Overhaul or Upgrade:
Governor Decision Factors

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Abstract

Mechanical governors have been the stalwart hydroelectric control system for over a century. The reliability and longevity of these governors has inspired confidence in generations of hydro maintenance crews, and literally thousands of them remain in service today in North America. But, governor technology has long since moved into the digital age, leaving owners in a quandary: Should I maintain my existing governors or upgrade them? This paper presents a method for assembling and prioritizing the factors to consider before making a decision.

Introduction

Through most of the 20th century, governor upgrades were low on most owners' priority list. The original equipment governors worked well and were extremely reliable; maintenance crews understood how they worked and knew how to service them; spare parts were either on-hand or readily available; and the major Original Equipment Manufacturers (OEMs) continued to provide good support. There was no reason to upgrade.

All that changed by the end of the 20th century. All of the governor-only OEMs had either gone out of business or been acquired by other firms. Parts were increasingly expensive and lead times were long. Powerplant crews found creative ways to get parts: they bought them locally, borrowed from other plants, or simply made the parts themselves. With little to be gained in terms of unit efficiency, and concerns about computer technology, digital upgrades remained a low priority.

Yet, governor technology had long since evolved into digital control, and governor OEMs made a business decision to cut off support for their legacy governors. When customers requested parts, they heard that their governors were obsolete and, although some parts were still available, support would eventually end. They were encouraged to begin planning for digital upgrades. This sent a shock wave through the hydro industry.

Today, there are new options available for owners of 'orphaned' governors. Parts, service, and training are available from non-OEM providers. Digital upgrades are no longer mandatory. With the immediate urgency of "No Support Available" removed, owners and operators can make a reasoned decision whether or not to upgrade their governors.

This paper presents the arguments for and against upgrading legacy governor systems, and describes a rational, systematic method for determining which approach – upgrade or maintain - is appropriate for each unit and powerplant.

Reasons to Upgrade

Legacy governors were designed primarily to provide speed and frequency control, however, new functions were added in the mid-20th century in response to customer operational needs. Remote control, megawatt control, level control, and bypass valve control were all achieved by adding auxiliary devices to the basic governor mechanisms.

But, with only electrical and mechanical technology to work with, implementation of these control modes tended to be imprecise. Remote control originally referred to being able to control the governors from the Main Control Room upstairs. In the 1970's new technology called Supervisory Control and Data Acquisition (SCADA) joined the lexicon of utility vocabulary. Remote control now referred to remote *computer* control, from tens or hundreds of miles away.

The only way to change governor setpoint was pulsing the DC motors in the governor cabinet, and early SCADA systems struggled with controlling the unit using this method. Due to gear lash and overtravel, there was no fixed correlation between pulse length and resultant unit output. Complicated methods were devised using variable pulse lengths and time delays. Some utilities devised governor shaft braking systems to prevent overtravel after a motor was pulsed. These workarounds proved acceptable until relicensing, when wholesale control improvements were typically required.

Relicensing-Driven Control Upgrades

During the relicensing process, utilities are often required to improve the operation of their plants. They may have to guarantee stable river flows, with or without the generating units, and they may have to adhere to strict limits on the rate of change of downstream flows. These requirements are valid reasons to upgrade the governors, especially when myriad 'stakeholders' can and do monitor USGS streamflows over the Internet. Penalties for violating flow requirements can be very severe.

Figure 1 PG&E's Chili Bar plant needed a governor upgrade to meet stringent, new downstream flow requirements.

New functionality driven by relicensing includes:

- Better downstream flow control
- Time-of-day water releases
- Automatic flow ramping, within prescribed limits
- Better coordination of turbine and bypass valve or spillway gates

Market-Driven Enhancements

Today, utilities are constrained by rising energy prices, end-user demands for cheap, reliable power, and shareholder demands for profitability. To succeed in an environment of deregulated markets and spot pricing structures, some utilities invest heavily in unit and plant automation.

For example, to capture the best price for power, a utility Dispatch Center may need to start a unit hundreds of miles away and ramp it up to load in just ten or fifteen minutes. All the remote, automatic systems must work: The power market makes no allowance for delays due to balky relay logic, slow communications, or worn governor equipment, and there's not enough time to dispatch a crew to manually start and synchronize the unit. If power is not delivered to the grid at the agreed-upon time, the utility can be penalized. To avoid this, utilities invest in unit automation systems that can include the following governor enhancements:

- Remote Auto-start
- Automatic sequencing of auxiliaries
- Automatic synchronizing
- Faster on-line load ramping
- High-level SCADA interface
  (Ethernet/RS485/Setpoint Control)

During unit automation projects, utilities may also try to improve efficiency:

- Improved 3D Cam control (Kaplan turbines)
- Improved needle sequencing (Impulse turbines)
- Smart Unit Dispatching (Replaces Joint Load Control)

New vs. Old: Technology and O&M Staffs

Many utilities have already reduced their Operations and Maintenance (O&M) staff and converted, or plan to convert, their plants to unattended operation. With a generation of senior plant mechanics and electricians approaching retirement, the average age of O&M crews is getting younger. More familiar with digital technology, new-generation O&M crews view the benefits of digital upgrades in terms of:

- Intuitive, informative governor interface (color touchscreen replaces meters)
- Improved governor diagnostics
- Simplified maintenance procedures
- Extended maintenance intervals

Figure 2 Digital technology reduces periodic maintenance

Other Reasons to Upgrade

The arguments cited below used to apply to all legacy governors, but with the advent of non-OEM governor support, many of these reasons no longer apply. It depends on the specific model and type of governor you have. **Note:** None of these arguments remain valid for Woodward governors.

1. Fear of Downtime and Lost Revenue

The major OEMs – as well as a host of third-party digital governor suppliers – are intent on convincing owners of legacy governor systems to think in terms of downtime: "What would a governor failure cost you in terms of lost revenue?"

2. OEM Parts Too Expensive / Lead Times Too Long

Mechanical governors need to be overhauled regularly, so long-term parts availability is a must. Beginning in the mid-90's, lead times for common spare parts went from in-stock to weeks or months and prices skyrocketed.

3. OEM Field Service Difficult to Obtain

Layoffs, retirements and corporate buyouts often correlate with the loss of senior talent and the substitution of younger engineers. The new talent may be up to speed on the latest digital governors, but can be woefully inexperienced with legacy governor equipment, much of it put in before they were born. Some customers have noted to the authors that site staff knew more about the governors than the OEM-provided Service Engineer.

4. OEM Technical Support Weak

Mirroring the trend in field service, OEM Technical Support has struggled to retain the people most knowledgeable about legacy governors. Retirement can prove too enticing to pass up for senior governor specialists, who see their company swerving away from the traditional values.

5. Customer In-House Expertise Lost

Revisit Item 3 and see if it applies to your powerplant staff. With the loss of senior plant technicians and mechanics, there can be a general unraveling of the knowledge of how the governors work, when to service them, how to calibrate them, and how well they can be expected to perform.

Reasons to Maintain

Now that you're ready to upgrade, let's take a step back and consider some of the reasons you might actually want to hold on to your governors.

1. Legacy Governor Parts and Service Available

Mechanical governors were designed to last 100 years with regular overhauls. Although many experienced governor specialists and field service engineers are no longer working for the OEM doesn't mean they left the industry.

Third-party vendors hired many of them, and they continue to provide support for legacy governors. Without the physical overhead and ideological baggage of an OEM, these vendors offer world-class governor parts, service and training at down-to-earth rates.

Figure 3 Governor overhaul parts are now stocked by national companies.

2. Legacy Governor Training Available

Professional training is also available from third-party vendors, at your site or in their classroom. Whether for a new crop of apprentices or a group of seasoned mechanics or electricians, periodic site training is the best way to keep your staff up to speed on legacy governor technology. The more you know about your legacy governor, the less intimidating it is to work on.

3. Retrofit Kits Improve Performance

Retrofit kits are available to eliminate weak spots in your legacy governor system. These kits may be all you need to extend the useful life of a legacy governor. Modern-technology kits can replace:

- Obsolete 3D Cam controllers
- Selsyn transmitters and receivers
- Mechanical overspeed switches
- 'Snap-action' pump pilot valves

Figure 4
PLC-based 3D-Cam

If you like the reliability of your mechanical governor but want to incorporate some modern control and communications features, a Digital Governor Interface Kit may be right for you. Small and inexpensive, this kit includes a PLC controller that provides a bridge between your mechanical or analog governor and your SCADA system. It preserves everything you like about your legacy governor, including auxiliary valve control, and adds enhancements like remote setpoint control, fast on-line ramp rates, governor out-of-calibration alarms, and digital communication. To the rest of your system, your legacy governor will look like a digital governor.

4. Product Life Cycle of Digital Governors is Relatively Short

Whether proprietary or off-the-shelf, the product life cycle of modern digital controls and hydraulic components is poor compared to a mechanical governor. This is due to the rapid development of newer technology. The result is that spare parts can be difficult to find and expensive to purchase just ten years from installation. Software and the computers that can run it become obsolete. We call this the "digital treadmill." Some customers have remarked to us that their newest governors are the most difficult and expensive to support and maintain.

Maintain or Upgrade?

At this point you may be thoroughly confused. "If the governor upgrade I thought was inevitable is once again optional, what should I do?" This section describes a method for analyzing and evaluating all the pros and cons. You will prioritize the things that are important to you, grade your current situation, and in the end, arrive at a score for each unit and powerplant.

Let's begin by answering a few preliminary questions:

1. Has your governor been reliable?
2. Are spare parts available at reasonable prices for your governor?
3. Is technical support available at reasonable prices for your governor?
4. Are field service engineers readily available at reasonable prices?
5. Are training classes available for your governor?
6. Can your governor provide the control features you need now?

If your answer to <u>all</u> of the above questions is Yes, then a governor upgrade is <u>not</u> necessary and the Decision Matrix may be skipped.

If you answered Yes to Question 6, and the new functionality you require cannot be obtained through minor modifications (Retrofit Kits or Digital Governor Interface), then a governor upgrade is necessary and the Decision Matrix may be skipped.

Governor Decision Matrix

This section lays out all the governor decision factors, then lets you rank them individually according to your unique situation and preferences. Based on Six Sigma concepts and methodology, the Governor Decision Matrix (sample shown in Table 1) is the tool that will provide your answer. The Weighting factors can be adjusted from 1 – 5, depending on whether you believe the factor is Not Important or Extremely Important.

Before you start, you'll need to do a little homework. Gather up the last few years of operator logs (five years is best) and dig into them to determine the answer to the first two factors.

Factor 1: Frequency of Failure

Although governors rarely cause an outage, it can happen. Review your logs to see if any trips or failed starts were attributed to governor problems. Count how many times you had a governor problem that either caused the unit to shutdown or prevented it from restarting normally. Do not include scheduled outages for periodic maintenance.

Failure frequency over five years	Ranking
Five or less failures	1
Six to twelve failures	3
More than twelve failures	9

Factor 2: Cost

Specifically, what have you been spending on your governors? Average the amount spent on parts and service (in-house and/or vendor-supplied) over the last five years, on a per-unit basis.

Average Parts & Service Cost	Score
Less than $10K per year	1
Between $10K and $15K per year	3
More than $15K per year	9

Factor 3: Support

Aftermarket support is available to varying degrees for many types of legacy governors. Identify the manufacturer of the legacy governor for the plant in question and use the criteria below to rank each unit.

Governor Manufacturer	Score
Woodward	1
Pelton, Allis-Chalmers, Lombard or Voith	3
Most others	9

Factor 4: New Features Desired

New features, such as unit sequencing, downstream flow control, plant control, automatic synchronizing and enhanced remote communications will be accounted for without the need to estimate costs for each. Simply select the features you want or need and add up your score. Then, use the evaluation criteria to rank this factor.

New Feature Desired	Rating	Your Score
Automatic unit sequencing	2	
Improved 3D Cam control	1	
Enhanced remote control (setpoints vs. R/L)	1	
Direct SCADA interface (Ethernet, Data Highway)	2	
Synchronous bypass valve control	3	
Downstream flow control	3	
Touchscreen operator interface	1	
Needle Sequencing (Impulse)	3	
Automatic synchronizing	3	
	TOTAL	

New Feature Index	Score
Your Score is less than 6	1
Your Score is between 7 and 12	3
Your Score is greater than 12	9

Entering Data into the Matrix

The Decision Matrix allows you to apply your own experience and preferences and determine a score for each unit, and a plant average. Using the sample matrix shown in Table 1 as a guide, let's walk through an example of using the matrix.

Each unit's Total Score is the sum of Weighting x Unit Score in each of the four factors. Weighting varies from 1 (Not Important) to 5 (Extremely Important) and reflects your organization's priorities and expertise. Suppose your organization has established the following priorities:

Factor	Our Priority	Weighting
Frequency of Failure	Very important	4
Cost to Repair	Moderate	3
Support	We can make some parts	3
New Features Desired	Mild interest; not required	2

Here's how the data might look in the matrix:

Table 1 Governor Decision Matrix

Factor	Weighting	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10	
Frequency of Outage	5	1	9	1	9	3	3	9	1	3	3	
Cost to Repair	3	3	1	3	1	1	3	9	1	3	3	
Support	3	1	1	1	1	1	1	3	3	3	3	
New Features	2	1	1	3	3	3	3	3	3	3	3	**Plant Average**
Total		19	53	23	57	27	33	87	23	39	39	40

Unit Scoring	Decision
Unit score greater than 100	Unit should be upgraded
Unit score between 50 and 100	Subject to owner discretion
Unit score below 50	Unit should be maintained

Units are seldom individually upgraded, therefore a plant average may be useful in determining when to convert all the governors in an entire plant:

Plant Average Scoring	Decision
Plant average greater than 50	Upgrades recommended
Plant average less than 50	Units should be maintained

In the example above, Units 2 and 4 appear to be in need of an overhaul. Unit 7 merits further investigation. Why was the cost to repair so high? If the governor was hunting severely, and still is despite numerous parts replaced, a visit by a governor specialist is indicated. The plant average of 40 suggests that the governors at this plant should be maintained.

Conclusion

Digital governor upgrades are no longer mandatory. The decision whether to maintain or upgrade your legacy governors should be made based on sound analysis, not emotion or fashion. Application of the evaluation criteria and Decision Matrix described in this paper will enable owners to make sensible choices, saving time and money in the process.

Authors

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