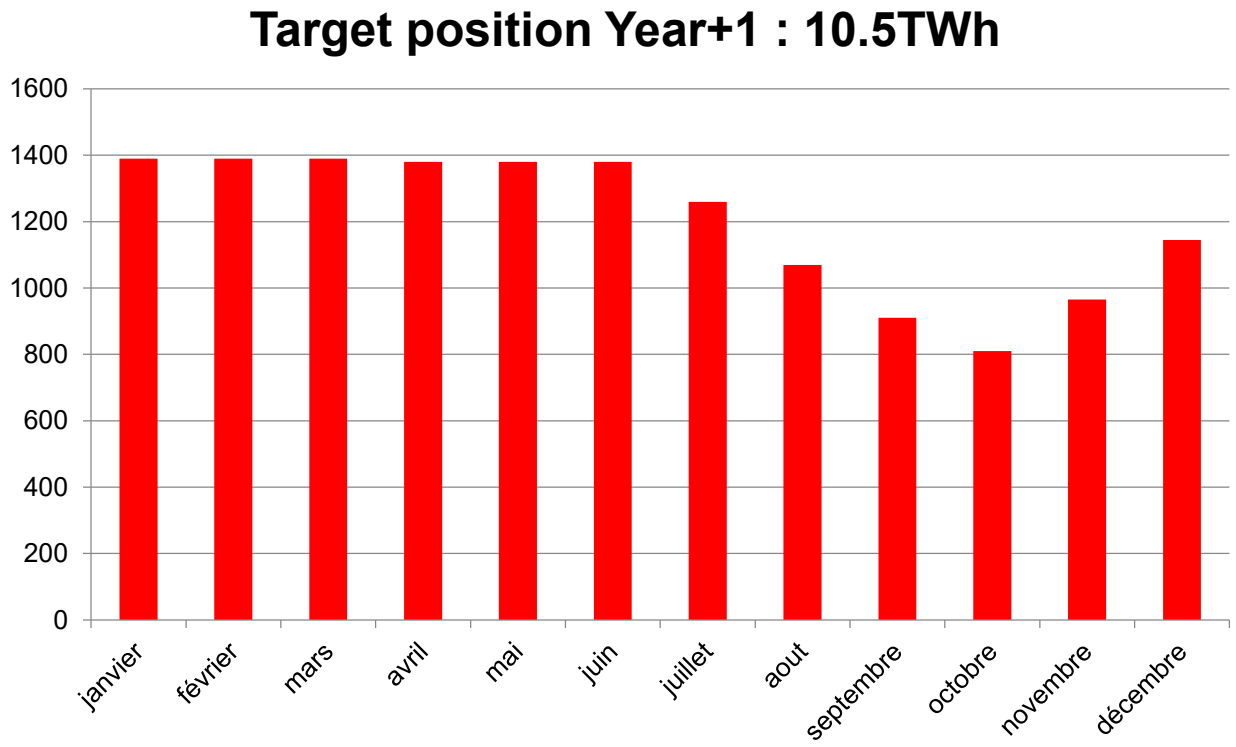
Electricity is the most volatile commodity. In the last 10 years, the hourly price has been fluctuating between -200 et +3000€/MWh.

Sell in advance permit to

1- Secure against a price drop

2- Limit the scattering of the turn over

EXPERTISE IN INTERMITTENT RENEWABLE ENERGIES MANAGEMENT – HEDGING LONG TERM



975MW of yearly contracts from jan Y-3 to dec Y-1
Then,
Q1 + 415MW, Q2 + 405MW et Q3 +105MW

During the year, monthly contracts in Q3 and Q4 to adapt the position with the statistics of the production

EXPERTISE IN INTERMITTENT RENEWABLE ENERGIES MANAGEMENT – SHORT TERM ORGANISATION

CNR System

Anticipation & **Reaction**

J-4 … J-2 | J-1 | J

Meteo / Hydro forecasts

Production program

Sales on markets

Upstream hydro manager

Remote supervision / Monitoring of assets

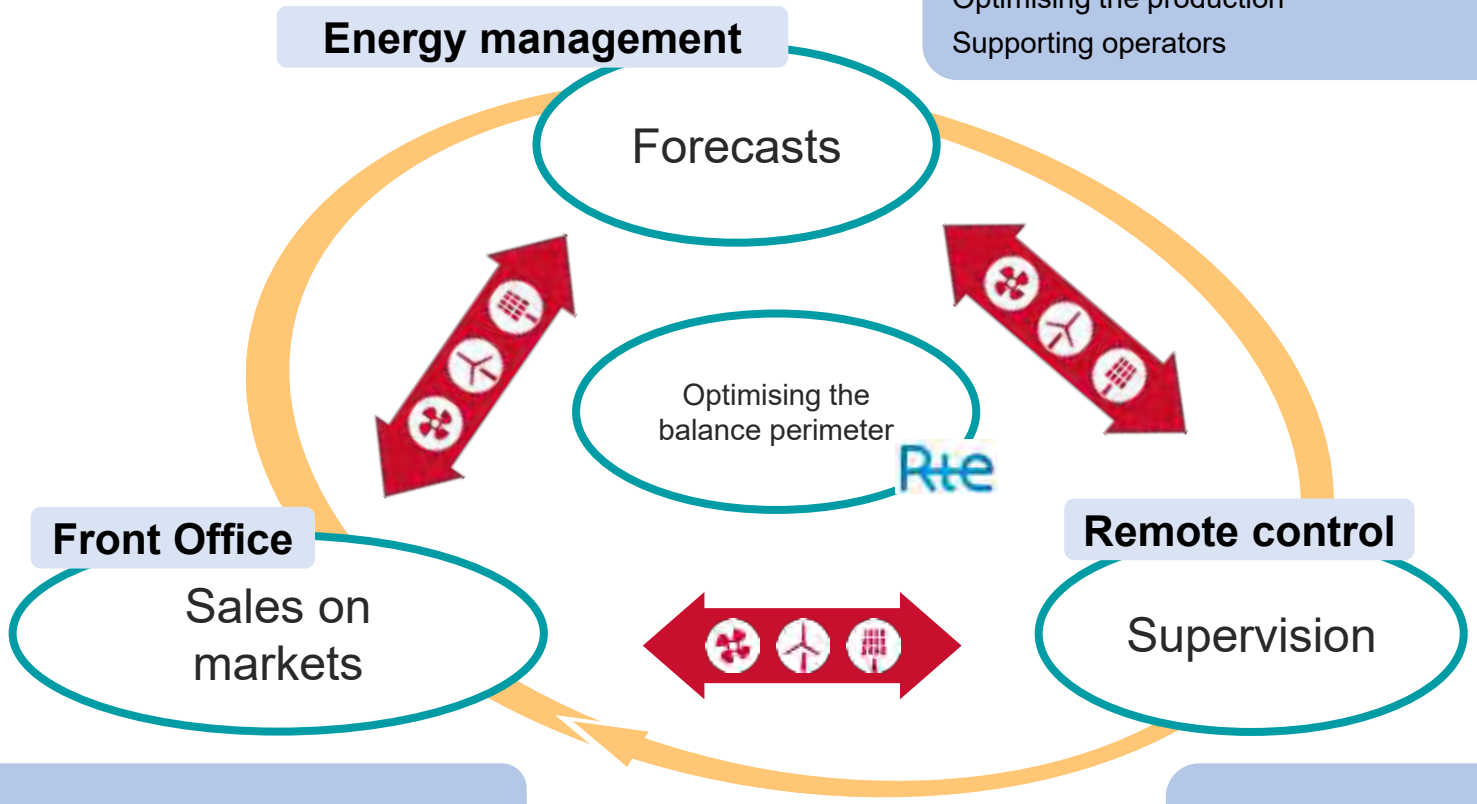
VARIATION = Penalty

Real-time correction of variances → Inertia

Balancing of Purchases / Sales → Volume / Liquidity

CNR'S SPECIFICITY

Hydrometeorological forecasts
Managing facility availability
Optimising the production
Supporting operators

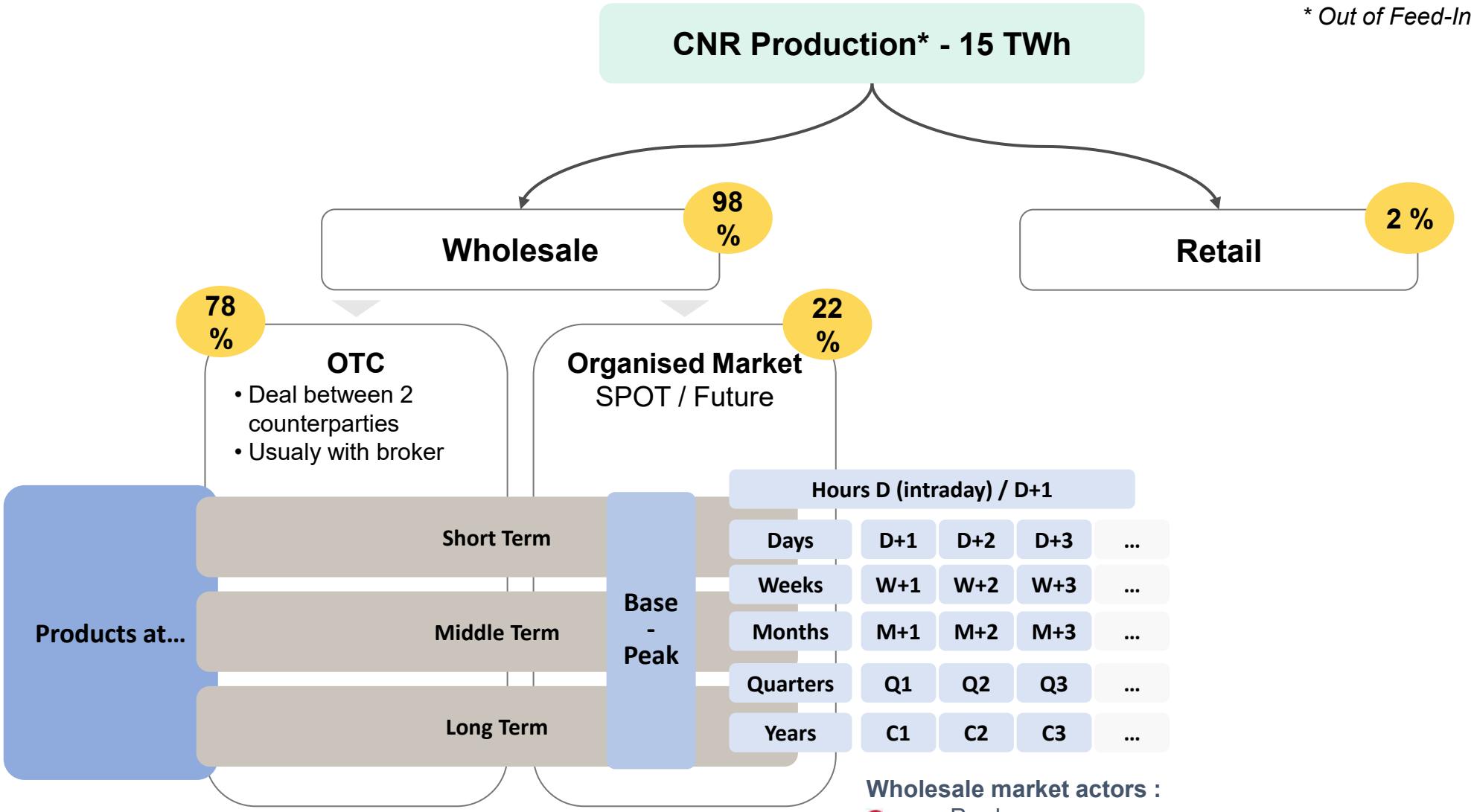


Access to markets
Optimising profits from production

Live supervision of plants
Live balancing according to facility status
Dialogue with local operators

ENERGY SALES BY CNR

** Out of Feed-In Tariff*



Wholesale market actors :

- Producers
- Suppliers
- Invest banks
- Large industrials
- Networks

Base : every hours
Peak : from 8 AM to 8 PM – working days

THE FORECAST NEEDS

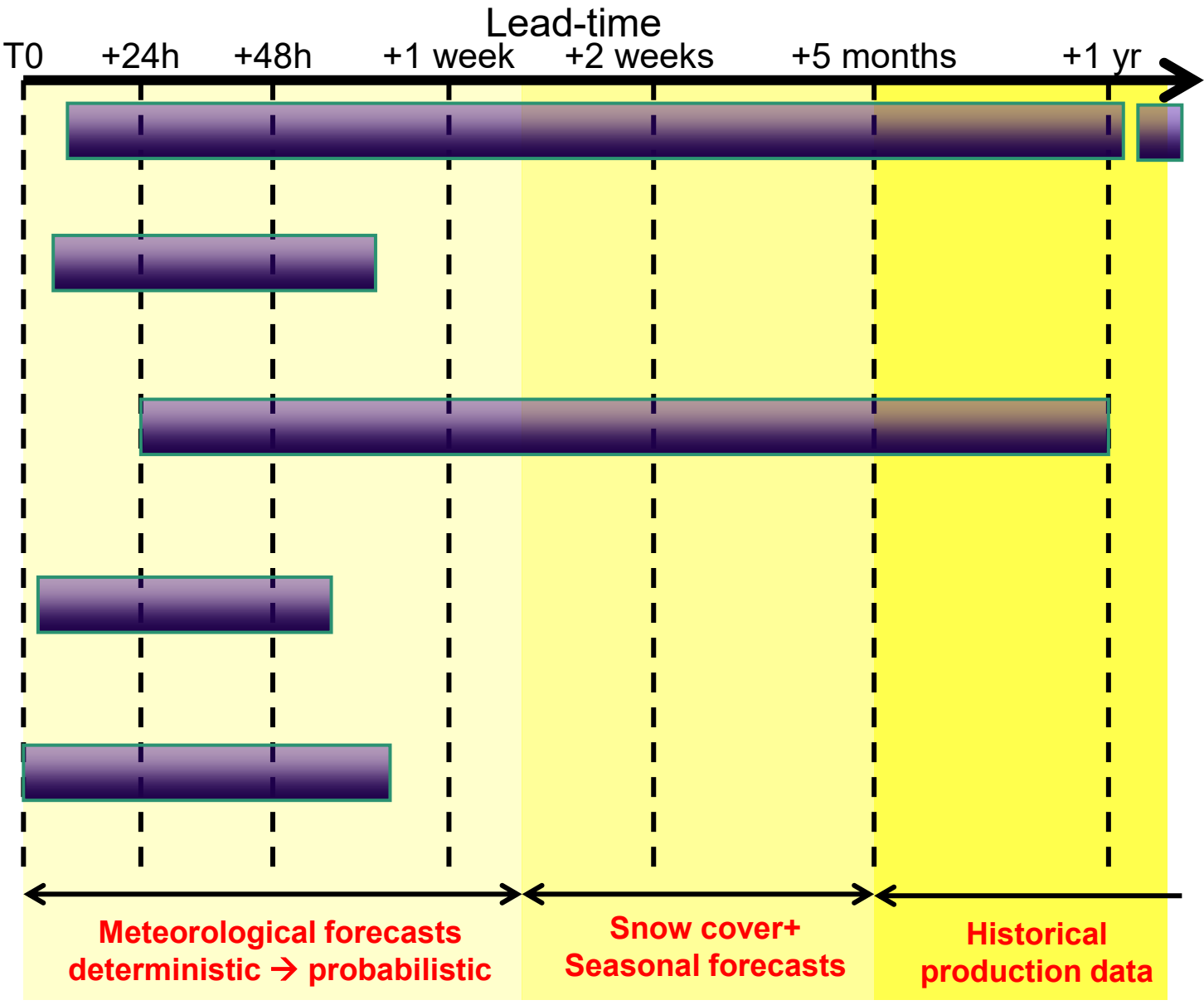
Sell the energy on the wholesale market

Production optimization, navigation information

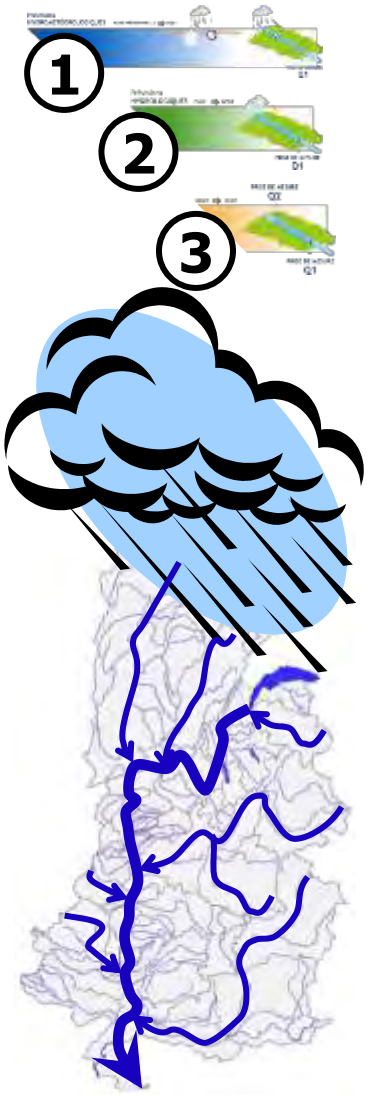
Operation & maintenance optimization

TSO requirements

Hydraulic safety: flood forecasting



CNR HYDRO-METEOROLOGICAL FORECASTING TOOLS



Observations

Observation network
METEO FRANCE

Weather radar
AEGIR CNR

Hydrometric network
CNR

Forecasts

NWP forecasts
METEO FRANCE
NCEP
ECMWF

Analog rainfall forecasting
OPALE CNR

Snowmelt
Flocon CNR

HYDROMET CNR
Data-base

Observed runoff

Unavailability of production facilities

Constraints

Optimization

1 Rainfall scenario construction
OPALE CNR
Rainfall scenario

Expertise

2 Rainfall / Runoff modeling
PHARE CNR
Hydrological scenario

Expertise

3 Hydraulic propagation
GAIPAR
PUMA CNR

Flood forecasting by numerical hydraulic modelling
CRUE CNR

Runoff forecasts

Production programs

Water level forecasts

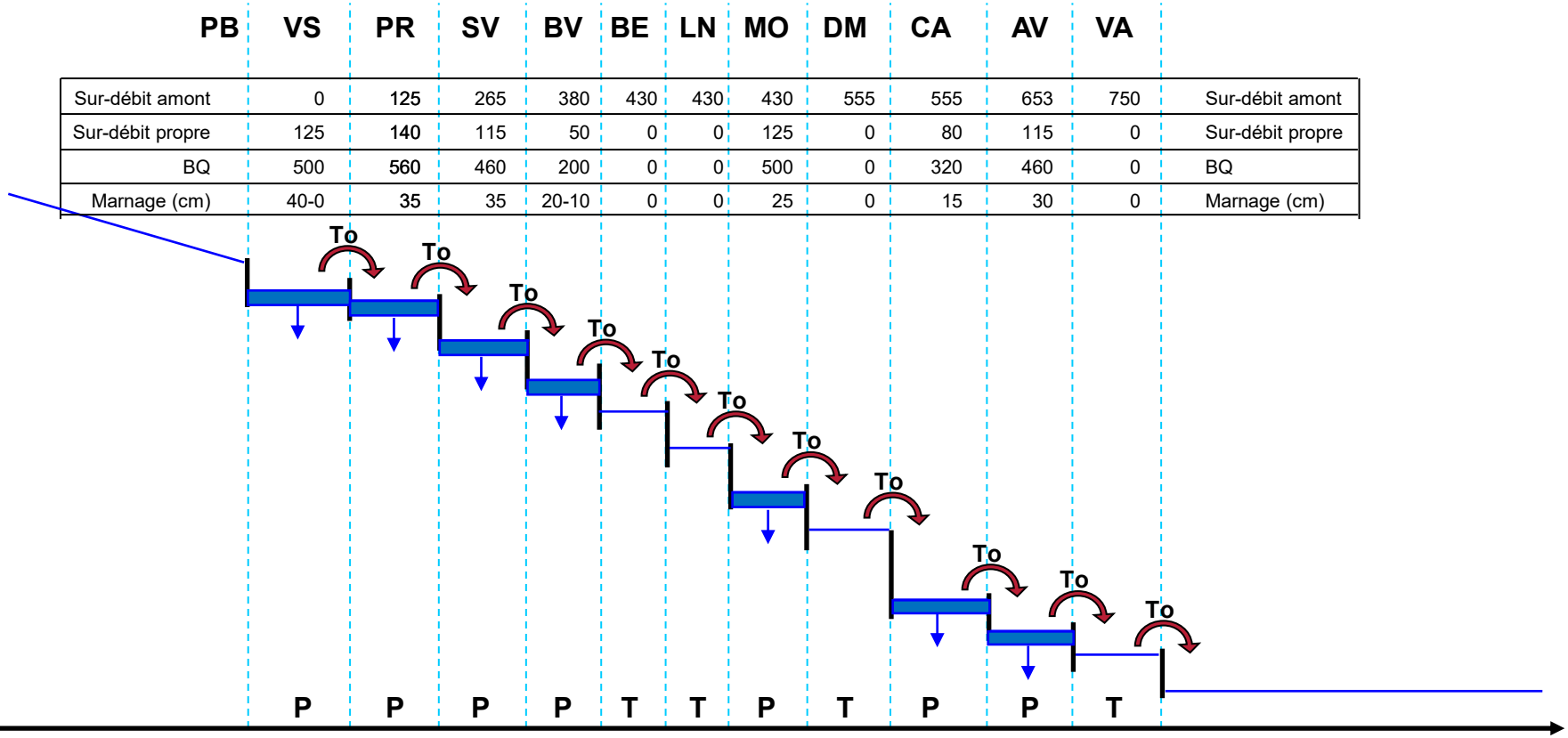
Discharge forecasts

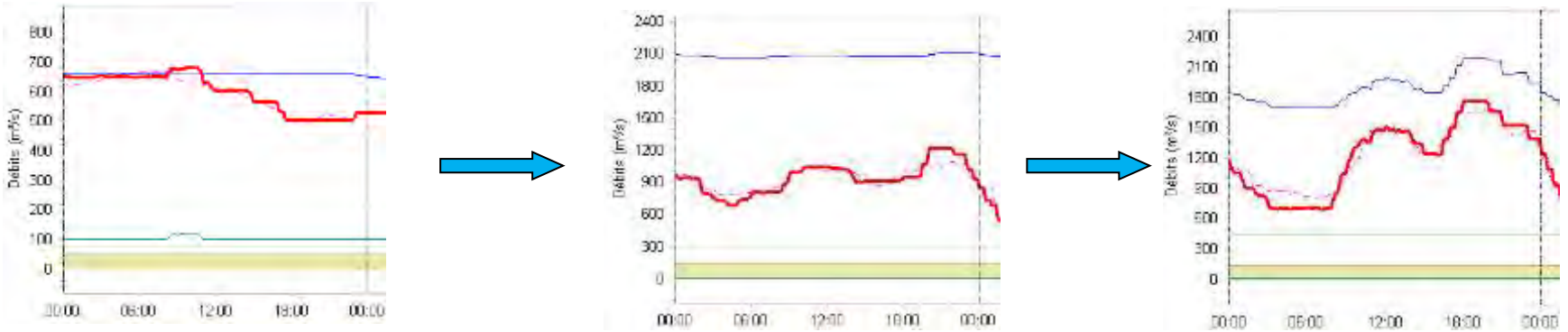
ACCURACY: < 3%

ENERGETIC LOCKAGES (DAILY HYDROPEAKING) TO FIT TO THE HOURLY PRICE

VALUATION OF THE RIVER FLEXIBILITY

	PB	VS	PR	SV	BV	BE	LN	MO	DM	CA	AV	VA	
Sur-débit amont		0	125	265	380	430	430	430	555	555	653	750	Sur-débit amont
Sur-débit propre		125	140	115	50	0	0	125	0	80	115	0	Sur-débit propre
BQ		500	560	460	200	0	0	500	0	320	460	0	BQ
Marnage (cm)		40-0	35	35	20-10	0	0	25	0	15	30	0	Marnage (cm)





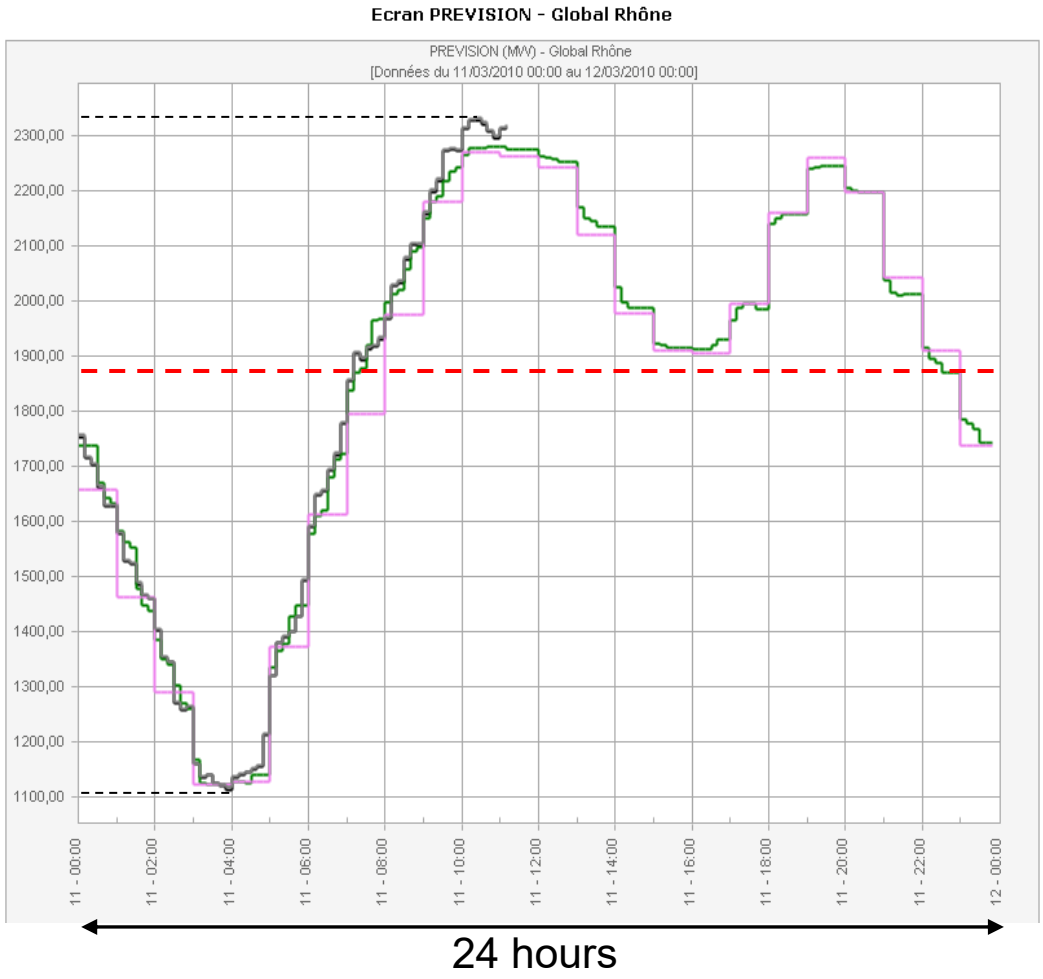
ENERGETIC LOCKAGES (DAILY HYDROPEAKING) TO FIT TO THE HOURLY PRICE

VALUATION OF THE RIVER FLEXIBILITY

2300 MW

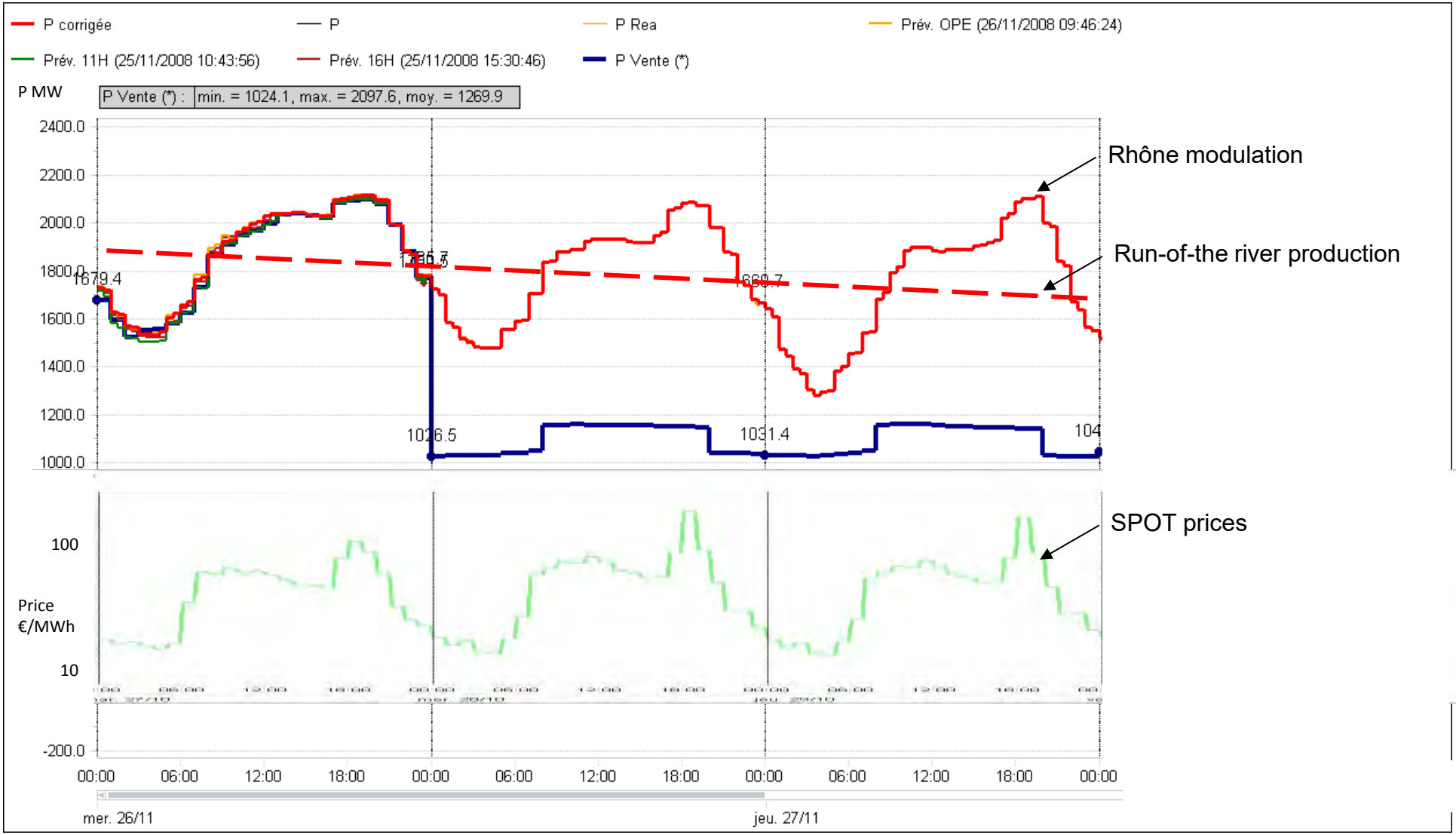
Average Power : 1875 MW

1100 MW



ENERGETIC LOCKAGES (DAILY HYDROPEAKING) TO FIT TO THE HOURLY PRICE

VALUATION OF THE RIVER FLEXIBILITY



L’énergie au cœur des territoires

cnr.tm.fr

Annex 5

TRANSBOUNDARY AND COOPERATIVE MANAGEMENT OF SEDIMENT FLUXES IN REGULATED RIVERS

Rhône River case study

Mekong River Commission exchange visit

Christophe PETEUIL

June 6th 2018

L'énergie au cœur des territoires

CONTENT

CONTEXT

Specificities of Rhone River Basin

- Transboundary basin
- Multi-purposes developments on mainstream (CNR)
- Several dam operators in the basin
  - CNR on mainstream
  - Others on tributaries & Swiss Rhône

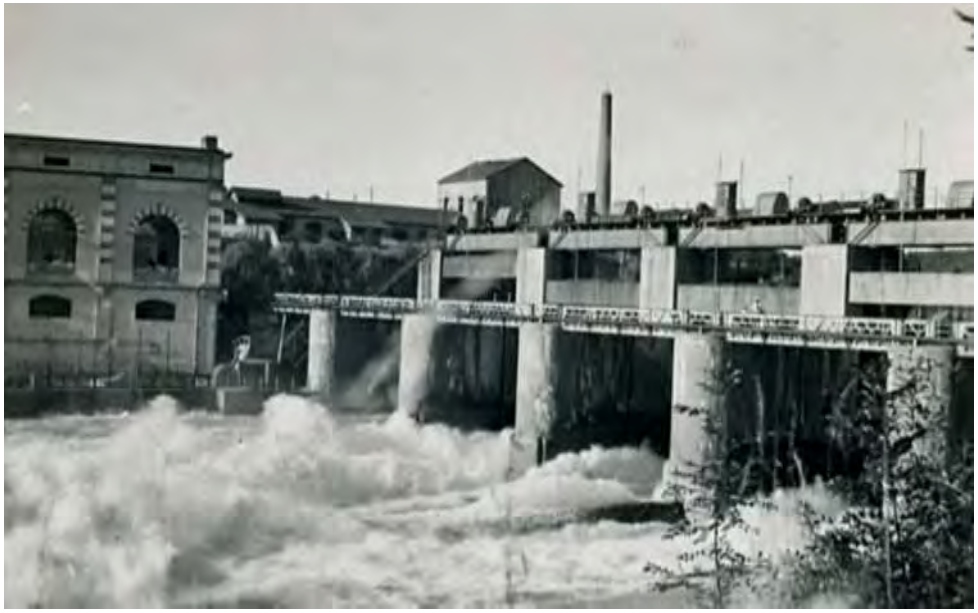
CONTEXT

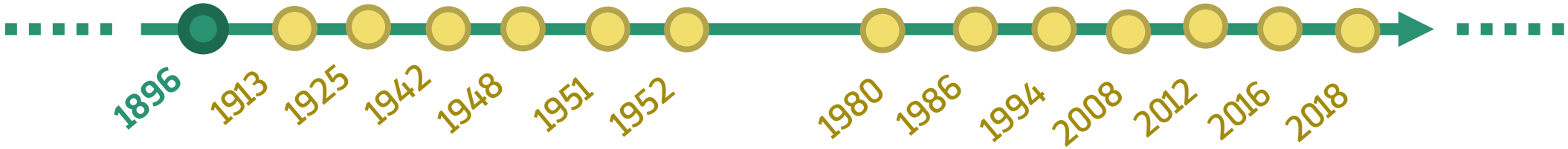
Main sediment-related issues at stake in the basin

- Human activities
  - Flood safety (extra-flood hazards due to bed aggradation…)
  - Water resource (effect of fines on drinking water quality…)
  - Leisure (fishing, bathing water quality, navigation safety…)
- Agriculture
  - Water resource (intakes and wellfields clogging…)
- Environment
  - Aquatic life protection (lethal effects of fines excess…)…
  - Habitats quality and diversity (bed clogging by fine deposits…)
  - Sediment continuity (possible disruption in reservoirs…)…
- Industry
  - Nuclear power generation (cooling system clogging)
  - Hydro power generation (water intake clogging, loss of storage capacity)
  - Dam safety (overload on structures, spillways obstruction …)
  - Navigation safety (channel obstruction by deposits…)…

Historical timeline

- Completion of Chèvres dam & hydropower plant on Swiss Rhône
- Sedimentation processes observed in the reservoir

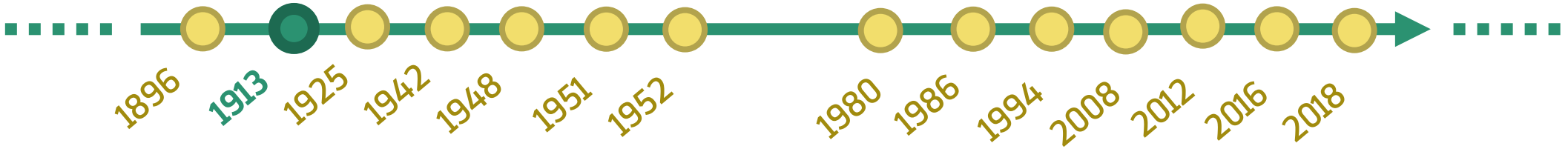




RHÔNE RIVER SEDIMENT MANAGEMENT

Historical timeline

- 1st flushing event organized by Swiss operators on the Rhône River at Chèvre reservoir
- Required to prevent extra-flood hazards in Geneva due to bed-aggradation induced by reservoir sedimentation

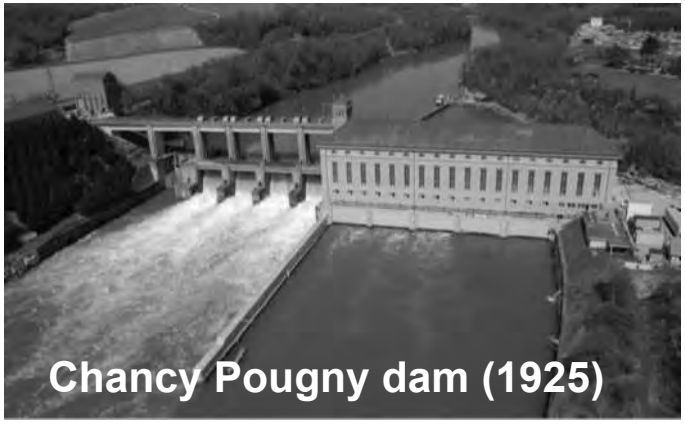


URR

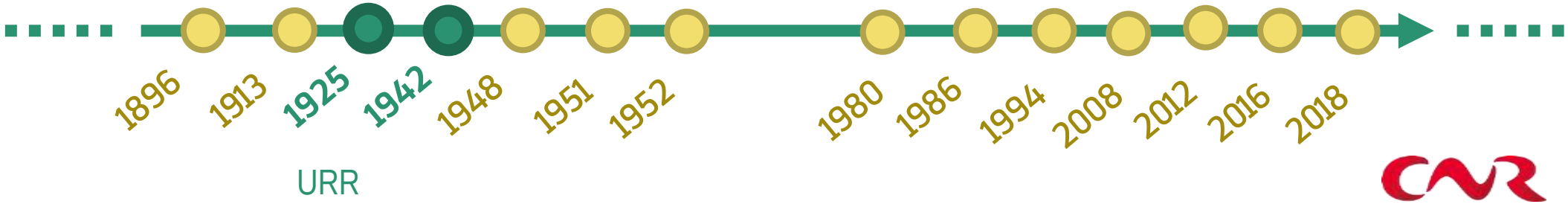
RHÔNE RIVER SEDIMENT MANAGEMENT

Historical timeline

- Completion of Chancy-Pougny and Verbois dams on Swiss Rhône
- Deposit remobilization ensured by full drawdown flushing of reservoir supported by an artificial flood released from Lake Geneva
- Events organized every 3 years by Swiss operators
- Suspended Sediment Concentration (SSC) released from dams reaching up to 40 g/l


Chancy Pougny dam (1925)

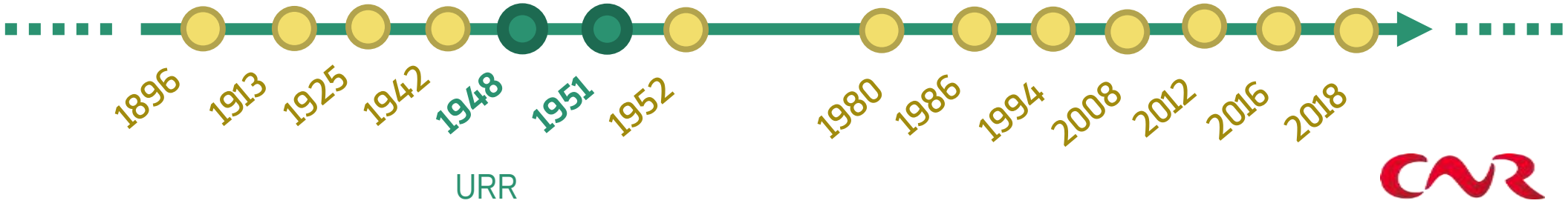

Verbois dam (1942)



RHÔNE RIVER SEDIMENT MANAGEMENT

Historical timeline

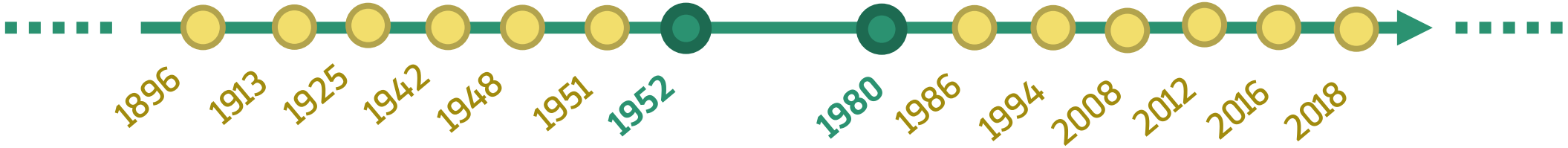
- Completion of Génissiat and Seyssel dams on the French Upper Rhône River (URR)
- 1st experimentations performed by CNR to route sediments released from Swiss dams through French reservoirs (transfer efficiency < 10%)



RHÔNE RIVER SEDIMENT MANAGEMENT

Historical timeline

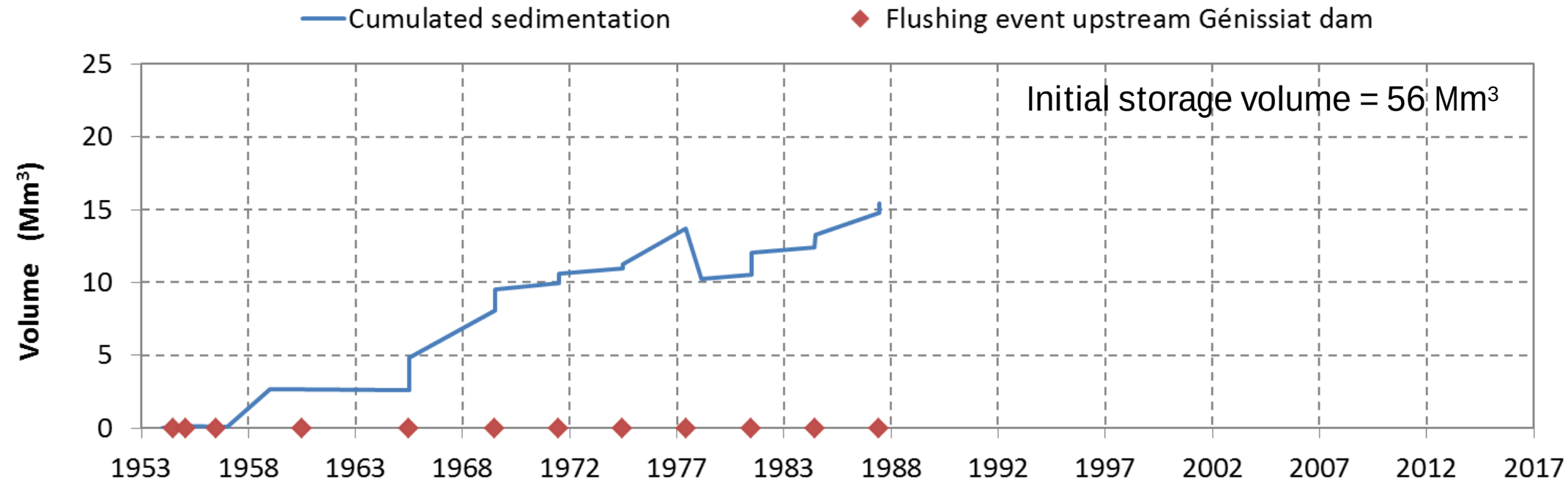
- Completion of 12 hydropower developments by CNR on the Lower Rhône River (LRR)
- Management of sediment fluxes in CNR reservoirs
  - Permanent bathymetric monitoring with in-house survey boats
  - Upper Rhône River
    - Sluicing of inflowing sediments by preventive and partial drawdown of reservoir water level during Swiss flushing
    - Increase of transfer efficiency up to 50-80%
  - Lower Rhône River
    - **Deposit dredging, sediment bar and vegetation maintenance…**
    - Reservoirs drawdown constrained by navigation out of flood periods



LRR+URR

Historical timeline

- Completion of 4 other hydropower developments on the Upper Rhône River
- Cumulated sedimentation reaching 15 Mm^3 in Génissiat reservoir



URR

RHÔNE RIVER SEDIMENT MANAGEMENT

Historical timeline

- Completion of 4 other hydropower developments on the Upper Rhône River
- Cumulated sedimentation reaching 15 Mm^3 in Génissiat reservoir
- Significant change in regulatory constraints on the French side of the border
  - Better consideration of existing and new environmental, industrial and domestic issues

1896 1913 1925 1942 1948 1951 1952 1980 1986 1994 2008 2012 2016 2018

URR

RHÔNE RIVER SEDIMENT MANAGEMENT

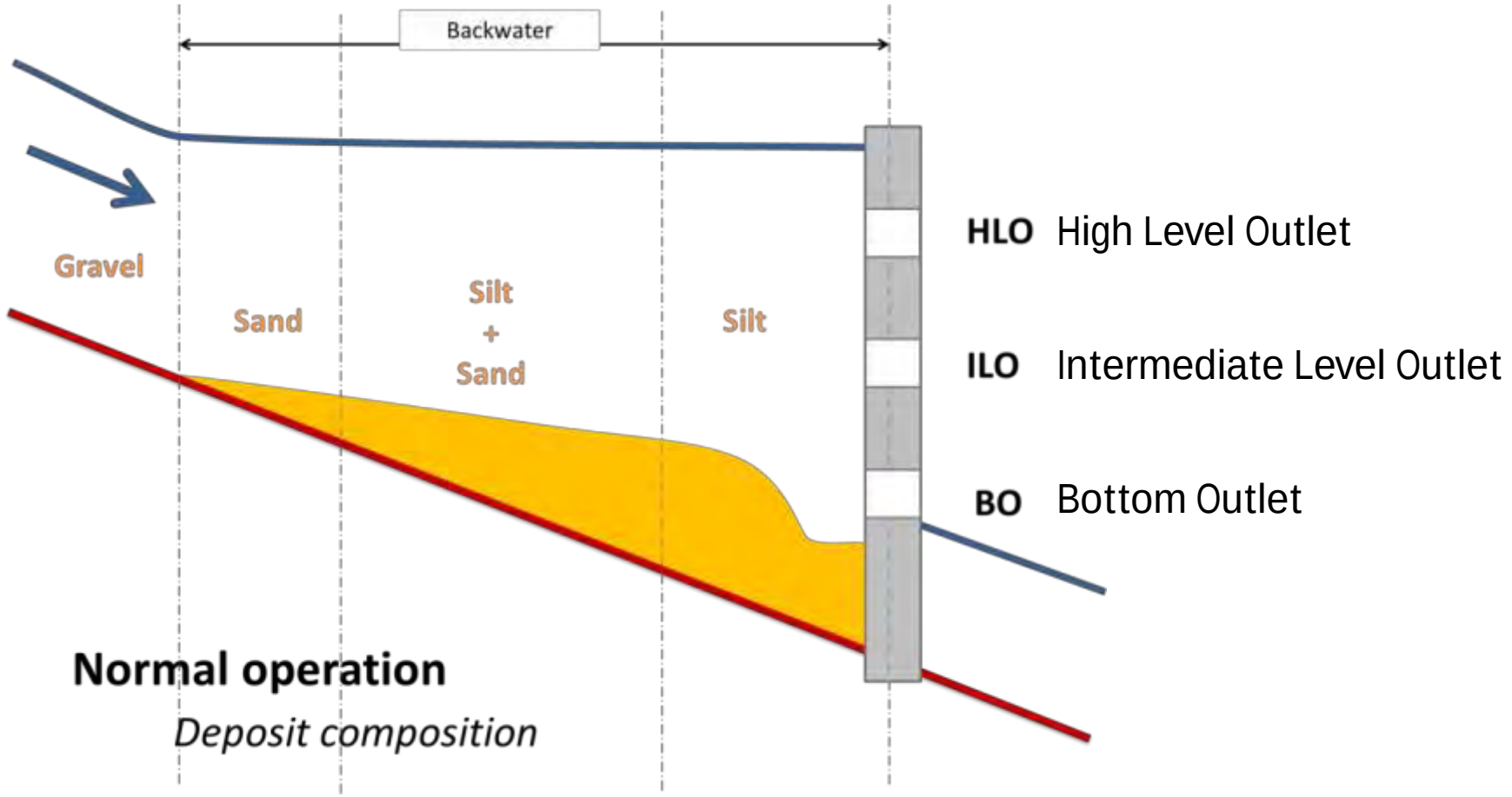
Historical timeline

- Completion of 4 other hydropower developments on the Upper Rhône River
- Cumulated sedimentation reaching 15 Mm^3 in Génissiat reservoir
- Significant change in regulatory constraints on the French side of the border
  - Better consideration of existing and new environmental, industrial and domestic issues
  - Definition and strict respect of maximum limits regarding Suspended Sediment Concentrations (SSC) released downstream Génissiat dam
    - Average concentration during the entire flushing operation: < 5 g/l
    - Average concentration for a continuous period of 6 hours running: < 10 g/l
    - Average concentration for a continuous period of 30 minutes running: < 15 g/l
  - No evolution in operation rules during flushing on the Swiss side (40 g/l still possible !)
  - Need to ensure a challenging regulation of sediments fluxes released from Swiss dams in Génissiat reservoir

URR

Focus on Génissiat dam and other Upper Rhône River developments

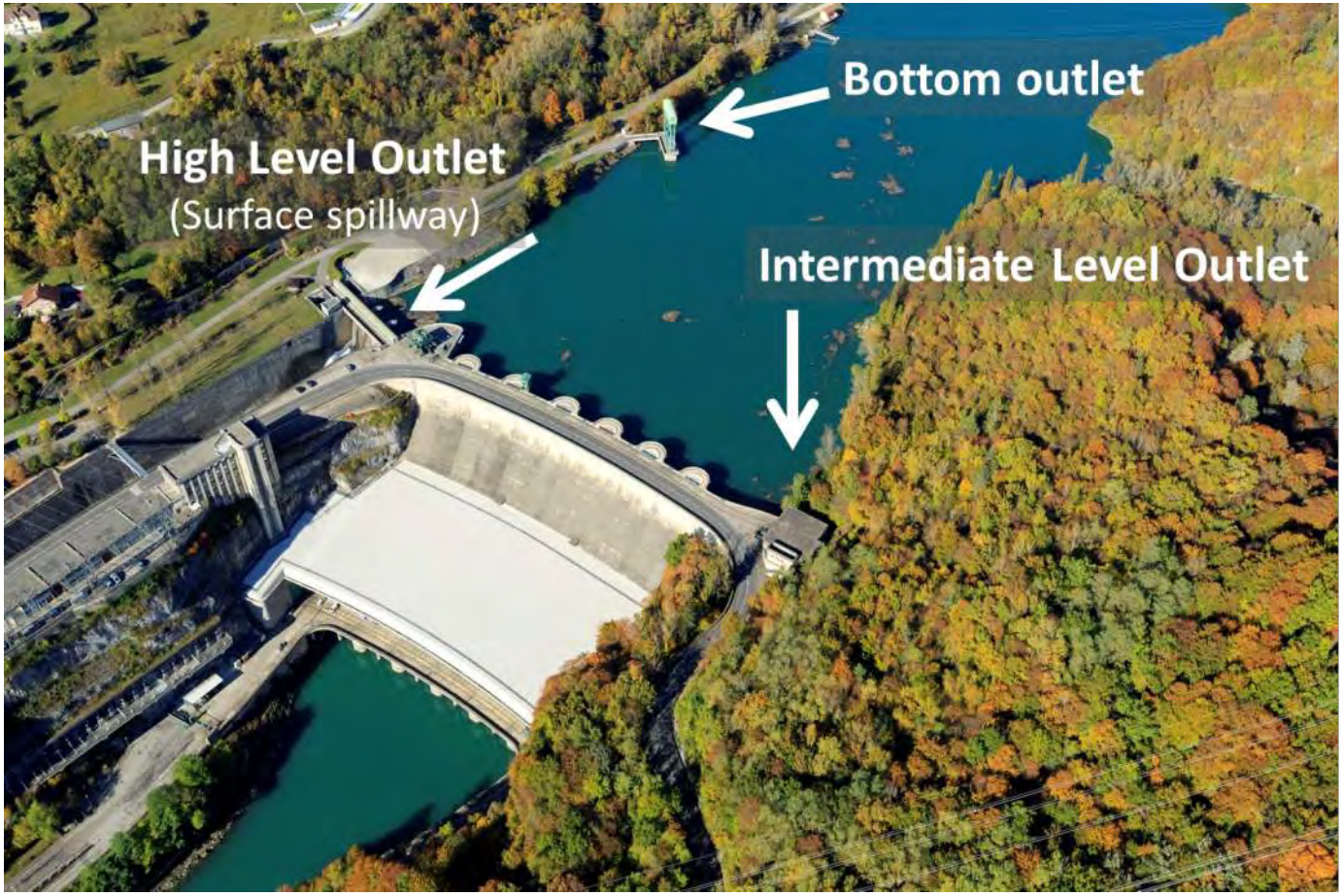
- Features of Génissiat reservoir deposits and sediment outlet facilities



RHÔNE RIVER SEDIMENT MANAGEMENT

Focus on Génissiat dam and other Upper Rhône River developments

- Features of Génissiat reservoir deposits and sediment outlet facilities



RHÔNE RIVER SEDIMENT MANAGEMENT

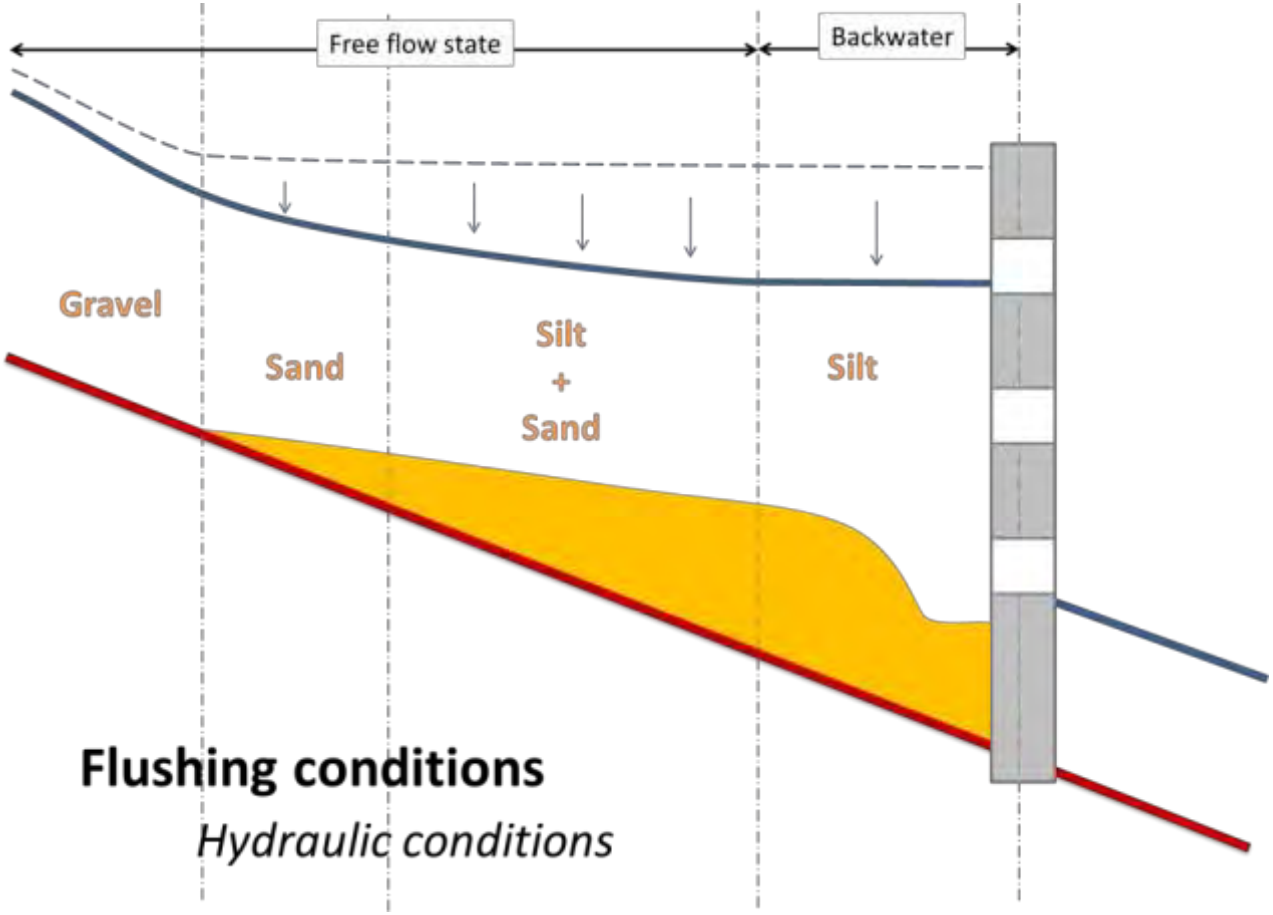
Focus on Génissiat dam and other Upper Rhône River developments

- Features of reservoir deposits and sediment outlet facilities

RHÔNE RIVER SEDIMENT MANAGEMENT

Focus on Génissiat dam and other Upper Rhône River developments

- Hydraulic conditions during sediment management operation

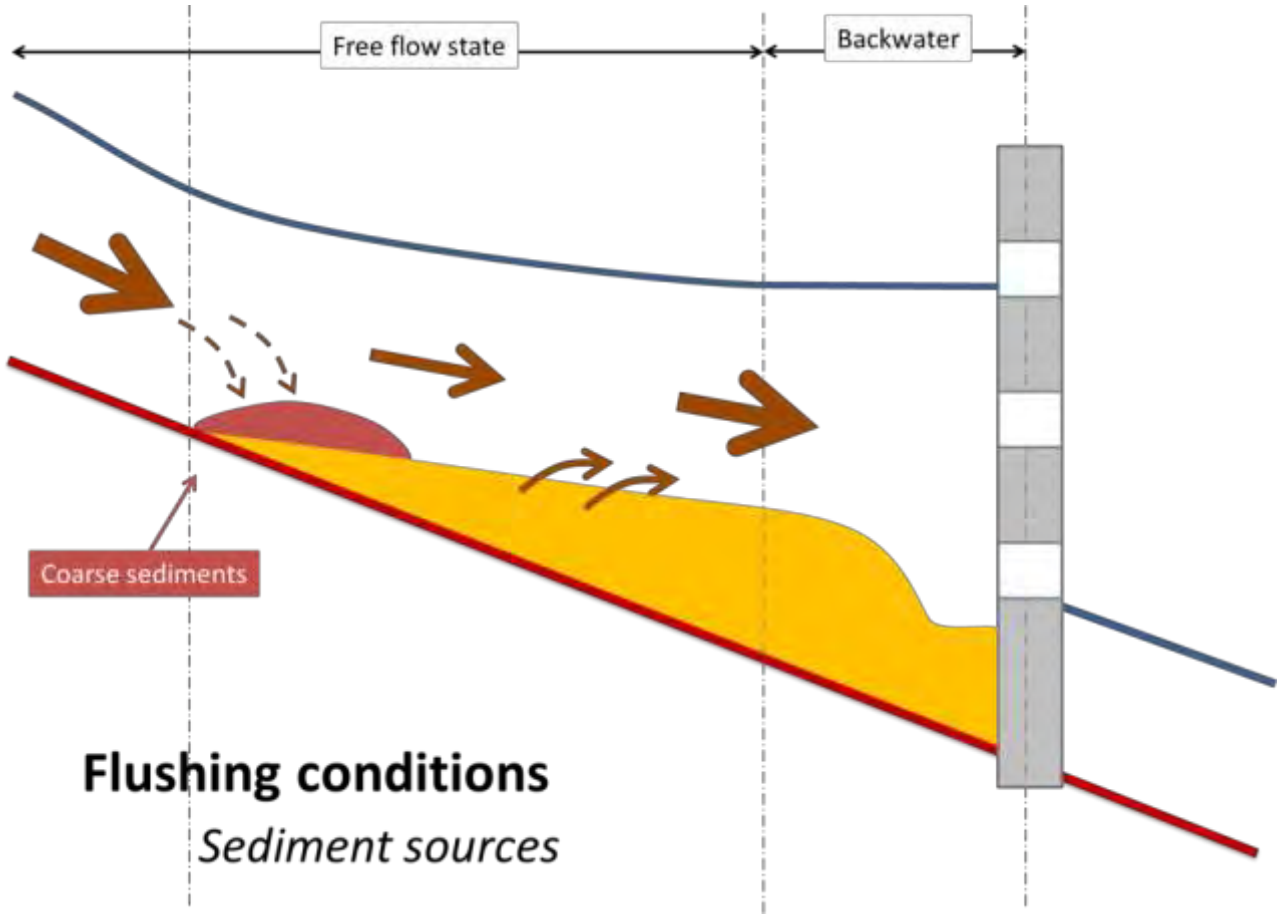


RHÔNE RIVER SEDIMENT MANAGEMENT

Focus on Génissiat dam and other Upper Rhône River developments

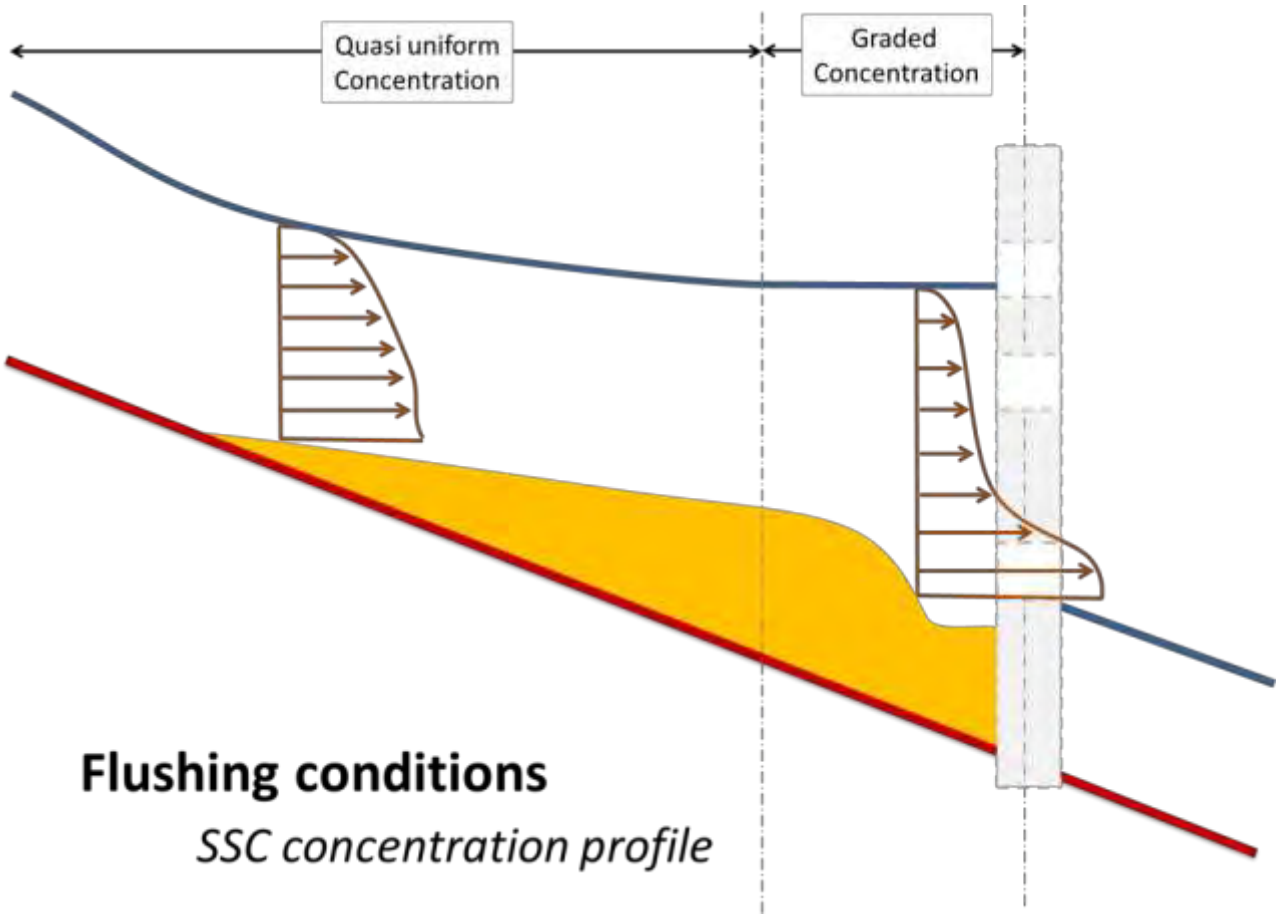
- Sediment sources during sediment management operation

Sediments from Swiss reservoirs



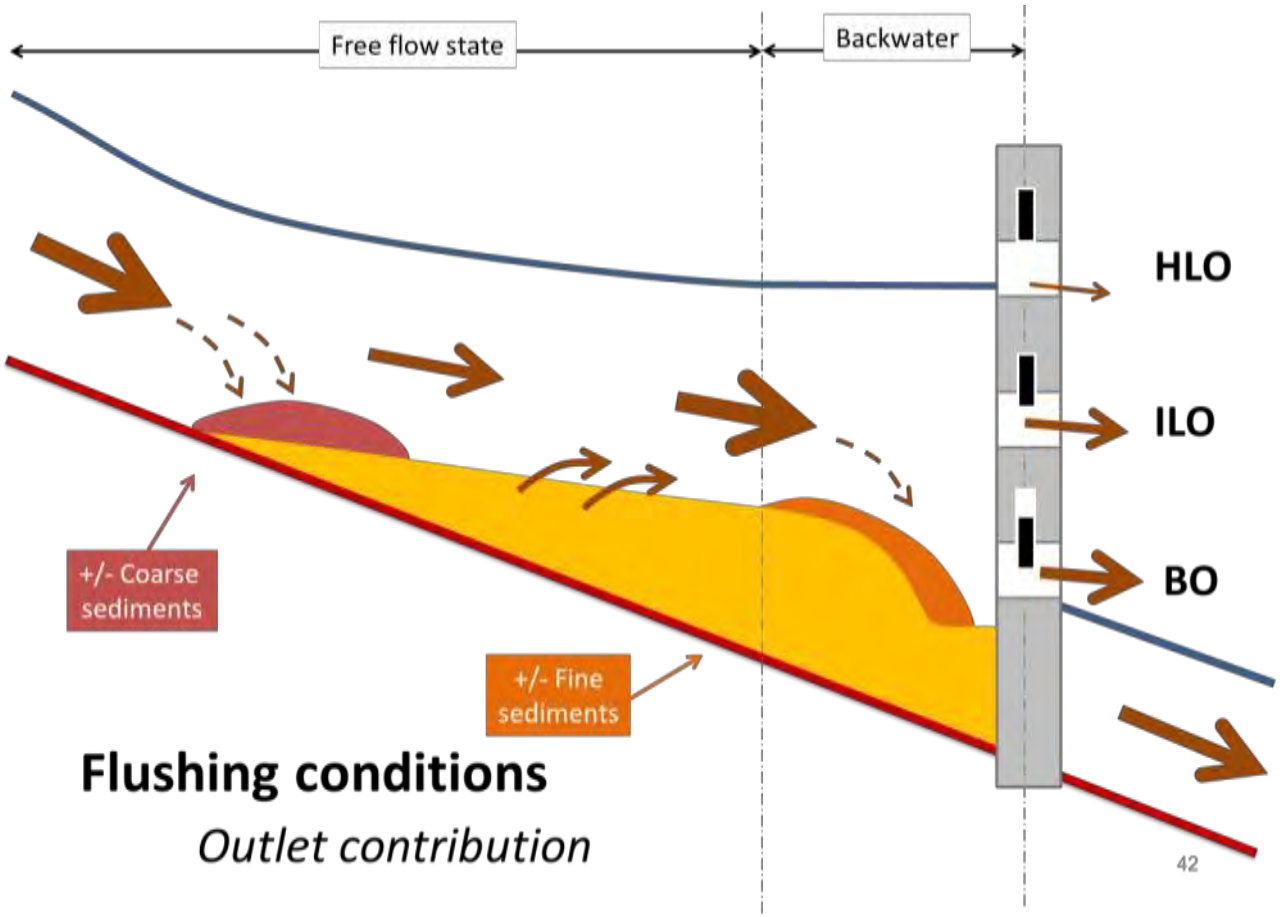
Focus on Génissiat dam and other Upper Rhône River developments

- Suspended Sediment Concentration profiles



Focus on Génissiat dam and other Upper Rhône River developments

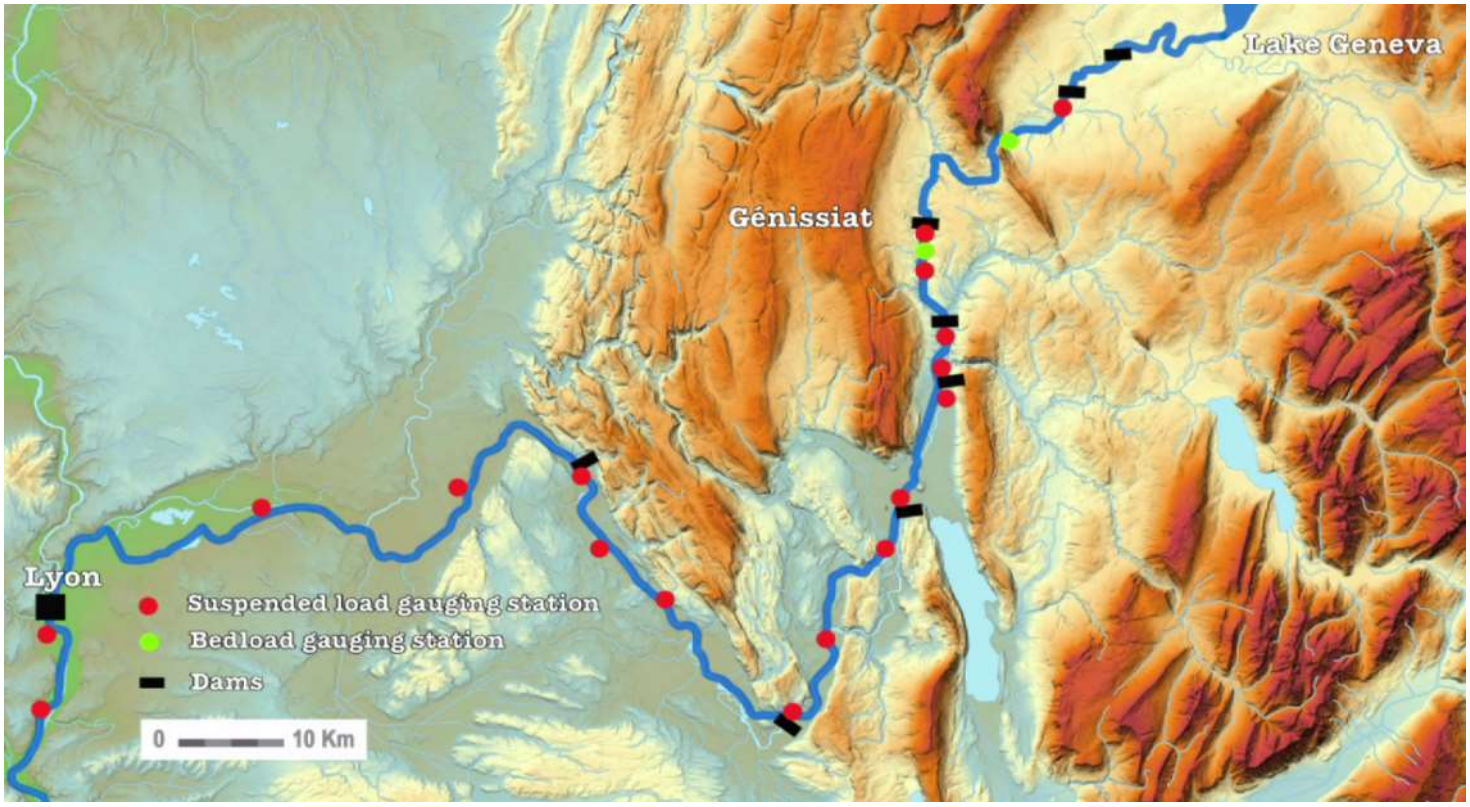
- Contribution of water and sediment outlet facilities



RHÔNE RIVER SEDIMENT MANAGEMENT

Focus on Génissiat dam and other Upper Rhône River developments

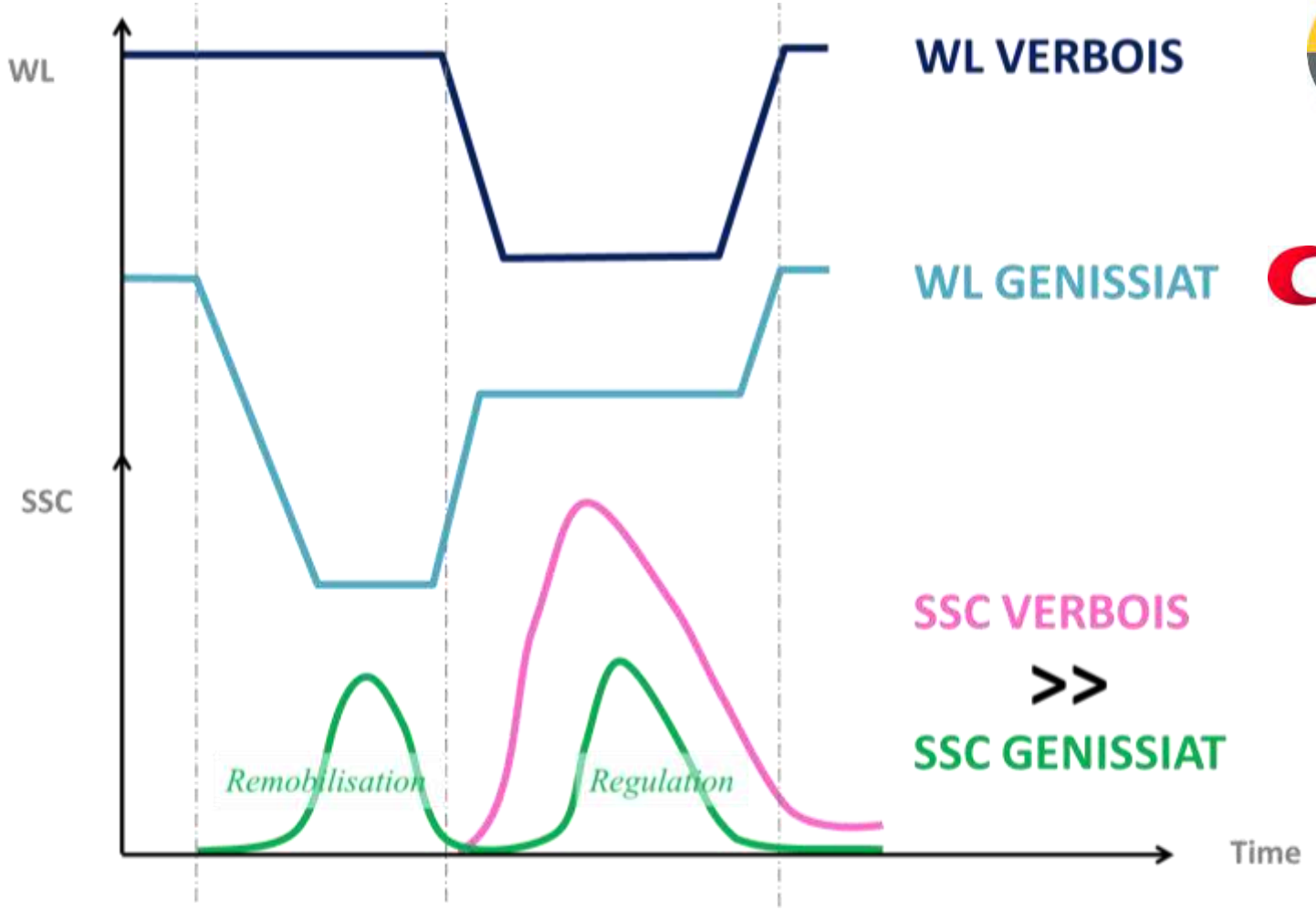
- Throughout the operation, several sediment gauging stations located at different key points provide real time data 24h/day to Génissiat dam command center
- Some stations are managed by mixt French-Swiss teams
- The gates opening as well as the reservoir water level are then adjusted so as to obtain appropriate solid concentrations



RHÔNE RIVER SEDIMENT MANAGEMENT

Focus on Génissiat dam and other Upper Rhône River developments

- Cascade management (until 2012)



RHÔNE RIVER SEDIMENT MANAGEMENT

Focus on Génissiat dam and other Upper Rhône River developments

- Normal situation at Seyssel dam

RHÔNE RIVER SEDIMENT MANAGEMENT

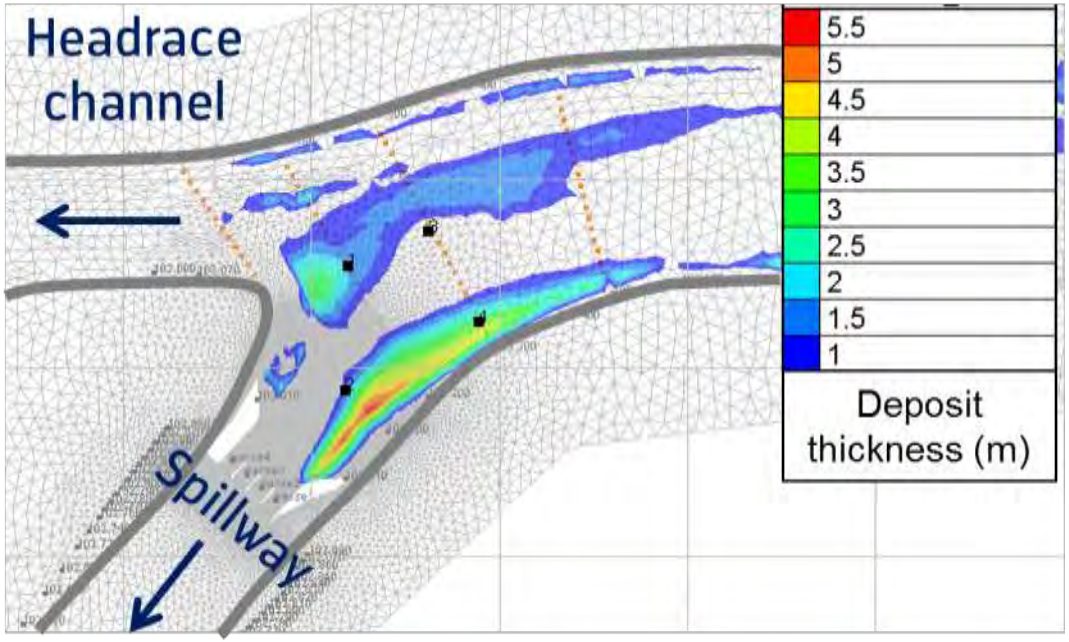
Focus on Génissiat dam and other Upper Rhône River developments

- Preventive drawdown of Seyssel reservoir water level to sluice inflowing sediments

RHÔNE RIVER SEDIMENT MANAGEMENT

Focus on Génissiat dam and other Upper Rhône River developments

- Derivation of sediment laden flow through the headrace channels and partial closure of dams to preserve the natural course of the river from fine sediment inflows
- Deposition hazards increased upstream dams



Old-Rhône (preserved during flushing)

Focus on Génissiat dam and other Upper Rhône River developments

- Monitoring network
  - During the flushing operation, ecological surveys are conducted in the field to evaluate the impact of the operation on the aquatic life
  - In particular, several refuge areas are subject to a close monitoring to check that the fish fauna are not too stressed

RHÔNE RIVER SEDIMENT MANAGEMENT

Focus on Génissiat dam and other Upper Rhône River developments

- Management of environment issues
  - Field data are sent to a scientific committee which, every evening, decides whether rescue-fishing operations are necessary
  - The Génissiat dam control station can also be alerted to adapt the dilution process

RHÔNE RIVER SEDIMENT MANAGEMENT

Historical timeline

- New significant changes regarding regulatory constraints on sediment management in France

France

RHÔNE RIVER SEDIMENT MANAGEMENT

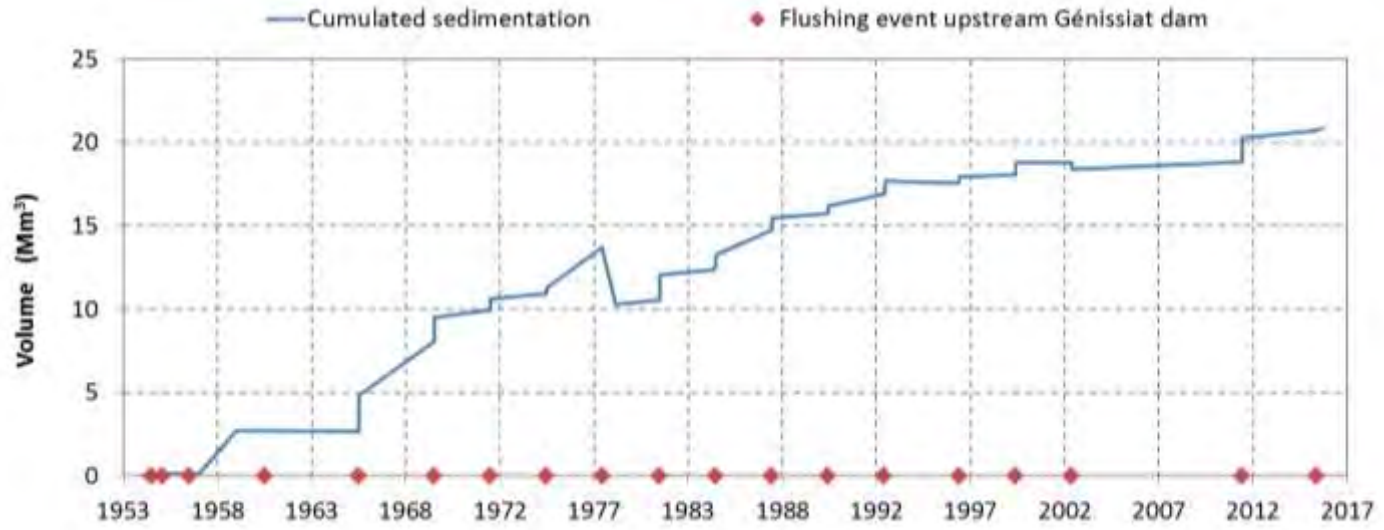
Historical timeline

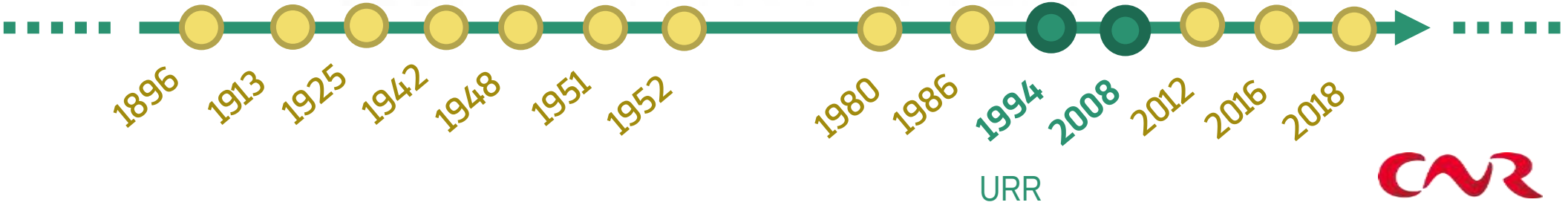
- New significant changes regarding regulatory constraints on sediment management in France
  - 1994
    - Sediment mining in river channels forbidden for civil works purposes
    - Sediment extraction from reservoirs authorized if no alternative for sediment management
  - 2008
    - Deposits extracted from reservoirs for sediment management purposes must be reinjected downstream of dams if costs are acceptable
- Need for CNR to establish a new framework for managing the Rhône River sediments
  - Management plan regarding the supervision and maintenance of the Rhône River bed (deposit **relocation, bar maintenance, vegetation maintenance, restoration works…**)
  - Established and applied by CNR since 2010

France

Historical timeline

- **Situation at Génissiat in the meantime…**
  - Relative stabilization of sedimentation processes in Génissiat reservoir since **1990's thanks** to new operation rules implemented
  - But huge sedimentation during 2012 event (+1.2Mm^3) due to lengthy maintenance works at Verbois dam



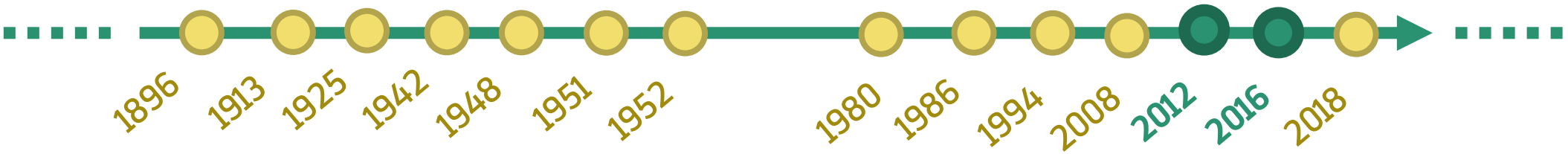


URR

RHÔNE RIVER SEDIMENT MANAGEMENT

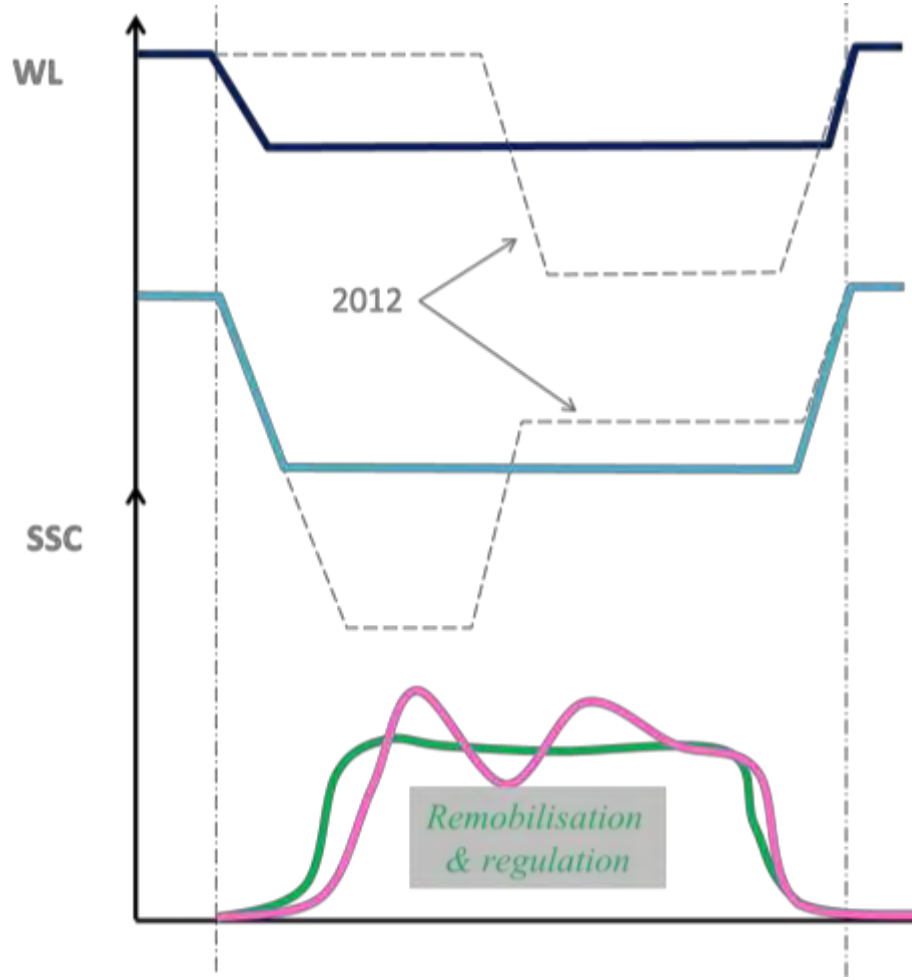
Historical timeline

- Launching of a binational technical committee for the Upper Rhône River composed of Industrial operators (SIG, SFMCP and CNR) and French and Swiss authorities
- Cooperative definition and evaluation of different sediment managing scenarios in line with both French and Swiss regulatory constraints
- Wide consultation through public meetings with different stakeholders to facilitate the emergence of the most consensual sediment management scheme
- Sediment management finally considered combines following actions
  - Facilitation of sediment routing during floods by an extra-flow discharged from Lake Geneva
  - Partial drawdown of reservoirs during flushing events and scrupulous respect of same constrains than CNR regarding fine suspended sediment concentration released from dams
  - Local and complementary dredging wherever required



Focus on Génissiat dam

- Cascade management (since2016)



WL VERBOIS (CH)

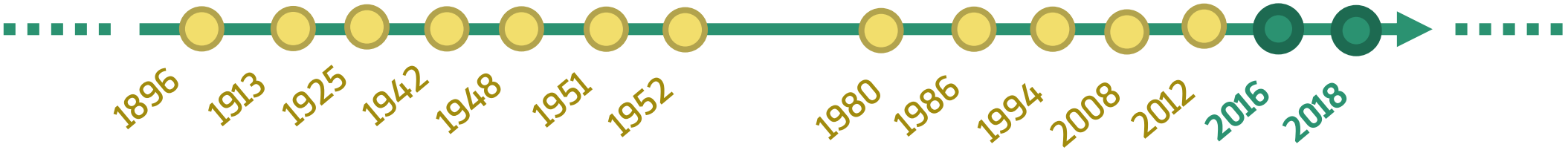
WL GENISSIAT (F)

SSC VERBOIS
=
SSC GENISSIAT

RHÔNE RIVER SEDIMENT MANAGEMENT

Historical timeline

- Ongoing survey to establish a masterplan regarding the sediment management of the whole Rhône River Basin from the Lake Geneva outlet down to the Mediterranean Sea
- Objectives: implement a consistent sediment management policy in order to tend toward a good ecological potential as required by the masterplan for water management of the Rhône-Méditerranée basin area
- Methodology
  - Synthesis of existing surveys
  - Consensus-based diagnosis regarding sediment, ecological and socio-economic issues
  - Establishment of a masterplan for sediment management at different working scales
    - Overall River Basin
    - Homogeneous hydrographic units



URR+LRR

CONCLUSION

- The sediment management of the Rhône River Basin evolves from a long history
- Continuous changes have been required to integrate evolutions regarding regulatory constraints, uses, developments…
- The Rhône River case provides practical and successful examples about the "state of the art" knowledge on conception, operation and maintenance of dams and regulated rivers with regards to sediment issues
- This experience can help managing authorities to save time when dealing with such issues on basins with similar issues
- Regarding dam conception and reservoir operation in particular:
  - Flushing and routing of sediment through reservoirs can be conducted according to eco-friendly principle
  - Dams should be equipped with water and sediment release facilities located at different elevations depending on their height
  - To facilitate sediment routing, dam conception should allow recovering natural like flow conditions in the reservoir for a large panel of discharges
  - A close cooperation and coordination is needed between operators to manage sediment fluxes from a consistent manner throughout a cascade of dams, especially in the case of a transboundary context

CONCLUSION

- Regarding management of sediment issues in particular :
  - The decision process regarding sediment management should rely as much as possible on a consensus–based approach involving all relevant stakeholders
  - Sediment management should be considered as a whole and planned as much as possible at basin scale
  - Ideally, local actions should result from this masterplan (and not the contrary) in order to be consistent with global objectives and other actions planned on neighboring reaches
  - Experiments, field supervision and evaluations based on objective criterion are needed to determine the relevancy and efficiency of actions in the long run
  - Models can be helpful to simulate the impact of different managing scenarios but will never provide results more accurate than the calibration data precision
  - Permanent and comprehensive field observations on hydraulics AND sediment fluxes are required both as a decision-making tool and as a calibration dataset used to test managing scenarios

Thank you for your attention & questions

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Annex 6

THE RHONE TRAFFIC MANAGEMENT CENTER

L'énergie au cœur des territoires

OVERVIEW OF CNR

100% RENEWABLE PRODUCTION ASSETS

19 hydropower plants
21 small and mini-hydropower plants

14 solar power plants

32 wind farms

=

3,453 MW of installed capacity

14.4 TWh produced

RIVER TRANSPORT

5.11 million tons transported (-4% versus 2014)

1.12 billion tons/km

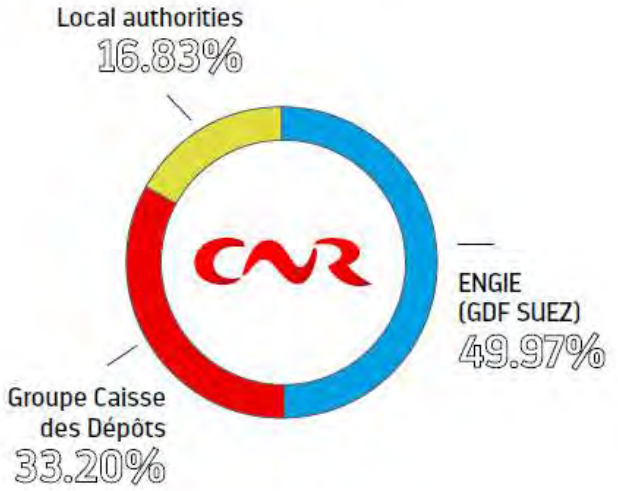
93,675 Lock passages between Lyon and the Mediterranean (-1.4%)

97,319 containers transported (+1.9 %)

203,318 pleasure boaters (-6.8%)

330 km of wide-gauge **navigable waterway**

DISTRIBUTION OF SHARE CAPITAL



OTHER ASSETS

19 dams

14 wide gauge locks

5 locks for pleasure craft

8 enterprise parks

18 industrial and port sites including Port de Lyon

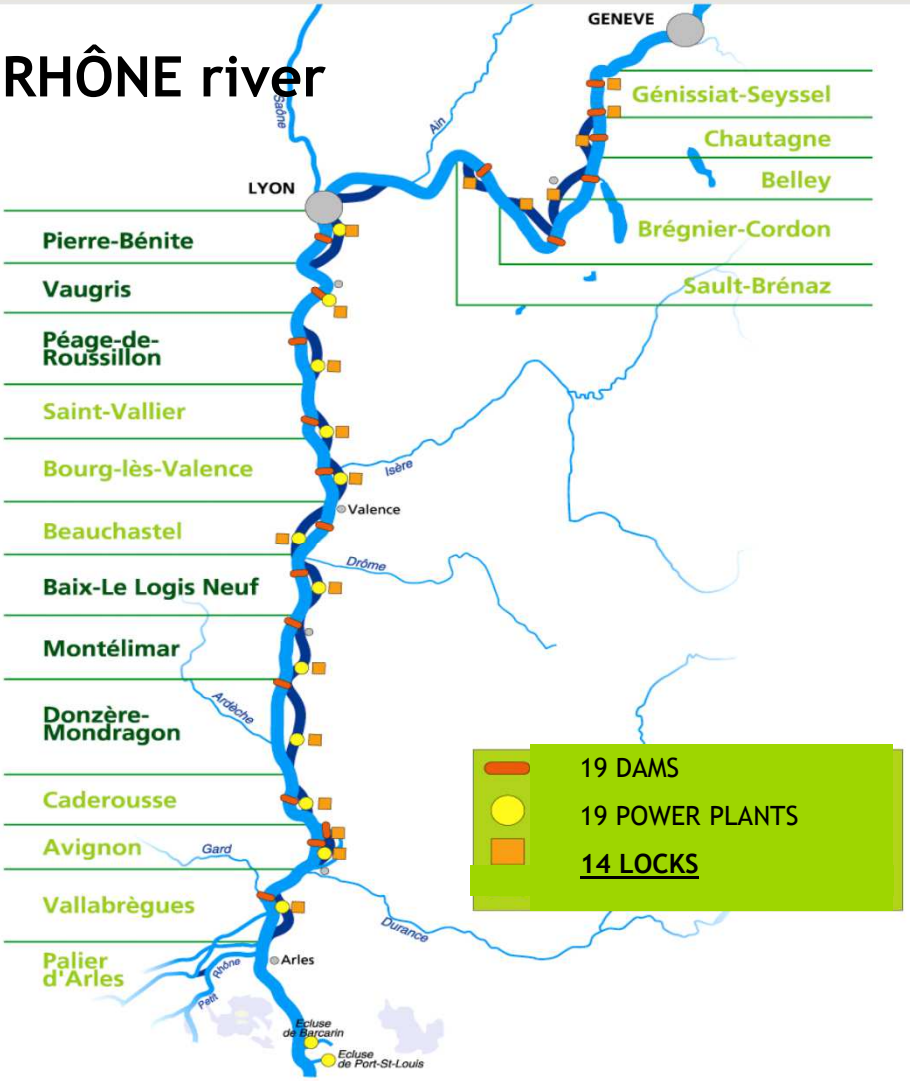
32 pumping stations for irrigating the concession

27,000 ha
surface area under concession
(14,000 ha of river, 13,000 ha of land including 836 farmed out)

OVERVIEW OF CNR

FRANCE

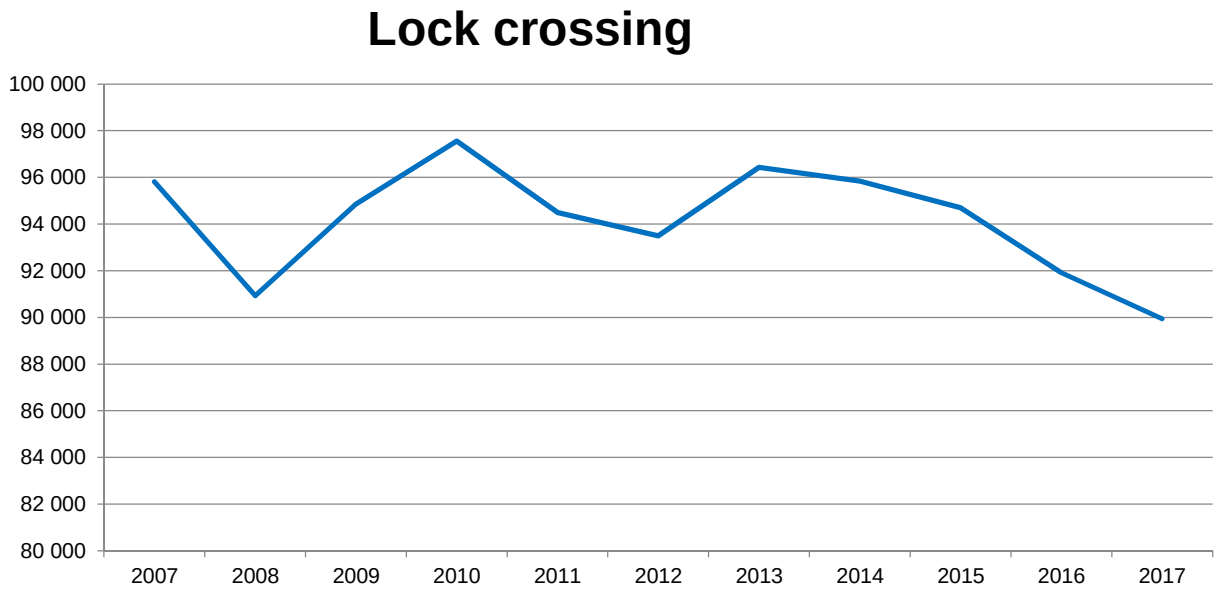
The RHÔNE river



Navigation between Lyon and the sea

- 330 km of large gauge waterway
- 13 locks (190 x 12 x 3 m)
- 1 maritime lock (135 X19X 5.50 m)

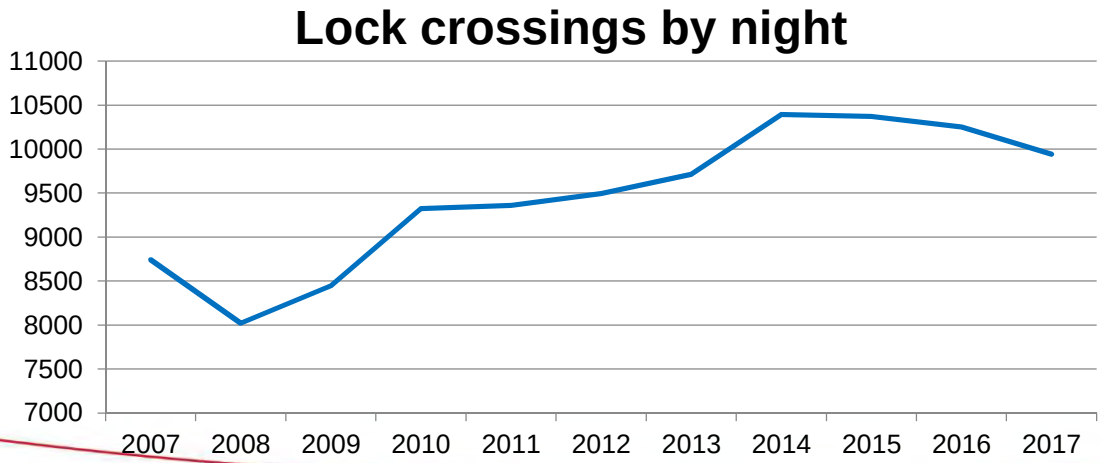
TRAFFIC DATA



2007 – 2017

Total lock crossings : - 6.14 %

2/3 lockage – 1/3 false pond

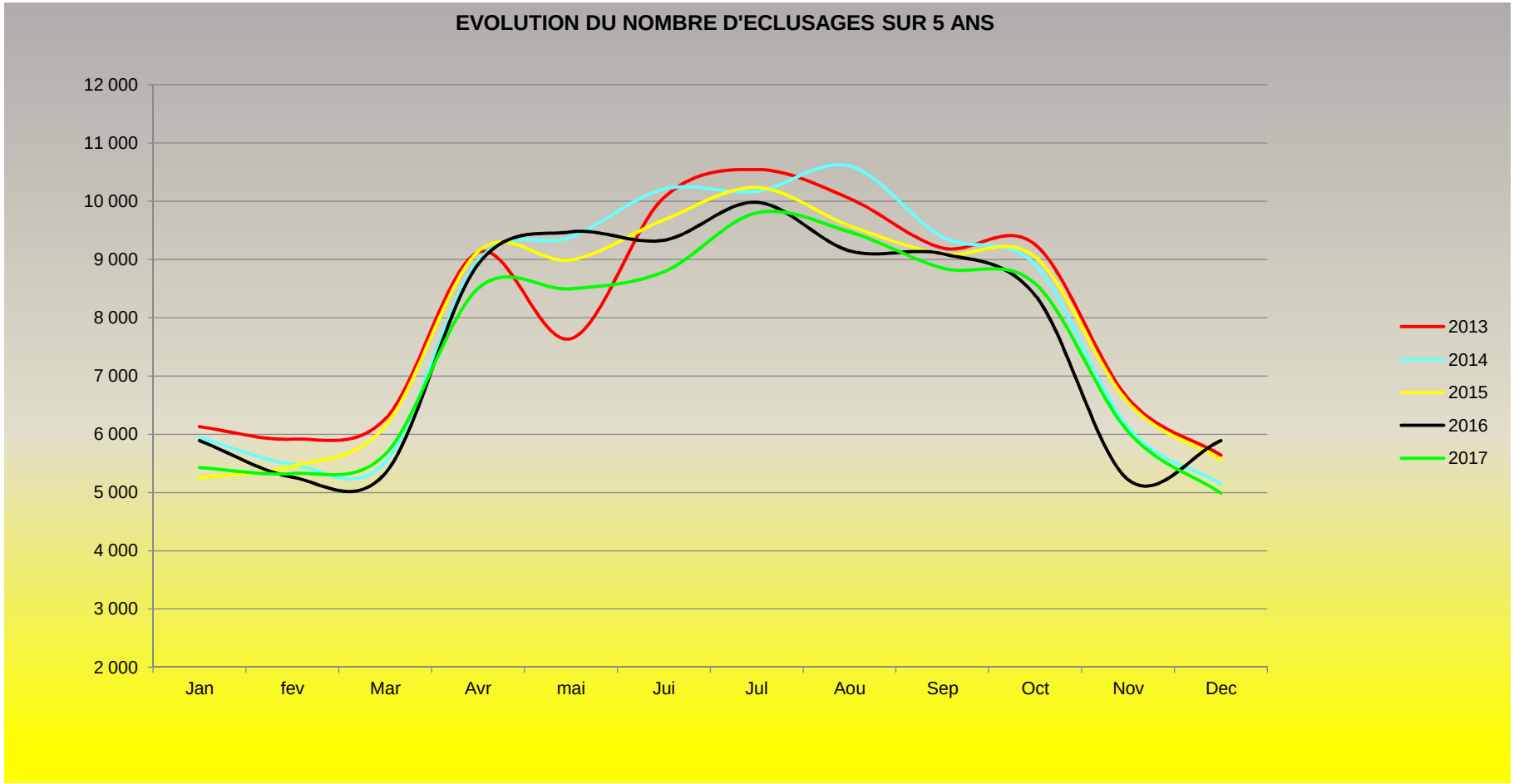


2007 - 2017

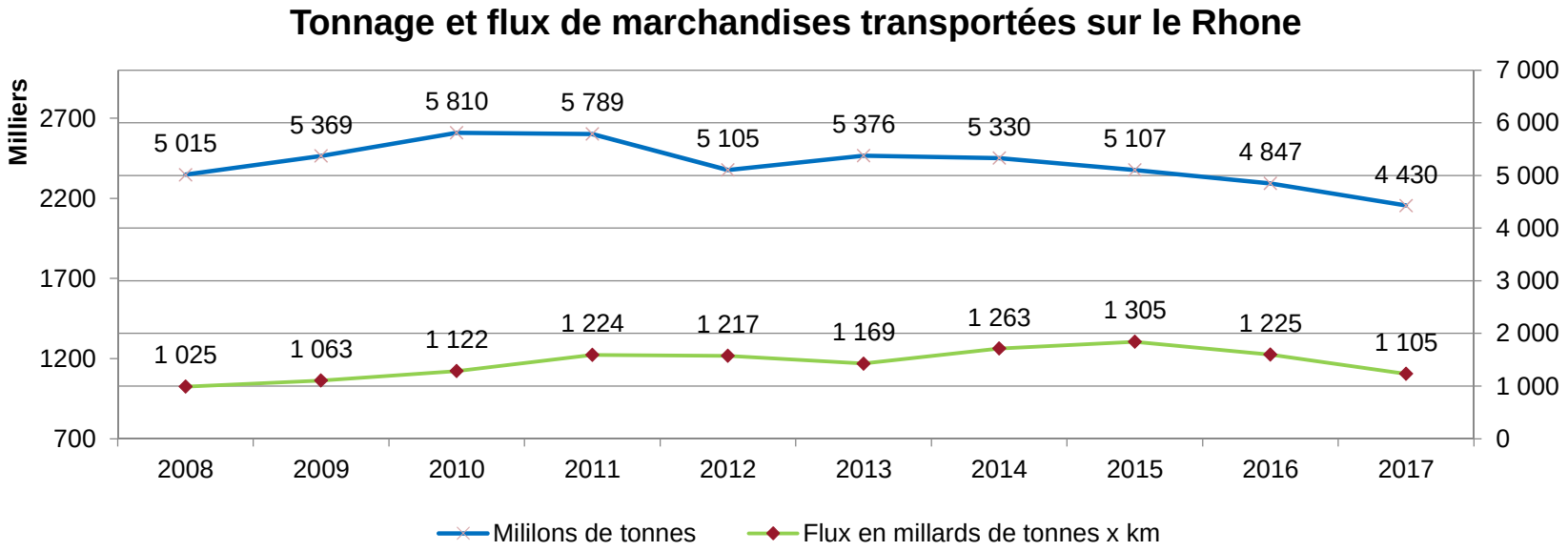
lock crossings by night : + 13.74 %

2016-2017 : - 3.2 %

TRAFFIC DATA



TRAFFIC DATA



ZOOM

2017 :

4,43 millions de Tonnes de commoditys transported (-8.6 % par rapport à 2016)

➔ **221 500 trucks**

CENTRE DE GESTION DE LA NAVIGATION (CGN)

2017 :

Number of trading boat lockage : 38327 (-1.97% par rapport à 2016)

Number of cruise ship lockage : 13587 (- 5.07 % par rapport à 2016)

Number of pleasure boat lockage : 14821 (+15.55% par rapport à 2016)

April 2009 : CGN + 2 locks

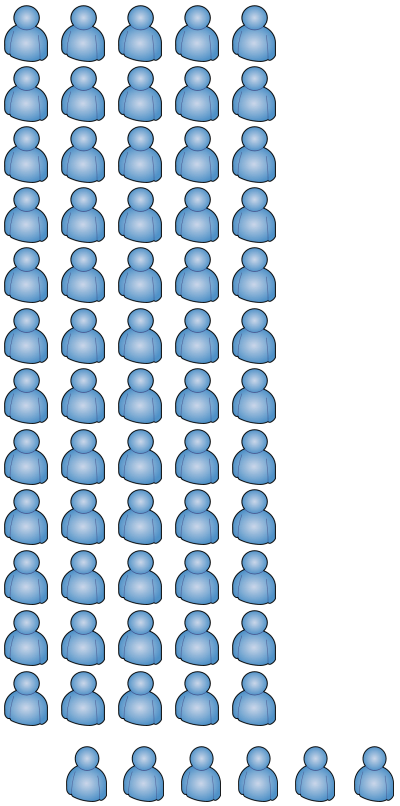
November 2009 : CGN + 5 locks

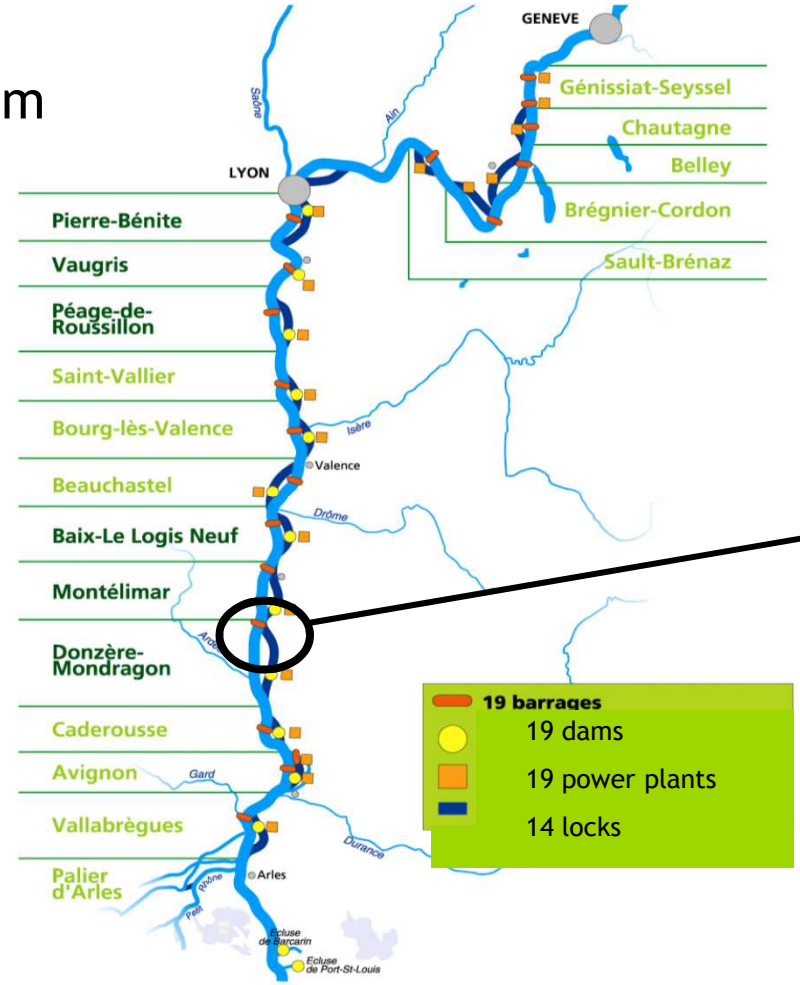
November 2010 : CGN + 10 locks

End of 2011 : CGN + 14 locks

BEFORE

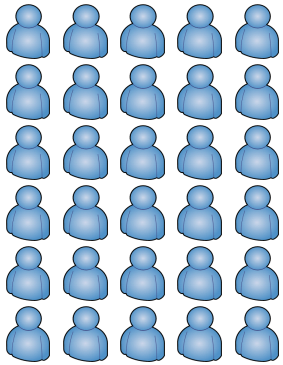
Open from 5 am to 9 pm





AFTER

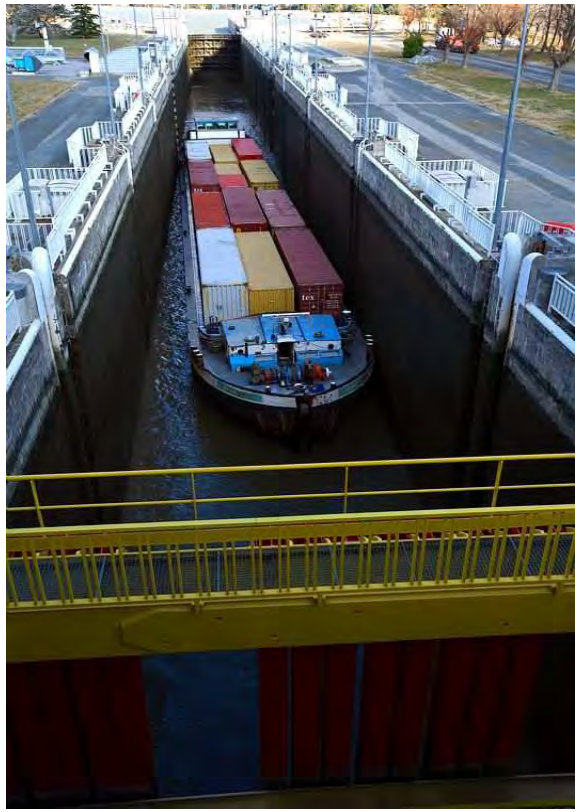
Open 24/7



9

CENTRE DE GESTION DE LA NAVIGATION (CGN)

- Navigation technician in contact with the boats that are locked and in navigation
- Simultaneous operation of two locks by a navigation technician
- rotating organization posted 3/8 et 2/8
- 4 technicians the night, 7 technicians the day



FONCTIONS PRÉSENTES DANS LA SALLE

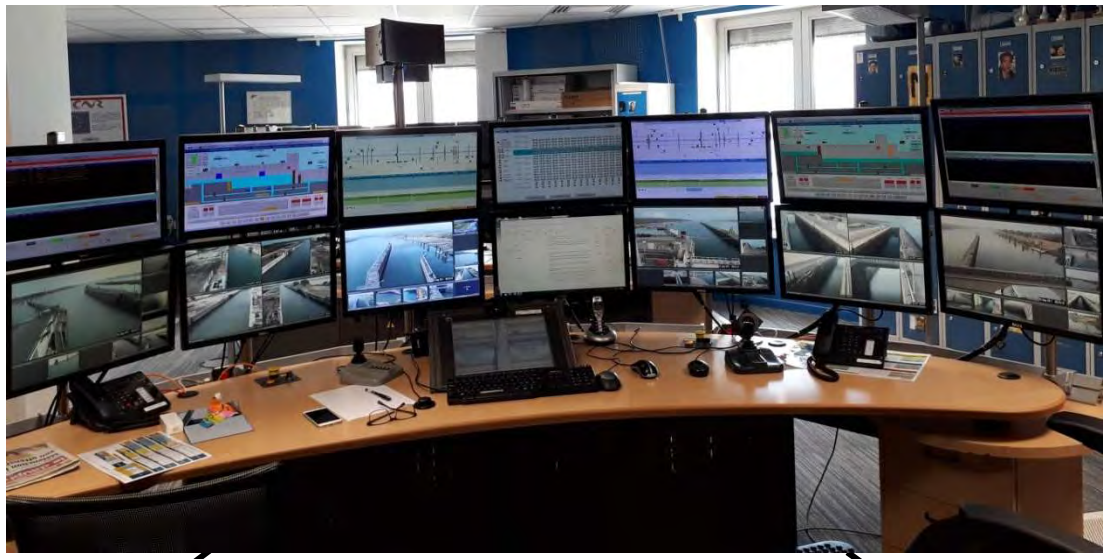
Je suis Technicien de Navigation.
Nous sommes 1 à 7 et nous conduisons les écluses.

Je suis Technicien Chargé de Navigation.
Je suis le chef d'orchestre de la salle.
J'accepte (ou refuse) la prise en charge des écluses au CGN et je vérifie que toutes les écluses confiées au CGN sont bien prises en charge par un Technicien de Navigation.

J'organise ma salle (pause, déjeuner, …).

Je gère le trafic fluvial.

TWO TYPES OF ACTIONS



OPERATE

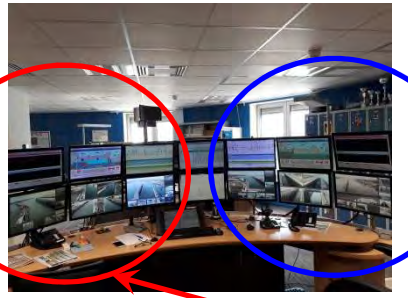
- 2 locks simultaneously
- High vigilance required
- Step by step processing

MONITOR

- A selection of locks simultaneously
- Radio VHF or phone communication to survey approaching boats

Au CGN

OPERATEUR 1

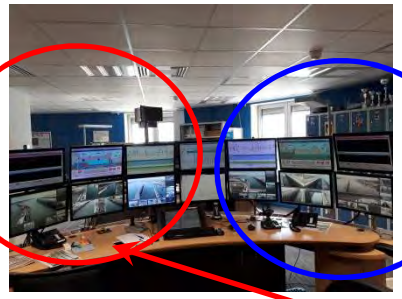


1 operate lock on the left side

3 monitoring locks on te right side

Au CGN

OPERATEUR 1



1 operate lock on the left side

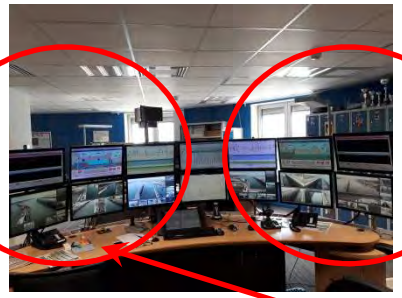
3 monitoring locks on te right side

1 boat is annonced in the VHF at PB

LYON
PB
VS
SA
GV
BV
BE
LN
CHATEAUNEUF
BO
CA
AV
BC
BA
SL

Au CGN

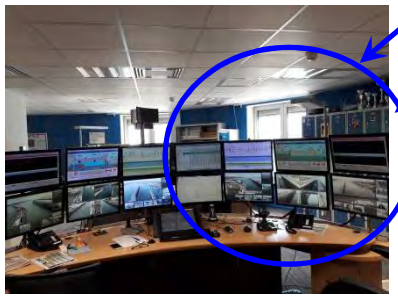
OPERATEUR 1



OP1 : 2 operate(1G, 1D)

OP2 : 2 monitoring (2D)

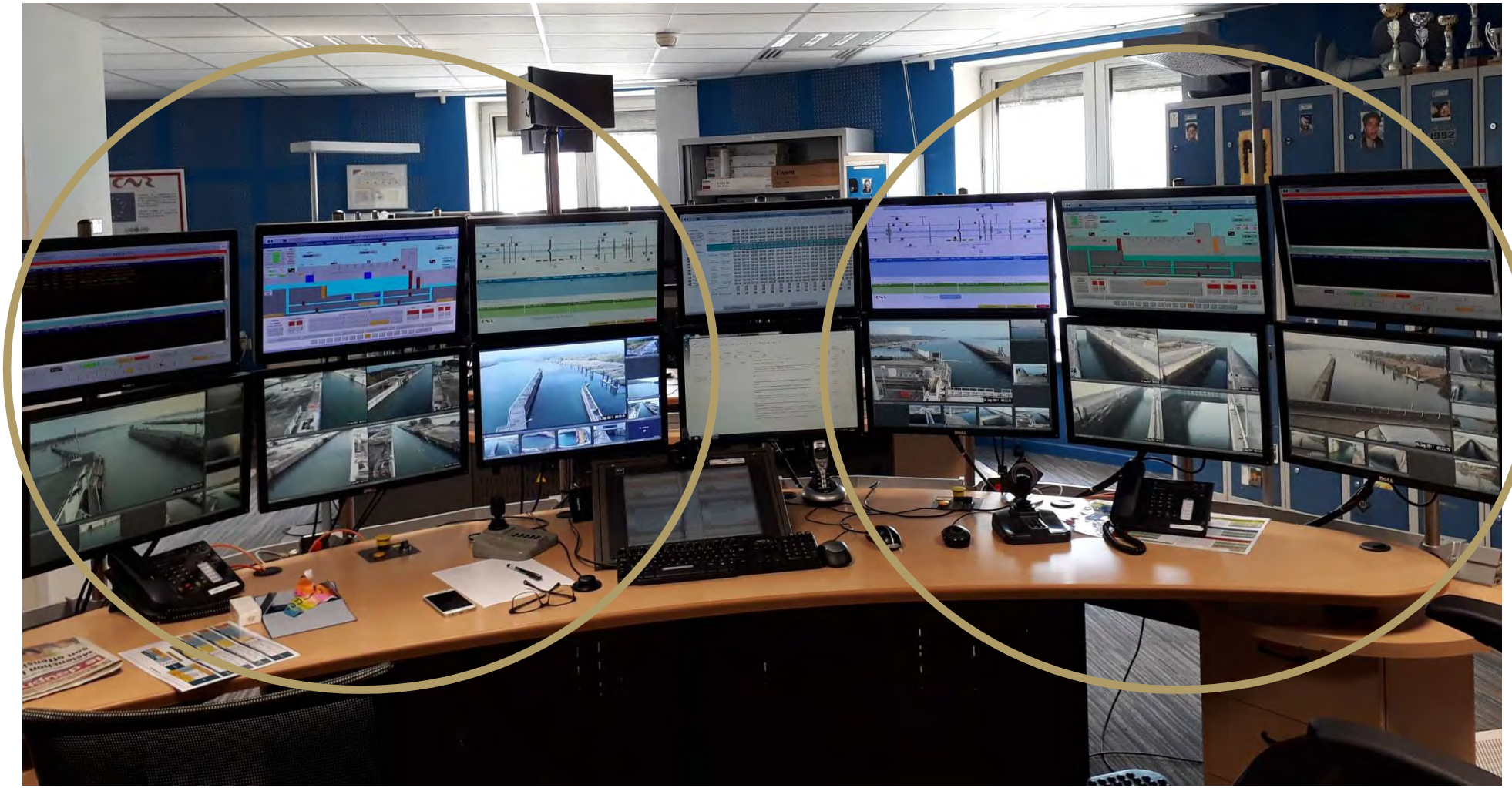
OPERATEUR 2



LYON
PB
VS
SA
GV
BV
BE
LN
CHATEAUNEUF
BO
CA
AV
BC
BA
SL

CENTRE DE GESTION DE LA NAVIGATION (CGN)

UN POSTE DE TELECONDUITE



CENTRE DE GESTION DE LA NAVIGATION (CGN)

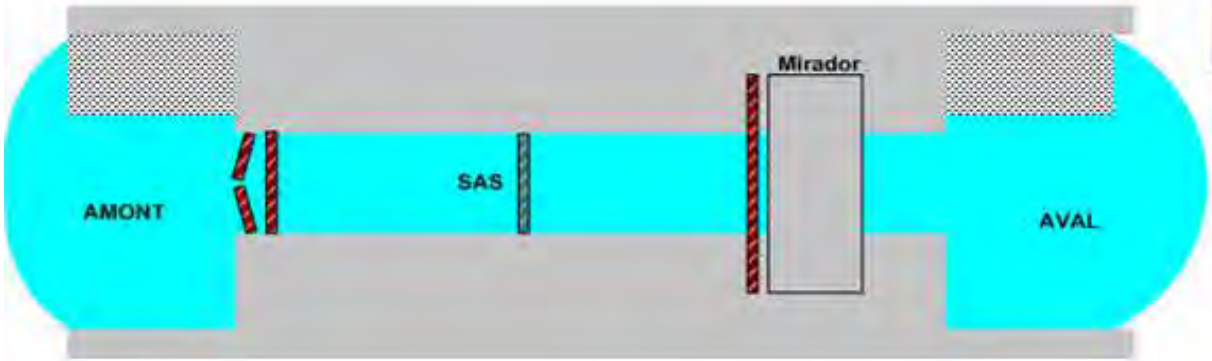
4 SYSTEMES

IHM
Contrôle commande

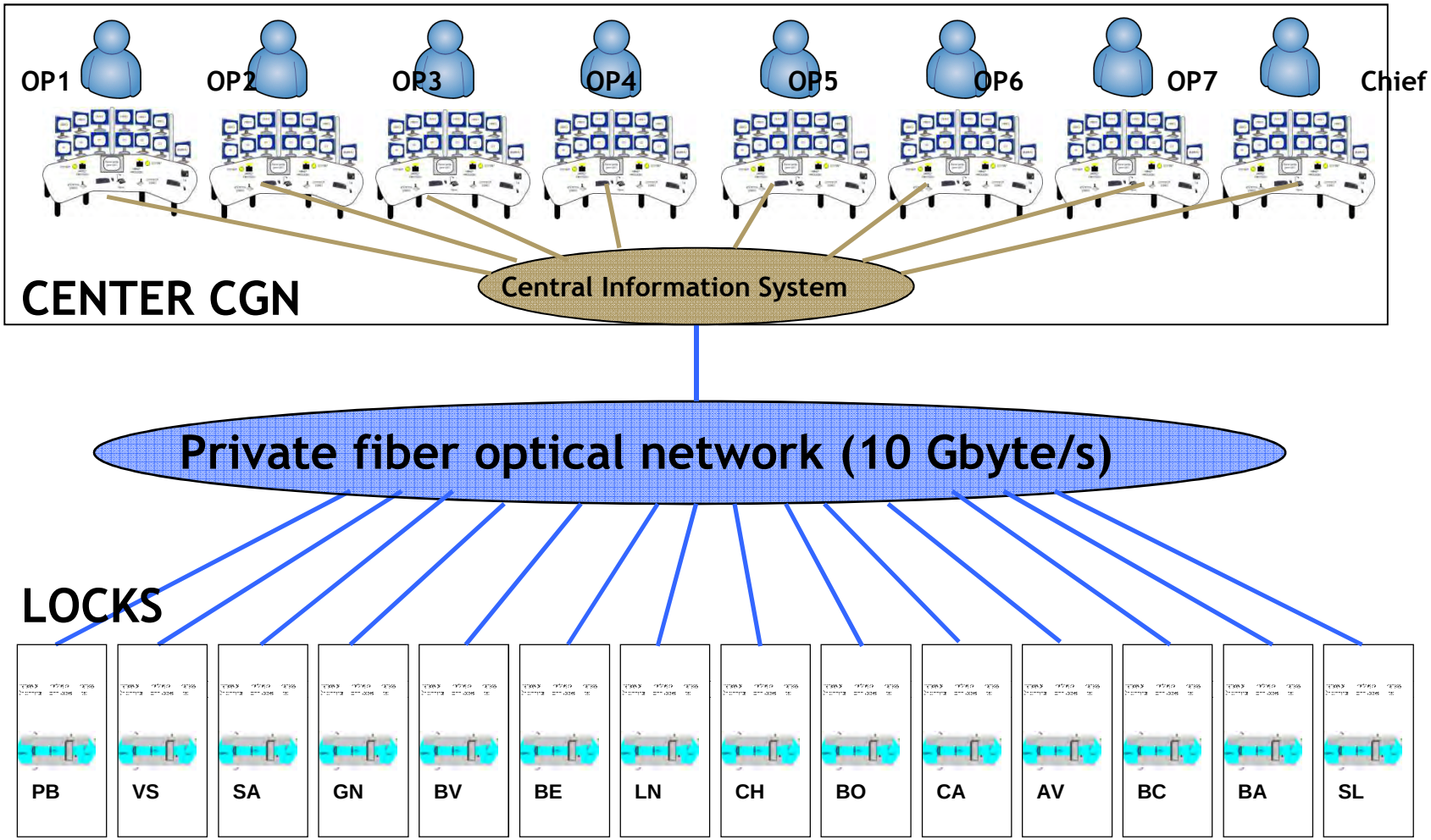
SECURITE
Arrêt d'urgence

AUDIO
radio VHF, téléphone, sono

VIDEO
Cameras, monitoring



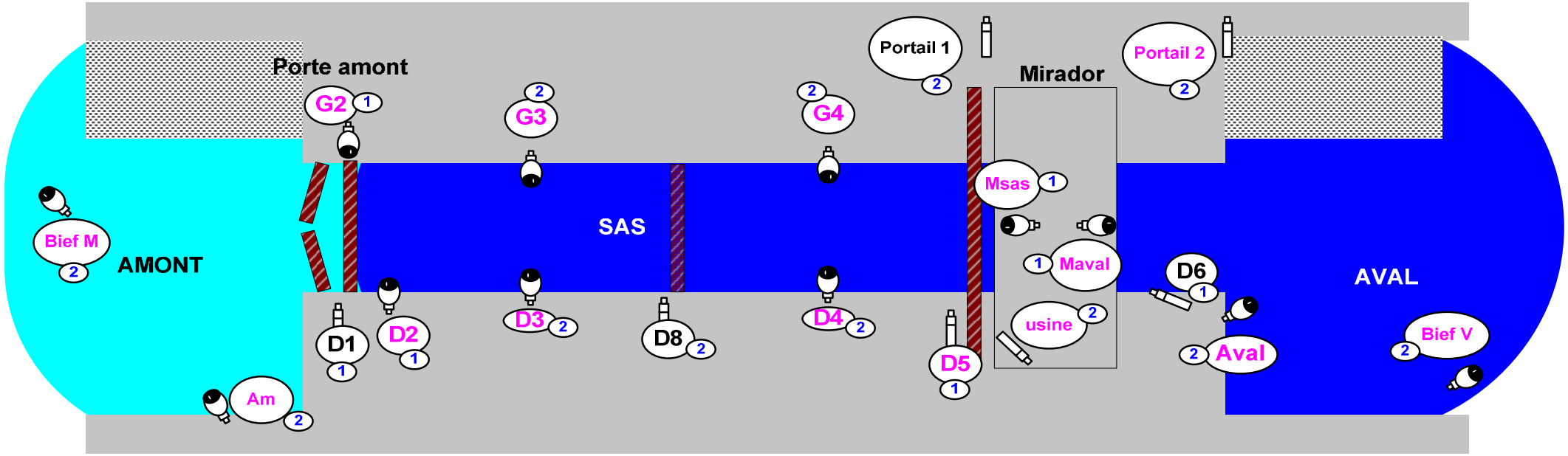
FONCTIONNEMENT DU CENTRE



LE SYSTÈME AUDIO

L’interface audio est regroupée sur un même poste de conduite

LE SYSTÈME VIDEO



Caméras fixes

Caméras dômes

Caméras de très haute qualité (1)

Caméras de bonne qualité (2)

L'implantation des caméras a fait l'objet d'une étude dans le cadre du groupe « ergonomie » du projet

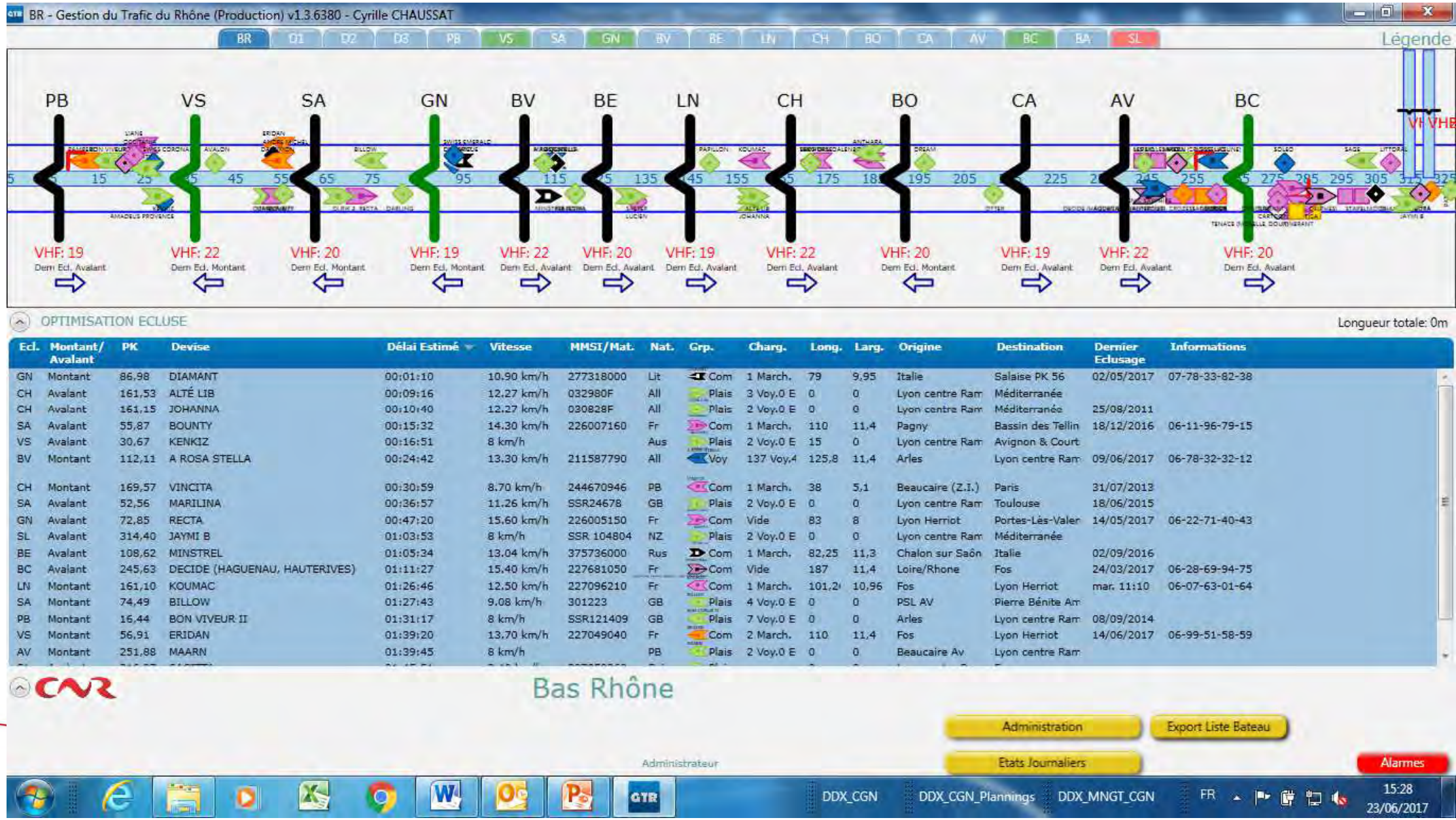
AIS OBJECTIVES

- **01-2016 - CNR put in place an AIS (Automatic Identification System) on the Rhône**

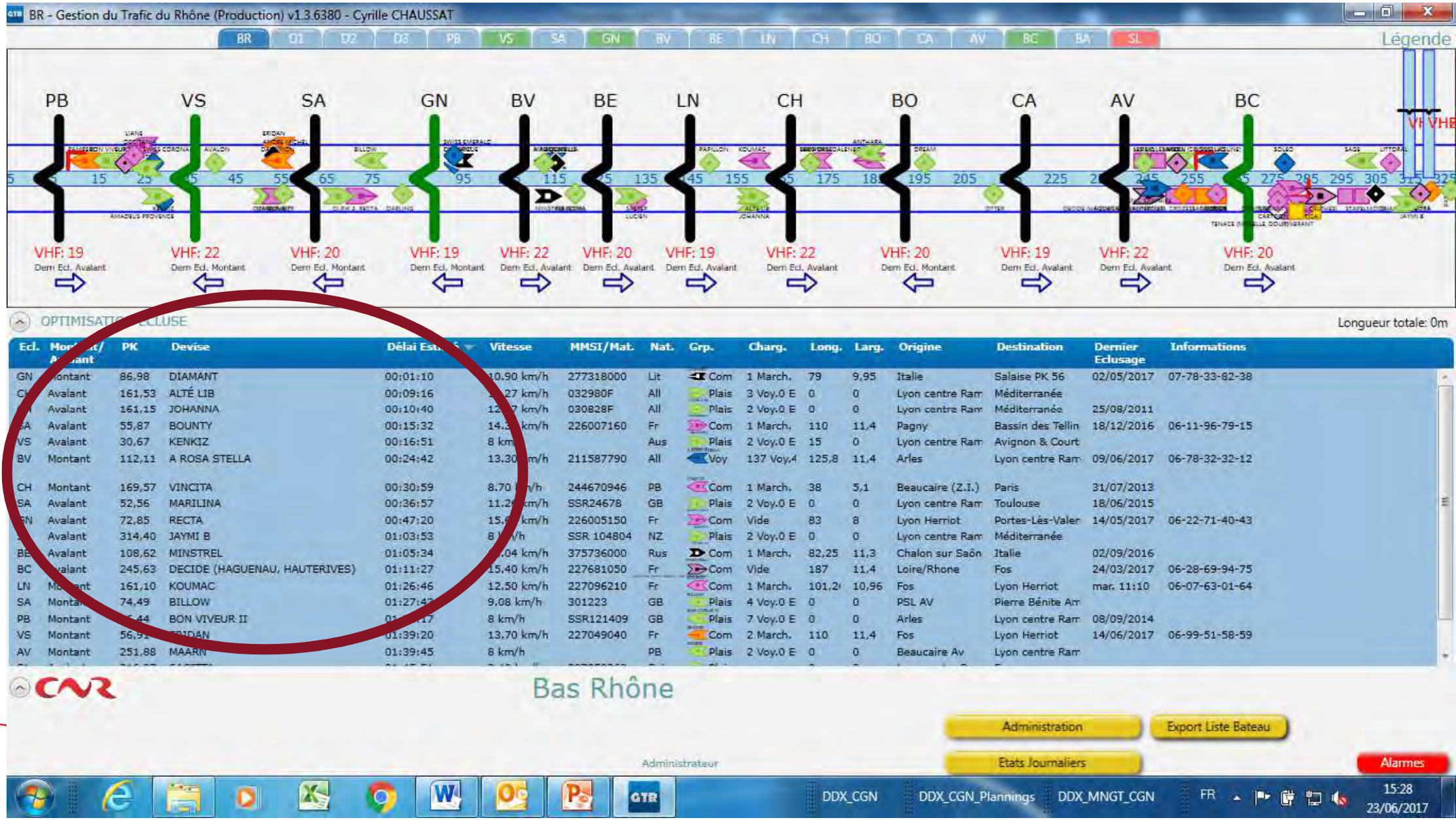
- **Information recovered on the CNR information system**

- **Objectives:**
  - To improve the efficiency of the navigation management by perfect knowledge of the traffic on Rhône
  - To reinforce the security of people by better knowledge of the exact position of boats at any moment

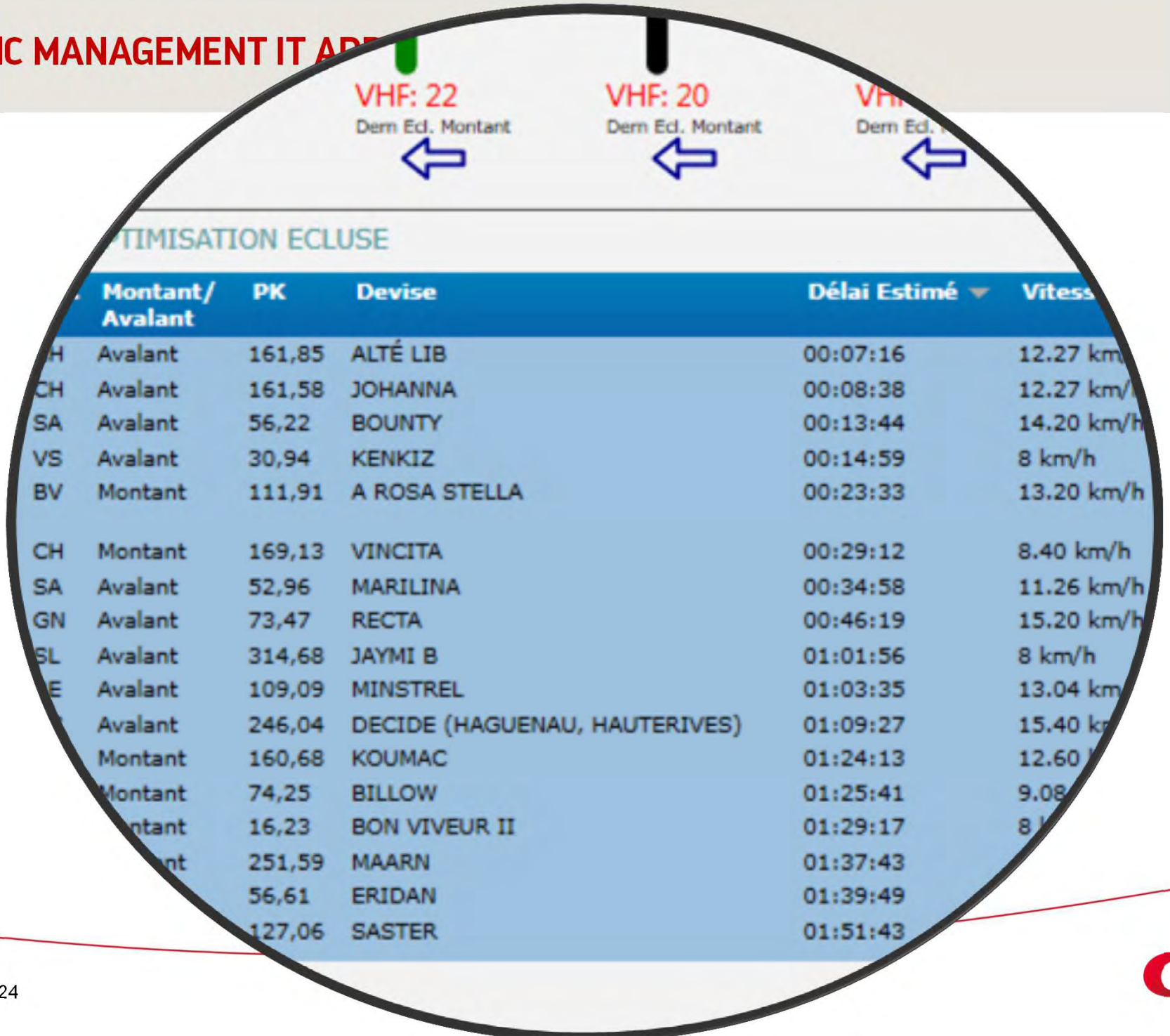
TRAFIC MANAGEMENT IT APPLICATION



TRAFIC MANAGEMENT IT APPLICATION

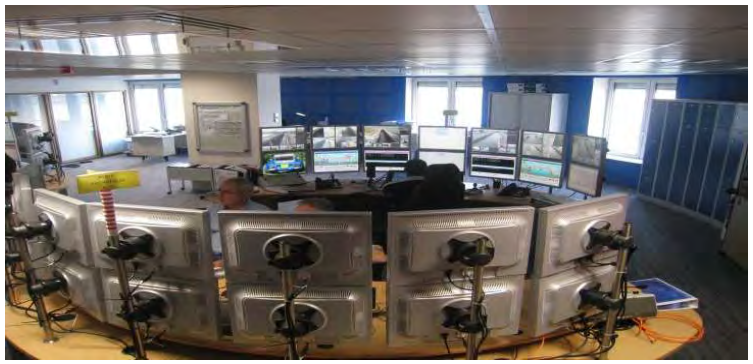


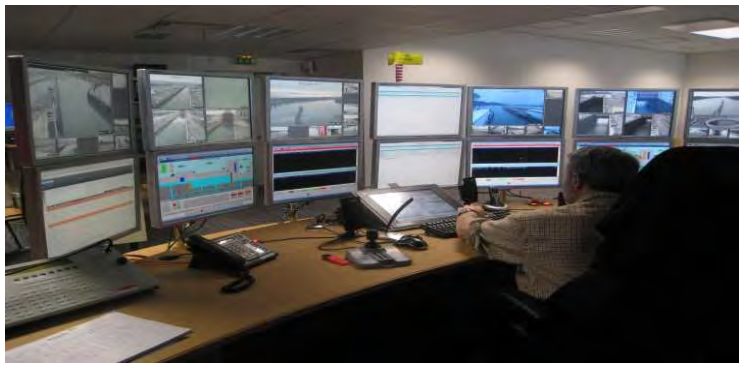
TRAFIC MANAGEMENT IT AR

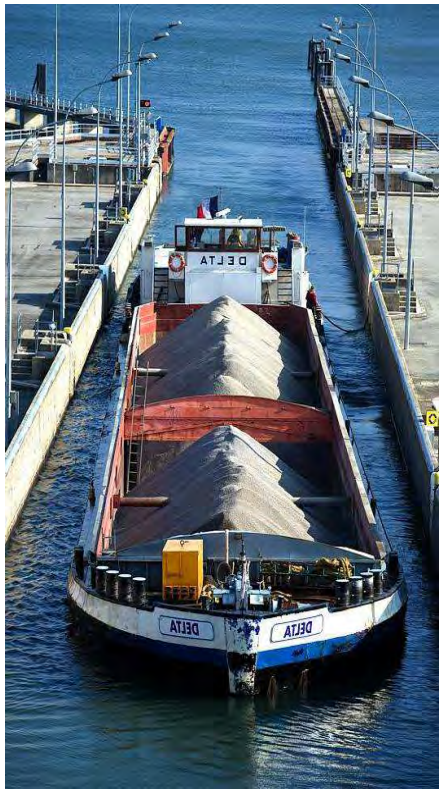


	Montant/ Avalant	PK	Devise	Délai Estimé	Vitess
H	Avalant	161,85	ALTÉ LIB	00:07:16	12.27 km
CH	Avalant	161,58	JOHANNA	00:08:38	12.27 km/
SA	Avalant	56,22	BOUNTY	00:13:44	14.20 km/h
VS	Avalant	30,94	KENKIZ	00:14:59	8 km/h
BV	Montant	111,91	A ROSA STELLA	00:23:33	13.20 km/h
CH	Montant	169,13	VINCITA	00:29:12	8.40 km/h
SA	Avalant	52,96	MARILINA	00:34:58	11.26 km/h
GN	Avalant	73,47	RECTA	00:46:19	15.20 km/h
SL	Avalant	314,68	JAYMI B	01:01:56	8 km/h
E	Avalant	109,09	MINSTREL	01:03:35	13.04 km
	Avalant	246,04	DECIDE (HAGUENAU, HAUTERIVES)	01:09:27	15.40 k
	Montant	160,68	KOUMAC	01:24:13	12.60
	Montant	74,25	BILLOW	01:25:41	9.08
	ntant	16,23	BON VIVEUR II	01:29:17	8
	nt	251,59	MAARN	01:37:43	
		56,61	ERIDAN	01:39:49	
		127,06	SASTER	01:51:43	

CONCLUSION







MODERNIZING NAVIGATION

Managing traffic with C.G.N.

Conducting locks

Thanks

L’énergie au cœur des territoires

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