Industrial

“Load follows Supply”

Initial Assessment on Benefits & Feasibility

September 2021

Project commissioned by TenneT

GLEAM Consultancy & Management

WaterEnergySolutions

Management Summary

Background

- The Energy Transition will lead to a different composition of the power price compared to today
  - "Baseload will become an expensive product"
  - Avoiding high prices periods can lead up to 30% reduction on total future power bill
- Industrial power users may benefit, provided they can modify the off take profile of their processes
- TenneT wants to start a dialogue with Industry to better understand the potential for such process modification
  - Cornerstone for '2030+ power system adequacy ' assessment

Project done in 3 step approach

1. Setting the Scene: composition power prices in 2030, cost saving potential of "load follows supply"
2. Harvesting Creativity: Assess opportunities & hurdles in sessions with 6 industrials
3. Initial Assessment: impact for TenneT (system adequacy) and Industry (energy bill, contribution to energy transition)

Results

- Industrials expect major increase in power consumption, due to energy transition (replacing natural gas)
- Various opportunities exist to 'time shift' peak demand (by installing utility buffers, continuing using natural gas for limited number of hours etc.). Several hurdles identified
- Limited awareness in industrial sector of flexibility demand and value; high risk of missed opportunities in investment analysis & power purchasing contracts (often aggravated by gap between 'site' and 'centralized purchasing'), resulting in higher costs for the overarching power system

Introduction

- From 2020 to 2030 the impact of renewables (RES) for electricity production will increase

- This will lead to moments of "surplus" and "deficits" in RES supply
  - risks of short periods (several hours -> days) of high electricity prices
  - opportunities to avoid high prices, use low prices and pay below average (and contribute to Energy Transition) by adapting your off take profile.
    - We call this **"load follows supply"**

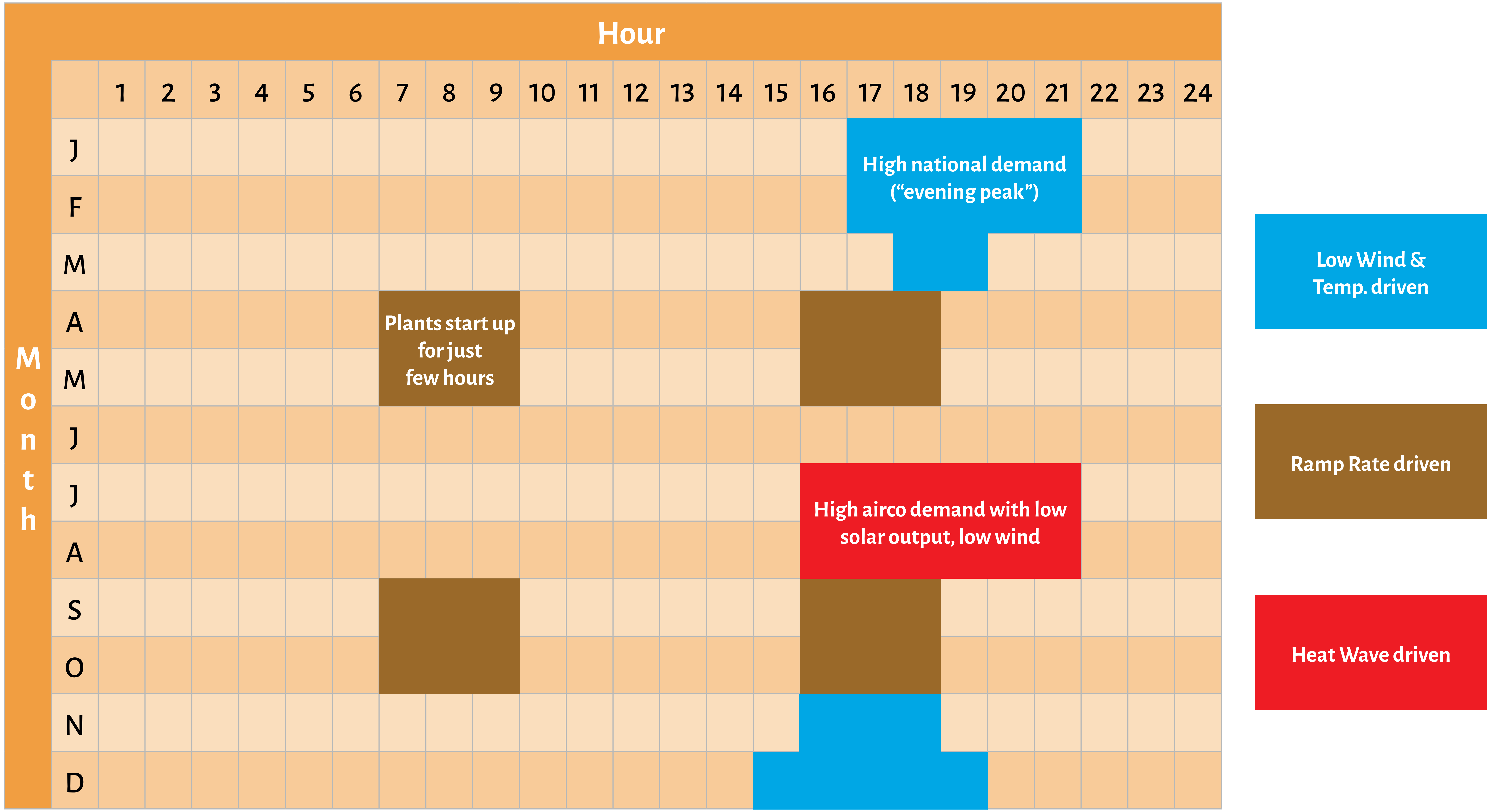
- For Long Term Grid Planning & Adequacy Assessments, TenneT wants to get insights in ability & willingness of industrials to act to above mentioned price signals

- TenneT has hence asked a team of Gleam Consultancy (specialist in energy markets) and WaterEnergySolutions (specialist in industrial processes) to assess the (im)possiblities via "challenge & inspire" sessions with selected industrials

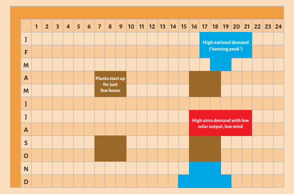
Project conducted in 3 phases

PHASE	RESULTS
Setting the scene	• Determine Price Profile & High Price Risks in '2030' • Summarize trends in 3 contract structures, reflecting the value of flexibility while keeping it explainable & workable for non-expert Industria
Harvesting Creativity	• Conduct "Challenge & Inspire" sessions with 6 industrials. Format: a) explanation of manufacturing process & potential impact energy transition (industrials) b) explanation of future value of power flexibility (consultants) c) discussion on opportunities; how can manufacturing processes be mapped on future power prices d) Initial cost/benefit assessment of opportunities (in euro and carbon footprint), what are (potential) hurdles
Initial Assessment	• Impact on Long Term Grid Planning & Adequacy Assessments • Outline feasibility "Load follows Supply" for industrials including benefits across the value chain • Conclusions & Recommendations

Setting the scene: the high price risks in 2030



The ‘2030 high price risks’ is translated into 3 new Contract Structures suitable for industrials

#	NAME	HOW WOULD IT WORK	EXAMPLE
REF	Business as Usual	Current way of working	Peak/off-peak tariff
1	Yearly Operating Envelop	Every year in October, 200 blocks of 4 consecutive hours are defined as “red hours” for next year	Red hours: 
2	Days Ahead Weather Related Rate	Determined Days Ahead (KNMI prediction). High rate during low wind & low temp and/or daytime low solar/ low wind hours. Low rate during any other time.	Low wind means < 2 ms/s (in The Bilt) Low temp means < -2° Low solar means full cloud cover during 90% of day time.
3	Day Ahead System Stress Relieve Discount	Every morning the “red hours” for next day are communicated (4 con. Hours). Max 200 hr/y	On Nov 17 at 14h00 it is communicated that on Nov 18 from 17h-21h there are “red hours”.

(*) Red hours: Energy (MWh) is factor 7-15 more expensive (but consumption still possible). See appendix for more background

Setting the scene

Adapting industrial process to the '2030' contract structures can lead to 30% power cost reduction

#	NAME	# NORMAL HOURS	# RED/HIGH TARIFF HOURS	TARIFF DURING NORMAL HOURS (€/MWH)	TARIFF DURING RED/ HIGH HOURS (€/MWH)	EFFECT ON ENERGY BILL
REF	Business as Usual	8760 (100%)	0 (0%)	77* (100%)	77 (=100%)	Just accept price increase
1	Yearly Operating Envelop	7960	800 (9.1%)	39 (50%)	462 (600%)	30% discount, if process modified such that neglectable consumption in Red hours (see appendix)
2	Days A. Weather Related Rate	7008	1752 (20%)	39 (50%)	231 (300%)	
3	Day A. System Stress Relieve Discount	8560	200 (2.3%)	54 (70%)	1078 (1400%)	

(*) Industrial commodity price: ~ 77 €/MWh (status summer 2021). Grid costs & Energy Tax are additional 30 €/MWh

Lessons learned – General

1. Industrials are largely unaware of potential of mutual value driven flexibility opportunities, especially related to the increases in power prices towards 2030
   - Topic "Load follows supply" needed to "sink in". As one industrial stated at start of the meeting:

     "Can't TenneT simply buy whatever they need to accommodate the energy transition? Why bother us as industry ?"

   - Various industrials were not yet aware all costs for system stability made by TenneT are charged back to the users of the power system.
   - Once the discussion started it really triggered interest
     - Money talks; impact on business case, potential of hourly price contract versus 2-3 yearly price contracts. How can mid/long term 'pay back' be assured?
     - Awareness that this also may help reducing carbon footprint
     - So as we ended the meeting, same industrial concluded:

     "Aha, it is a win/win to keep those costs low"

Lessons learned – General

Setting the scene

Harvesting Creativity

2. There is never a single driver for change for a production location. There are always multiple drivers that are typically interdependent. E.g., energy saving combined with expansion projects to minimize CAPEX, environmental compliance with technology shifts and energy saving, etc.
   - Value of flexibility is hence 'just' one of the strategic value drivers

3. Sustainable investments with a high degree of (financial) certainty can have longer payback periods than the typical 3 – 5 year. Suggestions to improve certainty:
   - A revised & firm outlook on tax/tariff structure for the next 10 years (as offering flexibility impacts grid costs, energy tax, connection fees etc.)
   - Partnerships with suppliers related to the wholesale value of flexibility (linking demand and supply, multiyear)

Lessons learned – Existing flex

1. Electricity represents a too small part of total energy costs to reduce consumption easily, even for the '30% energy costs' group
   - Most energy intensive processes are most efficient at full load
   - Quality risks may increase by stopping and starting of the process

2. Continuous production sites have little to no flexibility in the core process; either everything is on, or it's off. Both shutdown and start-up times & -costs are significant
   - For those sites, flexibility should hence be found in the generation of secondary utilities

3. Batch production sites can offer more flexibility in the short term (week/month) with production planning due to the existence of process buffers
   - This however leads to relative low electricity flex/savings, as the energy intensive part of production remains continuous

4. Existing CHP installations are expected to remain till End-of-Life, they are already used to react on major changes in energy prices (but various hurdles apply, see slide 12)

Lessons learned – Existing flex

5. The main driver for flex is cost saving; the environmental aspect is currently only a supporting value driver. The benefits are recognized but it is considered too early to adjust electricity consumption patterns
6. Day ahead flexibility demand is currently favorable for most industrials (scenario 3 on slide 6) given the least amount of impacted hours on the production process
7. For maintenance stops (several day shutdown) some costs savings may be achieved by planning outside high price periods (scenario 1 on slide 6)
8. 200 hours of flex is seen as manageable, but 1000 hours will have significant impact
    - Most production sites have sold out their production capacity for the year; changes in E pricing are relevant but not dominant in the decision to produce
9. On 'yet unused' flex potential: One company had several MW back up capacity ("diesel"), tested once per 2-3 months, but not offered on flex market because
    - Logistically complex (bidding, scheduling etc.)
    - Assuring no negative impact on operations (risk of permit issues; effects of switching to bio diesel etc.)

Lessons learned – Hurdles flex

1. Production yield goes down when not operating at full load or when introducing discontinuity
2. Shutting down of equipment is mostly done manually since it is infrequently required. The business case for automation seems strong enough to implement this in the future
3. Safety risks increase with increasing variation in equipment use (process control/changing routine in a regular process)
4. The 30%-requirement for efficiency of E-production in CHPs limits flex combination potential with e-boilers and/or biomass boilers
    - Changing the electricity output of a CHP to offer flex can lower the efficiency in a sub- process (while keeping the overall efficiency unchanged)
    - As certain tax benefits are based on this sub-process, they may be lost if flex is offered. A modification of the relevant tax law will solve this problem
5. Offering flexibility in 4 hour blocks is better doable than 24 hour blocks. One interviewee indicated 1 MW flex potential for 24 hours, but 10 MW for 1 – 4 hours

Lessons learned – future flex

1. Energy transition will lead to the replacement of natural gas, often with electricity, by the interviewed industrials. The increase in electricity intake offers more electricity flex potential, as e-boilers are typical more flexible than industrial CHP

2. Electricity demand will increase significantly due to the combination of e-boilers with CHPs and steam boilers

3. Industrials require a clear and steady outlook in order to consider flexibility in their sustainability/energy transition plans

4. Energy purchasing is sometimes far removed from the production location and is unaware of flex potential. The following quote was in that respect eye opening:

"Our energy procurement is done via Corporate HQ. Every 2-3 years they request historical consumption profiles. A standardized tender process uses those historical figures to create a single price for all MWh consumed. The topic of flexibility has never been explored by either HQ or our supplier. Quite revealing to learn that this misalignment is not cost efficient as future power bills could potentially be reduced by up to 30% !"

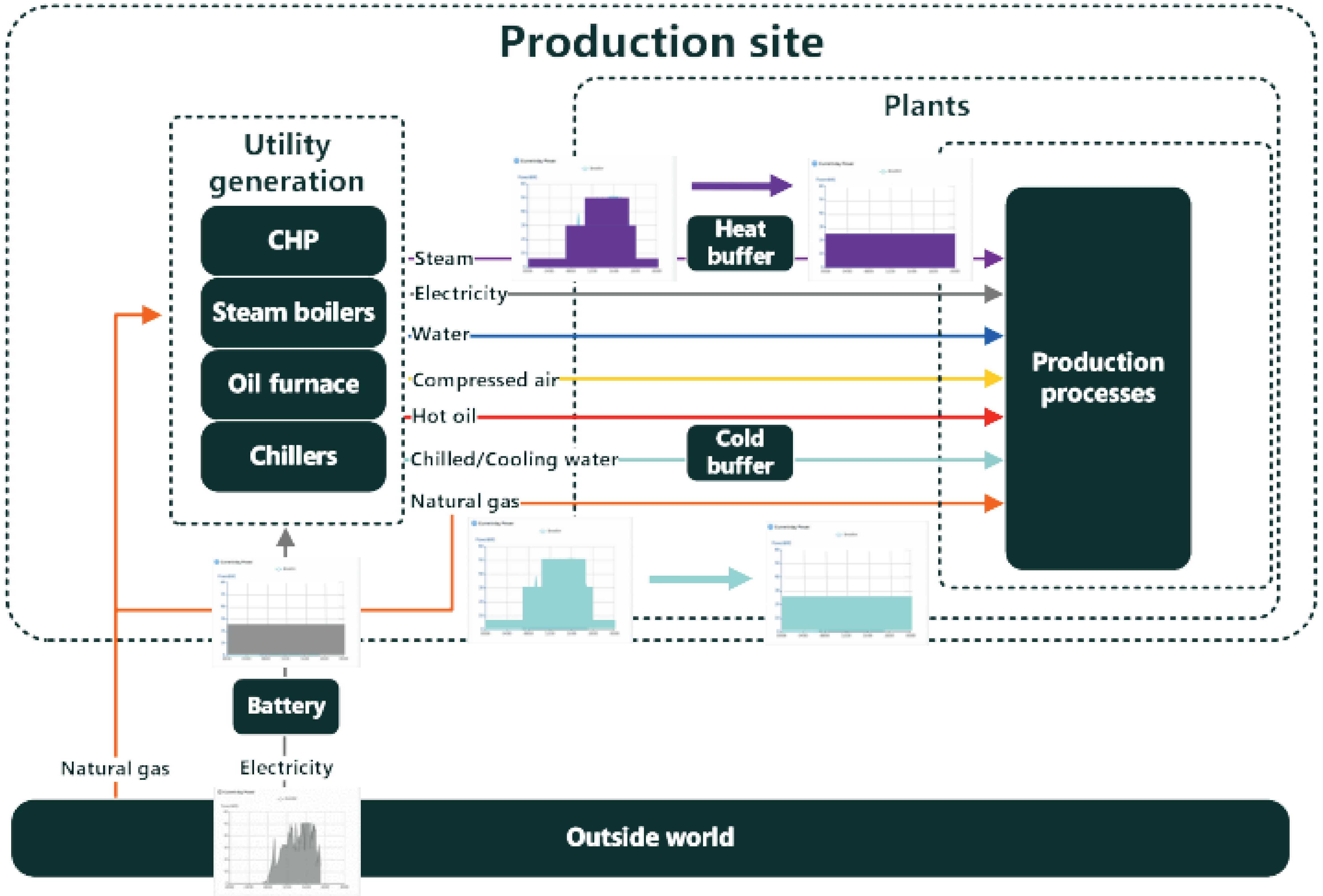
Lessons learned – future flex potential

1. Buffering of energy is required to deliver flex. As a bonus, it also provides better security of supply for primary processes
   - Voltage fluctuations or fluctuations in cooling/heating can lead to factory trips/safety shutdowns

2. Hot and cold storage can be a cost effective alternative to batteries and hydrogen conversion and utilization
   - Industrials will need to invest in equipment to store & buffer heat or cold
   - Industrials can utilize low price moments to fill/charge buffers
   - As storage need is local, no general role for grid companies

3. To make the benefits of flexibility to reduce the carbon footprint more tangible, the concept of an hourly timestamp on Guarantees Of Origin (GoO) can help
   - Currently, 'green' is defined on yearly volume (compensating moments of low wind/solar supply with moments of high wind/solar supply on a yearly basis)
   - For 'real green', off take needs to come from renewable sources on every moment

Enhancing utility generation on site with buffers enables flexibility in power offtake



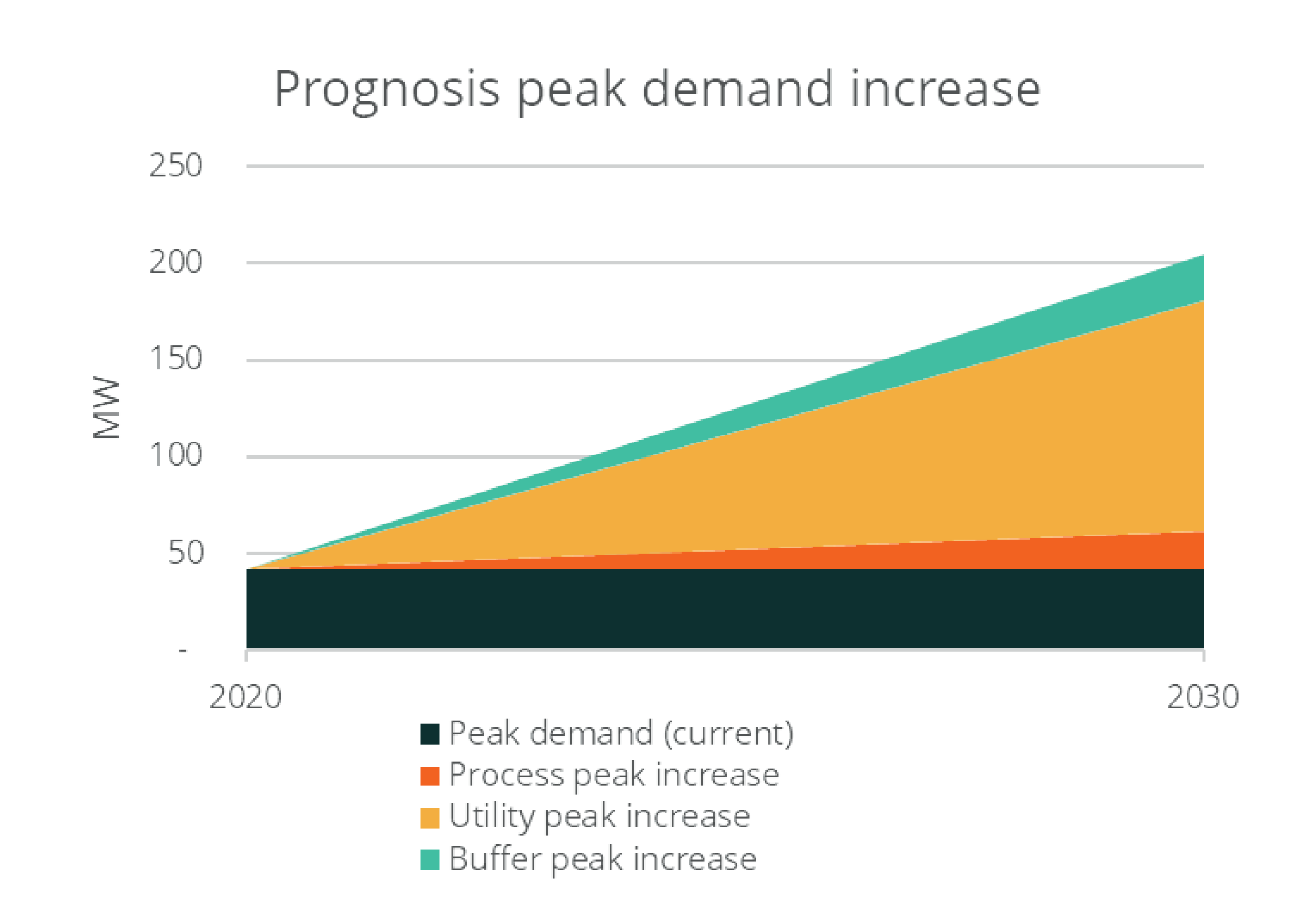
Buffers (heat/cold/battery) are core to achieve flexibility at production sites.

Increasing flexibility at sites hence requires additional investments, but so does increasing flex from the 'outside world'. Hence, the trade off between 'site flex' and 'system flex' should be analyzed to structure the right incentives

Setting the scene
Harvesting Creativity
Initial Assessment

Peak demand will increase factor 4. Flex can limit increase to factor 2 on critical moments

- Power peak demand will increase due to gas replacement
- Buffering enables shifting the moment of 'peak demand' away from 'system stress moments', leading to lower energy system costs (less back up etc.)
- Buffering has horizon of 3-4 hours, to be ~planned 1 day in advance
- Peak demand after buffer use will increase, as the buffers need to be filled again (and primary process continue running normally)
- Table below provides our estimate for '2030', presuming that the industrials will have achieved their CO_2 emission reduction targets



	CURRENT (MW)	2030 (MW)
Peak demand (without flex focus)	43	181
Existing Flex potential (reduction peak)	-10	-10
Additional Flex potential (when installing buffers)	0	- 82
Reduced demand while using flex potential)	33 (not yet used)	89
Peak demand during buffering ("make up capacity")	43	200

Conclusions (1/2)

- Energy transition leads to significantly higher industrial electricity consumption and hence to a much higher peak demand
  - Significant system costs involved, as covering 'peak demand' is expensive
- Industrial sites offer potential to reduce own costs and system costs for covering their own demand during peak prices / scarcity periods, but investments in buffers & automation are required
- Focus for flexibility harvesting on the so called 'secondary utilities' on site (supply of heat/steam/cold to the core manufacturing process)
- Sweet spot of industrial flex seems 3 - 4 hours per day (provided buffering available). The flex contract #3 (slide 6) seems most attractive

Conclusions (2/2)

Setting the scene

Harvesting Creativity

Initial Assessment

- The business case for flex investments is not obvious, mainly due to low awareness of electricity price drivers but also due to regulatory/grid tariff framework
- **Low awareness** of future value of flexibility and benefits for carbon footprint (within the wider industrial organization, but also with suppliers)
- A **“Window of Opportunity”** is currently present, as many industrials are currently assessing their production processes
- ‘Load follows supply’ contracts not common in market yet; partnership opportunity for energy suppliers who invest in subsidy free renewables

Recommendations

- Communicate 'value of flexibility', as that leads to
  - Lower energy bill for industrials (compared to Business as Usual)
  - Lower system costs for society
  - Lower carbon footprint for national energy supply
- Use current 'window of opportunity' (coming 2 years)
  - Industry: consider 'flexibility potential' while considering Energy Transition related investments
  - TenneT: assess potential role of industrial flex in the 'merit order' for assuring system adequacy
  - TenneT (and related stakeholders): consider options to stimulate the business case for flex with industrials
  - Suppliers: work with Industry to provide 'load follow supply' framework contracts/partnerships

Thanks for your attention !

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Appendix

Background on the 3 newly designed contract structures for ‘2030’ and on batch/continuous production

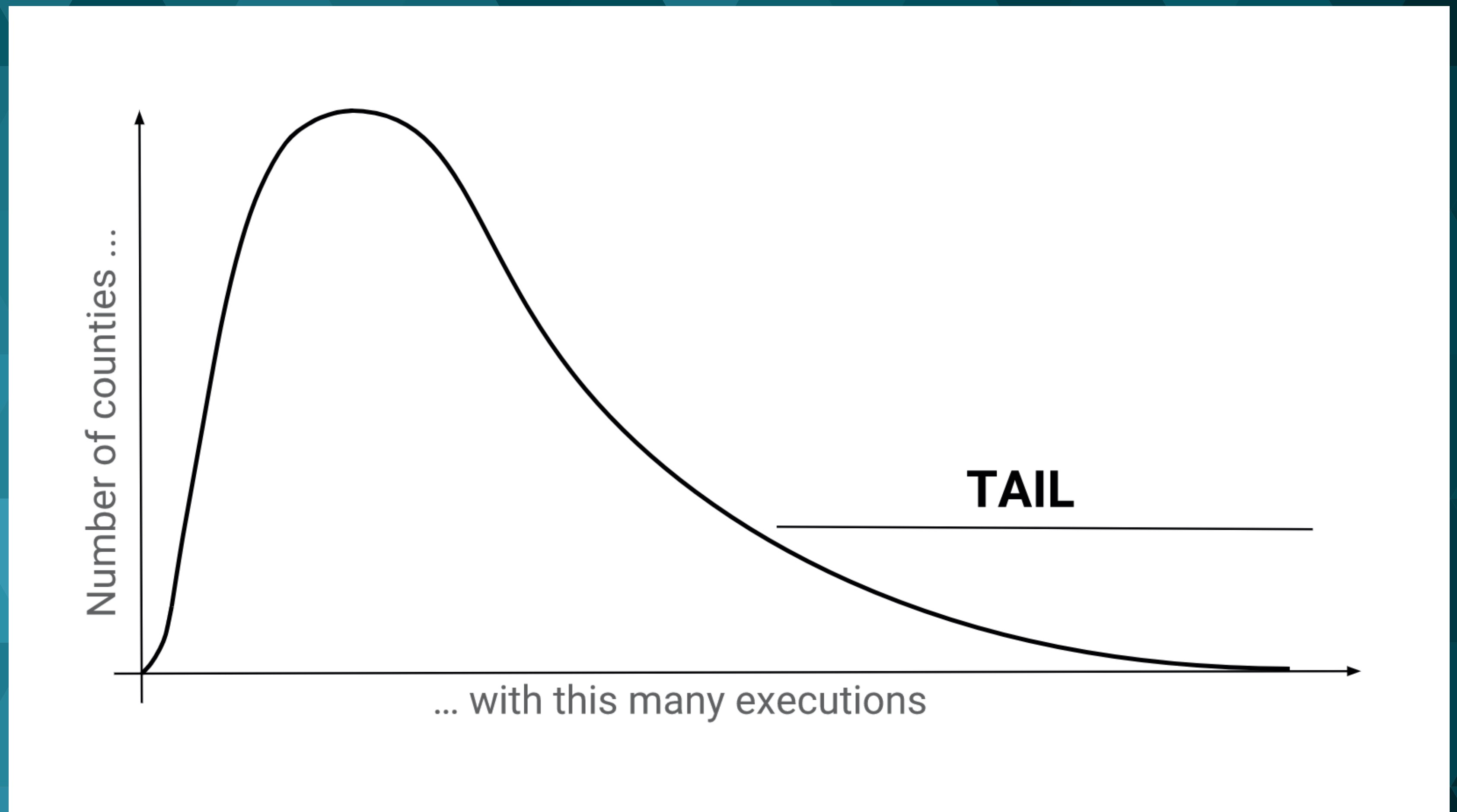
Step 1: identify very high price periods

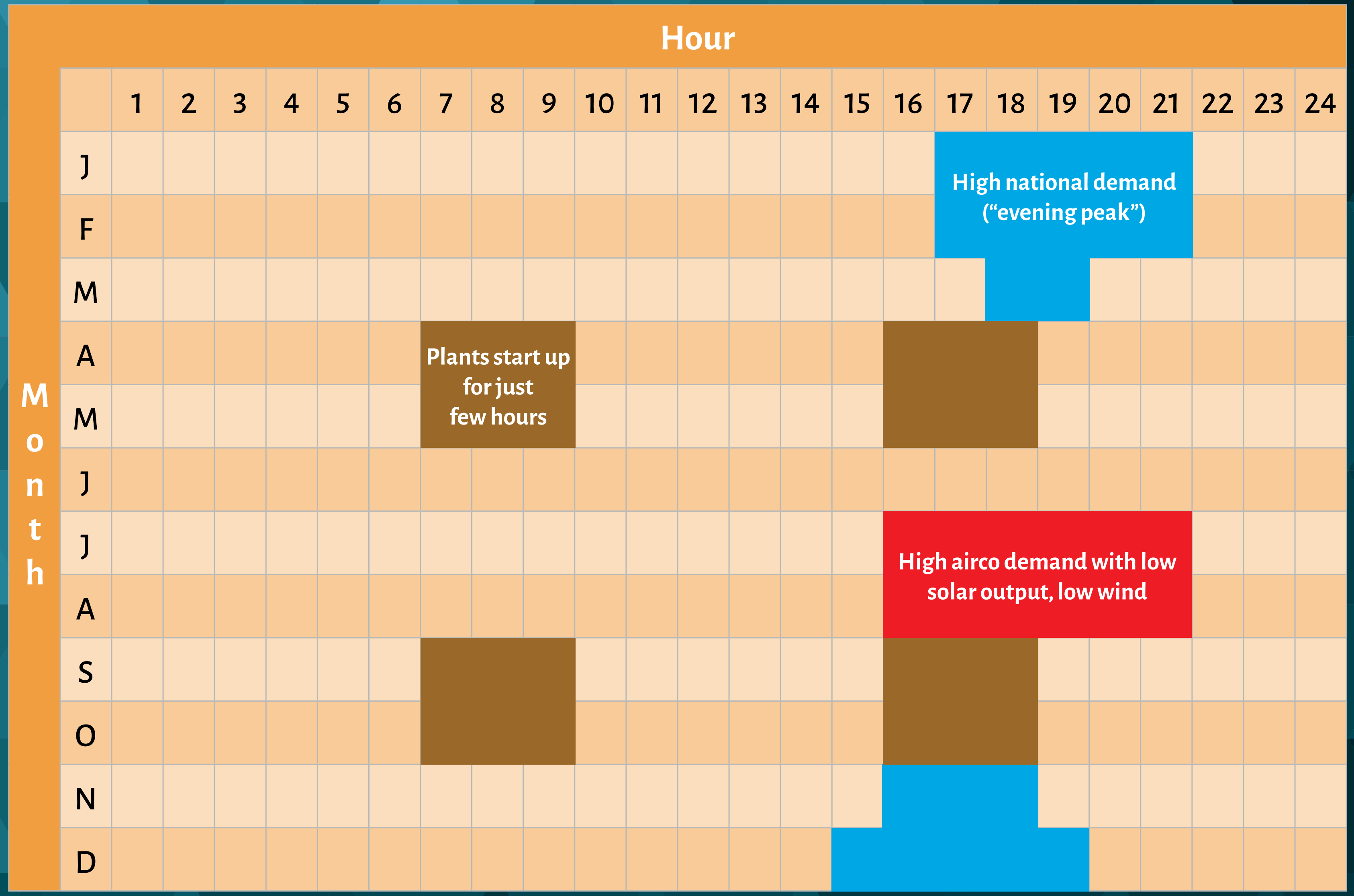
- For most industrials, benefitting from the ‘renewables driven market’ is about avoiding the ‘tail’ of most expensive hours, not about taking more in cheap hours

  - Average baseload in 2030 will be in the 60-100 €/MWh range
    - Price baseload forward market 2022-2025: 60 € /MWh

  - Hourly prices will not be very low (so not < -10 €/MWh), as non-subsidized renewables switch off at negative prices

  - Hourly prices will be very high (> 1000 €/MWh) to incentivize load management and reflecting scarcity premium





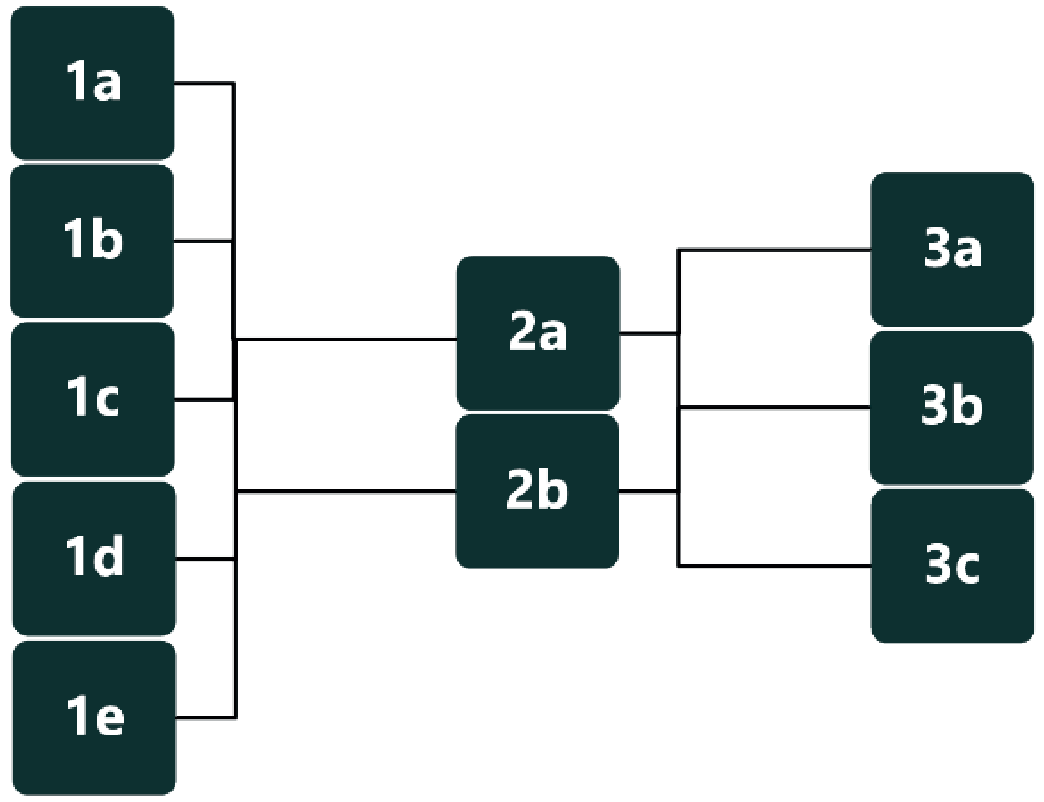
Step 2: Translate ‘2030 price risk’ into Energy Transition driven Contract Structures for Industrials

- Many industrials (*) have a full service contract
  - Fixed price for 1-3 years ahead, split over a peak and off-peak rate
  - Price based on historical consumption profile and forward baseload price
  - Currently, a change in consumption profile (“load shifting) leads to max. 5% discount on the energy bill
    - especially when looking at total energy bill incl. grid costs and energy taxes
- In “2030”, the consumption profile will significantly impact the total energy bill, due to the renewables driven price profile. To illustrate this, we drafted several ‘2030’ contract structures based on 3 criteria
  1. Workable for industrials
  2. Noticeable financial reward; structured such that 30% discount can be achieved in all 3 variants. This 30% is an expert assumption based on extrapolation of recent price trends
  3. Robust: if your profile is not modified, you pay the original bill

(*) apart from the so-called base metals & base chemicals industry

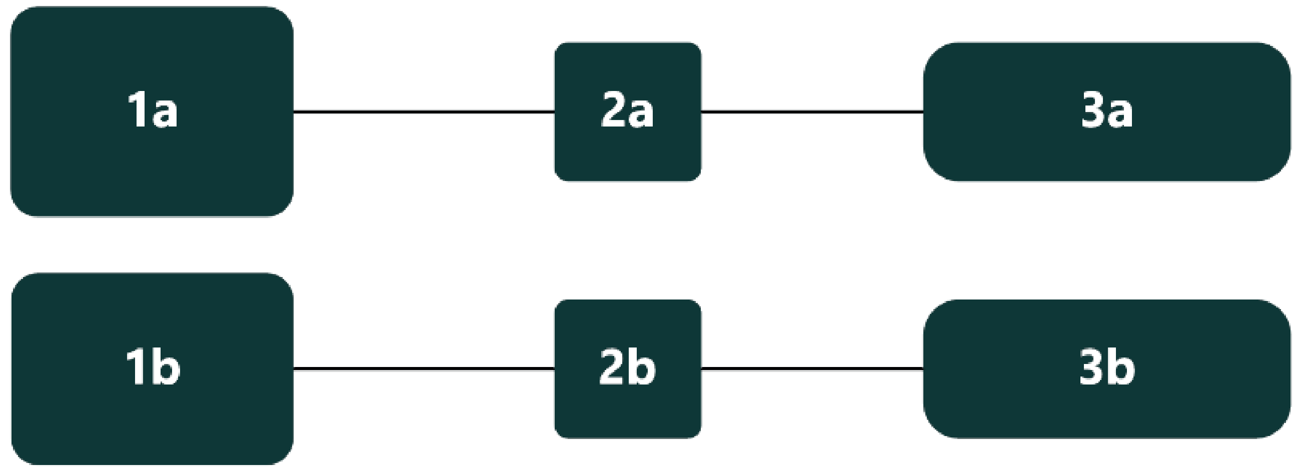
Batch versus continuous production

Typical batch



- Multiple copies of same equipment
- Multiple production routes possible
- Large variety in final products, perishable raw materials, and/or tightly controlled chemical reactions
- Lots of starts/stops and clean-up in between changeover

Typical continuous



- Large equipment dedicated to one product type
- Can be seen as one connected chain
- Low variety in end products
- Production stops are minimized, often everything is on or off

With gratitude to the interviewed companies