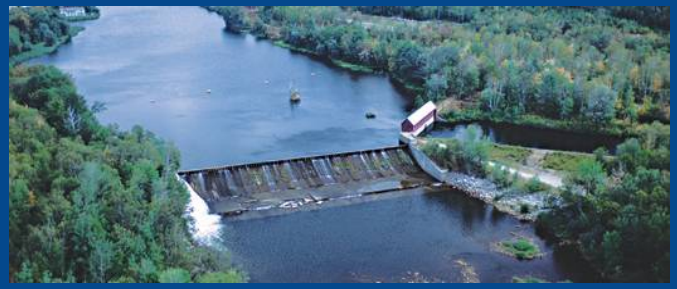


DSS:

Building the future from experience

CEATI-WMIG Water Management Decision-Support Software Workshop Nov 16-17, 2005, Niagara Falls, NY

BRASCAN POWER CORPORATION

CEATI

Brascan Power

In Profile

Brascan Power Corporation is a wholly-owned subsidiary of Brascan Corporation, which owns and/or operates all of the power operations of Brascan. Today these operations include:

- **130 hydroelectric power generating stations and 2 cogeneration plants**
- **Located on 43 river systems in US, Canada and Brazil**
- **Generating approximately 12,000 GWh of electricity annually**
- **3,385 MW of installed capacity**
- **Regulated business in Ontario with 725 km of transmission line and more than 11,000 customers**
- **Geographically diverse with strategic interconnections**

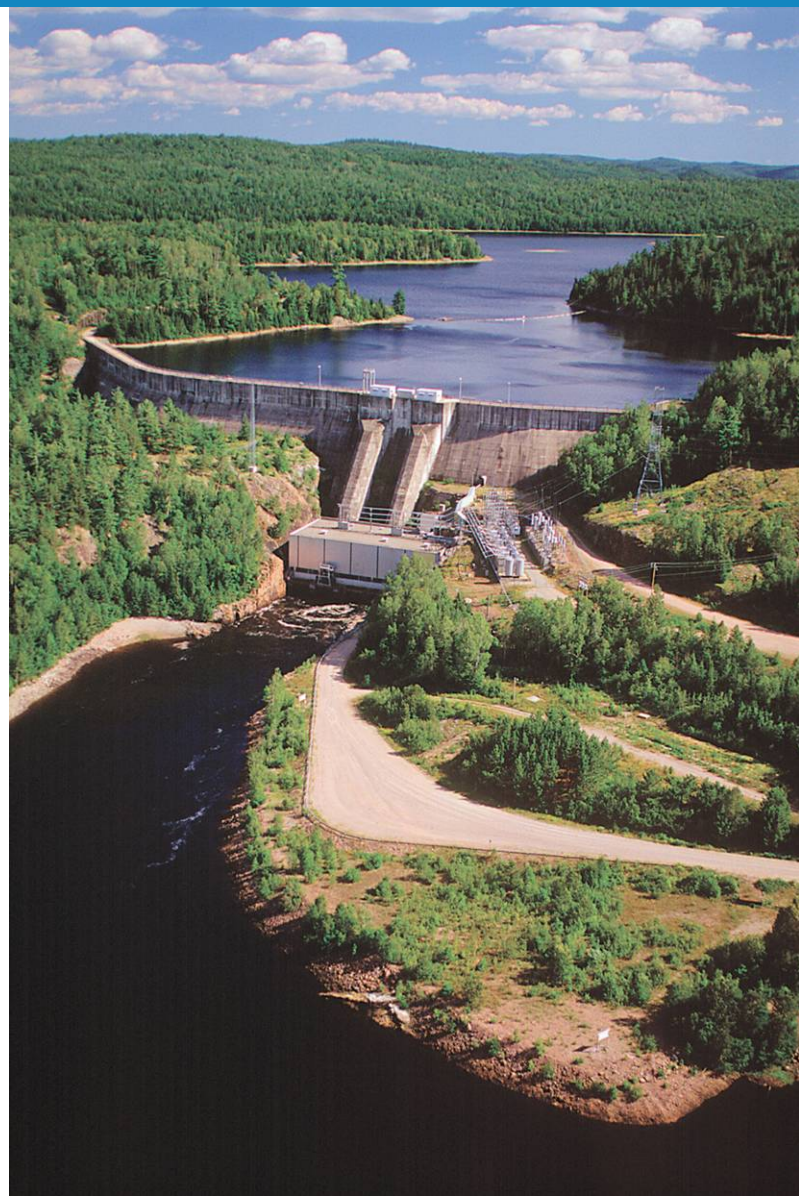
Strategic Priorities

BRASCAN POWER CORPORATION

Enhance Power Base

Enhance and Optimize Power Base

- Improve revenue from facilities by increasing contract pricing
- Maintain comprehensive capital program to preserve reliability and value of facilities
- Improve on-peak capabilities and maximize storage value
- Optimize ancillary value of hydroelectric facilities
- Improve efficiency of facilities and reduce costs



Decision Support Systems

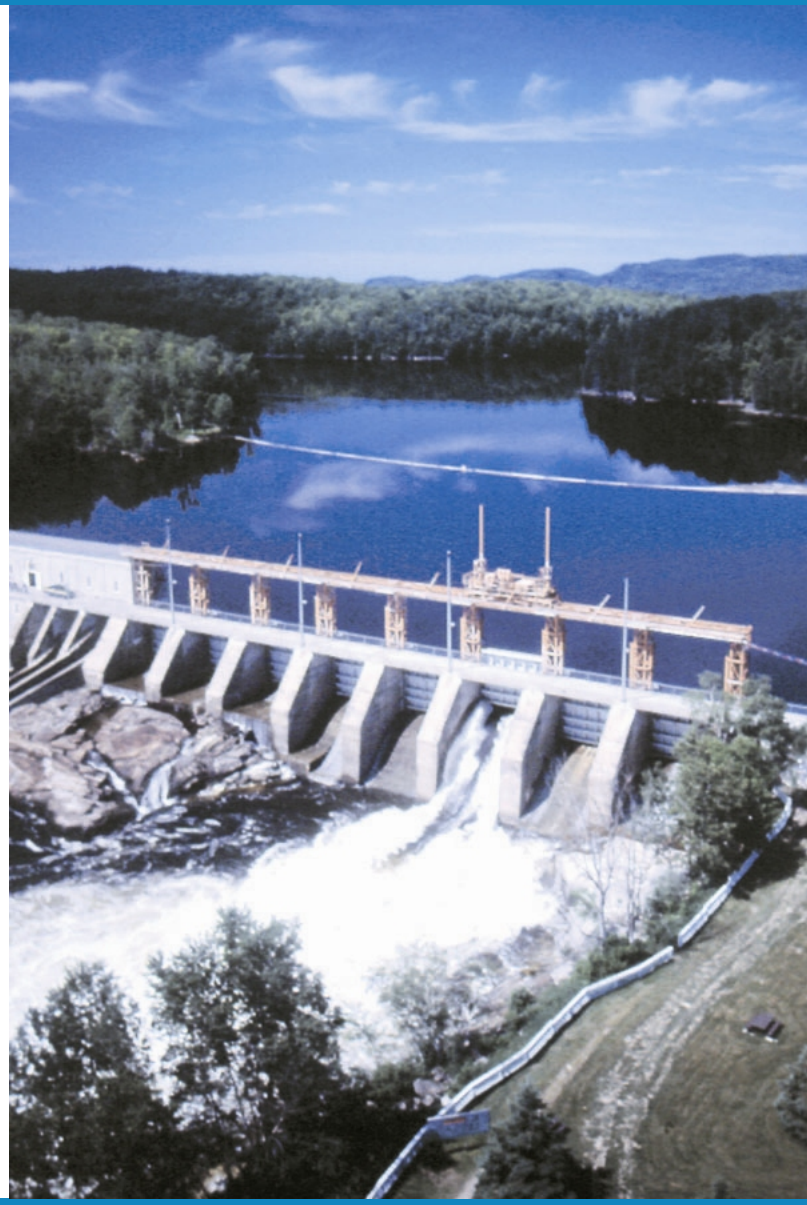
BRASCAN POWER CORPORATION

Historical highlights

- **20 years of history with DSS implementation**
- **4 implementations:**

  (excluding actual activities around a DSS in one region)

  - **Approx 1988: 2 stations, 2 watersheds, 1 reservoir on each in BC**
  - **Approx 1995: 12 stations on 3 watersheds with 1 reservoir on each watershed in Ontario**
  - **1999: 3 stations on 1 watershed with 3 reservoirs in Québec**
  - **2004: DSS implemented for Ontario and Québec assets: 19 stations on 5 watersheds with 7 reservoirs**
  - **All developed using external consultants or vendors**
  - **Maximize revenues, manage constraints**



DSS 1st generation

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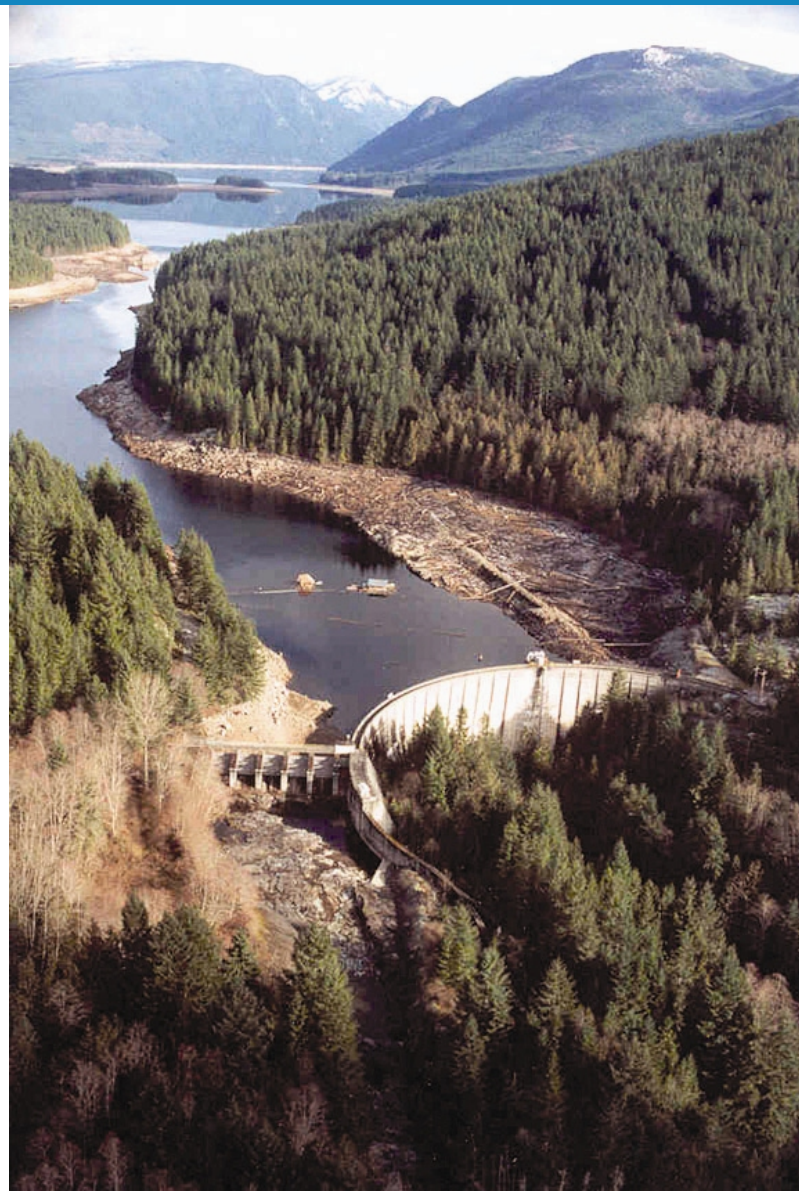
Long term reservoir management

- **Optimization Function:**
  1. Minimize spills while maximizing head
- **Main Characteristics:**
  1. Deterministic inflow scenario
  2. Monthly periods (weekly)
  3. No maintenance scenario
  4. Fixed price energy
  5. DOS based
- **Status**
  - Used extensively
  - Phased out (old technology) and not replaced



DSS 1st generation

Long term reservoir management

- **General assessment**
  - ✓ **Positive:**
    - ✓ Showed various inflow and generation scenario helping decision making for maintenance and load serving
  - ✖ **Negative:**
    - ✖ Hard coded software
    - ✖ Impossible to modify, extract or view parameters
    - ✖ Not very user friendly interface

DSS 2nd generation

BRASCAN POWER CORPORATION

Long term revenue optimization

- **Optimization Function:**
  1. Maximize revenues
- **Main Characteristics:**
  1. Deterministic inflow scenarios
  2. Monthly to weekly (hourly) periods
  3. Maintenance planning
  4. Seasonal energy prices
  5. Peak and off-peak definition
  6. OS2 based
- **Status:**
  - LT Used extensively
  - Phased out because of market changes and technology
  - Tentatively replaced by 4th generation

DSS 2nd generation

Long term revenue optimization

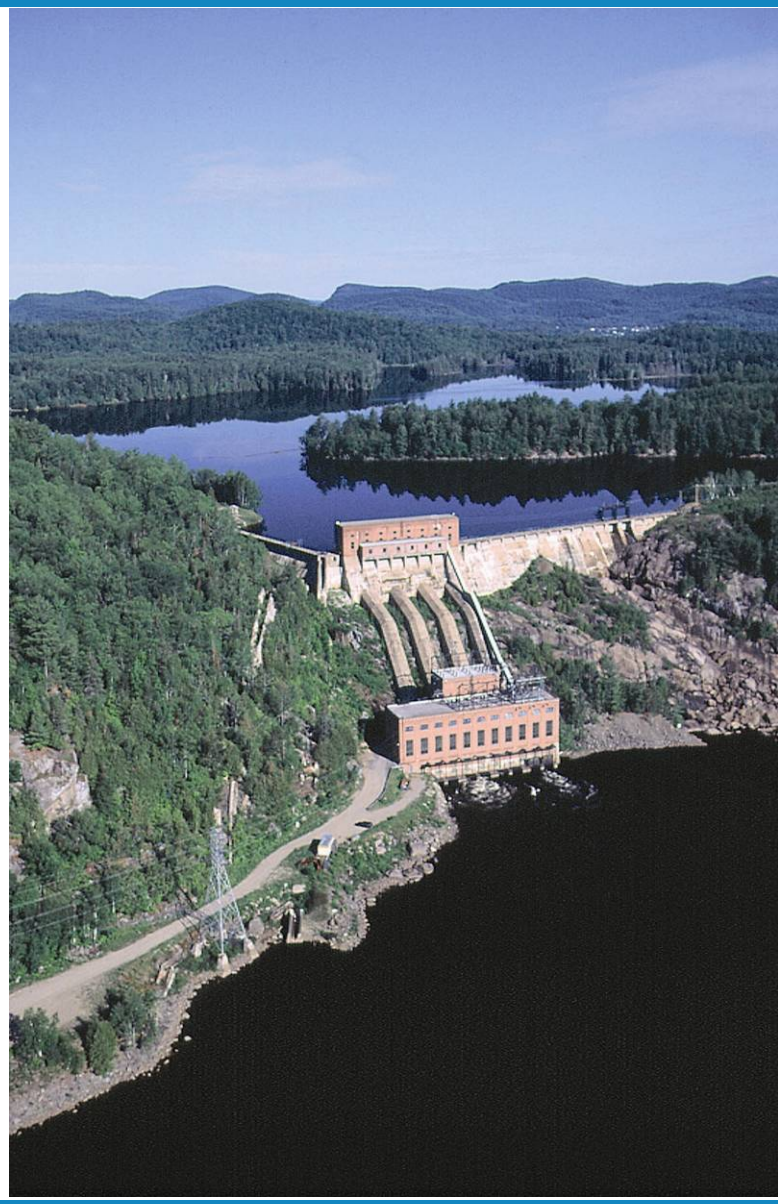
- **General assessment**
  - ✓ **Positive:**
    - ✓ View multi inflow, generation and maintenance scenarios
    - ✓ Capability to change parameters (prices, capacity, levels)
    - ✓ Could evaluate changes in constraints or equipment
    - ✓ Some automatic data transfer from SCADA to DSS
    - ✓ Provide data management interface with SCADA historian
  - ✗ **Negative:**
    - ✗ Long process to set a “run”
    - ✗ Results tended to favor extreme of constraint ranges
    - ✗ No evaluation or validation of data
    - ✗ Computer process time was excessive (more than 2 hours)

DSS 3rd generation

BRASCAN POWER CORPORATION

Short term efficiency optimization

- **Optimization Function:**
  1. Maximize energy production by
     a) Maximizing head
     b) Optimizing unit loading
- **Main Characteristics:**
  1. Inflow forecasting (10 days)
  2. Hourly periods updated every 5 min
  3. Maintenance planning
  4. Fixed energy price
  5. UNIX based
- **Status:**
  1. Became obsolete after 6 months when assets became exposed to market prices (maximization of revenues over ruled generation maximization)



DSS 3rd generation

Short term efficiency optimization

- **General assessment**
  - ✓ **Positive**
    - ✓ Identified weaknesses in operational guidelines and data quality
    - ✓ Excellent river routing model
  - ✗ **Negative:**
    - ✗ Runoff module required daily calibration (>1hr/day)
    - ✗ Required excellent precipitation forecasts
    - ✗ Model could not work with bad data (negative inflows)
    - ✗ 5-min updates required perfect computer performance
    - ✗ Could not accept price fluctuation
    - ✗ Weak long term analysis

DSS 4th generation

BRASCAN POWER CORPORATION

Short term & Long term revenue maximization

- **Optimization Function:**
  1. Maximize energy and operating reserve revenues over 18 months
- **Main Characteristics:**
  1. Inflow forecasting (10 days) with regression to mean
  2. Hourly optimization (10 days), weekly (6 weeks), monthly (18 months)
  3. Maintenance optimization module
  4. Volatile energy price
  5. Operating Reserve Revenues included
  6. Evaluates Marginal Value of Water
- **Status:**
  1. Development halted when risk management policy got updated
  2. Needs further funding to review optimization function and execute calibration

DSS 4th generation

BRASCAN POWER CORPORATION

Short term & Long term revenue maximization

- **General assessment**
  - ✓ **Positive:**
    - ✓ Integration of long term and short term
    - ✓ Looked at hourly price forecasts based on volatility curve
    - ✓ Evaluation of Marginal Value of Water
    - ✓ Global revenue optimization
  - ✗ **Negative:**
    - ✗ Cumbersome comparison of scenarios
    - ✗ No quantification of the volume risks
    - ✗ Optimizer was a “black box”
    - ✗ Required good precipitation forecasts
    - ✗ Sensitive to data quality (no possible solution 60% of time)
    - ✗ Simplistic approximation of set of constraints in model

DSS Implementation

Unexpected challenges

- **Data Acquisition**
  - **Real-time data are (often) not validated and of low quality and filters can't correct everything**
  - **Validation/correction of equipment and river characteristics**
- **Hydrology**
  - **Inflow forecasting:**
    - Short Term (is 10 day too optimistic ?):
      - Reliable precipitation forecasts next 3 days
      - Runoff model difficult to calibrate
    - Long Term
      - How to approach this (both prices and inflows)?
  - **Modeling constraints:**
    - Increased complexity of constraints is often tricky to translate into equations
- **HR**
  - **Human resistance to change**

DSS Implementation

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Observed evolution

- **Inflow Scenarios:**
  - Still using deterministic approach
- **Inflow Forecasting:**
  - None in generations 1 & 2 to 10 day inflow forecasts in generations 3 & 4
- **Term and periods:**
  - Monthly to weekly to hourly
- **Maintenance:**
  - Maintenance planning evolved from a separate evaluation to a fully integrated optimization function
- **Prices:**
  - Not considered to full hourly price forecasts
- **Other Trends:**
  - Include ancillary services in analysis
  - Evaluate marginal value of water
  - Risk management still needs to be addressed

DSS 5th generation

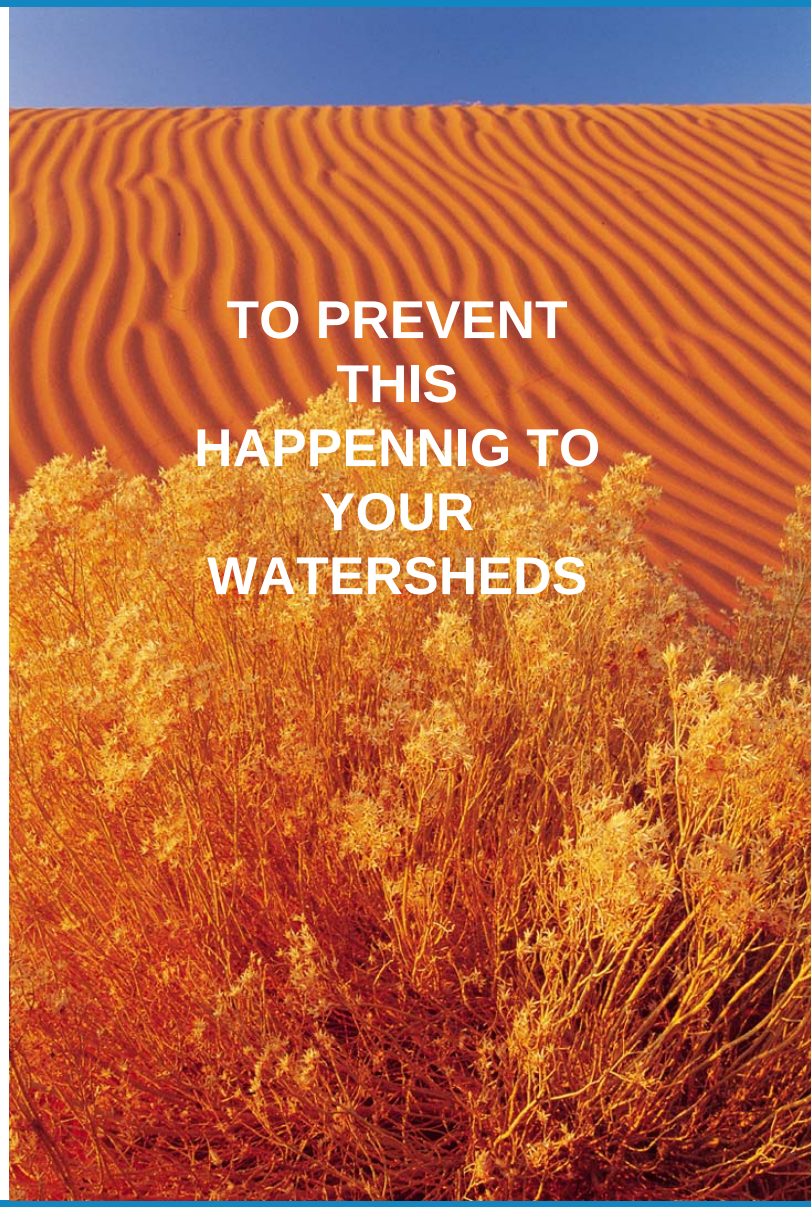
BRASCAN POWER CORPORATION

Why ?

- **To**
  - Better use of the water
  - Continuous monitoring of generation efficiency/performance
  - « What if » scenarios based on constraints, prices, inflows, upgrade of units, etc.
  - Maintenance planning coupled with market opportunities
  - Integration of generation planning and risk management
  - Risk analysis for transacting energy
  - Risk analysis for dam safety

- **Because**

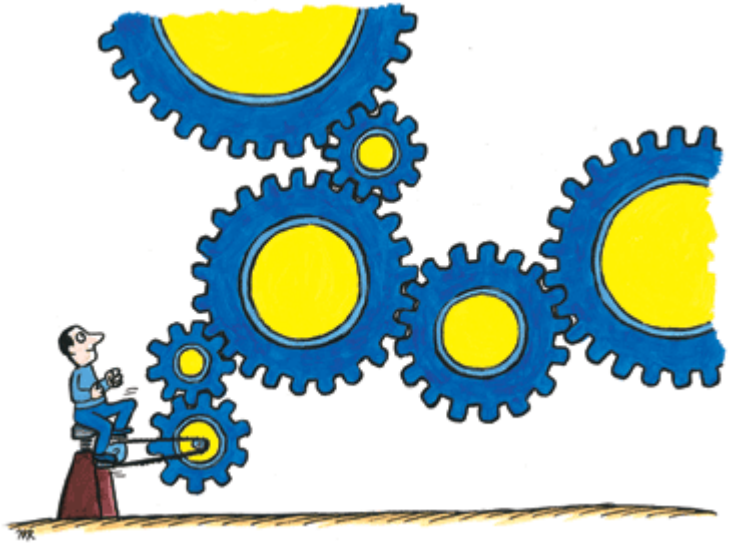
There is a PROVEN and MEASURABLE return on investment.



DSS 5th generation

How ?

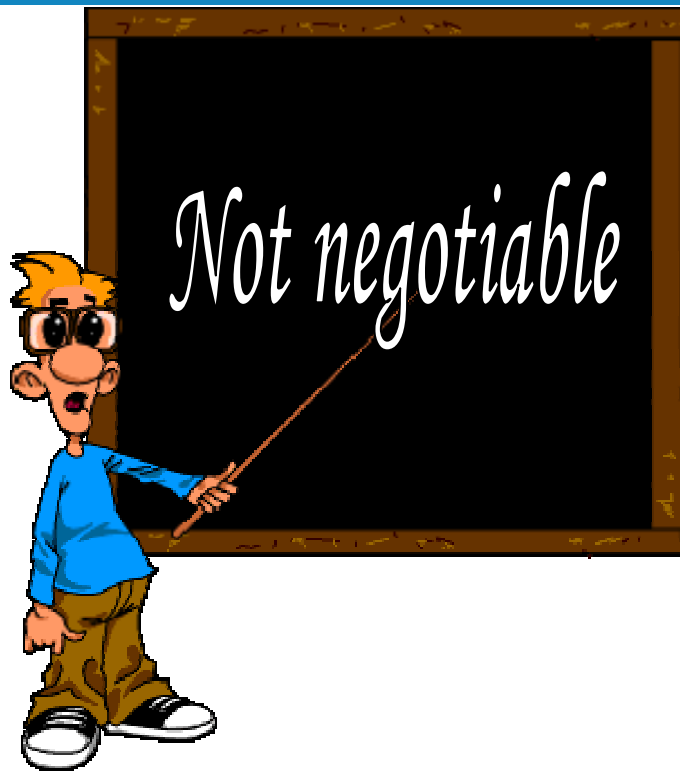
- **Define and fix goal:**
  - Maximize the revenues vs optimize efficiency vs minimize spills
- **Set list of objectives to achieve your goal:**
  - Planning of water allocation to market ST & LT price signals
  - Achieve best possible efficiency
  - Plan maintenance in the right periods
  - Manage environmental constraints
  - Provide volume risk evaluation
- **Phases:**
  - Implement the DSS step by step:
    - start with the easiest simulation that can be validated
    - progress to adding components and complexity
      - variable prices
      - maintenance schedule
      - changing constraints
      - multi-inflow scenarios
- **Realistic deadlines:**
  - Add 25% to 50% to the estimated schedule
- **Budget:**
  - Changes to IT and monitoring equipment
  - Hydrological/hydraulic studies



DSS 5th generation

When ?

- **Prerequisites:**
  - **Review quality assurance of data:**
    - Flow measurement (spills and generation)
    - Level gauges (reliable and continuous readings)
    - Reservoir volume curves
    - Generation (yes, not always good…)
    - Precipitation forecasts and quantity estimation
    - Reliability of runoff and inflow models
  - **Staffing:**
    - Experienced planning personnel
    - Dedicated operation personnel
    - Instrumentation and IT experts (SCADA and data archiving)
    - Engineering (characteristics of equipment)



DSS 5th generation

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Reality check

- **Don't dream:**
  - Aim for a 1.238% efficiency improvement if your flow measurements have a 3% error margin
  - Expect your inflow forecasting to exceed your precipitation estimation accuracy
  - Justify your return by cutting human resources: DSS is a complement to the experience
  - Think your hydro system will work by itself

- **Don't forget: although computers can now solve quickly complex algorithms,**
  - Electricity markets have evolved rapidly (and will continue to)
  - Environmental and social constraints have also evolved rapidly
  - Same old rain gages (trend is towards fewer)
  - Same old ways of flow monitoring (trend is towards fewer)
  - Same questions about forecast reliability (precipitations and inflows)

DSS 5th generation

Won't do this:

Before DSS

After DSS