



Chemical Looping Gasification for Sustainable Production of Biofuels



Techno-economic assessment of the full BtL process

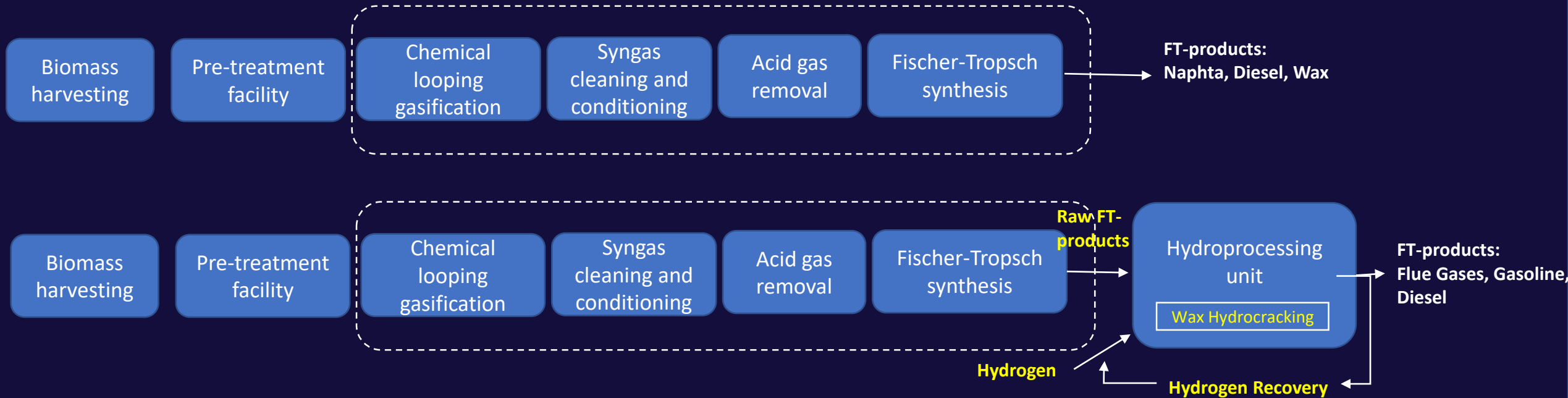
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25 April 2023

- **Methodology**
 - **Cost estimation**
 - **Techno-economic assessment**
 - **Risk assessment**
- **Results**
 - **Break-even selling price**
 - **Economic risk and mitigation strategies**
- **Conclusion**

- Cases analysed (with and without hydroprocessing):



NO HYDROPROCESSING	WITH HYDROPROCESSING
CASE 1. BASELINE - NO CCS and NO HYDROPROCESSING	
CASE 2. WITH CCS	CASE 4. WITH CCS
CASE 3. WITH CCS AND POSSIBILITY OF SELLING THE EXCESS HEAT	CASE 5. WITH CCS AND POSSIBILITY OF SELLING THE EXCESS HEAT

- Step 1. Cost estimation (standard or new component?)
- Step 2. Assessment of the Break Even Selling Price for FT products and for hydroprocessing products

Return on Investment

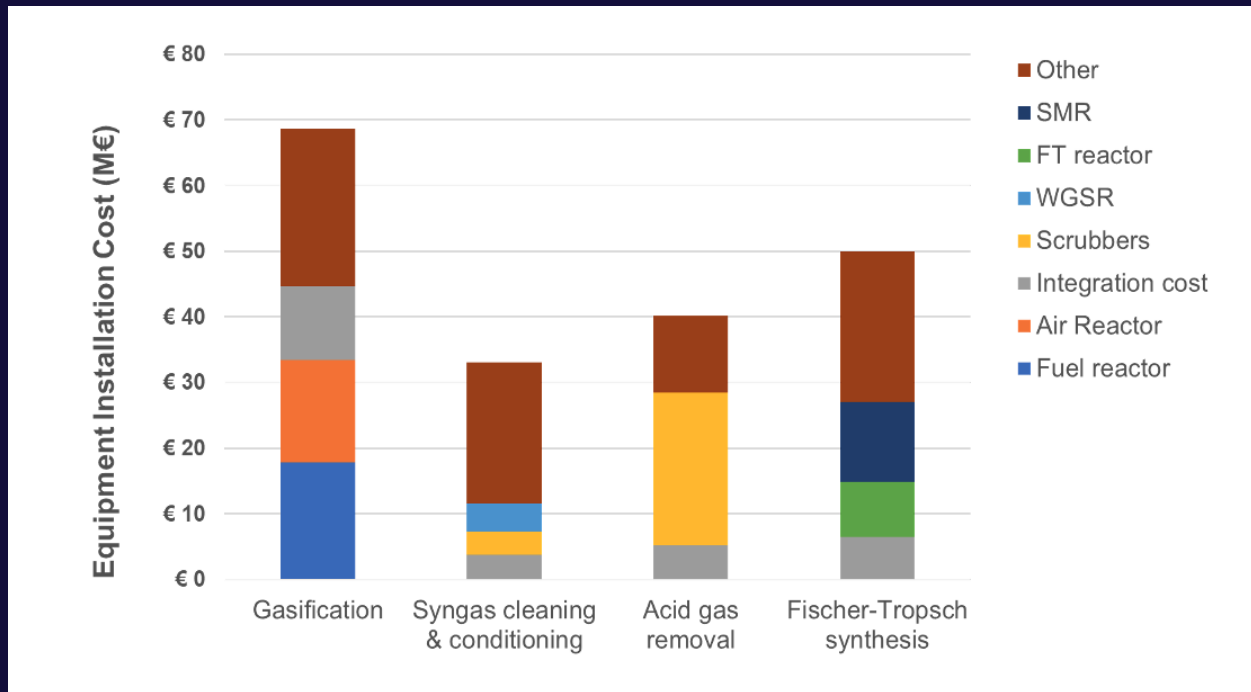
$$BESP = \frac{ROI + C_{personnel} + C_{consumables} + C_{maintenance} - R_{by-products}}{Prod_{F-T syncrude}}$$

Revenues from both F-T products
and hydroprocessing products

- Step 3. Sensitivity analysis
- Step 4. Economic risk assessment (Monte Carlo simulation and @Risk8 software)

Techno-Economic assumptions

	Baseline	
Operating hours	8000	hrs/year
Discounted cash flow rate	6	%
Interest rate & Inflation	6	%
Construction time	3	years
Tax rate	0	
Contingencies	15	% (EPC)
Cost year	2020	
Project life	25	years
Location	Europe	
Working capital & Commission cost	10	% (EPC)
Average electricity price	80	€/MWh
Insurance	1.5	% TCI/y
Maintenance and labour	3.5	% TCI/y
MDEA	1500	€/tonne
WGS Catalyst	16,000	€/tonne
F-T Catalyst	35,000	€/tonne
Oxygen carrier (Ilmenite)	300	€/tonne
Fresh Water	2	€/m ³
Wastewater	4	€/m ³
Solid waste disposal	25	€/tonne
Pine forest residue	110.2	€/tonne
Wheat straw	76.9	€/tonne



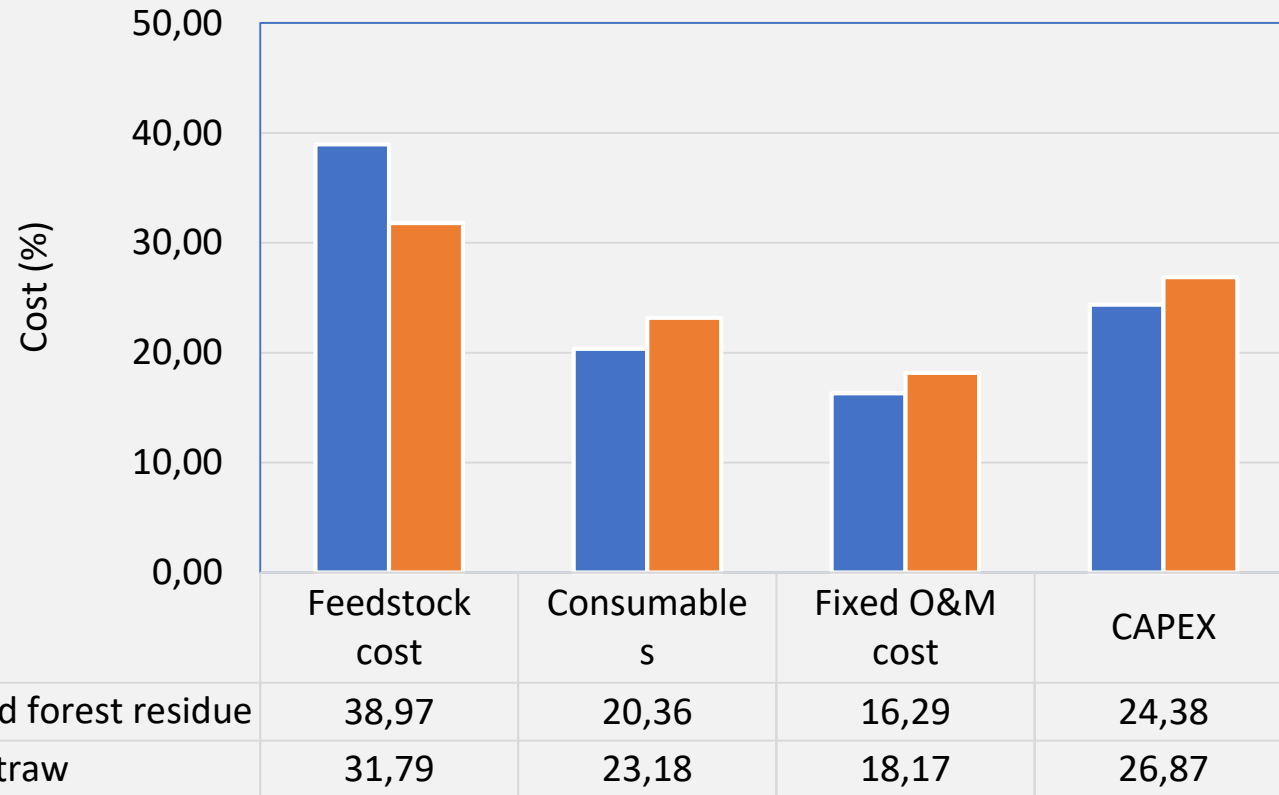
- **€165.13 million** of the total **equipment** installation price shown in the Figure, **plus**
- **€28 million integration and start-up cost, plus**
- **€9.87 million building and land cost**
- The **total is €203.4 million.**

Total installed cost (M€)	203.4
Total capital cost (including owner cost M€)	223.7
Total capital investment (including contingency, M€)	254.3
Total project investment (including interest charges, M€)	272.9

BESP for PFR and WS with no hydroprocessing

BESP for FT products with PFR = €816/Nm³ and BESP for WS = €781/Nm³

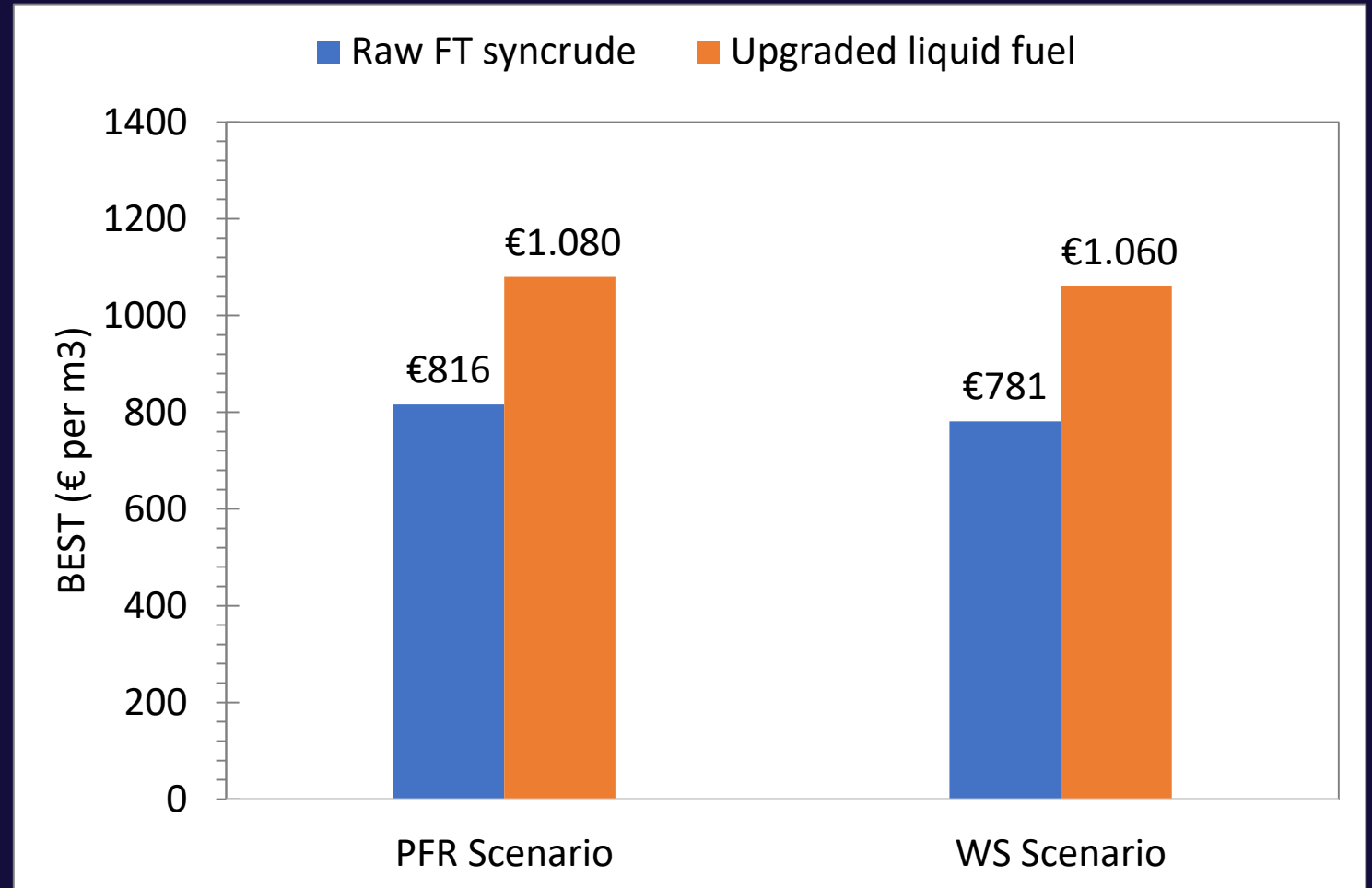
Breakdown of the break-even selling price for FT liquid fuels



Raw F-T products	Pine Residue	Wheat straw
F-T Naphtha (m ³ /h)	2.718	2.479
F-T Diesel (m ³ /h)	2.340	2.140
F-T Wax (tonne/h)	4.003	3.654

- The BESP for Biodiesel blend coming from hydroprocessing
- The value is higher due to a lower volume of products and a higher cost of investment

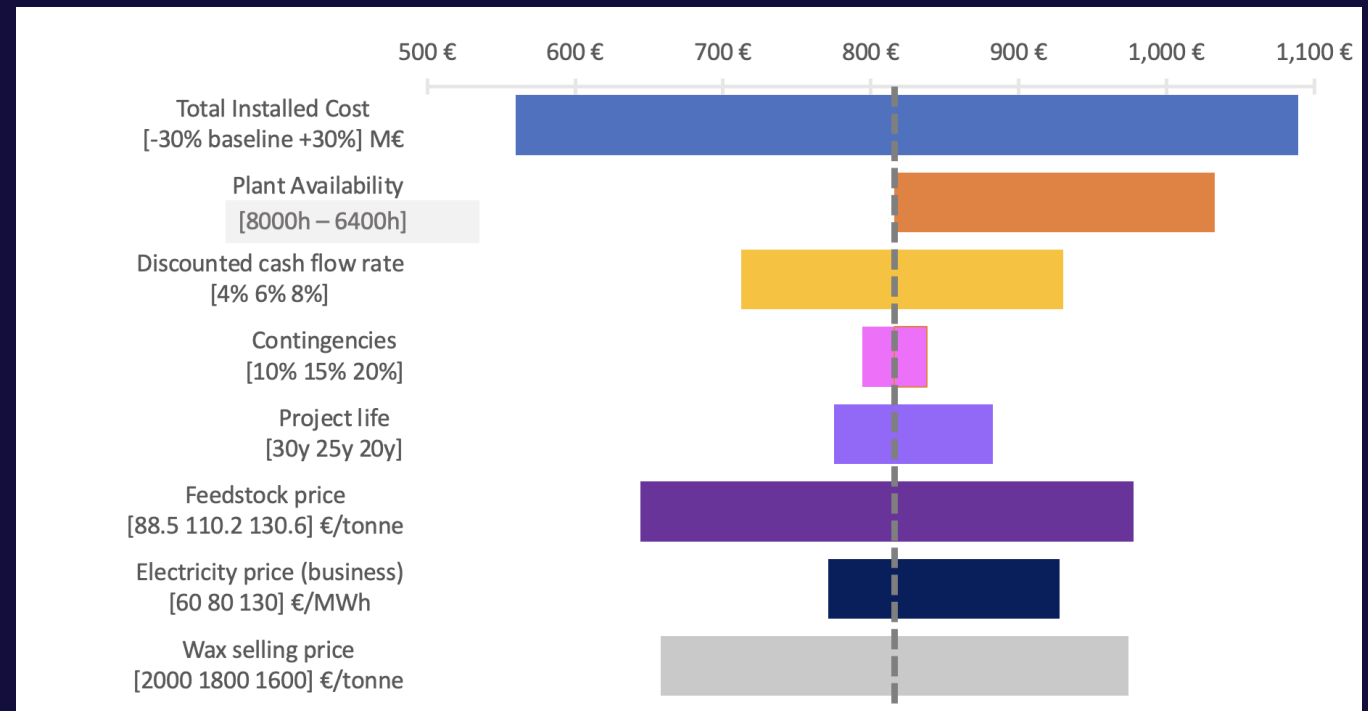
Feedstock type	Pine Forest Residue	Wheat Straw
Raw FT products, tonne/h (dry basis)	7.99	7.30
Hydrogen consumption, tonne/h	0.06	0.05
Light fuel gases, MWh/h	29.57	27.00
Bio-gasoline, m ³ /h	4.14	3.78
Biodiesel, m ³ /h	5.08	4.64



The influence of variations in capital cost, biomass feedstock cost, plant availability and lifetime, discounted cash flow rate, wax selling price, electricity price and contingency value was investigated

The **most significant economic parameters** are:

- wax selling price/biodiesel **selling products price**
- **plant availability** (20% reduction leads a 30% BESP – 1€/l)
- **fixed capital investment**
- **feedstock price** (cheaper biomass – 0.66€/l)



Example of sensitivity results for PFR

The risk of capital cost and cash flow was estimated

- ✓ **Contingency budget: 14%** (for 95% confidence of not overrunning the capital cost estimated)
- ✓ Economic risk on cash flow was assessed:

CASE	PFR		WS	
	Probability of having a negative NPV	Probability of having an IRR below 6%	Probability of having a negative NPV	Probability of having an IRR below 6%
BTL plant without CCS no hydroprocessing	46.2%	42.8%	45.2%	42.1%
BTL plant with CCS no hydroprocessing	15.5%	15%	12.9%	12.8%
BTL plant with a CCS and the possibility of selling excess heat (no hydroprocessing)	7.3%	7.3%	6.7%	6.7%
BTL plant with CCS and hydroprocessing	22.5%	20.9%	19.3%	18.6%
BTL plant with a CCS and the possibility of selling excess heat and hydroprocessing	14%	13.7%	12.9%	12.7%

- ✓ To upscale Chemical looping gasification, several technical and economic aspects must be first elucidated. .
- ✓ The **plant requires a total project investment of €272.97 million**, with annual operating costs ranging from €58.9 to €68.1 million for the wheat straw and pine residue scenarios, respectively.
- ✓ The resulting **break-even selling prices are approximately 9% lower than** those produced using a **conventional gasification set-up**, but still higher than fossil fuel prices reported between 2013-2021
- ✓ The **sensitivity analysis**, confirmed by the **risk assessment analysis** on the cash flow, showed that FT products or biodiesel products are the main parameters to influence the economy. Reducing capital investment, sourcing cheaper biomass feedstocks and is also an effective way to achieve BESPs comparable with fossil fuel prices.
- ✓ **Without CCS**, which allows selling carbon credits, there is a **high risk of having a negative NPV** or an IRR below the discount rate, making the investment not feasible for both PFR and WS
- ✓ In this case, mitigation strategies: i) **a long-term bilateral contract** to fix wax and biodiesel price (responsible for more the 90% of the variation of the NPV) and ii) **utilization of the CO₂ captured** to collect extra revenues
- ✓ Also, in the case of hydroprocessing, **BTL plant with CCS and selling of excess heat** reduce the risk of the investment (**below 15%**)



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**Thanks
Any questions?**

