Highland Economics LLC

Highland Economics

Memo

To: Brett Golden, Julie Davies O'Shea, FCA

From: Barbara Wyse, Highland Economics

cc:

Date: July 19, 2019

Re: District of the Future Economic Benefits Analysis

This memo summarizes information on economic benefits of district modernization, including a section on different ways of portraying the quantified economic benefits of East Fork Irrigation District (EFID) and Central Oregon Irrigation District (COID) modernization, and a section on the potential other economic benefits of modernization in a 'district of the future'.

Quantified Economic Benefits of EFID and COID Modernization

As documented in the National Economic Development analyses developed as part of the Watershed Plan processes for EFID and COID, the energy, habitat, and agricultural benefits of irrigation modernization outweigh the costs. These benefits are summarized below in Tables 1 and 2. Modernizing EFID will provide $80.0 million of economic benefits over the 100-year life of the project, with $60.9 million of benefits accruing directly to patrons though reduced operations, maintenance and repair costs and increased agricultural production (Table 1). Modernizing COID will provide $314.3 million of economic benefits over the 100-year live of the project, with $26.5 million of benefits accruing directly to patrons through reduced operations, maintenance and repair costs (Table 2).

Table 1: Quantified Economic Benefits of Irrigation Modernization: EFID

Net Benefit	**Present Value Over 100 Years**	**Annualized Average Value**
Reduced District OMR	$8,133,000	$248,000
Reduced Patron OMR (total)	$11,331,000	$347,000
District Energy Generation	N/A	N/A
Agricultural Net Income (total)	$49,621,000	$1,516,000
Habitat/Instream Benefits	$9,654,000	$295,000
Climate Regulation (Carbon) Value	$1,291,000	$39,000
Per District Subtotal	*$80,030,000*	*$2,445,000*
Average Reduced Patron OMR per patron	$11,445	$351
Average Agricultural Net Income per patron	$50,122	$1,531
Per Patron Subtotal	*$61,568*	*$1,882*

Table 2: Quantified Economic Benefits of Irrigation Modernization: COID

Net Benefit	**Present Value Over 100 Years**	**Annualized Average Value**
Reduced District OMR	$2,284,000	$70,000
Reduced Patron OMR (total)	$26,518,000	$810,000
District Energy Generation	$77,857,000	$2,378,000
Agricultural Net Income (total)	N/A	N/A
Habitat/Instream Benefits	$199,623,000	$6,097,000
Climate Regulation (Carbon) Value	$8,006,000	$245,000
Per District Subtotal	*$314,288,000*	*$9,600,000*
Average Reduced Patron OMR per patron	$14,295	$437
Average Agricultural Net Income per patron	N/A	N/A
Per Patron Subtotal	*$14,295*	*$437*

In the tables above, the second column shows the present value of benefits over the 100 years of the project life. For each benefit category, we modeled the benefits in each year of the project life and converted the future stream of benefits into the equivalent value of receiving all benefits this year (i.e., the present value presented in the second column of the table); this conversion is done applying a annual discount rate of 2.875 percent to future values and then summing the resulting values.[1] The value in the third column takes the total benefits (in the second column) and calculates the annualized average benefit if the total value were allocated evenly in each year of the project life (while also considering the discount rate). In reality, the future stream of benefits varies annually, so this process simply finds the average annual value expected from the project, considering the discount rate. Put

[1] A discount rate is a tool used by economists to account for the time value of money, or the preference people have for receiving benefits sooner rather than later. The 2.875-percent discount rate used in this study is the rate for federal water projects in 2019 (Natural Resources Conservation Service n.d.).

differently, if the flow of benefits in each year of the project was equal to the annualized average value and converted to a present-day value using the discount rate, the sum of these values would equal the total present value shown in the second column.

Table 3 presents the total economic activity supported in the Hood River County economy (EFID) and the Deschutes County economy (COID), including direct, indirect, and induced impacts of modernization. The first several rows in Table 3 highlight how construction spending would increase total economic activity during construction (annualized average impacts over the 10-year period). The lower rows of the table highlight how EFID modernization, through increased reliability of water supply, supports increased agricultural production value and associated jobs and income in Hood River County. COID modernization supports continuation of existing agricultural production by enabling irrigation districts to maintain irrigation supply to farmers while simultaneously enhancing instream flow for endangered species.

Table 3: Economic Development Impacts

Economic Impact Category	EFID	COID
Construction Period Impacts – 10 Years Duration		
Total Construction spending over 10 Years	$79.1 million	$267 million
Annual Average Jobs Supported During Construction[1]	75	330
Annualized Average Regional income Supported During Construction[1]	$3.0	$15.4 million
Ongoing Project Life Impacts – 100 Years Duration		
Increased Annualized Value of Agricultural Production	$2.8 million	*Supports continuation of existing agricultural production.*
Annual Jobs Supported Throughout Project Life[2]	55	
Annualized Average Regional income[2]	$2.0 million	

Note: All figures represent the increased impact resulting from Piping over the No Action Alternative.
1/ Includes direct/indirect/induced jobs and income supported in the county economy by construction spending; these economic development effects will be experienced during the 10-year construction period.
2/ Includes direct, indirect, and induced annualized income and jobs supported in the county economy due to increased value of agricultural production.

District of the Future: Supporting Environmental Quality & Rural Economic Prosperity

Districts of the future that holistically plan and provide for infrastructure development together with irrigation district modernization pave the way for rural economic development and quality of life benefits. In particular, there are significant opportunities to achieve cost savings and benefits with co-locating communications, electrical, and recreation infrastructure in the rights of way for modern irrigation conveyance systems. There are also opportunities for provision of habitat in district rights of way.

American rural economies, in general, and agricultural competitiveness in particular, depend on strong infrastructure – not only transportation infrastructure for receiving supplies and sending products to market, but also communication infrastructure such as broadband, and energy infrastructure providing access to affordable and reliable energy (American Farm Bureau Federation 2019). The 2018 Interagency Task Force on Agriculture and Rural Prosperity identified five foundations to grow rural economies: access to high speed internet, high quality of life, skilled workforce, ability to access and incorporate technological innovation, and enhancing economic development through growing strong rural businesses and agricultural economies (US Department of Agriculture 2017). All of these five foundations are enhanced through irrigation district modernization in a district of the future, in particular through communications infrastructure. This section highlights the benefits of co-locating high speed internet (or broadband) infrastructure in irrigation conveyance rights of way (which helps to enable precision agriculture and additional water use efficiency among other benefits), smart grid electricity technologies (which increases the potential and benefits of additional renewable distributive power generation), and recreation infrastructure.

Modernization & Broadband Communications Infrastructure: Rural Economic Development Benefits & Environmental Benefits of Precision Agriculture

Connectivity through high-speed internet is a foundation for the other pillars of rural economic development – it supports quality of life through accessibility of diverse entertainment, educational, and professional resources; enables employees to work remotely; helps promote a skilled workforce by allowing for online job training; provides access to technological tools and information; and is vital for rural business productivity.

Numerous studies have shown that in areas where high speed internet access increased, there were associated benefits to household income, the number of businesses, employment and population growth, and productivity. For example, a study of zip codes across the U.S. found that areas with available high speed internet were associated with a 1.0 to 1.4 percent higher employment growth, and a 0.5 to 1.2 percent higher growth in the number of businesses established over a four-year period (Gillett, Lehr, Osorio, Sirbu, 2006). Another study found that gaining access to high speed internet in a county is associated with 1.8 percentage points in higher growth employment over an eight-year period, and found the impact to be larger in rural and isolated areas (Atasoy, 2011). Still another study (Kolko, 2010) found that zip codes with at least one provider of broadband access had 6.4 percent higher employment growth and 2.4 percent higher population growth over a seven-year period than those with no broadband providers, and that the relationship is stronger in areas with lower population densities (Hupka 2014).

For agriculture, connectivity is critical for farmers to have access to accurate, high quality information and tools for data-driven decision making, access to continuing education resources, access to new customers, and information on changing market conditions. It is also necessary for adoption of precision agricultural techniques that analyze field data and enable crop management that enhances crop yields, food safety, and efficient resource use (US Department of Agriculture 2019). These techniques, often referred to as 'precision agriculture' or 'site specific crop management', are information- and technology-based agricultural management systems that vary farm inputs (including nutrient and pesticide application, tillage, and irrigation) within a field to match site conditions.

Precision agriculture techniques increase agricultural productivity and income, and enhance environmental sustainability through increasing yields and quality while reducing water, energy, and nutrient inputs. One study found that these techniques can translate into a 3 to 18% increase in crop yield while also resulting in savings to the farmer of $28 per acre from reduced water, nutrient, and herbicide inputs (US Department of Agriculture 2017). Nationwide, gross agricultural production value could increase 18%, or by an estimated $47 billion to $67 billion, if there were investment in broadband internet infrastructure, digital technologies, and on-farm prevision agricultural capabilities. However, rural internet infrastructure (together with sensors, satellite imagery, software, and machines) is needed for full realization of precision agriculture's benefits. The role of widespread high speed internet accounts for approximately 36%, or $18 billion to $23 billion of the potential value of precision agriculture (US Department of Agriculture 2019).

As of 2014, 39% of rural Americans lacked access to high-speed internet, partly because of the expense associated with construction in challenging terrain and obtaining permits and regulatory approval (US Department of Agriculture 2017). Installing broadband with irrigation infrastructure reduces time and expense associated with identifying rights of way, obtaining regulatory approval, and installing cable. The National Broadband Plan notes that placement costs associated with burying the fiber in the ground account for nearly three-quarters of total costs of fiber deployment (Federal Communication Commission 2010). At average cost of fiber deployment across the United States, this would save $128,000 per mile in fiber deployment (Federal Communication Commission 2010).[2] Further, running a strand of fiber through an existing conduit underground is three to four times cheaper than constructing a new aerial build (Federal Communication Commission 2010). Thus, substantial cost savings can be captured if fiber (and electrical infrastructure) are co-located and coordinated with irrigation modernization projects in which the right-of-way is already being excavated.

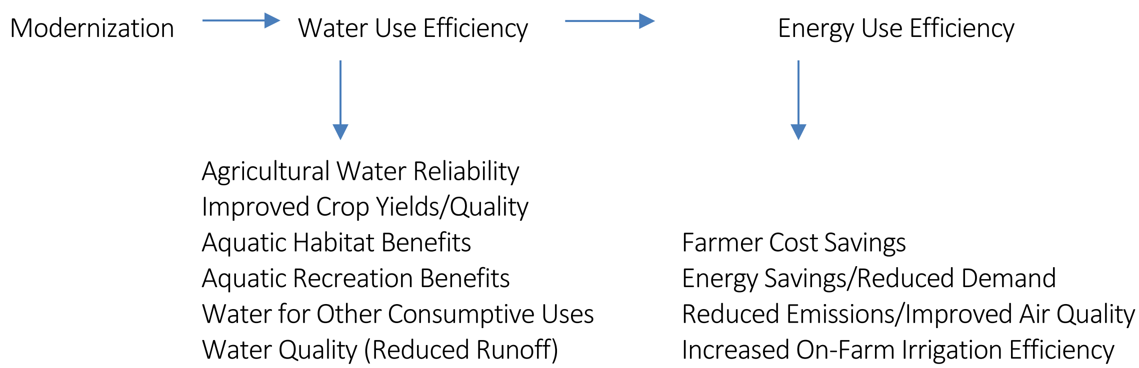
Several urban areas area already capitalizing on these cost savings:

- City of San Francisco has a “trench once” policy, in which a 5-year moratorium is placed on opening up a road bed once the trench along the road bed has been closed. A notification process is used to ensure that other interested parties have the opportunity to install conduits and cable in the open trench.
- City of Boston has implemented a “Shadow Conduit Policy” in which the first company to request a trench takes a lead role, inviting other companies to add empty (or “shadow”) conduits for

Modernization & Water Use Efficiency: Environmental and Economic Benefits

Modernization, and precision agriculture, also pave the way for tremendous water conservation, with associated environmental and economic benefits. In Oregon, there are nearly 16 million acres of lands in farms, with approximately 10% of this land (1.66 million acres) irrigated (USDA National Agricultural Statistics 2017). Agriculture is the largest water user in the state, accounting for 86% of state-wide consumptive water demand in 2015 (Oregon Department of Water Resources 2017). Water use means energy use – pumping water to convey it and pressurize it requires energy. As such, increasing agricultural water use efficiency translates into energy savings—reducing energy demand, reducing emissions (thereby improving air quality), and saving farmers money. It also means more water available for other uses, including other instream flows for habitat and recreational benefits, or other consumptive agricultural, municipal, industrial, commercial uses. Irrigation modernization is a key component of increasing agricultural water use efficiency. Across the western United States, the federal Economic Research Service estimates that more than 50% of cropland continues to be irrigated with traditional, less-efficient irrigation systems, and that over 90% of farms could increase efficiency through use of soil/plant-moisture sensing devices or computer-based simulations models to deliver the precise amount of water to meet crop water needs (USDA Economic Research Service 2019).

[2] Original costs were $110,000 per mile in 2010 dollars; these were inflated to 2019 dollars using the Consumer Price Index.



Modernization of district conveyance facilities directly conserves water by reducing seepage and enabling that water to remain instream for habitat/recreational benefits and for other, downstream consumptive uses. It also indirectly conserves water by making on-farm irrigation efficiency improvements much more affordable and feasible for farmers and ranchers. For example, a study for Central Oregon Irrigation District found that by piping district canals and providing pressurized water to patrons, the cost to farmers to convert from flood irrigation to more efficient irrigation would decrease by 50% due to cost savings from not needing to install electricity and pay energy costs to pressurize water (Energy Trust of Oregon and Farmers Conservation Alliance 2017). A fully piped COID system would eliminate 2,300 pumps and 33,287 MW of power use annually (Energy Trust of Oregon and Farmers Conservation Alliance 2017). Furthermore, if all farmers in the District were to convert, this would result in a water savings of 48,255 acre-feet annually, resulting in even more energy savings (Energy Trust of Oregon and Farmers Conservation Alliance 2017).

Finally, higher on-farm irrigation efficiency reduces the volume of run-off from agricultural lands (which often has sediment and nutrients in it), resulting in higher water quality in adjacent water bodies. Of more than 100,000 miles of rivers and streams in Oregon, water quality in about 24,500 stream miles (or nearly one-quarter of the total) is impaired and does not meet water quality standards (Oregon Department of Water Resources 2017). Agricultural runoff if a major source of water quality impairments in Oregon. According to the 2017 Oregon Integrated Water Resources Strategy, temperature, sedimentation, and nutrients are the most common types of pollution that impair Oregon's rivers and streams (Oregon Department of Water Resources 2017). Reducing these pollutants in waterbodies can decrease the cost of water treatment and beneficially impact fish and other aquatic species, drinking water, agriculture, and recreation.

The incorporation of precision technologies in irrigation management has grown rapidly over the past decade. Precision technologies such as satellite data, sensor networks, data analytics, and drones, are being used for better understanding crop water requirements and available moisture with the intent of scheduling irrigation to maximize efficiency, thereby reducing input costs and increasing crop yields. Key components of a system that uses precision technologies in developing an irrigation schedule include but are not limited to the following:

- Variable Rate Irrigation: where sprinkler valves are equipped with the capacity to actuate valves for groups of sprinklers, or regulate speed of a linear move system during operation. A control system is then used to open and close the valves at various rates (or change speed) based on the position of the pivot and desired application depth.
- Soil Mapping: Electromagnetic sensing and physical soil sampling can be used to produce soil data properties including holding capacity, field capacity and root zone restriction depth.
- Flow Monitors: Ultrasonic flow meters can be used to record water use records for individual farms.

- Weather Monitoring: Weather stations can be equipped with sensors required to calculate reference Evapotranspiration (ET).
- Soil Moisture Monitoring: Soil moisture probes track plant available water and can be connected to weather stations for data logging.
- Yield Mapping: Harvest monitors with GPS tracking or infrared photographs can be used to compare the spatial variability in production.
- Satellite Imagery: when combined with climate information, satellite imagery can be used to map crop ET. Mapping ET at high Resolution with Internalized Calibration (METRIC) is one process available today that uses Landsat imagery and gridded climate data (PRISM Climate Group data from Oregon State University or AgriMet data) to estimate crop ET.

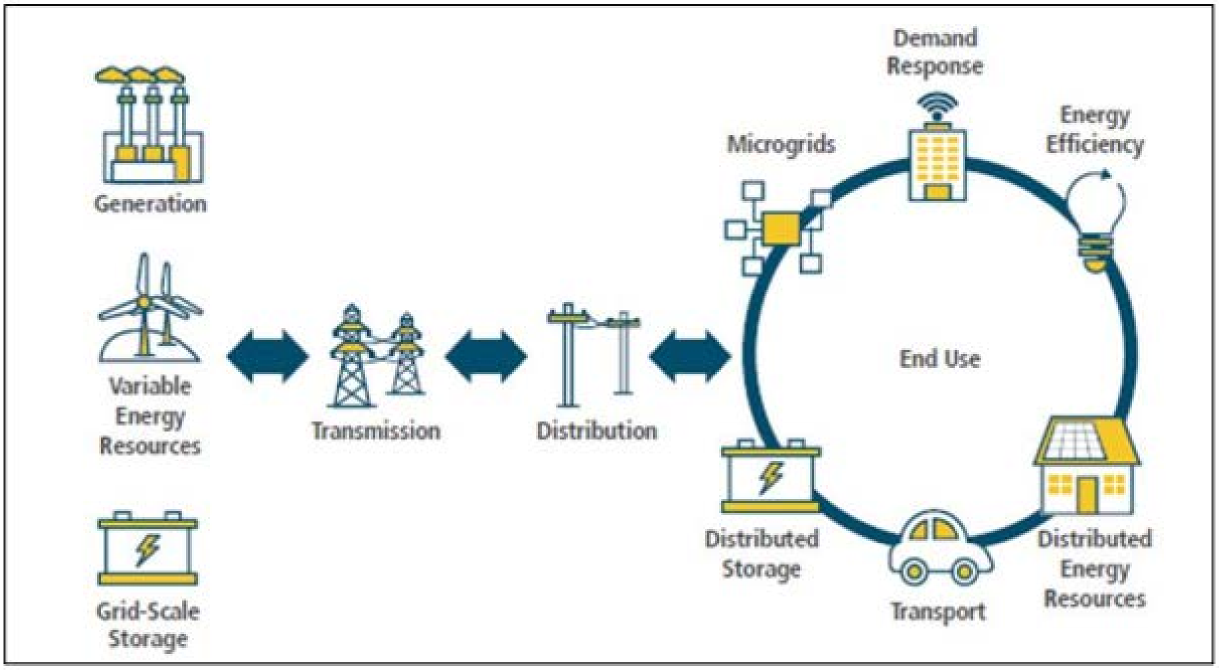
A demonstration of the economic potential of optimal irrigation has recently been modeled in three farms in the Columbia River basin. Partial results suggest that water use can be reduced by 20 to 50 percent with negligible impacts on crop yield through implementation of some of the precision irrigation methods described above. This preliminary observation suggests the potential for substantial opportunities in irrigation optimization and water conservation across the region is significant (Rhodig 2013).

Smart Grid Electrical Infrastructure & Distributive Generation

Modernization of irrigation conveyance canals can also go hand in hand with modernization of the electrical grid, through installation of smart grid technologies (fiber and electrical co-located) and/or upgraded transmission line capacity. The Department of Energy identifies smart grid technologies as those that are able to 'monitor, protect, and automatically optimize the operation of including central and distributed generation; transmission and distribution systems; commercial and industrial users; buildings; energy storage; electric vehicles; and thermostats, appliances, and consumer devices" (U.S. Department of Energy 2015). As noted above, to the extent that smart grid technologies and communications fiber are installed with new distribution power lines, or with higher capacity transmission lines to enable more commercial-scale generation facilities, the installation of this new infrastructure can likely be achieved much more cost-effectively if co-located and installed together with irrigation modernization projects. Smart grid technology adoption paves the way for enhanced small-scale renewable energy generation and storage within irrigation districts of the future, as discussed below. The next section discusses the benefits of burying electrical lines underground on reliability and reduced wildfire risk.

Smart grid technology facilitates two-way power flows, increasing the ability of the grid to deliver and receive electrical energy from many points of generation (including distributive energy generation) and energy storage (including stationary or mobile storage such as batteries of electrical vehicles). Figure 3, developed by the US Department of Energy, highlights the potential of a smart grid to accommodate diverse types and sources of local energy generation and storage (U.S. Department of Energy 2017). Generating power from multiple local sources is often referred to as "distributed generation" (DG), as electricity is produced by smaller facilities in service areas rather than being centrally located and delivered across long distances via high-voltage power lines. DG can come in a variety of forms, including small-scale gas-powered generating facilities, photovoltaic solar power systems, wind farms, and hydropower facilities.

Figure 1: Emerging "Two-Way" Grid Infrastructure



Source: DOE, Quadrennial Energy Review Report: An Integrated Study of the U.S. Electricity System, January 2017

Smart grid adoption in rural areas can enable rural areas to harness their energy generation potential and increase rural economic development while simultaneously improving power quality and energy efficiency (Zubia, et al. 2013). As shown in Figure 1, a smart micro-grid network can be developed in rural areas with distributed renewable generation that can meet local demand and feed unused electricity into the grid during peak generation periods, and receive energy from the grid during low generation periods. The smart grid meters and sensors would be capable of measuring and communicating energy information quickly and reliably and enabling generation sources to make adjustments to meet utility requirements. Such micro-grids are expected to improve electric service reliability, improve power quality, and benefit local utilities by providing dispatchable load for use during peak power periods and reducing the need for distribution system upgrades (Zubia, et al. 2013).

With the advent of smart grid technologies, on-farm renewable distributive energy generation is a natural fit. Wind, solar, and biomass energy can reduce energy costs and increase self-sufficiency and reliability for farmers, while also providing farmers and rural landowners with a long-term source of diversified income and reducing air pollution. Renewable energy can be used to pump water and generate electricity for on-farm uses and can also be sold back to the grid when generation exceeds on-farm demand. Movable or portable DG can be used to power irrigation systems or used for electrifying portable fences or can be in the form of electric vehicles and farm machinery; with the addition of smart grid technology, can be used to feed energy to the grid. In Oregon any utility customer can generate their own electricity and there is no additional cost for the 'net' meter which keeps track of electricity put (or 'sold') onto the grid and electricity purchased from the utility. No additional infrastructure is needed for such developments.

For commercial solar and wind energy projects, important siting factors include the presence of high quality solar or wind resources, slope of less than 5% (solar) or 20% (wind), and transmission capacity nearby (345 kV and 500 kV lines). Solar and wind farms are almost exclusively built by developers with renewable expertise. On a commercial scale, where there are strong winds and suitable sites, commercial wind developers may pay as much as $2,000 to $5,000 per year for each turbine installed (General Accountability Office 2004). Wind and solar projects provide a variety of economic benefits to a community including construction and operations jobs (estimated at between 6 to 14 jobs per 60 megawatts of capacity) (USDA,RD, 2011) (OMA, 2013), project spending that supports local businesses, ongoing landowner payments for easements, and annual sales and property taxes paid to local governments. Oregon's Renewable Portfolio Standard (RPS) mandates that 50 percent of electricity used by Oregonians comes from renewable (solar or wind) sources by 2040, providing a clear source of demand within the state for additional renewable generation.

Whether small-scale or commercial-scale, generating power at the local level can bring a number of advantages over importing power from outside the area, including improving the overall efficiency of the power system, creating a more resilient system, enhancing power reliability, and reducing land-use impacts and acquisition costs (U.S. Department of Energy, 2007). Because power is lost when it is transmitted over distances, producing power near where it is consumed avoids transmission losses. In this way, DG can enhance the overall efficiency of the power system, as well as extend the life of existing transmission infrastructure by minimizing wear-and-tear from use (Bernhardt, 2014). DG has the potential to increase resilience in the power system by limiting the vulnerability to natural and human disasters that cause failures in the system. A diversified power system that relies on multiple sources of power can benefit from redundancy, whereas a single source of power leaves the entire system vulnerable in the event that source fails (Bernhardt, 2014).

Enhanced reliability during peak use periods can be another benefit of DG. For example, some utilities offer incentives to owners of emergency power generation systems to make their units available during periods of peak power demand. Some customers are also able to use DG systems to meet their demand during peak times, thereby reducing loads on primary providers while also enhancing total system reliability. DG systems can provide further reliability through ancillary services and voltage support (U.S. Department of Energy, 2007).

Hydropower DG systems have already been installed in agricultural districts in Hood River County: one system is owned by Farmers Irrigation District and the other is owned by Middle Fork Irrigation District. Both sell their electricity to Pacific Power. There is also a third DG source of photovoltaic solar energy. Together, these sources supply roughly 18 percent of the county's energy needs (Hood River County, 2017). Pacific Power delivers power through a network of transmission lines that run along or roughly parallel to the Columbia River Gorge (Bonneville Power Administration, 2018; PacifiCorp, 2016). The power is further distributed through substations at numerous sites throughout the county and by Hood River Electric Co-op through local utility distribution lines (University of Oregon Institute for Policy Research and Engagement, 2018).

According to the Hood River Natural Disaster Mitigation Plan, the transmission network that serves the county is vulnerable to a variety of natural disasters (Hood River County, 2017). Winter storms, wildfires, and earthquake events representation the most significant threat, while windstorms and landslides also present threats. Even moderate winter storms can bring down power lines and cause outages and have left thousands of county residents without power in past instances. In some areas of the county where storms knock out power for several days, some residents face life-threating problems when their dialysis machines, respirators, and oxygen generators are without power. Hood River's proximity to multiple fault lines puts its utilities (including electrical transmission lines) at risk of 'significant damage' from an earthquake. While the probability of such an earthquake is low, the potential damage is high. High winds threaten power lines both in forested areas and in the Columbia River Gorge, where high winds occur yearly (University of Oregon Institute for Policy Research and Engagement, 2018). These threats are part of the reason the Hood River County Energy Plan is seeking to increase local and diversified energy sources, which the City of Hood River has agreed to support (Hood River County, 2017; Hood River City Council, 2018).

In summary, adding more DG resources to a smart grid system can have the following benefits (Reitenbach 2011):

- Incremental supply can be added close to demand sources, deferring or reducing the expense and regulatory challenge of building utility-scale/central station generation.
- DG can be sited where distribution lines already exist and does not require new transmission lines as do utility-scale projects.
- DG improves efficiency by lowering transmission line losses because the power travels a shorter distance to end users.
- DG can alleviate grid congestion and improve reliability.
- DG, particularly building-mounted photovoltaics, typically requires less water and land than similar capacity totals provided by central station plants.

Buried Electrical Cable: Reliability, Public Safety, and Wildfire Risk

Extreme weather and other natural disasters are a common threat to above-ground utility. High winds regularly send trees and other debris into powerlines, breaking them, and in some cases even blow down the utility poles themselves (Cummins 2018). Heavy snow and ice can break power lines.

The costs of power outages can be significant; or said differently, the benefits of increased reliability are significant. A nationwide 2009 study found that, on average, an eight-hour power outage cost a residential customer $12.60.[3] The same study found that a one-hour power outage causes some businesses to lose over $23,000 (Sullivan, Mercurio and Schellenberg 2009).[4] Specialized facilities, such as museums, can have priceless resources irreversibly damaged by lack of power. Vulnerable populations, such as those on respirators, can lose their lives (Cummins 2018).

Burying electric lines also has the benefit of reducing the risk of wildlife. Electrical lines can start branches on fire when nearby trees are blown into power lines, and downed live wires can set fires to dry plant matter on the ground. The California Department of Forestry and Fire Protection reported that at least 17 major wildfires were triggered by power lines in the summer of 2018 (Atkinson 2018). In 2017, power lines were blamed for 12 wildfires in California that contributed to 18 deaths. An investigation into the Camp Fire, which killed 85 people in 2018, concluded that it was caused by electrical transmission lines (Robertson 2019). The California Public Utilities Commission (CPUC) estimates that about 10 percent of the state's wildfires are triggered by power lines (Atkinson 2018). If this is representative of the national wildfire risk, above-ground electrical lines would be responsible for more than $300 million in federal firefighting costs alone.[5]

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3 The original dollar value was adjusted for inflation from 2008 dollars to 2019 dollars using the Consumer Price Index.

4 Includes businesses that are non-residential customers with sales over 50,000 kilowatt-hours (kWh) per year losing power on a summer weekday afternoon. The original dollar value was adjusted for inflation from 2008 dollars to 2019 dollars using the Consumer Price Index.

5 In 2018, federal costs costs to suppress wildfire totaled $3.143 billion (National Interagency Fire Center 2019). Ten percent of this total is $314 million. There are a variety of reasons why wildfire risk from electrical lines may differ across the nation, including differences in climate, vegetation, storm activity, and the prevalence and condition of above-ground power lines.

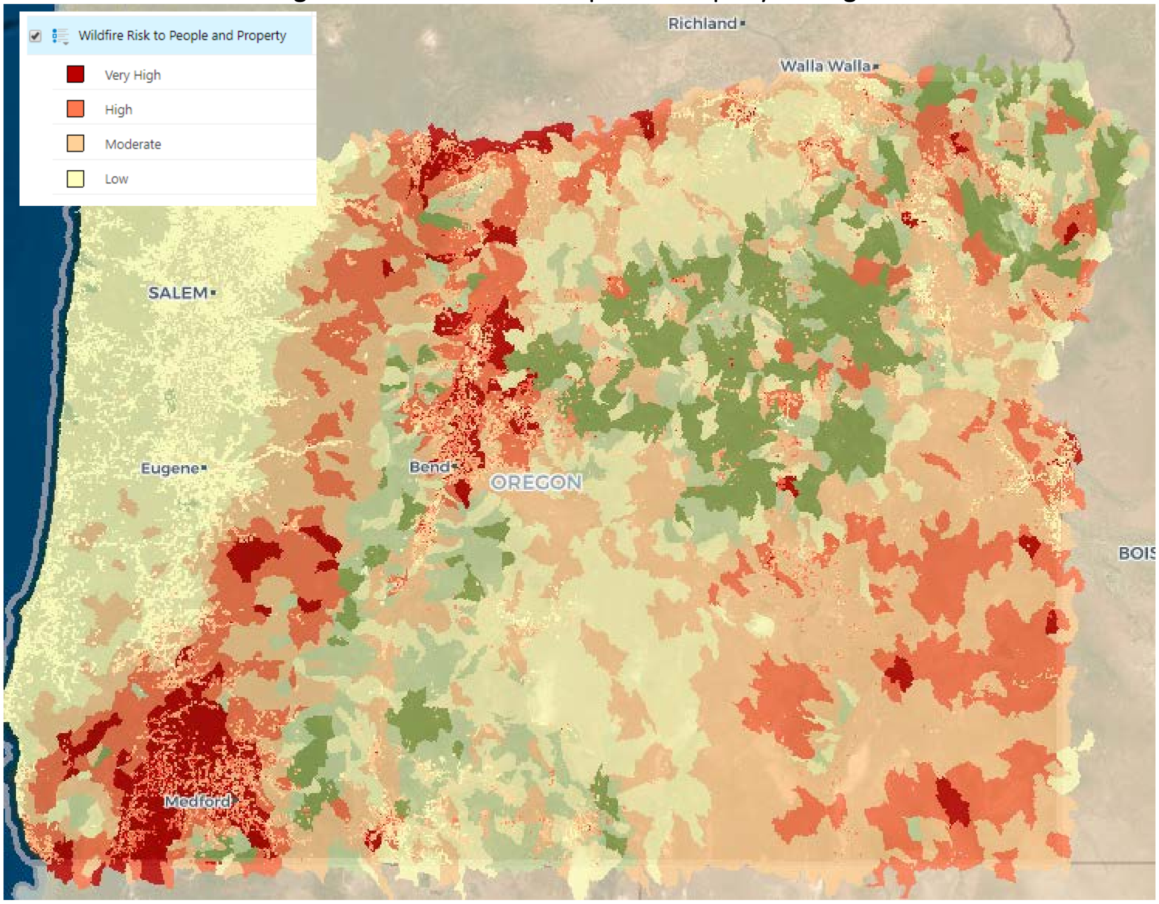
This represents only a fraction of total costs of wildfire, which include direct costs, rehabilitation costs, indirect costs, and additional costs. In addition to the federal costs of suppression, direct costs include suppression costs at the state and local levels, loss of property, and aid to evacuate residents. Rehabilitation costs are the expenses incurred to rebuild after a fire, such as rebuilding structures and infrastructure and repairing damage to the landscape. Indirect costs consist of lost tax revenues such as sales and county taxes, lost business revenues, and loss of property revenue. Additional costs include the loss of human life, detrimental health impacts, and the loss of ecosystem services (such as scenic beauty and reduced water quality). Case studies of six U.S. wildfires indicated that suppression costs represent between three and 53 percent of the total costs of wildfire (Western Forestry Leadership Coalition 2010). Another study indicated that the total costs of wildfire are typically 10 to 50 times the suppression costs, implying suppression costs represent only two to 10 percent of the total costs of wildfires (Howard 2014). A 2017 study by the U.S. Department of Commerce estimated that the total annualized net economic harm (including costs and net losses) of wildfire in the U.S. ranged from $71.1 billion to $347.8 billion (Thomas, et al. 2017). If these figures are accurate, and if electrical lines are responsible for 10 percent of wildfires as the CPUC has found, then above-ground power lines may be the cause of roughly $7.1 billion to $34.7 billion in economic losses in the nation each year.

At the state level, the Oregon Department of Forestry (ODF) estimates that an average of 47 fires on its lands are caused by power lines each year. In 2018, the average fire on ODF land burned 69 acres.[6] If 2018 represents a typical year, then power lines are responsible for burning roughly 3,200 acres on ODF lands each year. The 2018 Ramsey Canyon Fire, which started from a downed power line, cost $6.6 million to manage (ODF Public Affairs 2019). In 2018, the cost of fighting wildfires in Oregon reached $514.6 million, breaking the previous year's total (which was the previous historical record) of $447 million (The Associated Press 2018). The total area burned in 2018 was about 846,000, implying the average cost to fight fires in Oregon is about $608 per acre. If this represents only two to 53 percent of the total costs of wildfire (as the aforementioned studies indicate), the total cost of wildfires in Oregon averages somewhere between $1,100 and $30,000 per acre burned. If this average cost is representative of the fires on ODF lands, the total cost power line-caused wildfires on ODF lands alone ranges from $3.5 million to $96 million per year.

As indicated from these numbers, the risk of wildfire in Oregon is significant, both in the irrigation districts studied in this analysis and in other areas of the state. As Figure 2 below shows (based on analysis from the Oregon Wildfire Risk Explorer, which is a compilation of data sources relevant to wildfire risk), large sections of the state present a high risk of wildfire to people and property, notably along the Cascade Range, the southwest corner of the state, Central Oregon, the Columbia River Gorge between Hood River and Morrow County, and the southeast corner of the state. All areas where irrigation districts cover and serve many acres of land.

[6] In 2018, there were 1,112 fires on ODF land that burned a total of 76,774 acres (Oregon Department of Forestry 2019).

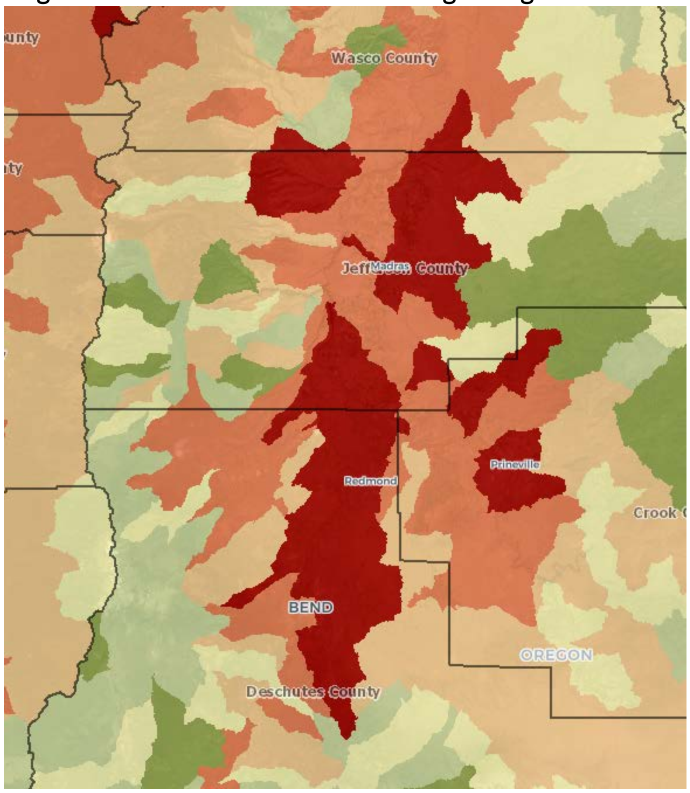
Figure 2: Wildfire Risk to People and Property in Oregon



Source: (Oregon Department of Forestry, Oregon State University, and U.S. Forest Service 2019)

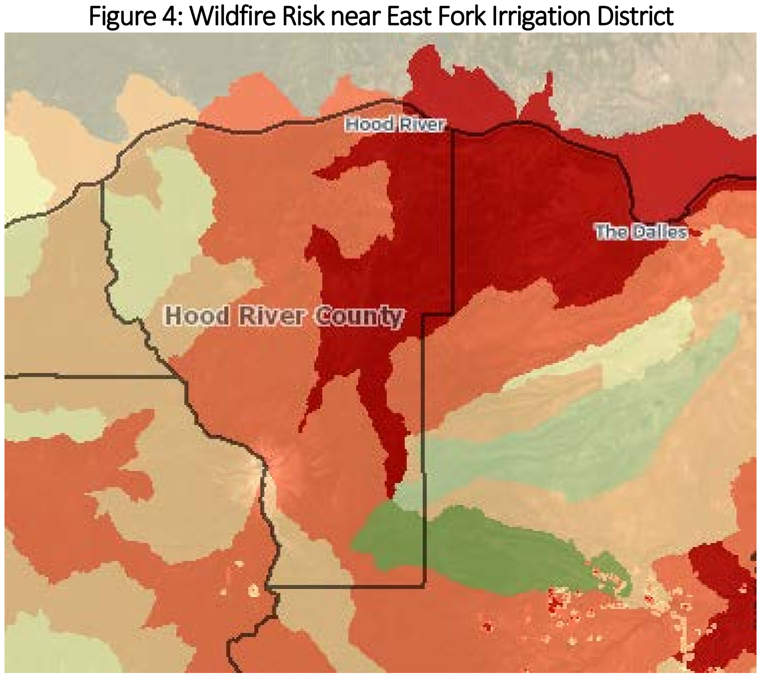
Examining more closely the areas where our EFIC an COID case studies are located, we see that wildfire risk is either "high" or "very high" for most of the land area in and around the districts (shown in Figure 3 and Figure 4). This indicates that these districts may be especially vulnerable to wildfires caused by above-ground electrical lines, and therefore may also gain higher benefits from reduced fire risk associated with burying electrical lines.

Figure 3: Wildfire Risk near Central Oregon Irrigation District



Source: (Oregon Department of Forestry, Oregon State University, and U.S. Forest Service 2019)

Figure 4: Wildfire Risk near East Fork Irrigation District



Source: (Oregon Department of Forestry, Oregon State University, and U.S. Forest Service 2019)

Hood River County, where EFID is located, recently received notice from its electric power provider that power may be shut off during high heat/high wind periods because of fire risk. As indicated above, power outages have the potential to adversely impact important economic activities in the county. In the case of Hood River County, in addition to health and safety concerns, the manufacturing sector and the tourism sectors may be particularly adversely affected by power outages. Manufacturing facilities may not be able to easily start up and stop activities with power outages, and tourists may decide to shorten their travel plans to the area or choose not to visit at all if the power outage is especially severe or if they fear an outage may occur. Although not quantified here, if power outages interfered with irrigation (i.e., if power outages continued for several days and nights during key irrigation periods), then the impacts on agricultural production (which is primarily orchard fruit that is highly sensitive to reduced water application) could also be significantly affected.

The total economic activity potentially at risk county-wide, as well as in the tourism sectors, is presented below. Note that while a detailed study would be required to estimate how power outages would affect these sectors, these figures provide information on the level of economic activity on a daily basis that may be affected by power outages.

- *Total Economic Activity.* In 2015 (the most recent year data is available), the county's GDP was approximately $1.15 billion (Bureau of Economic Analysis 2017). This implies that, on an average day, the county produces $3.15 million in GDP. While some economic activity could be shifted to later days, any day the county was without power would put this productivity at risk.
- *Manufacturing.* While GDP by industry is not reported at the county level, income from manufacturing accounts for nine percent of earned income in the county (Bureau of Economic Analysis 2017). Assuming GDP from manufacturing represents the same proportion of total GDP, then manufacturing GDP was approximately $98.3 million in 2015, or $269,000 on a daily basis. Any day without power would put this manufacturing production at high risk.
- *Tourism.* In 2018, visitors to the county spent a total of $110.8 million (Dean Runyan Associates 2019). Tourism in most areas experiences wide fluctuations depending on season, with Hood River likely having more tourists in the summer. However, on an "average" day, visitor spending in the county would be roughly $304,000. This spending supports a total of $31.2 million in income in all sectors, or a daily average of $85,000. If a power outage were to disrupt visitor spending or total visitation, this amount could be jeopardized. If power outages occur during the high tourist season (likely the summer months), the potential spending impacts would be higher. However, it is not certain that power outages would reduce visitor spending (rather than just delay it until power returned), or if power outages could be so severe that some visitors would choose not to visit the county at all.

Hydropower Generation Potential

For both EFID and COID, piping offers the potential for generating additional hydropower, providing clean, renewable energy and a new source of revenue to the districts. In both cases, studies were undertaken to determine the feasibility of building such facilities. In EFID, a study by NLine Energy determined that a site on Neal Creek was suitable for installing a 1.25-megawatt (MW) hydropower facility (NLine Energy 2019). The study estimated this facility would cost $4,275,000 to construct and require $10,000 annually for operations and maintenance (O&M) costs. The same study estimated the potential revenue from the power generation under three options to sell power to utilities in the area. The study modeled potential sales rates between $0.025 and $0.11/kWh (which generally increased over the study period), with associated total annual revenues ranging from $94,000 in Year 1 of Option 1 to $466,000 in the year 2050 in Option 3. After accounting for costs and incorporating wheeling charges paid to the utility companies, the study estimated the hydro facility would generate economic losses at a net present value that ranged from -$499,000 to -$2.6 million (NLine Energy 2019).

As alternative to selling power to a utility company, EFID could sell the electricity directly to customers. This could avoid the wheeling fees charged by an outside power company and allow the districts to collect a larger share of the revenues from power generation. Over 30 years, the total costs of the facility would have a present value of $4.45 million.[7] In order for the benefits of this facility to equal the present value of the costs over the 30-year period, the facility would need to generate annual revenues of roughly $257,000.[8] If the facility produces 3,769,000 kWh annually (as the NLine Energy study estimates), each kWh would need to generate $0.0682 in revenue. Currently, Hood River Electric Cooperative charges residential customers $0.0705/kWh. Assuming EFID could sell its hydropower at this rate, the potential revenue would be around $266,000 per year. At these annual revenues, the hydro facility would have a net present value of $141,000.

In COID, a study by Black Rock Consulting concluded that there were four suitable sites for new hydropower facilities within the district, which could have a combined capacity of 10.1 MW (Black Rock Consulting 2016). The estimated construction cost of the facilities is roughly $32.45 million.[9] Annual O&M costs (estimated to be one percent of installation costs, following the Black Rock Consulting study) would be approximately $324,600. Given these construction and O&M costs, the present value of costs for the facilities would total $39.7 million over 23 years (the time period used in the Black Rock Consulting study).[10] At that cost, the annual revenue required to breakeven on the facilities is about $2.51 million. In their study, Black Rock Consulting estimated the four hydro facilities would generate a total of 39,715,198 kWh annually, which, if true, would require average revenues of $0.0632 per kWh in order to breakeven with the costs over the 23-year period. This is less than the rate provided by Pacific Power to the Juniper Ridge Power Plant in COID under its current agreement, which range from blended rates of $0.0794/kWh in 2019 to $0.0807/kWh in 2023 (Pacific Power n.d.). In its study, Black Rock Consulting modeled a blended revenue rate that rose from $0.0301/kWh in 2018 to $0.1364/kWh in 2040.[11] After wheeling charges were subtracted, the net revenues of all four facilities was projected to grow from $1.2 million in 2018 to $5.4 million 2040. When weighed against the project costs, Black Rock Consulting estimated that the four facilities would provide a total net present value of $39.2 million (Black Rock Consulting 2016).

Recreation Infrastructure: Rural Quality of Life & Economic Development

Hood River and Deschutes counties where EFID and COID are located are outdoor recreation destinations in Oregon. Outdoor recreation infrastructure and amenities support local quality of life and help to attract and retain residents in rural areas, and also support tourism-related jobs and income in the local economy. The Deschutes County economy in particular is supported by the outdoor recreation industry and related spending; in 2018, with the exception of metropolitan counties near Portland and Eugene, Deschutes County had the highest visitor spending in the State of Oregon at $716.9 million,

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[7] Thirty years was the relevant study period used in the NLine Energy study. The cost calculation adjusts all future O&M costs to present values using a discount rate of four percent (the same used in the NLine Energy study). The estimate assumes all construction costs are incurred in Year 0 and O&M costs are incurred in Years 1 – 30. These costs do not include the overhead costs associated with the district selling its own electricity, such as administration, customer service, and billing. These costs were not included because reliable estimates were not available.

[8] This estimate uses the same discount rate in the NLine Energy study (four percent).

[9] The original 2016 estimate of $29.6 million was updated to 2019 construction costs using the RSMeans construction cost index (RSMeans 2019).

[10] This estimate uses the same discount rate in the NLine Energy study (four percent).

[11] The blended revenue rate is a weighted average of the on-peak rate and off-peak rate and was based on PacifiCorp's Schedule 37 Qualified Facilities Rates.

which supported an estimated $225.5 million in earnings and 7,560 jobs (Dean Runyan Associates 2019). While many rural areas are struggling with population and job losses, rural counties with strong recreation economies (as measured by employment and income in recreation and tourism-related industries and a higher share of seasonal use housing) actually gained slightly in population from 2010 to 2016. Also, households moving to rural recreation counties have higher incomes ($8,700/year higher on average) than households moving to rural non-recreation counties (Headwaters Economics 2019).

Irrigation modernization can help support the local quality of life and outdoor recreation economy through co-location of trails and other recreation infrastructure along the piped corridors. The development of high quality, multi-use trails has been shown to contribute to the economic development of small towns and rural communities – both by serving as an amenity and transportation asset for residents and by attracting non-local users to the area (Citizens' Institute on Rural Design 2017). Trails have other benefits too – supporting an active lifestyle for residents and reducing health care costs, reducing energy usage and energy costs by enabling safe corridors for bicycling and walking commuting, and providing an alternative evacuation route if roadways are damaged or inaccessible.

For Central Oregon Irrigation District, the Bend Park and Recreation District Comprehensive Plan recognizes the demand for trails, which were identified as the most frequently used facility and the number one facility the public was willing to invest taxpayer dollars (Bend Parks and Recreation District Comprehensive Plan 2018). The Plan identifies that trails are necessary for resident quality of life, to relieve traffic on roadways, and to increase connectivity, but that they are challenging to construct because of the difficulty in acquiring property or easements. With their linear nature, district irrigation conveyance rights of way are a cost-effective siting opportunity for new trail projects. Modernization projects, which eliminate the public hazard of open canals and open up space for trail construction, enhance the opportunity for locating trails along district rights of way. Such trails may provide a revenue source for irrigation districts through sale or lease of easements for trails, and/or enhance the quality of life of district patrons and other rural residents. Currently, COID is in the process of working with the Park and Recreation District in coordination with a planned piping project to construct the Central Oregon Historic Canal Trail that will run along the piping alignment and connect to the Deschutes River trail and other neighborhood trails (Bend Parks and Recreation District Comprehensive Plan 2018).

Burying power lines could avoid some of the costs associated with above-ground power lines. Underground power lines makes lines impervious to damage from wind and ice, and makes it more difficult for those who would seek to intentionally disrupt the power network (Simon 2017, Kury 2019). It could also prevent wildfires caused by the power lines (Bizjak, Bollag and Kasler 2018). While "undergrounding" is typically much more expensive than installing power lines above ground, one study found that it could be cost-effective if certain key criteria were met, including:

- Expected vulnerability to frequent and intense storms,
- A large number of customers per line mile,
- Potential for line installation economies-of-scale, and
- Easements are larger above ground than below ground (Larsen 2016).

One study in Florida found that customers served by underground power lines had shorter power outages and fewer interruptions, but that resolving outages took longer for the underground system (Sun Sentinel Editorial Board 2017). While undergrounding does prevent damage from some natural and manmade disasters, it is still vulnerable to others, including flooding, earthquakes, and damage from excavation (Pacific Gas & Electric Company 2017).

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