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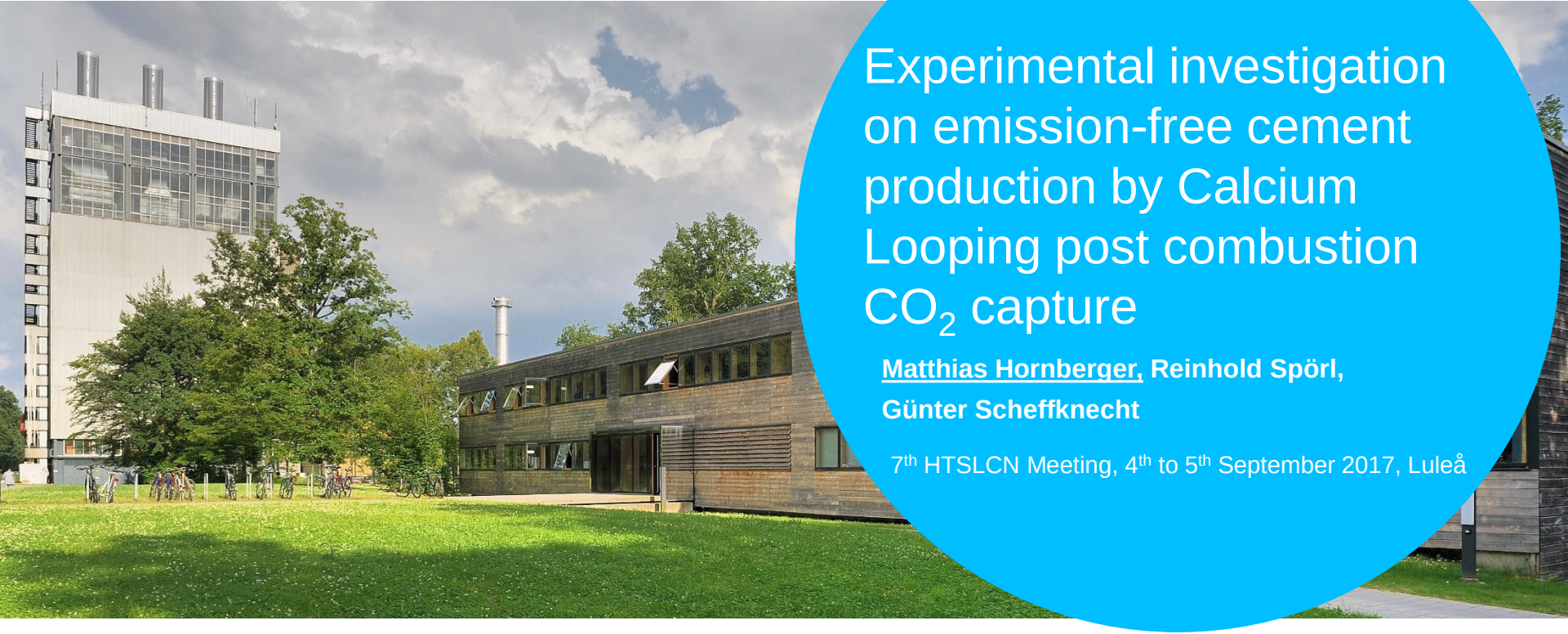

Experimental investigation on emission-free cement production by Calcium Looping post combustion CO_2 capture

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CEMCAP

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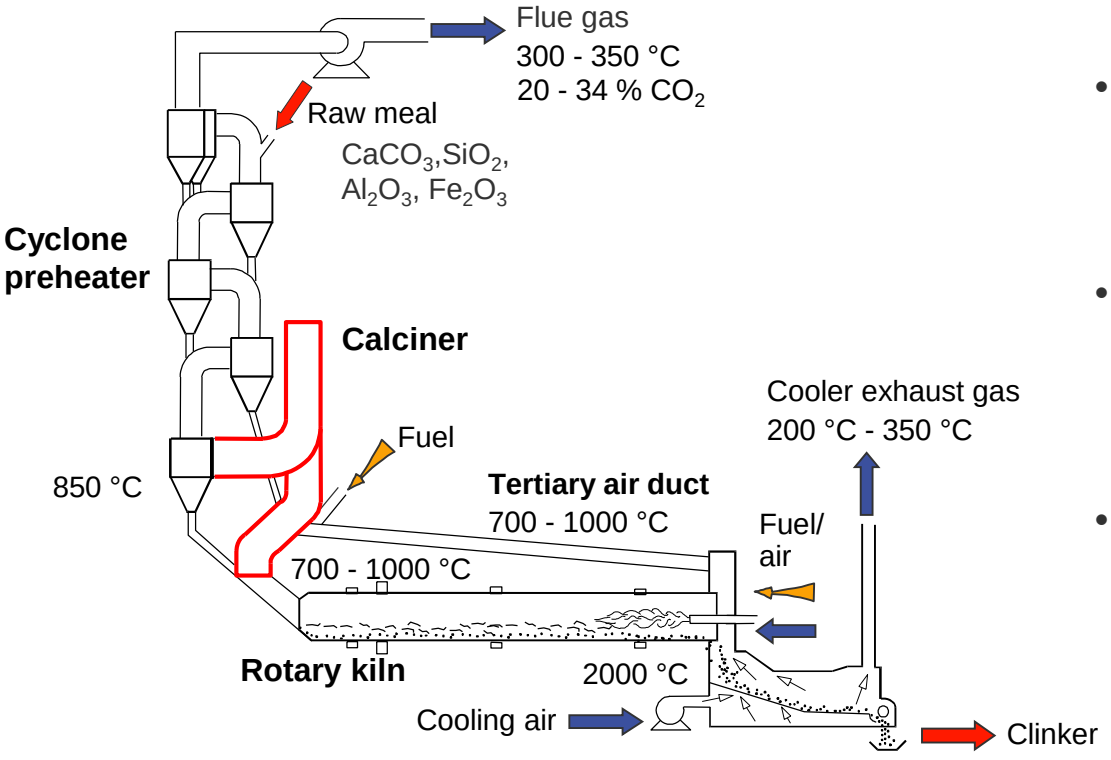
Clinker manufacturing

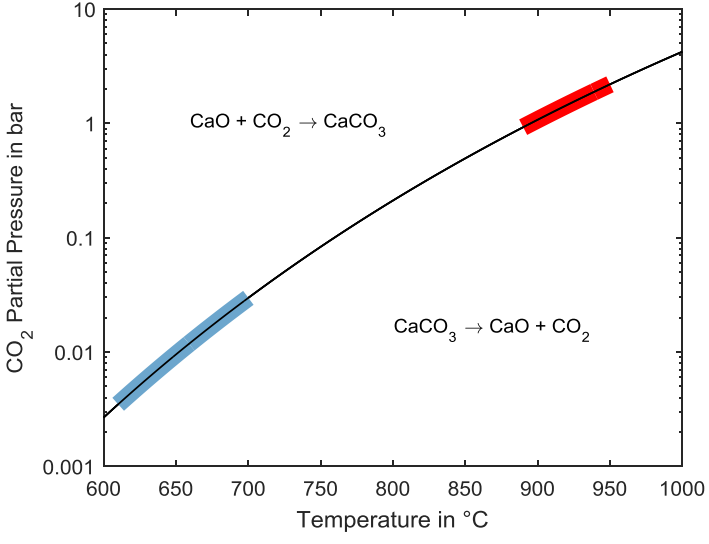


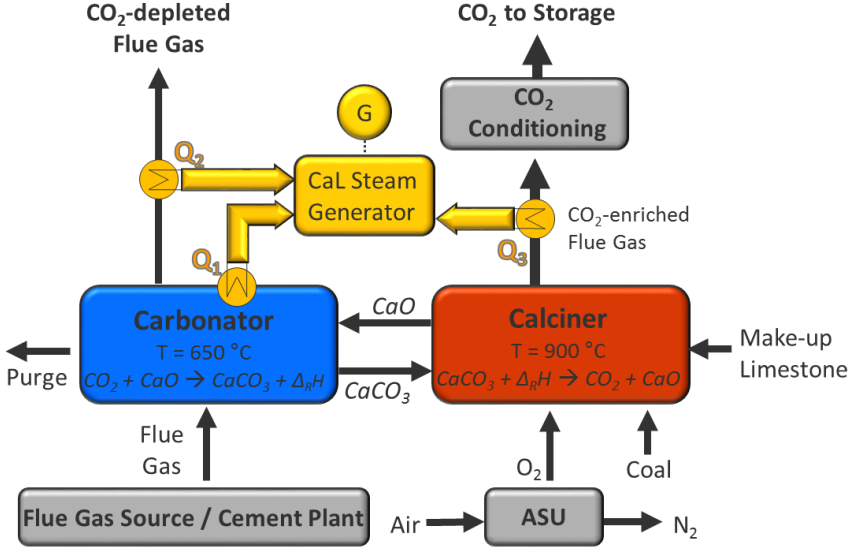
- Cement production constitute ~5 % of global anthropogenic CO_2 emissions
- CO_2 emissions:
  - 60 % by raw materials
  - 40 % by fuel
- Reduction of CO_2 emissions:
  - 56 % CCS
  - 44 % by increase of energy efficiency, alternative fuels, reduction of clinker share

Calcium – Looping

Calcium Looping – General Process Description

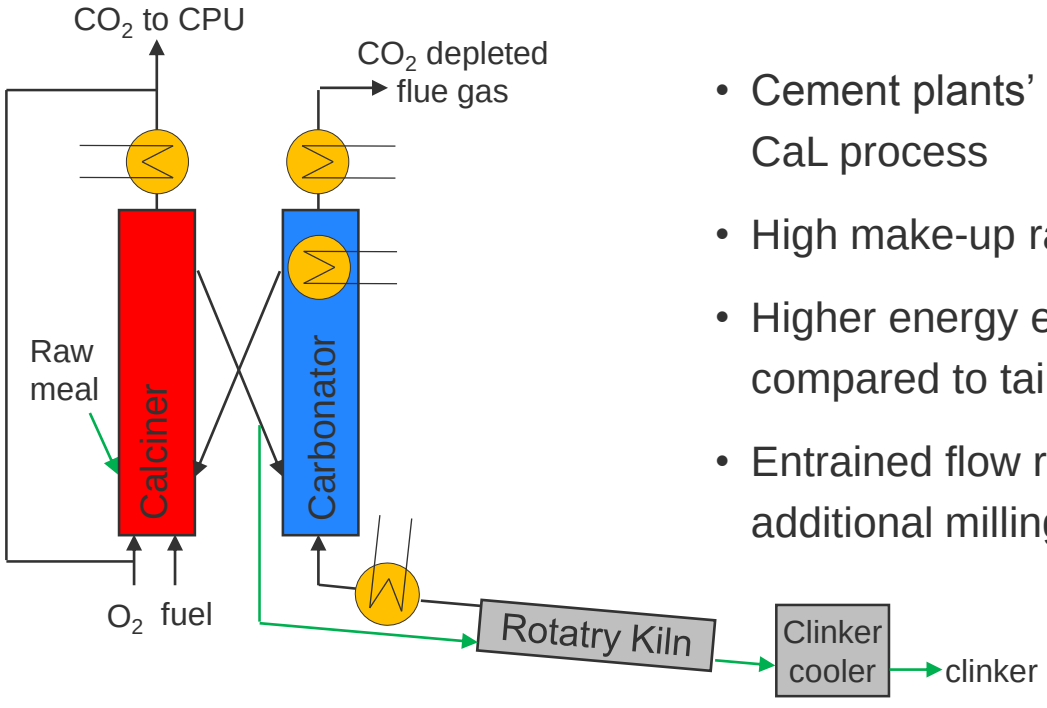
- CO_2 capture by cyclic calcination and carbonation of Calciumcarbonat ($CaCO_3$)
- High energy efficiency due to high temperature level





Calcium Looping – Cement Plant Integration

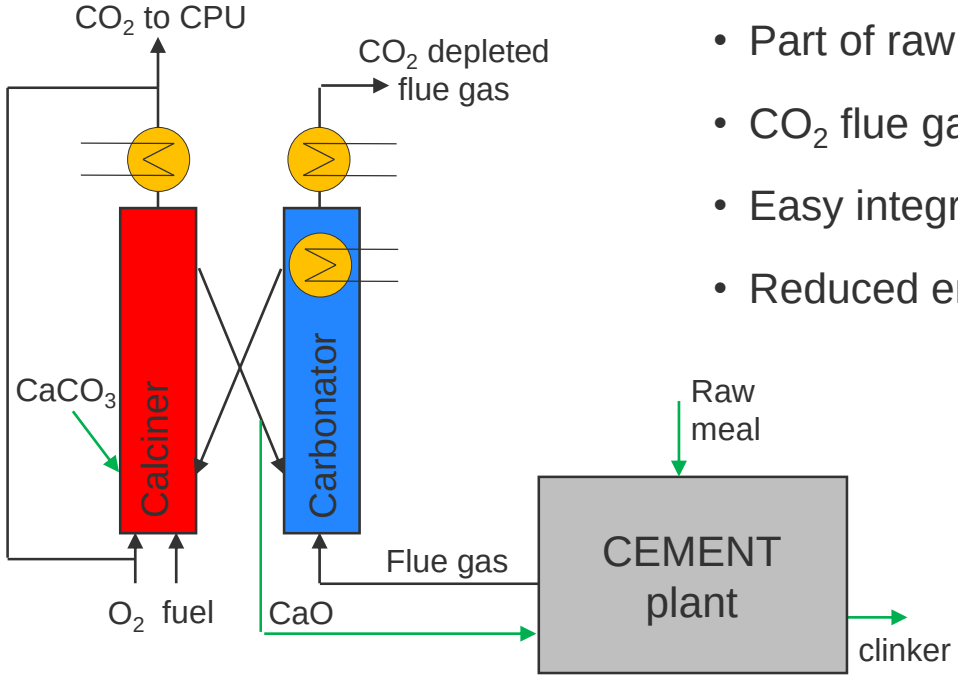
Integrated CaL



- Cement plants' raw meal completely calcined by CaL process
- High make-up ratio realizable
- Higher energy efficiency and higher complexity compared to tail-end
- Entrained flow reactors or CFB reactors with additional milling step if necessary

Calcium Looping – Cement Plant Integration

Tail-end CaL



- Part of raw meal calcined in CaL process
- CO_2 flue gas concentration ~ 20 - 35 %
- Easy integration
- Reduced energy efficiency

Experimental results

Experimental results – Experimental facility

200 – 230 kW_{th} pilot scale facility (3 reactors)

Bubbling bed reactor (1x)

- diameter: 330 mm
- height: 6 m

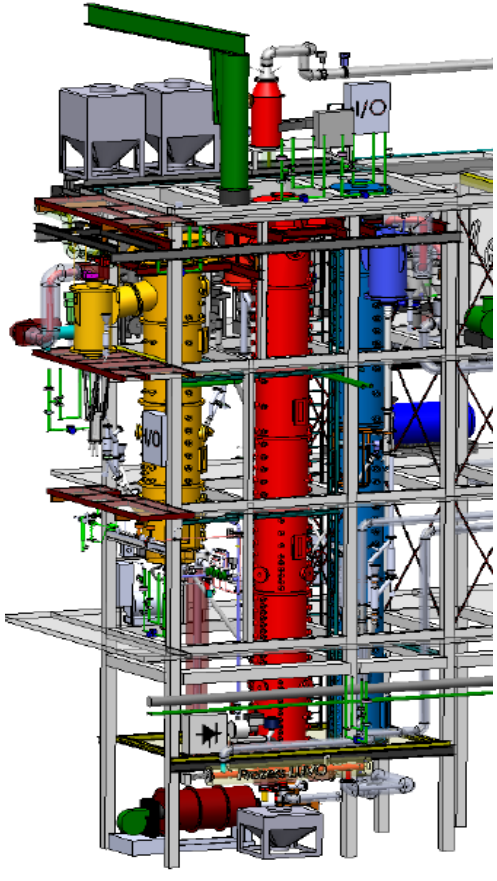
Circulating fluidized bed reactor (2x)

- diameter: 200 mm
- height: 10 m

Possible reactor configuration: CFB-CFB, BFB-CFB

No electrical heating (heated by combustion)

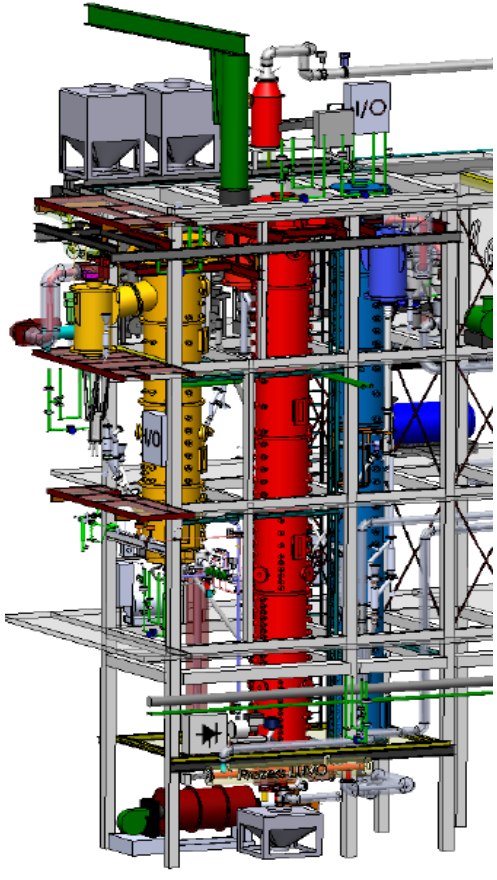
Gas analysis (H_2, CO, CH_4, O_2, CO_2, C_xH_y, SO_2, NO_X)



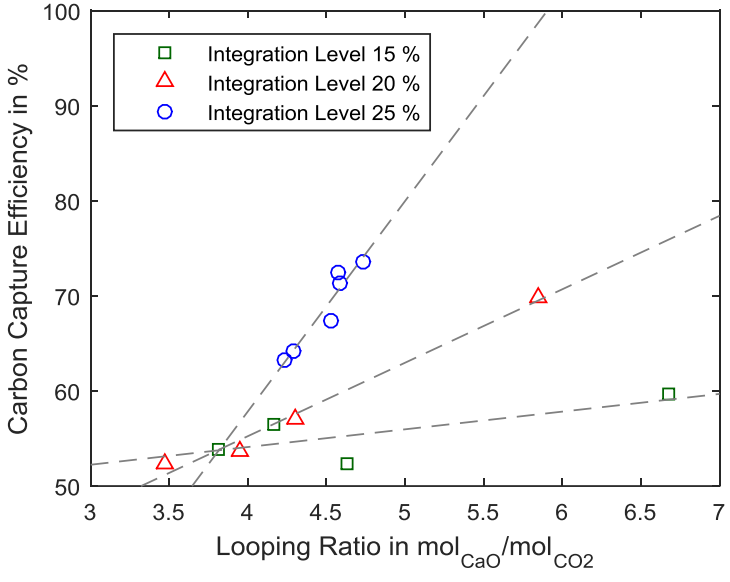
Experimental results – Experimental conditions

	Integrated CaL option	Tail-end CaL option
y_{CO_2}	15 %	20 .. 35 %
$\dot{N}_{CaO,0} / \dot{N}_{CO_2}$	0.6* , 1.0*	0.08 … 0.34
$\dot{N}_{CaO} / \dot{N}_{CO_2}$	8 … 20	0 … 9
$T_{Calciner}$	~ 910 °C	~ 910 °C
$T_{Carbonator}$	~ 650 °C	~ 650 °C

* limited by experimental facility – actual make up rate of ~ 4 mol_{CaO}/mol_{CO_2}



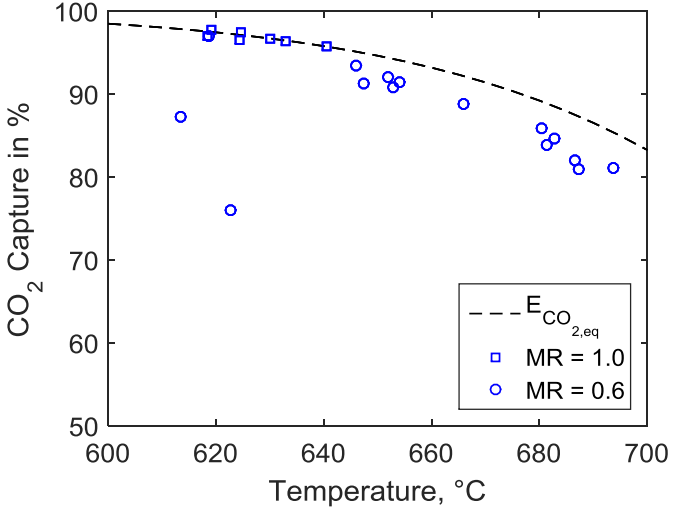
Experimental results – Tail-end CaL Option

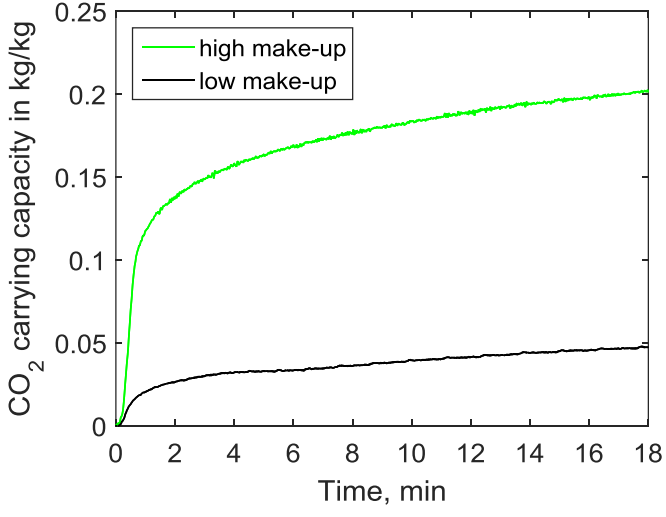


- CO_2 capture increases with increasing make-up ratio
- Strong influence of looping ratio upon CO_2 capture in Tail-end configuration
- Influence of looping ratio increases with increasing make-up rate / integration level

Experimental results – Integrated CaL Option

- CO_2 capture was limited by the equilibrium CO_2 capture
- High CO_2 capture rate above 90 % reached
- High sorbent activity due to high make-up flows





Conclusion

Conclusion and Outlook

CaL CO_2 capture:

- Beneficial Calcium Looping operation conditions due to reutilization of sorbent in cement plant
- High CO_2 capture rate >90 % CO_2 capture achieved over a wide range of parameters
- CO_2 capture adjustable by looping ratio, integration level

Tail-end CaL configuration:

- easy to integrated
- reduced energy efficiency
- minor technical uncertainties

Integrated CaL configuration:

- complex integration
- high energy efficiency
- research upon raw meal sorbent performance and entrained flow carbonator sizing

Thank you for your attention!

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Thank you!

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