The use of sustainable aviation fuels (SAF) in developing countries: A practical approach for distributing the green premium

Sustainability Assessments for the Low-Carbon Economy
4th Interdisciplinary Ph.D. Expert Course for Young Researchers

Hasselt 16-18 October 2024

Francis Mwangi

PhD Promoter: Prof. Dr. Robert Malina

Hasselt University, Belgium

17.10.2024

Francis Mwangi, Sumit Maharjan, Robert Malina

ASCENT
AVIATION SUSTAINABILITY CENTER

Content of this Presentation

Introduction 1

Overview of the PhD 2

TEA and Green Premium 3

Introduction-ASCENT Project 93: Regional Supply chain analysis

CMK CENTRE FOR ENVIRONMENTAL SCIENCES UHASSELT

Objective:

- Work with regional partners to design and analyze SAF supply chains in three regions: Latin America and the Caribbean, Africa and Southeast Asia.
- Create training modules/course/and graduate programs on the design and analysis of SAF production and supply chains.

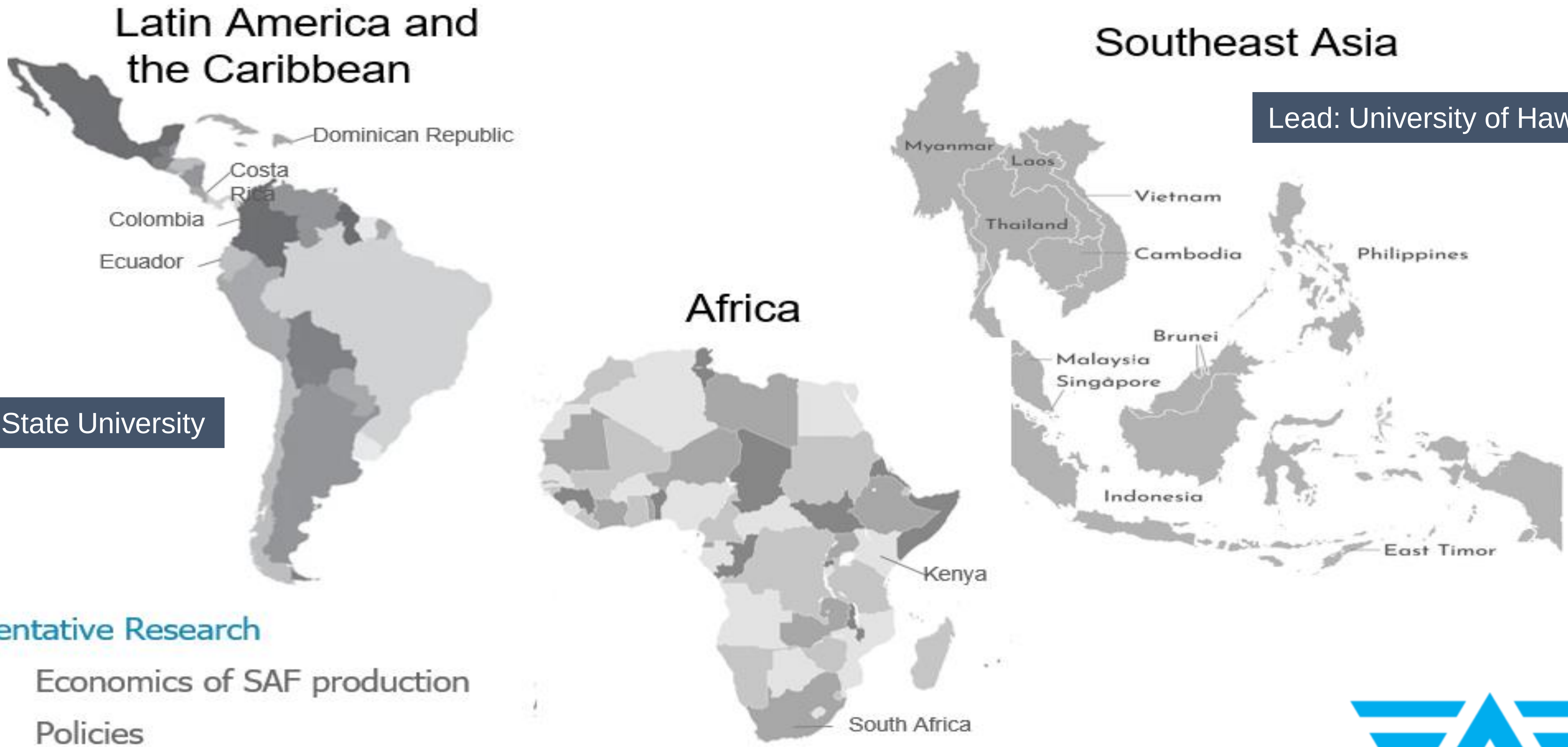
Project Benefits:

- Identify potential for SAF production in the 3 regions that consider new pathways to optimize SAF production.
- The data collected will direct stakeholders to identify desired locations and potential for SAF production.

ASCENT – the Aviation Sustainability Center – is a cooperative aviation research organization co-led by Washington State University and the Massachusetts Institute of Technology. Also known as the Center of Excellence for Alternative Jet Fuels and Environment, ASCENT is funded by the FAA, NASA, the Department of Defense, Transport Canada, and the Environmental Protection Agency. ASCENT works to create science-based solutions for the aviation industry's biggest challenges.

ASCENT AVIATION SUSTAINABILITY CENTER

Geographical scope ASCENT Project 93



Lead: Washington State University

Lead: University of Hawaii

Leads: Massachusetts Institute of Technology / Hasselt University

Tentative Research

- Economics of SAF production
- Policies
- Finance
- Feedstock Challenge

Research approach

Create working groups in each country

Working groups will consist of academia, biomass producers, fuel and aviation industry, government, NGOs.

Design and Analysis of Regional Supply Chains

Students will conduct their Ph.D. studies on the design and assessment of SAF Regional Supply chains on their countries.

Create training modules / courses

Create online courses and training modules to be used by all students.

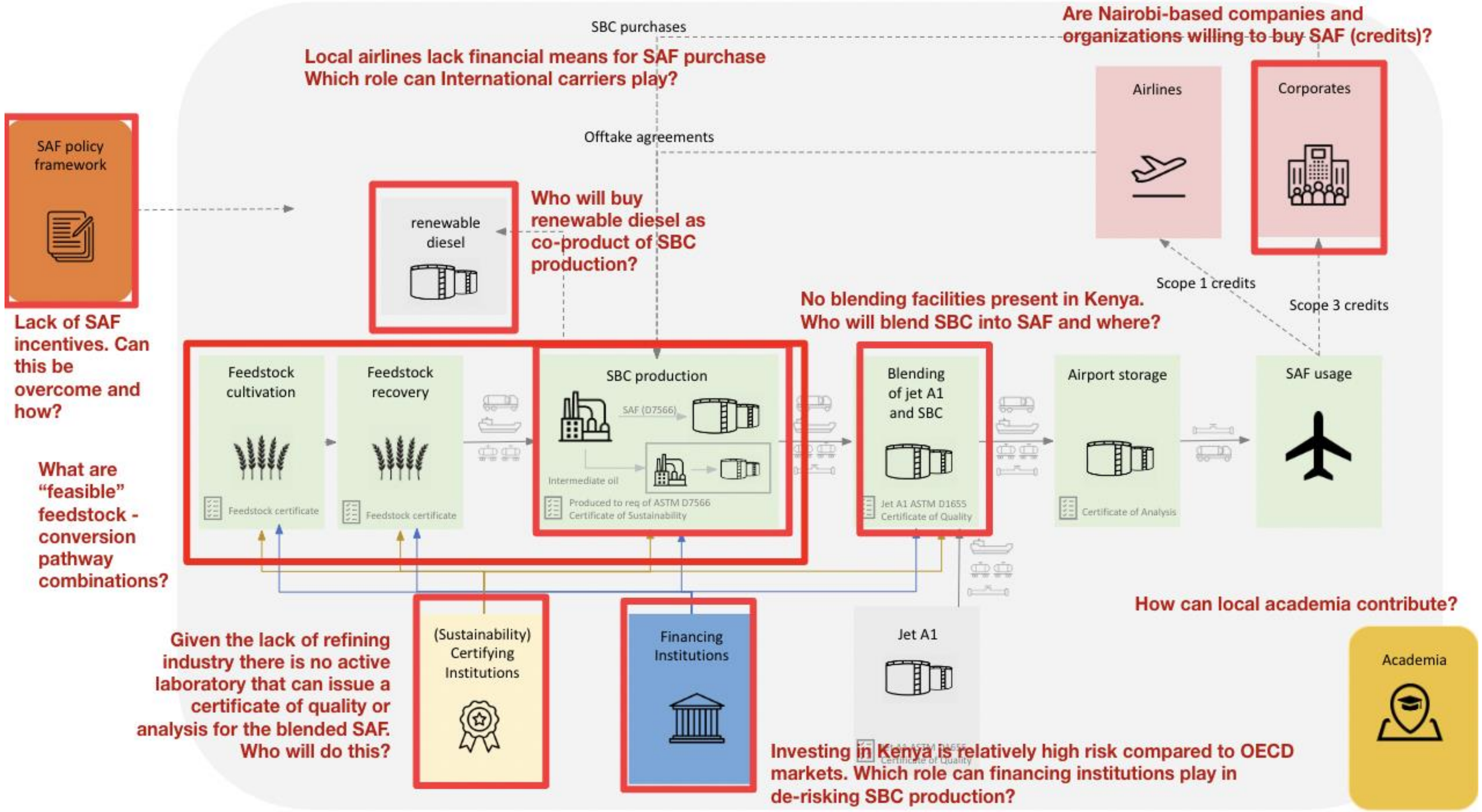
Overview of the PhD and Aims

The research theme focuses on the assessment of clean technologies in the aviation sector

Research Gap: Addressing supply chain challenges in the development of Sustainable Aviation Fuels (SAF) in Africa.

The goal is to advance SAF findings, Promote SAF production and reduce CO_2 emissions from aviation, and create jobs

Key SAF challenges



UHASSELT KNOWLEDGE IN ACTION

ASCENT AVIATION SUSTAINABILITY CENTER

CMK CENTRE FOR ENVIRONMENTAL SCIENCES UHASSELT

Overarching goals of Techno-Economic Analysis

Determine and **prioritize R&D** for the main drivers that will **improve** the **commercial viability** of the technology

Quantify technology performance and financial viability for a **given technology case** (including quantification of the main performance and viability drivers)

Provide quantitative guidance for **policy-makers** on how they can **improve the commercial viability** of the technology

Core focus during **Technology Development**

Core focus during **Technology Deployment**

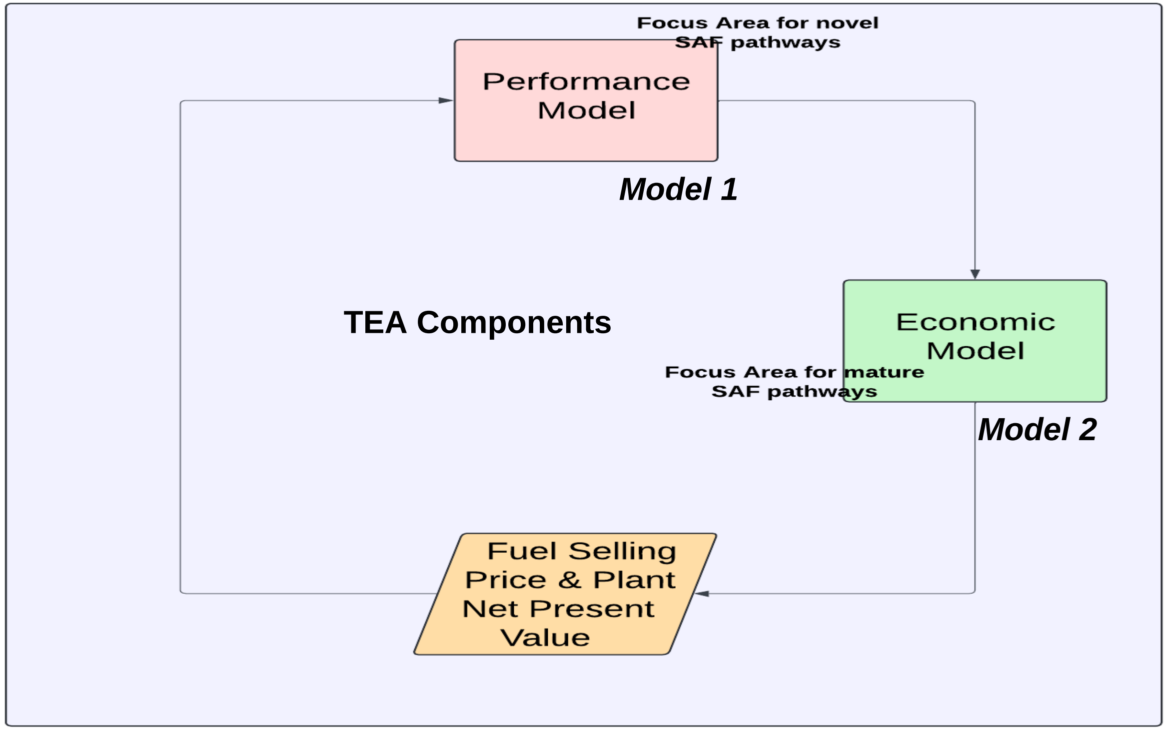
Analysis flow

Output Indicators

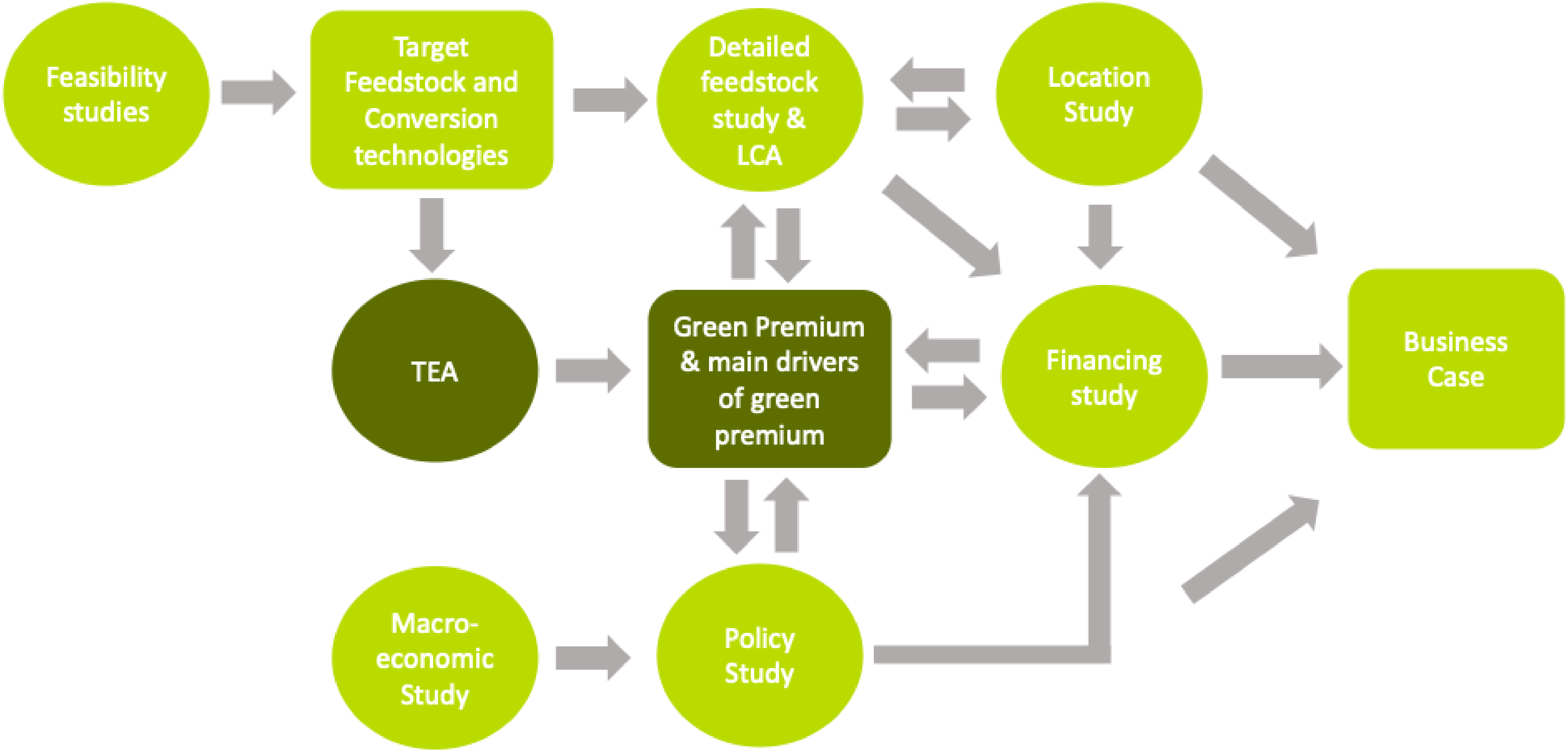
Fuel Selling Price:
Price of SAF needed for SAF plant investor to meet its own rate-of-return expectations.

- Yields **green premium** of SAF

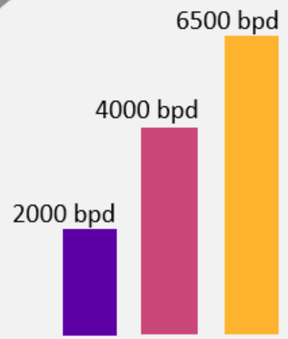
Net present value:
Net result of SAF plant operations when selling all outputs at market prices.



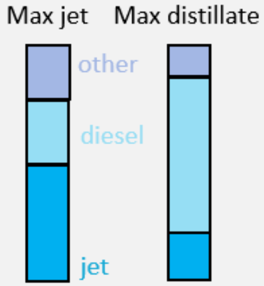
The role of TEA in the Supply Chain Development for SAF



SCOPE



3 factory sizes



2 product slates

Used cooking oil

Waste product, therefore low-cost
Limited sustainability issues
High GHG emissions benefit
Scalability questionable

Castor oil

Higher feedstock costs
Sustainability has to be safeguarded
Lower GHG emission benefit
Scalability high

2 feedstocks

SCOPE Cont.

Item	Value
Facility Size (BPD)	2000/4000/6500
Equity	30%
Loan Interest	15%
Loan Term, years	10
Working Capital (% of FCI)	5%
Type of Depreciation	VDB
Depreciation Period (Years)	10
Construction Period (Years)	3
% Spent in Year -3	8%
% Spent in Year -2	60%
% Spent in Year -1	32%
Discount Rate	35%
Income Tax Rate	30%
Operating Hours per Year	7878
Inflation [%/yr]	7.7%

Equity loan split: 30/70

Cost of debt: 15%

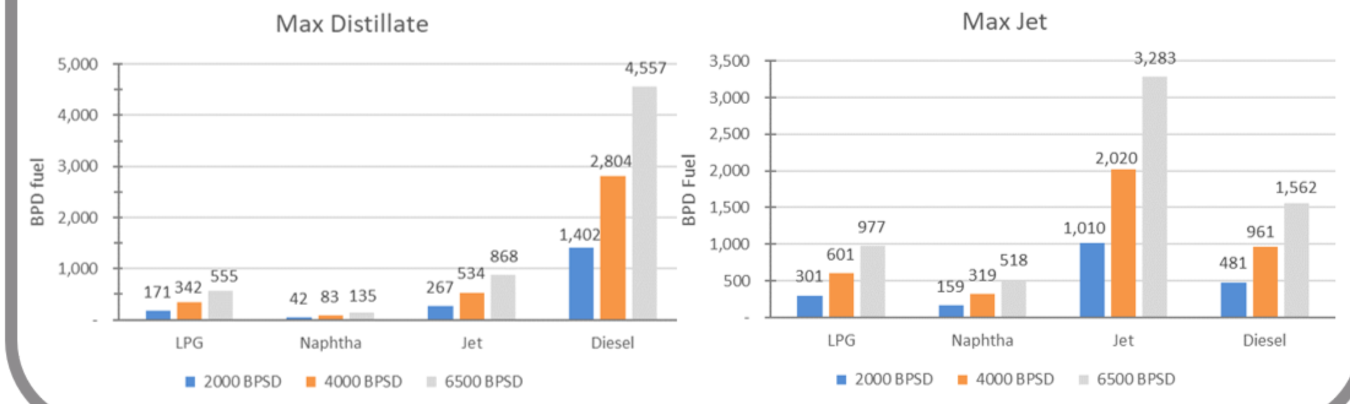
Cost of equity: 35%

SCOPE Cont.

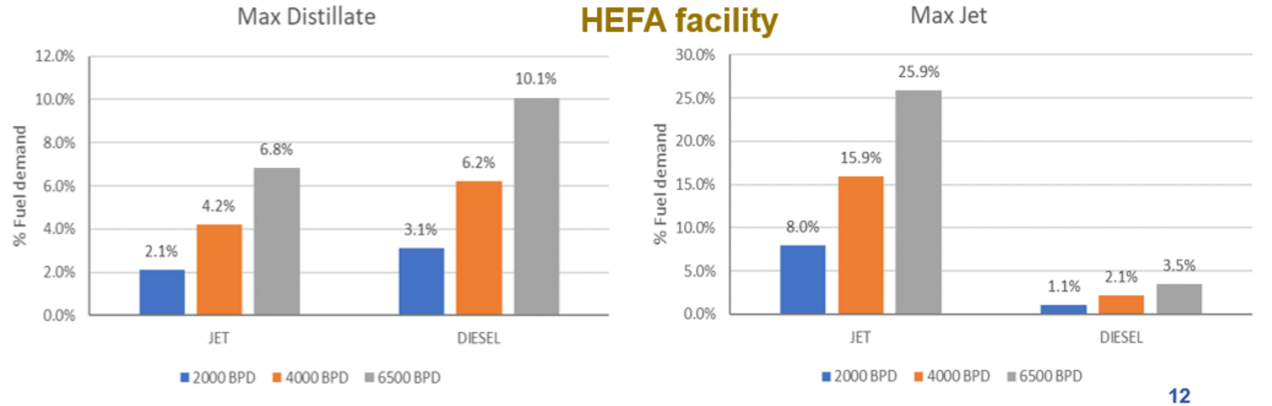
A commercial-scale facility aiming to maximize jet fuel production satisfies between **8%** and **26%** of the total year 2022 jet fuel demand in Kenya.

Feedstock and total Capex considerations imply that the **high-end** of the commercial-scale facilities **sizes** will be **difficult** to **build/operate**.

Fuel products that could be produced from maximum distillate and jet scenarios in barrels per day (BPD)



Share of daily jet and diesel fuel demand that could be met by the HEFA facility



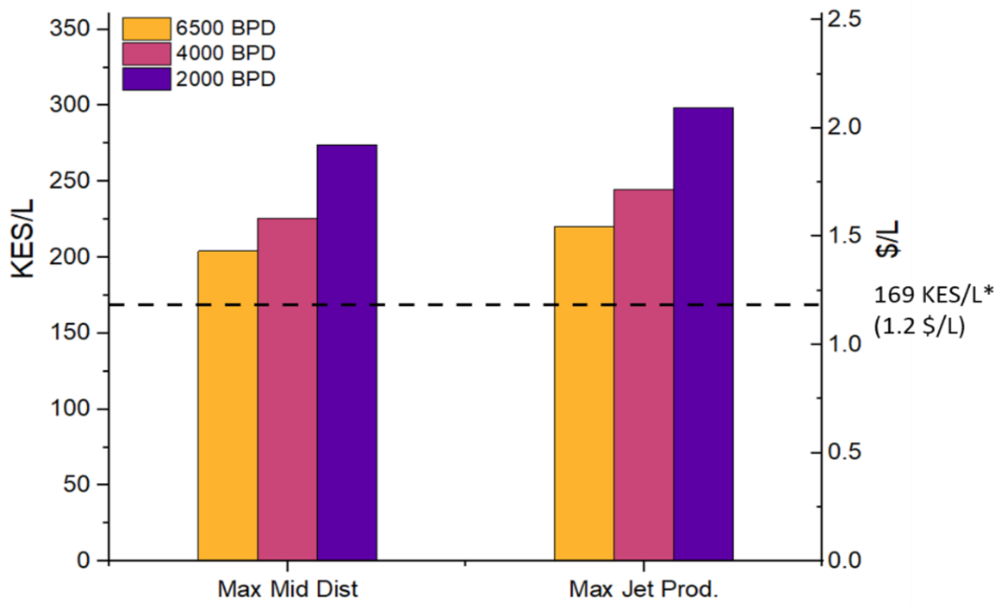
Minimum fuel selling price (MSP)

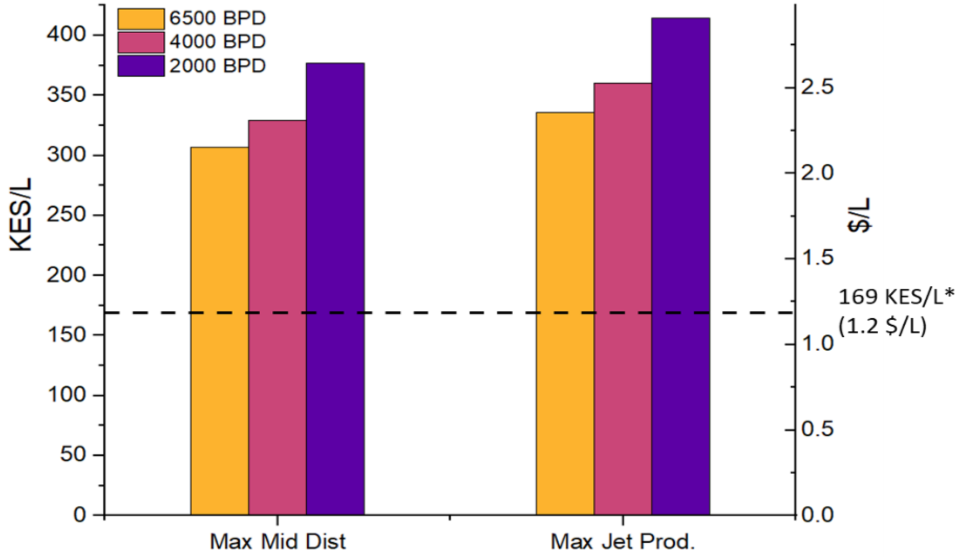
Minimum fuel selling price
The MSP is the price that the SAF needs to be sold for an investor to meeting the expected rate of return. This is the SAF price at which the net present value of the refinery project equals zero.

Under our baseline assumptions, depending on facility size and product slate assumptions, the MSP for **UCO HEFA** ranges from **204 KES/l - 299 KES/l**.

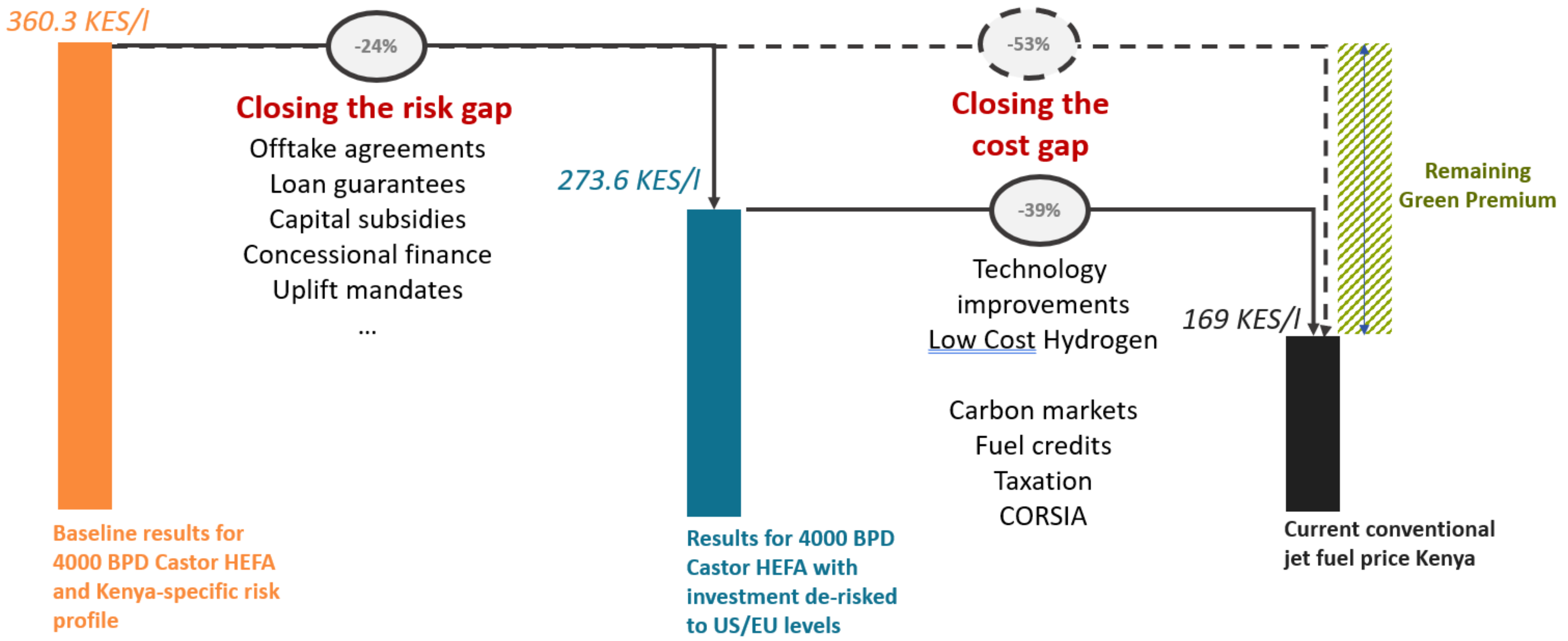
Under our baseline assumptions, depending on facility size and product slate assumptions, the MSP for **Castor HEFA** lies between **308 KES/l - 414 KES/l**.

If the renewable diesel co-produced cannot be sold at a mark-up needed for SAF, the Castor HEFA MSP increases to **>500 KES/l**.





Closing of risk and cost gaps



Context of Green Premium

The **green premium** estimated in the TEA can be covered in many different ways:

- Government incentives
- Tourist contributions
- Ticket price increases
- Corporate Companies

…

Here, we present a calculation in which we **translate the green premium of SAF** into a **cost impact per passenger**, per ticket.

We do this in order to transform the usually used cost impact per litre of SAF into **a metric that passengers and policy-makers can better understand** (impact per passenger per flight).

Context of Green Premium cont..

There is a **green premium** of SAF compared to conventional jet fuel that needs to be **covered** by someone.

The paper presents how the green premium of a 2000 bpd SAF-producing facility with a green premium multiplier of 2.3 compared to conventional jet fuel impacts on **ticket prices** on **international** (or **intercontinental**) routes from **NBO** and **MBA**.

The 2000 bpd facility produces enough SAF for a **10% blend** on all international flights out of NBO and MBA

We account for **CORSIA credits** in our analysis based on forecasts about offset prices under CORSIA.

The analysis is done at the route-level by estimating fuel burn per route using schedule data, seat load factor data and ICAO's fuel burn tool

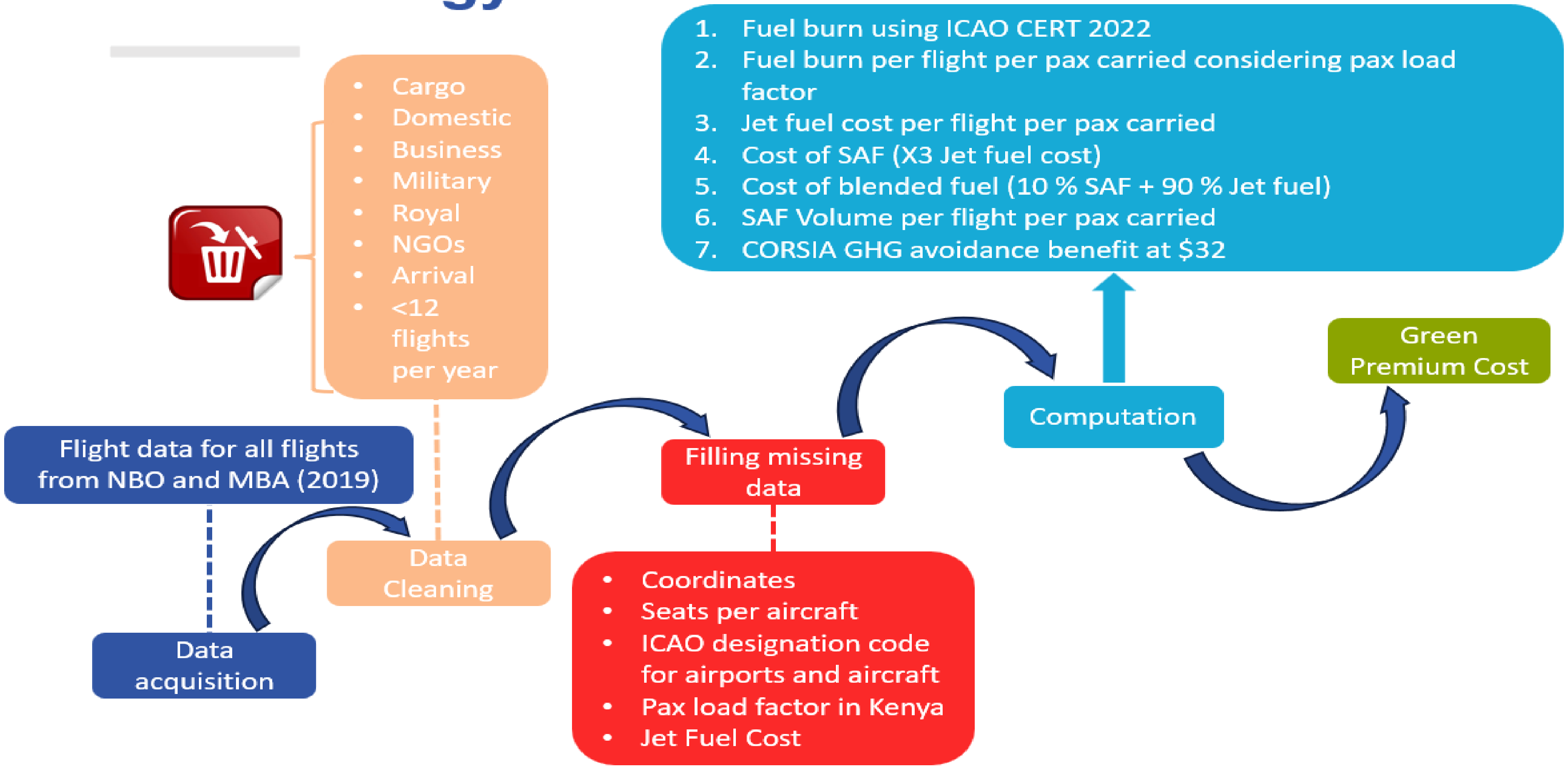
Costs are estimated with and without SAF, and the resulting green premium is allocated per passenger.

Green Premium Research Study cont..

CMK CENTRE FOR ENVIRONMENTAL SCIENCES UHASSELT

Green Premium Cost (allocated to all departing international flights)

Methodology



Green Premium Economic Model cont..

The cost of the green premium was determined using equation

$$GPC_{pax} = \left[90\% \times C_{jet} + 10\% \times C_{SAF} - C_{jet}\right] \times FC_{pax}$$

GPC_{pax} = Green premium cost per passenger ($)
C_{jet} = Cost of jet fuel ($/ton)
C_{SAF} = Cost of SAF, 3 X cost of jet fuel ($/ton)
FC_{pax} = Fuel consumption per passenger (ton)

The CORSIA GHG avoidance benefit cost was calculated using equation

Where,

CAB = CORSIA GHG avoidance benefit ($)

SAF_V = SAF volume required for 10% blend (ton)

FCF = Fuel conversion factor (3.16 kg CO_2/kg fuel)

L_{sf} = Life cycle emissions value for UCO (13.9 gCO_{2e}/MJ)

LC = Jet fuel baseline life cycle emission (89 gCO_{2e}/MJ)

A = CORSIA GHG benefit amount ($32/ton CO_2)

S = Number of seats

LF = Passenger load factor

F = Total number of flights

Where,

$AGPC_{pax}$ = Absolute green premium cost per passenger ($)

Green Premium Economic Model cont..

The CORSIA GHG avoidance benefit cost was calculated using equation

$$CAB = \frac{SAF_v \times FCF \times \frac{L_{sf}}{LC} \times A}{S \times LF \times F}$$

Where,

CAB = CORSIA GHG avoidance benefit ($)

SAF_V = SAF volume required for 10% blend (ton)

FCF = Fuel conversion factor (3.16 kg CO_2/kg fuel)

L_{sf} = Life cycle emissions value for UCO (13.9 gCO_{2e}/MJ)

LC = Jet fuel baseline life cycle emission (89 gCO_{2e}/MJ)

A = CORSIA GHG benefit amount ($32/ton CO_2)

S = Number of seats

LF = Passenger load factor

F = Total number of flights

$$AGPC_{pax} = GPC_{pax} - CAB$$

Where,

$AGPC_{pax}$ = Absolute green premium cost per passenger ($)

Green Premium Research Study Cont..

Green premium examples:
NBO-JFK: 45.83 USD
MBA-FRA: 24.68 USD
NBO-CPT: 13.16 USD

Green Premium Cost (allocated to all departing international flights)

Green Premium Research Study cont..

CMK
CENTRE FOR
ENVIRONMENTAL SCIENCES
UHASSELT

Green Premium Costs for sample routes

Origin	Destination	No. of Flights	Aircraft Type	Fuel burn per flight per Passenger carried (tons)	Cost of jet fuel per flight per pax carried (USD)	Cost of blended fuel per flight per passenger in USD	CORSIA GHG avoidance benefit per passenger per flight USD	Green premium cost allocation per passenger in USD	Green Premium Cost Range
HKJK	OOMS	277	B738	0.09	57.24	68.69	0.56	10.89	$11-$20
HKJK	FACT	28	B738	0.10	63.92	76.70	0.63	12.16	$11-$20
HKJK	FACT	226	B737	0.11	71.49	85.79	0.70	13.60	$11-$20
HKMO	EDDF	35	B763	0.20	129.76	155.72	1.27	24.68	$21-$30
HKMO	EDDF	51	B763	0.20	129.76	155.72	1.27	24.68	$21-$30
HKJK	EDDF	211	A333	0.21	137.41	164.89	1.34	26.14	$21-$30
HKJK	ZGGG	108	A332	0.30	197.65	237.18	1.93	37.60	$31-$40
HKJK	KJFK	221	B788	0.36	240.92	289.11	2.36	45.83	$41-$50

Source: Study results from Hasselt University

Green Premium Research Study Cont..

Green Premium Cost per passenger (only allocated to international flights departing to other continents)

Green premium examples:
NBO-JFK: 82.82 USD
MBA-FRA: 44.61 USD
NBO-CPT: 0.00 USD

Green Premium Research Study cont..

CMK CENTRE FOR ENVIRONMENTAL SCIENCES
UHASSELT

Green Premium Cost per PAX (only allocated to international flights departing to other continents)

Origin	Destination	No. of Flights	Aircraft Type	Fuel burn per flight per Passenger carried (tons)	Cost of jet fuel per flight per pax carried (USD)	Cost of blended fuel per flight per passenger in USD	CORSIA GHG avoidance benefit per passenger per flight USD	Green premium cost allocation per passenger in USD	Green Premium Cost Range
HKJK	OOMS	277	B738	0.09	57.24	68.69	0.56	19.68	$11-$20
HKJK	FACT	28	B738	0.10	63.92	76.70	0.63	0	$0-$10
HKJK	FACT	226	B737	0.11	71.49	85.79	0.70	0	$0-$10
HKMO	EDDF	35	B763	0.20	129.76	155.72	1.27	44.61	$41-$50
HKMO	EDDF	51	B763	0.20	129.76	155.72	1.27	44.61	$41-$50
HKJK	EDDF	211	A333	0.21	137.41	164.89	1.34	47.23	$41-$50
HKJK	ZGGG	108	A332	0.30	197.65	237.18	1.93	67.94	$61-$70
HKJK	KJFK	221	B788	0.36	240.92	289.11	2.36	82.82	$81-$90

Source: Study results from Hasselt University

Conclusions

Using **10 % SAF** on all **departing international flights** from Nairobi and Mombasa, the fuel-related cost of tickets for each passenger increases by approx. 12.0 %. Assuming a 30% share of fuel costs in total costs, this **yields a ticket price increase** of **4 %** if the costs are fully passed through.

Using SAF only on departing international flights from Nairobi and Mombasa **to other continents**, the fuel-related cost of tickets for each passenger increases by approx. 21.5 %. Assuming a 30% share of fuel costs in total costs, this **yields a ticket price increase** of **6 %** if the costs are fully passed through.

Source: Study results from Hasselt University

Thank you for your attention !

francis.mwangi@uhasselt.be