David Cunningham, M.Ed
Cunningham Enterprises

Hydro Power Plant
DACUM Report

February26, 2016

Center of Excellence for Clean Energy
Centralia College

Primary Meeting Focus

" What is the typical work profile of an entry level worker at a Northwest Hydro Power Plant?"

"What is the core knowledge, skills and aptitudes (KSAs) a person needs to do this work?"

Agenda

1. Welcome & Introduction Barbara Hins-Turner
2. Panel Introductions
3. DACUM Workshop Overview
4. Focus Questions Review
5. Workshop I - Mapping the work profile
6. Lunch
7. Workshop II - Mapping the KSAs
8. Final Plenary and next steps
9. Thanks to the Panel members Barbara Hins-Turner

Participants:

Name	Company or Municipality
Pat McCarty	Tacoma Power
Larry Burnett	Tacoma Power
Bob Gunther	IBEW 77
Dan Kay	Lewis County PUD
Jeremy Blue	PNECE
Micah Goo	Centralia City Light
Michelle Vargo	Seattle City Light
Terry Knight	Avista Corporation
Troy Nutter	Puget Sound Energy

In addition surveys were completed by 16 additional subject matter experts (SMEs) as follows:

Source	Number of completed surveys received
Seattle City Light	3
City of Tacoma	2
AVISTA Corporation	6
Tacoma Power	4
Canadian Hydro SME	1

Total number of Hydro Power Subject Matter Experts consulted	**25**

Staff present from Centralia Community College, Grays Harbor College and the Pacific Northwest, Center of Excellence for Clean Energy were as follows.

Barbara Hins-Turner	Director for the Pacific Northwest, Center of Excellence for Clean Energy
Angela Conley	Staff Support, Pacific Northwest, Center of Excellence for Clean Energy
Robert Topping	Faculty, Centralia College
John Steidel	Faculty, Centralia College
Mike Kelly	Workforce, Grays Harbor College

Facilitation: Dave Cunningham: Dr Susan Hoyne

Notes:

1. The SME survey and a summary of responses are in appendix B and C respectively.
2. All numbering and lettering in this document is for ease of reference only. It does not denote priority or level of importance.

The panel introduced themselves. Their experience and expertise was broad representing the utility industry in some depth covering the power generation sector, the business sector and training sector of the industry. Coupled to that, the pre-meeting survey that was sent, to Hydro Power Generation professionals in the Northwest and in Canada had been tabulated and brought to the meeting as an additional source of experience and ideas for the discussion. In the course of introductory remarks, the panel shared their thoughts on developments and challenges facing the industry - especially the sector involved with Hydro power generation. The challenges and developments that were discussed were as follows:

1. The new safety-related regulations from the Federal Energy Regulatory Commission or FERC raises the bar on safety standards. These new FERC standards call for changes in past practices and considerably more documentation, both of which complicate the work of management and technical staff at Hydro power generation plants. Small companies and Hydro Power Generation plants are especially burdened by the increased documentation required under FERC.
2. Shifts in the energy business markets with the influx of natural gas production, wind, solar and other energy sources have impacted pricing structures and other factors. These market shifts impact the power generation at Hydro power plants - changing the past power generation practices and therefore the work of DAM management and operators. For example, power demands over a typical day have shifted and in some cases - a lot. Maintenance work that was once done in the down times has to be re-scheduled which affects work shifts, life styles and more. The scale of these market changes was likened to a 180^0 shift in how some Hydro power plants operate.
3. The pending wave of retirements in this industry was raised. As in many industries in the Pacific Northwest, the energy industry is anticipating a big exodus of very experienced and skilled people. Tacoma Power and Light for example faces a potential retirement of 40% of their workers. Also, the concern is the labor market indicators suggest the pool of potential replacements for these people is quite inadequate to meet the industry need.
4. In the face of these retirements the industry seems challenged to address how the knowledge transfer of the retiring generation can be passed on to their replacements. New approaches with modern technology and some old tried-and-tested approaches like apprenticeship will need to be examined. This challenge appears to have some urgency associated with it.
5. Comments on the above point touched on some characteristics of the millennial generation. The perceptions shared suggested the observed work ethics of many millennial workers - as commonly understood - were unsuited to the safe and efficient operation of dams and their equipment. This perhaps challenges educators to give new emphasis to teaching professionalism for new entrants to this industry.

6. The phenomena of cyber security is a central challenge for this industry. In as much as the issue is national as well as local there are huge implications for large infrastructures like Hydro power generation plants. Centralia City Light, for example, reports as many as 15,000 hits per day on their website, many of which are suspected to be illegal attempts to hack the city's information core. Changes in security measures, work practices, technologies and education and training seem to be inevitable and as such will impact training programs for the industry.
7. Linked to this is the connection between hydro operations technology and information technology or the OT/IT challenge. Changes seem to be afoot which may impact the core knowledge, core skills and aptitudes required of workers at Hydro power sites.
8. The state of the aging infrastructure of dams and associated buildings present operators and municipalities with real fiscal challenges.
9. On Safety KSAs, it was pointed out that all employers, utilities and hydro sites have very developed safety training practices for all employees. That being so, any new training program within the college system can devote resources to other aspects of the field and rely on the safety KSAs to be taught on the work site.

The Preferred Attributes of the entry level worker

Mechanically oriented	Resourceful but knows his/her limits	Communicates well	Is able to multi-task easily
A self-starter	Dependable	Makes 'good coffee!'	Observant
Safety minded	Follows both written and verbal direction from superiors	Usually keeps calm in emergencies	Can work independently without too much supervision
Good team player	Has an eye for details	Self-motivated	Enjoys learning

Note:
The text in blue denotes attributes that are essential for a successful career in this aspect of the Energy industry

The Core Knowledge required of an entry-level worker to any Hydro Power Generation plant in the Pacific Northwest

Purple shading denotes in-depth knowledge required

<table>
<tr><th>Regulations & Terminology
A</th><th>Industry Basics
B</th><th colspan="2">Applied Engineering Basics
C</th><th>DAM Fundamentals
D</th><th>Control Systems Fundamentals
E</th></tr>
<tr><td>FERC and other Federal regulations
A1</td><td>Math fundamentals
B1</td><td>Basic Mechanical Principles & Technologies
C1</td><td>Electrical Theory
C2</td><td>DAM Basics
D1</td><td rowspan="2">All the indications of normal operations (Instrument readings etc)
E1</td></tr>
<tr><td>NERC, WECC & CIP regs
A2</td><td>Application of MMS or other input devices
B2</td><td>Compressors & pumps (common applications)
C3</td><td>Basic Hydraulics
C4</td><td>DAM Safety
D2</td></tr>
<tr><td>All pertinent Codes and State regulations
A3</td><td>Common Measurement tools, units & recording devises
B3</td><td>Hydro-Turbine Basics
C5</td><td>Station Batteries & Chargers (Both AC & DC)
C6</td><td>Signs, Sounds, Smells of abnormal conditions
D3</td><td rowspan="2">Relay Targets & how to recognize them
E2</td></tr>
<tr><td>Industry Terminology & Measurement Units
A4</td><td rowspan="3">Asset Management Fundamentals
B4</td><td>Basics of the Governor and Generators
C7</td><td>AC/DC Motors
C8</td><td>The plant and Spillways
D4</td></tr>
<tr><td rowspan="2">Personal Protective Equipment Types and uses
A5</td><td>Basic Blue Print Reading (Mech/Elect, other)
C9</td><td>Normal Flow Rates
C10</td><td>The 'Why' of how all systems work
D5</td><td>PLC technologies from a user perspective
E3</td></tr>
<tr><td colspan="2">Basic Fluid Dynamics
C11</td><td>Normal Operations versus Alarm or Action states
D6</td><td rowspan="2">General Supervisory & Data Acquisition Systems
E4</td></tr>
<tr><td colspan="2">Hydro Terminology
D7</td></tr>
<tr><td colspan="6">Safety Fundamentals as per each Company & Municipality Standard Operations Requirements</td></tr>
</table>

The Core Skills required of an entry-level worker to any Hydro Power Generation plant in the Pacific Northwest

Skills not prioritized. Each worker will be able to - demonstrate the following skills:

<table>
<tr><th>Job Preparation & Mathematics
A</th><th>Communications
B</th><th colspan="2">Mechanical Technologies & Tools
C</th><th>Technical Job-Based Skills
D</th></tr>
<tr><td>Create detailed work plans including tools and equipment lists
A1</td><td>Use Microsoft Office tools to make plans, do calculations, record work done and make reports
B1</td><td>Bend conduit
C1</td><td>Use thermal imaging technology to inspect and troubleshoot systems
C2</td><td>Troubleshoot a range of mechanical & electrical equipment as commonly found at Hydro Power sites
D1</td></tr>
<tr><td>Select the correct personal protective equipment for each job
A2</td><td>Demonstrate proficiency with Excel
B2</td><td>Demonstrate very basic skills with mechanics, welding, machining, plumbing and carpentry
C3</td><td>Use common hand and power tools
C4</td><td>Interpret blue prints (mechanical, electrical and other)
D2</td></tr>
<tr><td>Calculate water flows, electrical parameters, pressures,
A3</td><td>Communicate clearly verbally and electronically
B3</td><td>Make equipment alignments as necessary
C5</td><td>Use both left-hand and right hand threads with piping and other tools
C6</td><td>Read and comprehend detailed technical instructions
D3</td></tr>
<tr><td>Use common measuring devices
A4</td><td>Demonstrate proficiency with Touch Screen technology
B4</td><td rowspan="3">Inspect a wide range of tools for repairs, adjustments & calibration
C7</td><td rowspan="3">Cut gaskets for a range of equipment from several commonly used materials
C8</td><td rowspan="3">Operate equipment-moving vehicles and lifts
D4

Perform heavy equipment maintenance checks
D5</td></tr>
<tr><td rowspan="2">Demonstrate proficiency with the basic math functions as commonly used in Hydro Power Generation sites
A5</td><td>Write coherent, succinct & detailed maintenance logs
B5</td></tr>
<tr><td>Know those occasions when to call for assistance
B6</td></tr>
<tr><td colspan="5">Demonstrate skills in safety monitoring as per company S.O.P.s</td></tr>
</table>

The Work Profile of an Entry-Level worker to a Pacific Northwest Hydro Power Generation Facility

Major Work Functions	Typical Work Tasks (Tan denotes very challenging but also common for the new hire; Purple denotes very challenging task; Green denotes a very common task								
Power House Rounds **A**	Check the dam and spillways A1	Monitor computerized control systems A2	Check for signs of abnormal operations A4	Check all systems for safe operations A5	Follow all clearance tagging S.O.P.s closely A7	Check all auxiliary systems (Fire extinguishers, HVAC etc) A8	Check all oil levels, pressures, temperatures on generator bearings A9	Check all power house equipment & generators A10	Check the general plant conditions A11
	Check security monitoring system for proper operations A3		Monitor all equipment and instrument indicators A6						Check for visibility A12
The External Rounds **B**	Perform environmental & safety inspections B1	Check the substation & transmissions B2	Inspect waterways for sluffs, sink-holes and piping B3	Maintain access routes to critical facilities B4	Check Dam to water intake system B5	Check all critical infrastructure (Forebay, Motion analyzer etc) B6	Check for vegetation clearances B7	Check fish return lines B8	
Operations & Maintenance **C**	Troubleshoot all systems C1	Read and interpret all types of blue prints C2	Prepare Generators for operations C3	Monitor all instrument readings as per S.O.P.s C4	Operate the spillway C5	Conduct valve operations C6	Operate heavy equipment (CAT, Back Hoe, Crane etc) C7	Operate large grass mower C8	Do Asset Management on spare parts C9
Record keeping & Communications **D**	Maintain accurate daily records D1	Maintain FERC documentation D2	Maintain all maintenance records D3	Record time spent on the job - daily D4	Record river flow and line outages D5	Monitor conditions of all tools and document the deficiencies D6	Report all findings D7	Communicate with co-workers and supervisors D8	Interact with the public in a professional manner D9
Safety **E**	Maintain situational awareness at all times E1	Conduct morning 'Tail Boards' E2	Adhere to 'confined space' restrictions E3	Conduct L.O.T.O. As per S.O.P.s E4	Wear proper work attire including PPE at all times E5	Maintain a safe and productive work environment E6	Assess hazard potential to self and others E7	Maintain Haz.com awareness - always E8	

Appendices

Appendix A

Power Generation Skill Standards for Plant Operators & Plant Mechanics
(Not included in this report but available from the Pacific Northwest Center of Excellence for Clean Energy)

Appendix B

Industry Survey of Work Profile and KSAs required of entry level plant operators and maintenance technicians

Appendix C

Summary of results from 16 completed surveys

Appendix B

Industry Survey of Work Profile and KSAs required of entry level plant operators and maintenance technicians

Introduction:

On February 26, we will convene a group in Centralia of subject matter experts in Hydro Energy Generation. The purpose of the meeting is to guide the college in designing course work on the subject that will become part of the two year program in Energy Technology and Power Operations. Certain colleagues and partners of ours, including yourself, will not be able to attend this group meeting in person for a variety of reasons. However, we still want your input. Below are the four questions we will be exploring in some depth that day and if you provide us your responses, we will make sure they are built into the work of the group.

In an anticipation of your support, again, accept our deepest appreciation.

1. **Please list a minimum of 10-15 work tasks that are common on most sites for conducting day-to-day operations and maintenance**.
EXAMPLES: *'Monitor all instrument readings for signs of non-performance' 'Troubleshoot any indicators of possible instrument or system malfunction.' 'Complete daily, weekly reports as per S.O.P.s'*

For the workshop on the KSAs required to do this work:

2. **List 8-10 foundational knowledge elements that a typical HYDRO operator/maintenance technician must know**.

EXAMPLES: *'Instrument readings for normal operations' 'indicators for system malfunctions or out of compliance performance.' 'Regulatory safety standards for all HYDRO facilities'*

3. **List 8-10 skills that a typical HYDRO operator/maintenance technician must have**. (Note: skills must be observable or measureable)

EXAMPLES: Is able to " *use hand and power tools as required*" "work long hours in a sometimes uncomfortable, outdoor setting" "clearly document work done and system malfunctions"

4. **List 5-6 aptitudes a person needs to be successful in HYDRO Operations and Maintenance** (Like personality traits)
EXAMPLEs: *'Observant', 'reliable', 'self starter,' 'enjoys the out of doors', 'can assume responsibility'*

5. **On a scale of 1-7 please rate your interest in Hydro Operator training for Apprentice level staff with 7 being the strongest interest.**

1-2-3-4-5-6-7

6. **On a scale of 1-7 please rate your interest in Hydro Operator training for Journey level Hydro Operators with 7 being the strongest interest.**

1-2-3-4-5-6-7

7. **On a scale of 1-7 please rate your interest in Hydro Operator training delivered via internet with 7 being the strongest interest.**

1-2-3-4-5-6-7

8. **On a scale of 1-7 please rate your interest in Hydro Operator training delivered in a classroom and via internet with 7 being the strongest interest.**

1-2-3-4-5-6-7

9. **On a scale of 1-7 please rate your interest in Hydro Operator training delivered in a classroom with 7 being the strongest interest.**

10. **Please list any topics you feel should have been asked about.**

11. **Any Comments?**

Closure:
A copy of the report of this meeting will be sent to you for your edits and additions in early March. Although you will not be in attendance, should you send us your answers to this survey, we will include you in the participant list. Many thanks.

Appendix C

Summary of results from 16 completed surveys

Question 1: Typical Work tasks

A. Troubleshoot mechanical and electrical systems according to S.O.P.s

A1 Troubleshoot and report on all abnormalities
A2 Troubleshoot all systems; electrical, mechanical, pneumatic, hydraulic
A3 Analyze problems and determine necessary repairs
A4 Read and interpret drawings and schematics

B. Inspect all systems for proper functioning (weekly, monthly, annually)

B1 Observe functioning of station equipment - constantly
B2 Check oil levels and temperatures on generator bearings
B3 Inspect and do minor maintenance on the governor
B4 Check and maintain all EGs
B5 Check the daily event log
B6 Check generator brush rigging
B7 Check strong motion analyzers
B8 Do visual inspection of project switch yards and substations
B9 Run system checks as per S.O.P.s
B10 Inspect Operating Board
B11 Check for structure alignment and piping
B12 Check general plant conditions
B13 Check all HVAC systems are functioning
B14 identify needed improvements
B15 conduct oil analysis as needed
B6 Make oil and filter changes on mobile and fixed equipment
B17 Check all bearings and lubricate as needed
B18 Inspect all electrical transmission and distribution equipment outside of main plant
B19 Inspect the dam and head-works

C. Maintain equipment according to S.O.P.s

C1 Maintain all sub-station equipment
C2 Maintain proper lubrication of all equipment according to S.O.P.s
C3 Communicate with engineering on repairs, malfunctions & job planning
C4 Do routine mechanical maintenance through a work asset management system
C5 Evaluate and plan for repairs in-house
C6 Conduct annual generator maintenance
C7 Assist dispatchers with plant control
C8 Check all powerhouse equipment & generators
C9 Check dams and spillways

C10 Do routine daily sweeps
C11 Do daily inspections, inside and outside the plant
C12 Clean all walkways of snow and debris
C13 Check all critical infrastructure
C14 Evaluate and determine equipment shutdown and isolation requirements for maintenance

D. Security and safety Checks

D1 Check security monitoring system
D2 Check for signs and sounds of abnormal function
D3 Check all systems for safety while in operation (in plant, perimeter, downstream)
D4 Check the PC S alarm page
D5 Check all clearance and tagging S.O.P.s are closely followed
D6 Enforce all safety standards and procedures with outside crews and visitors
D7 Analyze a system for job hazards
D8 Consider HAZMAT, lead, asbestos contamination as part of work planning
D9 Adhere to confined space restrictions

E. Professional Development

E1 Stay informed on status of plant operations & projects
E2 Train apprentices
E3 Keep knowledge and skills up to date

F. Documentation

F1 Input service requests as per S.O.P.s
F2 Maintain accurate daily records
F3 Keep up on paper work
F4 Record river flow and line outages
F5 Complete FERC Weekly inspection logs
F6 Document all personnel movements into and out of the plant
F7 Complete all required reports on time
F8 Document operational run times
F9 Test and document critical equipment
F10 Exercise emergency generators
F11 Keep emergency truck stocked with tools, supplies as needed in an emergency

G. Standard Operations

G1 Restore equipment to normal function or remove from service
G2 Prepare turbines for operations and starts, stops; control the unit
G3 Perform switching operations (480V - 230KV) High voltage
G4 Operate spillway gates
G5 Monitor computerized control system
G6 Calculate flow and make adjustments as needed

G7 Synching generators online and take them off line
G8 Stop and start units with Plant Control System
G9 Wipe generator slip rings
G10 Monitor lake levels and debris build up
G11 Monitor instrument readings as per S.O.P.s
G12 Adjust electrical loads and voltages as necessary.
G13 Daily housekeeping
G14 Check powerhouse daily
G15 Order parts , expendable materials, and supplies for unique and routine jobs
G16 Do daily park checks, water samples, sewage checks, LOSS
G17 Plan upcoming jobs , arrange for labor and plan B if no-one shows
G18 Start, continue or finish diverse welding, machining, woodworking, plumbing or research tasks to keep the project going. (A Hydro project is its own municipality with its own water, power, sewage, communication systems to maintain and repair as needed.)
G19 Use Human Machine Interface (HMI) to view operating parameters
G20 Operate primary electrical devices, breakers, interrupters, disconnect switches etc)
G21 Communicate with Control Center System Operations (CCSO)
G22 Perform forebay and tailrace elevations and take corrective action as necessary
G23 Read Blue prints on electrical, mechanical and civil systems as necessary
G24 Conduct valve operations

Question 2: Core Knowledge:

A. Equipment Specs and limits

A1 Equipment performance limits
A2 Lock out and tag-out procedures for all equipment
A3 Generator RPM limits
A4. Standard equipment nomenclature & acronyms

B. Safety Regs and Procedures

B1 All safety standards and S.O.P.s
B2 Minimum safe approach distances for generators
B3 Relay targets and how to recognize them
B4 Arc/Flash boundaries
B5 HED license agreement & WECC standards
B6. Typical emergency conditions and responses
B7 Typical signs & sounds of abnormal or unsafe conditions
B8 Step/touch potential
B9 Circumstances requiring an electrical clearance
B10 The limits of electrical approach distances and boundaries
B11 The National Electrical Code (NEC) and Washington Admin Code (WAC) regards safety at Hydro plants
B12 Clearance and tagging requirements

B13 Switching and tagging requirements
B14 FERC/NERC/WAC/OSHA/NESC/NFPA/7OE rules Requirements
B15 Safety/PPE requirements for plant and switchyard
B16 Follow all dam safety emergency action plans as per S.O.P.s

C. All plant systems, mechanical and electrical

C1. Technician level knowledge of all systems & equipment
C2. Equipment control systems and procedures
C3. Fundamental electrical theory (AC/DC - Digital & Analog systems)
C4. Basics Hydraulics
C5. Compressors and pumps (low and medium pressures up to 500psi)
C6. Basic mechanical principals & technologies
C7. Hydro instrumentation and measurements
C8. Different hydro units and basic principles of how a Hydro plant works
C9 Dealing with high voltage systems, transmission and substatons
C10. Basics of the Governor and generators
C11. Voltage regulation
C12. Standard approaches to troubleshooting plant systems and technologies
C13. Basic blue print reading
C14 Protective relays
C15 AC/DC motors
C16 Switching technologies
C17 PLC technologies from a user perspective
C18 Standard electrical test equipment
C19 All the indicators of normal standard operations (sights, sounds, instrument readings etc
C20 Basics of power flow
C21 Plant & Spillway capacities
C22 Operation and maintenance of inter coolers and after coolers
C23 General supervisory and data acquisition systems
C24 Basic math to include arithmetic functions, algebra, geometry

D. S.O.P.s for various contingencies

D1. How to deal with outages
D2 Communications with power dispatchers
D3 Plant Failure modes and what to look for

E. River flow management

E1 S.O.P.s
E2 Normal flow rates

Question 3 Core Skills

A. Hand and power Tools

A1 Power drills, portable band saws & cordless tools

B. Boom lifts and other large equipment

B1 Operates various lifts

B2 Truck driving

B3 Equipment hauling

B4 Basic heavy equipment operations & maintenance

C. Specialty equipment

C1 Underground locating devices

C2 Hot sticks and other special equipment

C3 Operate primary system generators

C4 Selects correct PPE for a job

D. Computer IT skill

D1 User level skill with MS Office tools (Excel a must)

D2 Comfortable with touch screen technology

E. Troubleshooting

E1 Troubleshoot mechanical and electrical systems

F. Communications

F1 Clear communications, verbal, and electronic in English

F2. Documents clearly in English

F3 Knows the Trade language

F4 Knows when to call for help

F5 Read and comprehend detailed, technical instructions

G. Mechanical skills

G1 Can bend conduit

G2 Pipe threading tools

G3 Read and interpret blue prints

G4 Basic welding

G5 Basic machining

H. Other

H1 Interpret blue prints

H2 general skills as a mechanic, welder, machinist, plumber and carpenter are very helpful

H3 Calculate flows, electrical parameters, pressures etc

H4 Create detailed work plans including tools and equipment lists

H5 Write up a maintenance log

Operator Skills	Technician skills
1. Operate generators in all modes and methods of operation 2. Computer skills - strong in MS Office tools especially Excel 3. Physically fit and able to inspect the plant and its equipment	1. Computer skills - strong in MS Office tools especially Excel 2. Has all operators skills 3. Trouble shooting electrical systems 4. Troubleshooting mechanical systems 5. Basic welding, machining, fabrication 6. Crane rigging equipment 7. Operate trucks, fork lift and boats 8. Can read all prints 9. Basic plumbing and pneumatics

Question 4 - Required Aptitudes for success

1. Safety minded
2. Self starter
3. Eye for details
4. Mechanically oriented
5. Dependable - shows up on time
6. Communicates well
7. Keeps calm in emergency
8. Observant
9. Team player - can work with diverse personality types
10. Enjoys learning
11. Resourceful
12. Enjoys out of doors and OK with inclement weather
13. Flexible and able to work off hours when necessary and 12 hour shifts
14. Follows directions verbally and written
15. Can work at heights
16. Can work independently with minimal supervision
17. Good hand-eye coordination
18. Able to multi-task
19. Can access tight spaces
20. Can climb difficult terrain
21. Adheres to warning signs

Average scores between 1 and 7, 7 being the highest:

Question #	Question	Average score
5	Interest level in Hydro-Operator training for Apprentice level staff	5.8
6	Interest level in Hydro-Operator training for Journey-level level staff	5.0
7	Interest level in Hydro-Operator training delivered via the internet	4.7
8	Interest level in Hydro-Operator training delivered in a classroom and via the internet	4.7
9	Interest level in Hydro-Operator training delivered in a classroom	4.6

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