BLUE FOREST

Financial Innovation for Sustainable Solutions

FINANCIAL ANALYSIS OF INNOVATIVE WOOD PRODUCTS AND CARBON FINANCE TO SUPPORT FOREST RESTORATION IN CALIFORNIA

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EXECUTIVE SUMMARY

Our work finds that there is an opportunity to develop several highly profitable products, most notably fuels which are eligible for government carbon incentive programs such as California's Low Carbon Fuel Standard credits and the Federal Renewable Fuel Standard. Non-fuel products have an average IRR of 15% while fuels have an average IRR of 44% in a baseline scenario. Although products ineligible for government incentives are generally less profitable, voluntary carbon market protocols can greatly increase the Internal Rate of Return (IRR). Fostering investment into these products can encourage critically needed funding for forest management while developing a high impact Natural Climate Solution working towards state, federal, and voluntary climate initiatives.

In California alone, 90% of the largest and most destructive forest fires have occurred since 2010 with CalFire fire suppression costs increasing 600% over the 2000-2005 annual average. State and Federal goals have been put in place to lower the risk of high severity fires. In the western U.S. alone, at least 50 million acres are in need of treatment to reduce the risk of high severity fire, costing at least 50 billion dollars. California has signed a shared stewardship agreement with the US Forest Service with a stated goal to treat one million acres per year, representing roughly a fivefold increase in acres treated at a conservative cost of one billion dollars annually.

Traditional funding strategies of congressional appropriations supplemented by receipts from timber sales are currently insufficient to fund the forest management needed. Driving investment into markets for currently non-merchantable forest biomass - such as tops and branches of trees, small trees, and dead trees in the form of wood chips - will add value to forest raw materials and provide additional revenue streams to pay for critical forest management. Products which utilize biomass as a feedstock from ecologically sound forest management are highly carbon beneficial.

We evaluated the investment potential of products made from woody biomass using a discounted cash flow analysis of several possible forest products under various policy and market scenarios. These products included non-fuel products such as biopower, oriented strand board, biochar, and various fuels including hydrogen, Fischer-Tropsch fuels, pyrolysis fuels, and renewable natural gas. We demonstrate the carbon benefits provided by these products, attributed to their substitution for fossil fuel feedstocks and long term carbon storage.

The next strategic steps that can advance utilization of currently non-merchantable woody biomass in the western U.S. are to develop a carbon offset protocol for biochar with feedstock sourced from ecologically sound forest restoration projects (currently in progress at the Climate Action Reserve), review existing and proposed state and federal policies that can support investment in wood utilization infrastructure, economic evaluation of site-specific facilities, and survey the wood products and private investor sectors to identify challenges and opportunities to expand investment in wood utilization.

INTRODUCTION

In California, 90% of the largest and most destructive fires in recorded history have occurred since 2010. CalFire fire suppression expenditures have increased as well, topping $1 billion for the first time in both 2020 and 2021, in contrast to average yearly expenditures of $167 million between 2000-2005 (Cal Fire 2021). Although fire is a natural and necessary process in the Sierra Nevada and many other dry western forests, the increasing extent and severity of wildfires threatens the resilience of social-ecological systems (Barros et al. 2018).

The increasing severity of the wildfires throughout California has been caused by a combination of management decisions exacerbated by climate change. Fire exclusion policies enacted by the U.S. government in the early 1900s alongside extensive timber harvest have created younger, denser, and more homogeneous forests which are susceptible to high severity, stand replacing fires (Collins et al. 2011; Lydersen and Collins 2018; McIntyre et al. 2015). These management impacts have been amplified by a lengthening fire season and increasing occurrence of extreme fire weather (Jain et al. 2017), shifting seasonality of precipitation (Swain et al. 2021), and increasing temperature (Miller et al. 2019).

In order to increase the resilience of the Sierra Nevada and other Dry Western Forests to ensure the continuity of ecological function and ecosystem benefits to human populations, a substantial increase in forest management is needed. Oftentimes, this management takes the form of mechanical and hand thinning of dense, overcrowded forest stands followed by the reintroduction of low severity burning. The U.S. Forest Service estimates that 50 million acres need to be treated in the western U.S. alone (USDA Testimony 2021), with conservative cost estimates being at least $50 billion dollars (Forest Service FY 2017 Overview). The State of California and the Forest Service have goals to collectively reduce fire risk on one million acres of public and private forest per year, representing roughly a fivefold increase in acres treated (State of CA 2020).

To fund forest management historically, congressional appropriations have been combined with receipts from timber sales. These revenue sources have declined since the 1980's and will be further strained as forest management is scaled to achieve statewide goals. Additional sources of funding, including new markets for currently non-merchantable biomass, will help to achieve these statewide forest management goals. Developing and fostering markets for currently non-merchantable timber such as branches, small trees, dead trees, and tops in the form of biomass chips can increase the funding available for forest management.

A range of fuel and non-fuel products can be made from woody biomass residues and chips including fuel and non-fuel products (Figure 1). The non-fuel products included in this analysis include biopower, oriented strand board, and biochar. The fuel products include hydrogen, renewable natural gas, Fischer-Tropsch fuels, and pyrolysis fuels. These products vary in terms of market readiness, but represent a range of possible products which can be made from woody biomass.

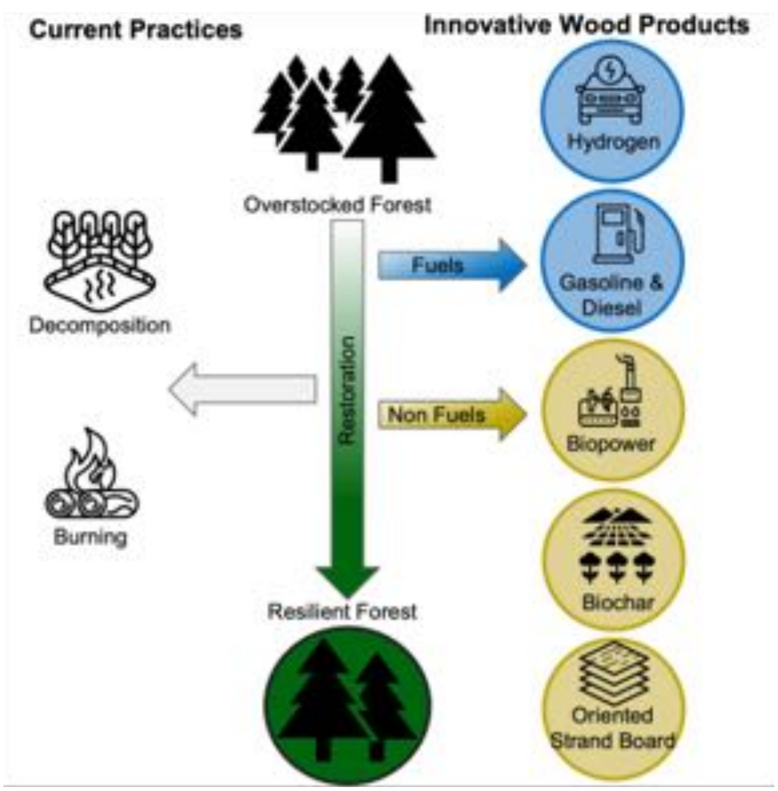


Figure 1 - Innovative Wood Products

Utilizing woody biomass chips as a feedstock to create innovative forest biomass products is highly beneficial from a carbon removal or abatement perspective (Baker et al. 2019). These carbon benefits primarily accrue from the substitution for fossil fuel feedstocks in products like transportation fuels as well as from the long-term storage of carbon in products like building materials and biochar. These substitution and storage benefits can be leveraged through incentive programs like California's Low Carbon Fuel Standard (LCFS) (California Air and Resources Board), the Federal Renewable Fuel Standard (RFS) (US EPA), 45Q tax credits (Internal Revenue Service 2015), and the voluntary carbon market to increase the profitability of these innovative forest biomass products.

Table 1 - Acronyms and Definitions

Term	Meaning	Description
Fuel Products		Fuel descriptions adapted from Baker et al 2020
FT Fuels	Fischer-Tropsch Fuels	Formation of liquid transportation fuels (gasoline and diesel) from the gasification of biomass followed by Fischer-Tropsch syntheses. The final products are typically gasoline and diesel blendstocks identical to their fossil-drived counterparts.
FT Fuels + CCS		Fischer-Tropsch Fuels produced with carbon capture and sequestration incorporated.
RNG	Renewable natural gas	Produced by upgrading biogas or syngas into a product which can supplement or replace traditional natural gas.
RNG + CCS		RNG produced along with the capture and sequestration of CO_2 emitted during production.
Hydrogen		Formed from syngas by converting carbon monoxide and water into CO_2 and hydrogen.
Hydrogen + CCS		Hydrogen has a high portential quantity of CO_2 which can be captured because the fuel produced (hydrogen) does not contain carbon. This is partially why hydrogen + CCS has the largest carbon benefits of the products modelled.
Pyrolysis Fuels		Thermochemical conversion which decomposes biomass in gas, liquid, and solid products. Bio-oil is upgraded into liquid transportation fuels (gasoline and diesel).
Non-Fuel Products		
BECCS	Bioenergy with carbon capture and storage	Creating electricity from biomassand capturing and storing the carbon, removing it from the atmosphere.
OSB	Oriented Strand Board	Building material formed by compressing adhesives and layers of wood strands in specific orientations, similar to particle board.
Incentive Programs		
45Q	Section 45Q of the Internal Revenue Code	Tax credit ($10-$50) for each metric ton of carbon captured and sequestered, depending on type of geologic storage.
RFS	Renewable Fuel Standard	Congressionally created program designed to reduce greenhouse gas emissions and expand renewable fuels sector.
LCFS	California Low Carbon Fuel Standard	State created program to decrease the carbon intensity of transportation fuels.
Abbreviations		
CAPEX	Capital Expenditures	Major long term expenses such as physical assets, buildings, equipment, vehicles, etc.
OPEX	Operational Expenditures	Day-to-day expenses including salaries, rent, utilities, costs of production, etc.
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies Model	Analytical tool that conducts a Life Cycle Analysis by simulating the energy use and emission outputs of various vehicles and fuels.
IRR	Internal Rate of Return	Method for calculating an investment's rate of return. The IRR estimates a projects breakeven discount rate, indicating profitability potential
RIN	Renewable identification number	Credit generated each time a gallon of renewable fuel is produced per the Renewable Fuel Standard (RFS)
CCS	Carbon capture and sequestration	Technologies which capture and compress CO_2 from industrial processes then inject the compressed CO_2 in deep grologic formations.

To determine the potential of increasing funding for forest management by developing additional sources of revenue from woody biomass chips, we examine twelve different products and ask several key questions:

1. What is the carbon benefit of using biomass to produce these products?
2. What is the economic feasibility of producing these products from biomass?
3. How do different carbon incentives and market scenarios affect economic feasibility?

To answer these questions, we conduct a financial analysis incorporating carbon incentives using existing or hypothetical voluntary carbon market credits as well as existing government subsidies and tax credits.

METHODS

There were twelve innovative biomass products examined in this study, divided into non-fuel products and fuel products. The non-fuel products included biopower, biopower with carbon capture and sequestration (CCS), oriented strand board (OSB), biochar in a mobile pyrolysis unit, and biochar produced in a centralized facility. The fuel products included pyrolysis fuels, Fischer Tropsch fuels, Fischer Tropsch fuels with CCS, hydrogen, hydrogen with CCS, renewable natural gas, and renewable natural gas with CCS. The carbon benefit of using biomass as a feedstock was first calculated using published values, followed by a baseline economic analysis of each product.

Carbon Benefit Analyses

To determine the carbon benefit of utilizing biomass to create each product, we relied on published values, primarily from Cabiyo et al. (2021), to model the cradle-to-grave and well-to-wheels carbon benefit of biomass utilization. The system boundaries are drawn such that we assess carbon emissions and benefits across four life cycle categories: 1) transportation emissions - we assume a 90 mile travel distance by heavy duty truck (we account for backhaul), 2) production emissions - accounts for all direct and upstream emissions from fossil fuels used onsite in handling and conversion of biomass. Biogenic carbon emissions are treated as neutral, as it is assumed these wastes would have returned carbon to the atmosphere via degradation or burning (see Discussion). 3) substitution of carbon-intensive products - assumes 1:1 replacement and emissions avoidance of conventional electricity and fuels in the California context, and 4) product end of life - includes combustion of final fuels and decay of recalcitrant and long-lived forest products. Data from the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model was used for all process and substituted fuels and electricity. Slow pyrolysis biochar is assumed to have an 85% recalcitrant carbon fraction while fast pyrolysis char is assumed to have a 93% fraction. Labile and recalcitrant half-lives when biochar is applied to soils are assumed to be 20 years and 300 years, respectively (Cabiyo et al. 2021; Lehman et al. 2015). Carbon storage and decay is modeled over 100 years for all long-lived products. Energy intensity and carbon capture rate for processes with CCS are cited from the published literature. RNG with CCS was assumed to have a CCS capture rate of 85% and require 200 kWh/t CO_2 for compression and sequestration. Removal is assumed to be permanent. All woody feedstocks are assumed to be 50% C by mass. Carbon benefit is the sum of all non-biogenic emissions minus avoided emissions and storage. Carbon benefits were calculated in terms of tC benefit per oven-dry tonne of woody biomass.

Baseline Economic Scenario and Discounted Cost Flow Analysis

To establish baseline economic scenarios for each product, we incorporated published techno-economic analyses to compile the initial capital expenditures required to build manufacturing facilities, the yearly operating expenditures, and the yearly feedstock required to achieve production targets. Income from primary products, co-products, and applicable carbon incentives (LCFS, RFS, 45Q) were incorporated into yearly revenue. Carbon incentives modeled include income from California's Low Carbon Fuel Standard, the Federal Renewable Fuel Standard, 45Q carbon capture and sequestration tax credits, and voluntary carbon market credits for applicable products. Once first year costs and revenue were calculated, the Internal Rate of Return (IRR) was calculated for each product over a 20-year timeframe to create baseline economic scenarios. Baseline economic assumptions are captured in Table 2.

Table 2 - Baseline Economic Assumptions

	Baseline	Unit
Feedstock	$60.00	Bone Dry Ton (BDT)
LCFS	$150.00	Ton CO2e
RIN	$0.91	Gallon Gasoline Equivalent (GGE)
45Q	$50*	Ton CO2e
Voluntary carbon market	$0.00	Ton CO2e
Electricity (large)	$120.00	Megawatt Hour (MWh)
Electricity (small)	$195.00	Megawatt Hour (MWh)
OSB	$224.00	3/8" Thousand Square Feet (MSF)
Biochar	$500.00	Ton
Diesel	$2.25	Gallon
Gasoline	$2.25	Gallon
Hydrogen	$1.00	Kilogram (KG)
RNG	$4.00	Million Metric British Thermal Unit (MMBTU)

* Policy cliff scenario was assumed. LCFS discontinued in 2031. RIN discontinued in 2023. 45Q discontinued in 2033.

Sensitivity Analyses

To understand how fluctuations in cost and income affect the baseline economic scenarios, a sensitivity analysis was conducted by increasing and decreasing various parameters by 40% in increments of 10%. The parameters analyzed included feedstock price, operational expenditures (OPEX), capital expenditures (CAPEX), price of the primary product, carbon benefit, LCFS price, RFS price, and 45Q credit for each eligible product. The associated percent changes in IRR were recorded and are displayed in Figures 3 and 4.

Table 3 - Market and Policy Scenario Assumptions

	Low	Baseline	High	Unit
Feedstock	$40	$60	$120	Bone Dry Ton (BDT)
LCFS	$150*	$150	$225	Ton CO2e
RIN	$0	$0.91	$3.04	Gallon Gasoline Equivalent (GGE)
45Q	$35*	$50*	$50	Ton CO2e
Voluntary carbon market	$20	$0	$100	Ton CO2e

* Policy cliff scenario was assumed. LCFS discontinued in 2031. RIN discontinued in 2023. 45Q discontinued in 2033.

Market and Policy Scenario Analysis

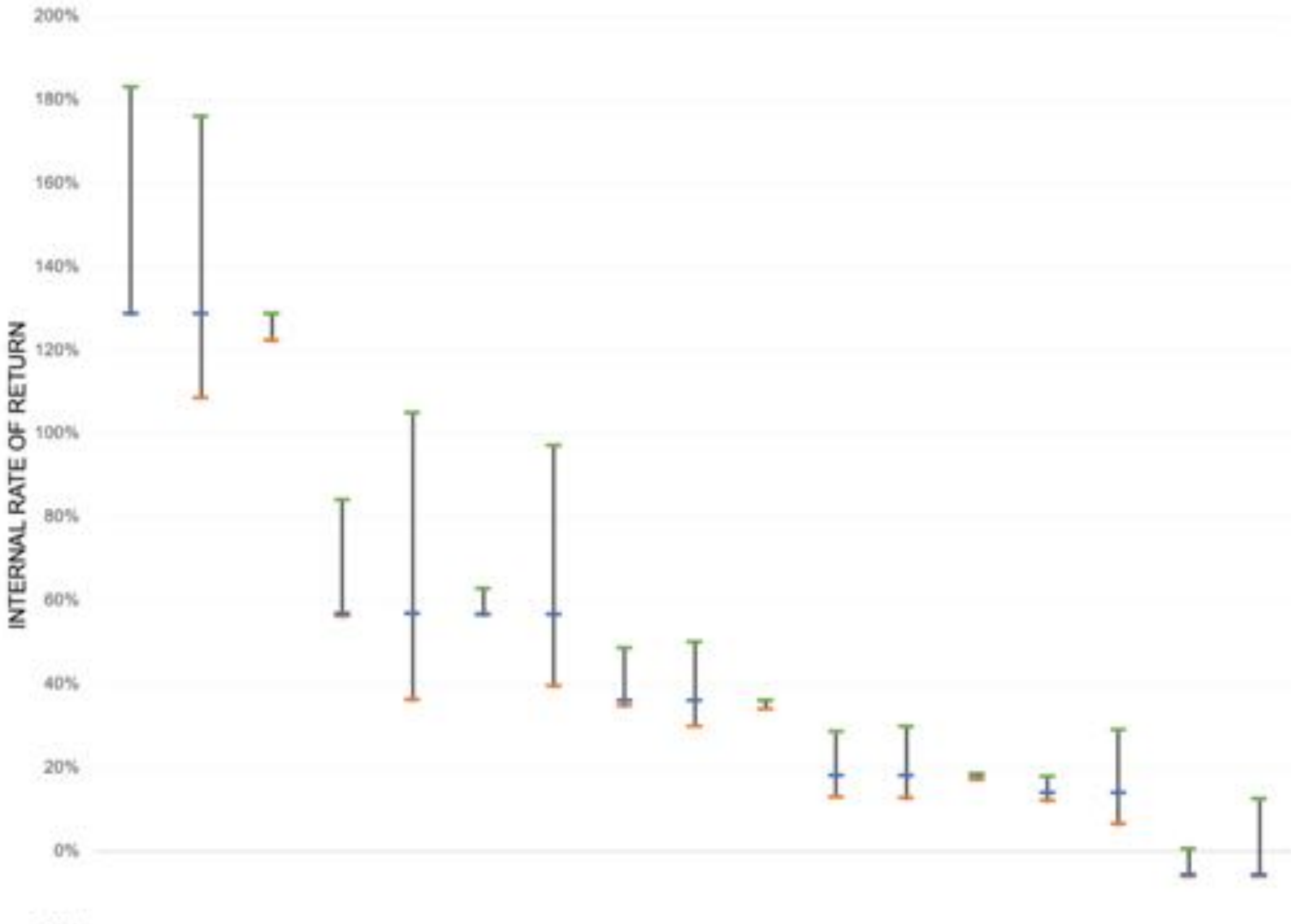
To complement the traditional sensitivity analysis, a scenario analysis was conducted which examined a high and low assumption of each important parameter identified in the sensitivity analysis. The high and low values for each parameter were chosen to represent realistic scenarios (see Table 3). LCFS credit spot price in 2020 and 2021 was

above \$200/ ton CO2e and the program will be evaluated for renewal in 2030. Feedstock originating on federal land is not eligible for RIN credits, which is why the low scenario is assumed to be no credit. The RIN baseline scenario assumed that the price is the median transacted over the last 5 years and that half of the feedstock originated on federal land. CCS operations are eligible for 45Q, which provides tax credits up to \$50 per ton CO2 stored depending on the type of storage. See Table 3 for low, baseline, and high scenarios.

RESULTS

An analysis of market and policy scenarios on fuel products highlighted both hydrogen and hydrogen + CCS as stand out products (Figure 2). Hydrogen + CCS has the highest IRR of the fuel products, with an IRR of over 100% even in the low policy scenario. Hydrogen is also highly profitable, with an IRR of over 100% in the high market scenario and still an IRR of 36% in the low market scenario, which assumes the Renewable Fuel Standard is discontinued. These two products are also key standouts due to their alignment with California Energy Commissions' Clean Transportation Program, established by California AB 118. SB 1505 further supports utilizing renewable biomass for hydrogen production as well, requiring at least 33.3% of the hydrogen produced for transportation be made from renewable energy sources (State of California 2020).

Along with clear policy support, the hydrogen facilities we modeled are also highly profitable and relatively market ready compared to some of the other fuels modeled. Although hydrogen and hydrogen + CCS are the standout products in this analysis most of the other fuel products have an IRR of 20% or higher in all of our market and policy scenarios, with the notable exception of renewable natural gas which had a negative IRR in most cases.



	Hydrogen + CCS			Hydrogen		Pyrolsis Fuels		FT Fuels + CCS			RNG + CCS			FT Fuels		RNG	
	LCFS	RIN	45Q	LCFS	RIN	LCFS	RIN	LCFS	RIN	45Q	LCFS	RIN	45Q	LCFS	RIN	LCFS	RIN
Low	129%	109%	122%	56%	36%	57%	40%	35%	30%	34%	13%	13%	17%	12%	7%	-6%	-6%
Baseline	129%	129%	129%	57%	57%	57%	57%	36%	36%	36%	18%	18%	18%	14%	14%	-6%	-6%
High	183%	176%	129%	84%	105%	63%	97%	49%	50%	36%	29%	30%	19%	18%	29%	1%	12%

Figure 2 - Fuel Products Market and Policy Analysis

Our lower policy and market assumptions for fuels included downward fluctuations in LCFS, RIN, and 45Q credit prices as those are the incentives over which policy has direct control. Due to the multiple sources of revenue, including state incentives as well as primary and secondary products, the IRR impacts from fluctuations in any one source of income were mediated by other income.

During this modelling, we had a conservative approach wherever possible. With that in mind, there are likely a number of unforeseen real world costs that were not captured by the techno-economic analyses incorporated in this study due to the novel characteristics of these products. Due to those limitations, these levels of profitability may be lower once unforeseen costs are fully incorporated.

An analysis of voluntary carbon market income on the IRR of non-fuel products (Figure 3) found that both biochar (mobile) and biochar (centralized) had an IRR of over 20% given both a carbon price of $20 (low estimate) and $100 (high estimate). Biopower was minimally affected by the addition of voluntary carbon market income. The IRR for OSB went from 13% in the baseline scenario with no carbon credits to 28% when carbon credits were assumed to be $100/ ton.

Table 4 displays the carbon benefit of the twelve biomass products. The most carbon beneficial products are fuel products coupled with CCS. The substantial carbon benefit of fuels coupled with CCS is in large part due to the substitution benefit of using biomass in place of fossil fuels alongside the CO2 captured and stored from the production processes. The least carbon beneficial product is biopower due to a lack of carbon storage benefits and minimal substitution benefits.

The sensitivity analysis of the biomass products was divided into non-fuel and fuel products. Non-fuel products (Figure 4) were highly sensitive to most parameters.

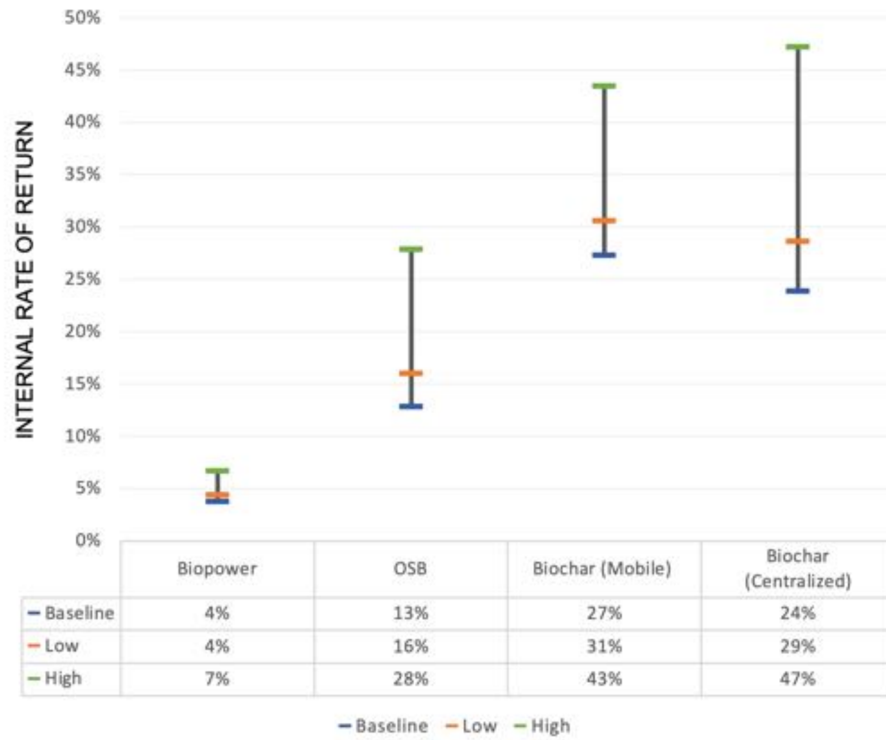


Figure 3 - Voluntary Carbon Market Analysis

Primary product price (which excludes price for any coproducts) in particular had a high impact on the IRR. For example, a 20% decrease in product price from the baseline scenario decreased the IRR for biopower by 154%, OSB by 98%, Biopower + CCS by 63, biochar (mobile) by 79%, and biochar (centralized) by 80%.

Table 4 - Carbon Benefits

Technologies	Substitution	Process Emissions	Storage	Total
Non-Fuel				
OSB	0.94	-0.30	0.44	**1.08**
Biopower + CCS	0.10	0.72	0.00	**0.82**
Biochar (Centralized)	0.04	-0.03	0.36	**0.36**
Biochar (Mobile)	0.00	-0.03	0.24	**0.21**
Biopower	0.13	-0.02	0.00	**0.11**
Fuel				
Hydrogen + CCS	0.80	0.85	0.00	**1.65**
RNG + CCS	0.49	0.64	0.00	**1.13**
Fischer-Tropsch + CCS	0.35	0.46	0.00	**0.81**
Hydrogen	0.80	0.01	0.00	**0.81**
Pyrolsis Fuels	0.63	-0.20	0.00	**0.44**
RNG	0.51	-0.20	0.00	**0.31**
Fischer-Tropsch Fuels	0.35	-0.13	0.00	**0.22**

Carbon benefit of each biomass product in terms of tC benefit / tC in feedstock. Storage includes landfilled wood and carbon in long-lived products. CCS storage benefits are included in process emissions.

The IRR for fuel products was generally less sensitive to fluctuations in primary product price than non-fuel products (Figure 5). For example, a 20% decrease in product price from the baseline scenario decreased the IRR for pyrolysis fuels by 14%, Fischer Tropsch Fuels + CCS by 10%, Fischer Tropsch fuels by 34%, hydrogen by 7%, hydrogen + CCS 3%, renewable natural gas by 27%, and renewable natural gas + CCS by 3%. This decreased sensitivity was due in part to the multiple sources of income for fuel products, particularly income from LCFS credits, RIN credits, and 45Q tax credits.

For the products which were eligible for programs like the LCFS and the RFS, fluctuations in the LCFS price in particular had a similar magnitude of impact on the IRR as changes in the product price. A 20% decrease in the LCFS price from the baseline scenario decreased the IRR for pyrolysis fuels by 4%, Fischer Tropsch fuels + CCS by 14%, Fischer Tropsch fuels by 11%, Hydrogen by 19%, Hydrogen + CCS by 17%, renewable natural gas by 70%, and renewable natural gas + CCS by 25%. Fluctuations in RIN credit pricing had a similar, but lower magnitude, impact on the IRR.

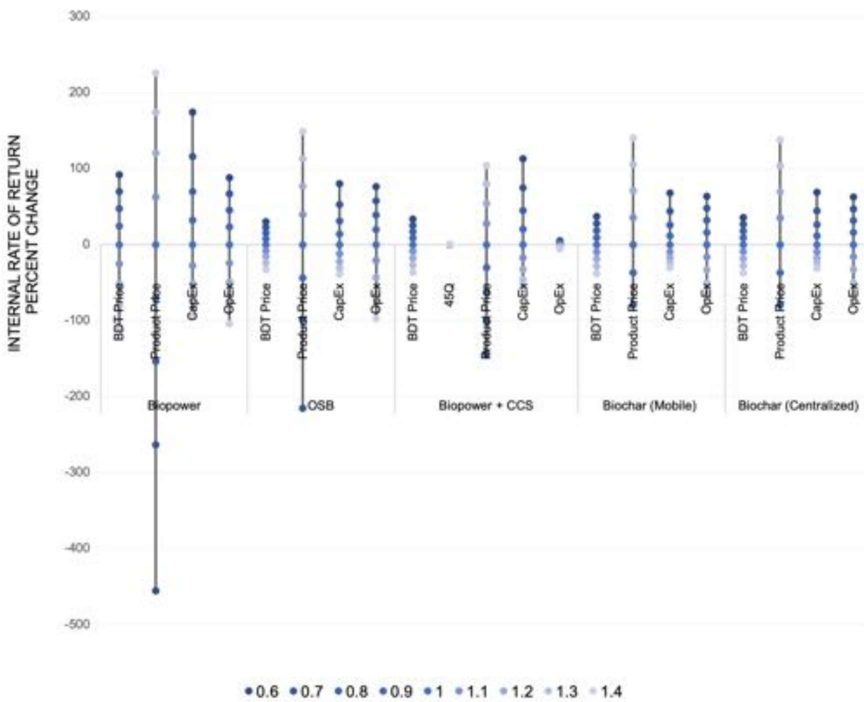


Figure 4 - Non-fuel Products Sensitivity Analysis

Fluctuations in the calculated carbon benefit had a significant effect on the IRR, given that the number of LCFS or RIN credits received was determined by the carbon benefit calculated. RIN and LCFS credits were a significant source of income for eligible products – all fuel products received at least 40% of their income from carbon incentives and five of the seven fuel products received 65% or more of their income from carbon incentives. All fuel products, with the exception of pyrolysis fuels, had a highly negative IRR when all carbon incentives were removed.

Changes in the feedstock price had a sizable impact on the IRR of many products. However, even in the high-cost scenario ($120/ bone dry ton feedstock) all fuel products (excluding Fischer Tropsch fuels and renewable natural gas) had an IRR over 20%. In the baseline scenario of $60/ bone dry ton feedstock, biochar (mobile) and biochar (centralized) had the highest IRR of the non-fuel products, but were very sensitive to upward fluctuations in feedstock price.

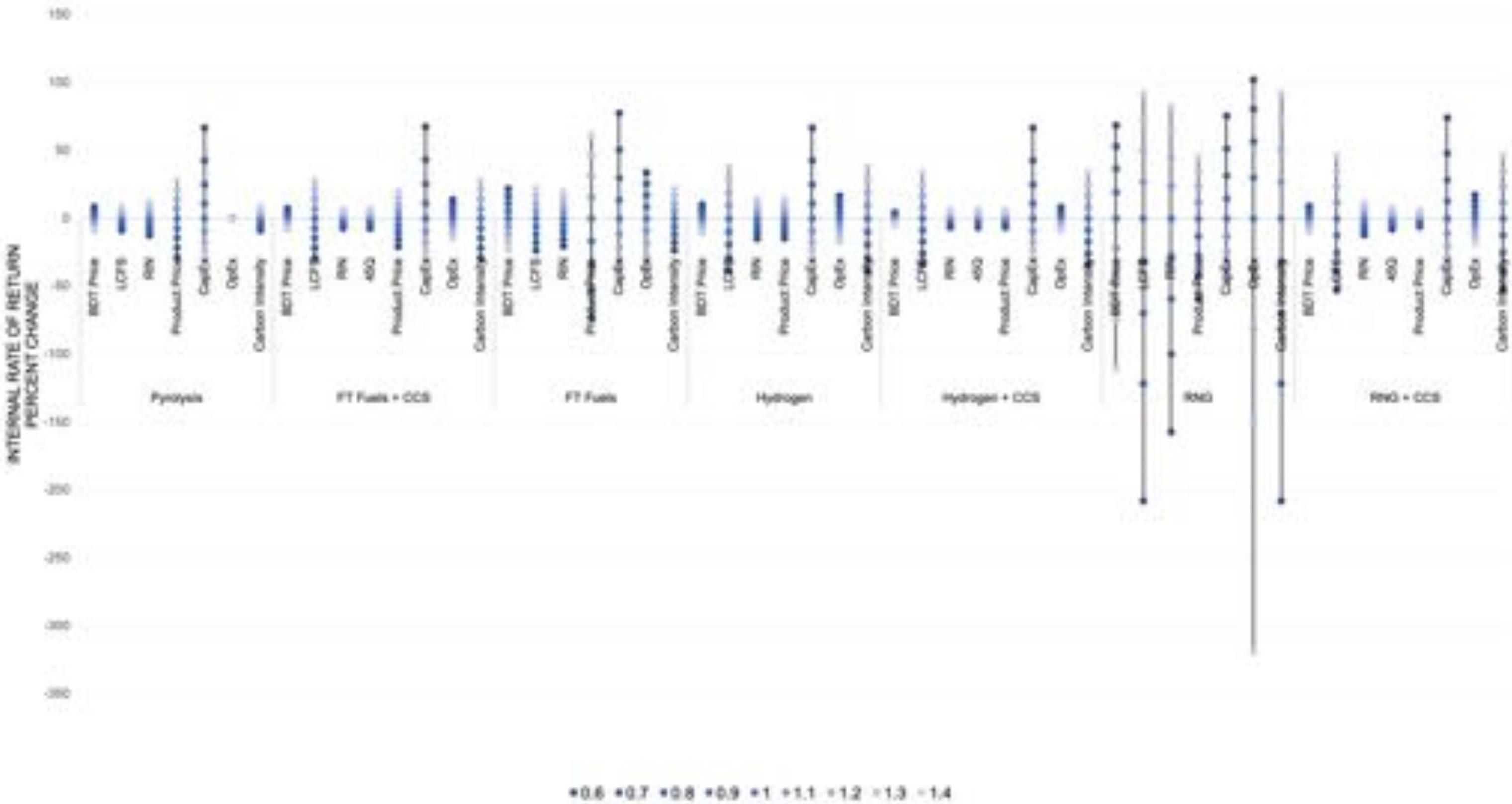


Figure 5 - Fuel Products Sensitivity Analysis

DISCUSSION

Existing and fuel products utilizing biomass as a feedstock can provide additional funding for critical forest restoration while helping to accomplish climate neutrality goals. Hydrogen and other fuel products in the form of fuels made from biomass are still highly profitable at feedstock prices over $120 per ton, while some non-fuel products are profitable up to prices of $100 per ton. With roughly 10 tons of biomass needing to be removed from each acre of overstocked forest (USDA Forest Service), these products could increase forest funding by over $1000 per acre in many instances. Assuming conservative land management costs in California of at least $1000 per acre (Forest Service FY 2017 Overview), this additional income could make forest restoration significantly less costly. Furthermore, breakeven prices for contractors to harvest, chip, and haul biomass range between are roughly between $50 -120 per ton in the Sierra (Swezy et al. 2021), meaning in certain instances these products could single handedly make biomass removal and the associated fuel treatment profitable.

However, the viability of both non-fuel and fuel products are dependent upon policy and market support in the form of consistent price support and the longevity of existing carbon incentive programs. Our analysis shows that non-fuel products like biochar, biopower, and building materials like OSB need reliable markets to ensure the profitability of their operations. A 20% change in the market price for each of these products created a 50% or more change in the IRR. Existing programs like California's BioMAT have failed to drive substantial investment in biopower facilities which utilize non-merchantable forest biomass and this research suggests that may be in part due to the need for further price support. Biopower and other non-fuel products are clearly highly sensitive to market price and various price support systems may help to encourage investment in this space.

On the other hand, fuel products like hydrogen and other transportation fuels are less sensitive to changes in market price and are highly profitable with existing carbon incentives like LCFS, RIN, and 45Q credits. For each fuel, over 40% of yearly income in our relatively conservative baseline scenario was directly from carbon incentives, with as much as 88% for Hydrogen + CCS and 92% for RNG + CCS. The continuance of these carbon incentive products will help to send signals to the market to invest in these climate beneficial fuels.

In other instances, leveraging carbon credit markets can help to encourage these products. The centralized biochar facility we modeled had a baseline IRR of 24% but increased to 29% and 47% when carbon credits of $20 and $100 per ton were included, respectively. Interest in biochar has increased as a possible component of mine remediation products or as a soil amendment in agricultural, range, or forest lands. Moreover, demand for scientifically rigorous and demonstrably additional carbon credits is increasing and biochar carbon offsets could help to fill this demand.

There are important limitations to this study. First, the capital expenditures used in this modelling are from published studies and may not represent the full spectrum of costs that might be faced by a new facility. Higher capital costs as a result of high land costs in California for example, may increase capital expenditures and reduce the IRR for specific products. Second, there are economic assumptions such as market price, which may be inaccurate or fluctuate overtime. Biochar prices are assumed to be $500/ton and although this is a realistic price for biochar in certain instances, not all markets may support this price. Lastly, we assume that biogenic carbon fluctuations are neutral, in other words it is assumed these wastes would have returned carbon to the atmosphere via degradation or burning. This is a valid assumption when forest management is planned with ecological outcomes in mind, however management which is not ecologically sound can have substantial carbon impacts.

With these limitations in mind, the technologies modeled in this study represent a mosaic of possibilities that could be implemented alongside one another to reinvigorate rural wood products and forest management industries. This study finds that not just one wood product is investible, but rather that there are several innovative wood products which warrant increased attention from private investors. A healthy and economically resilient wood products industry might be one which still incorporates traditional wood products such as dimensional timber while including innovative products like fuels which can add value to non merchantable woody biomass. Fostering markets for small diameter trees and non-merchantable biomass may enable the Forest Service and other landowners to manage landscapes for ecological resilience, without the need to focus exclusively on the economic timber value of old growth stands.

CONCLUSION AND NEXT STEPS

This analysis provides a clear rationale for fostering investment in these industries which can simultaneously provide funding for ecologically sound forest management, reduce fire risk, offer climate positive products, and provide green jobs in rural communities. However, investments in these products must be coupled with policies that enable a consistent feedstock supply, provide price support systems for certain products, and continue existing carbon incentives for others.

The next strategic steps that can advance utilization of currently non-merchantable woody biomass in the western U.S. are to develop a carbon offset protocol for biochar with feedstock sourced from ecologically sound forest restoration projects (currently in progress at the Climate Action Reserve), review existing and proposed state and federal policies that can support investment in wood utilization infrastructure, economic evaluation of site-specific facilities, and survey the wood products and private investor sectors to identify challenges and opportunities to expand investment in wood utilization.

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