

innovation in chemical industry

game changer



FLOWNETICS

CHEMISTRY IN MOTION

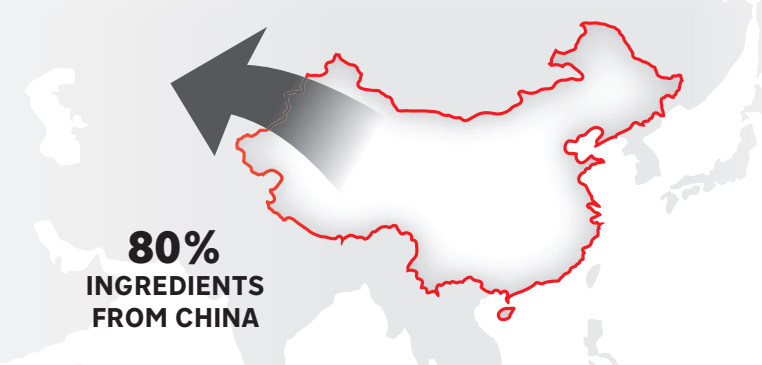
market

Unlock your potential of pharma production
with Flow Manufacturing by FLOWNETICS

Status quo and the future of the pharmaceutical industry

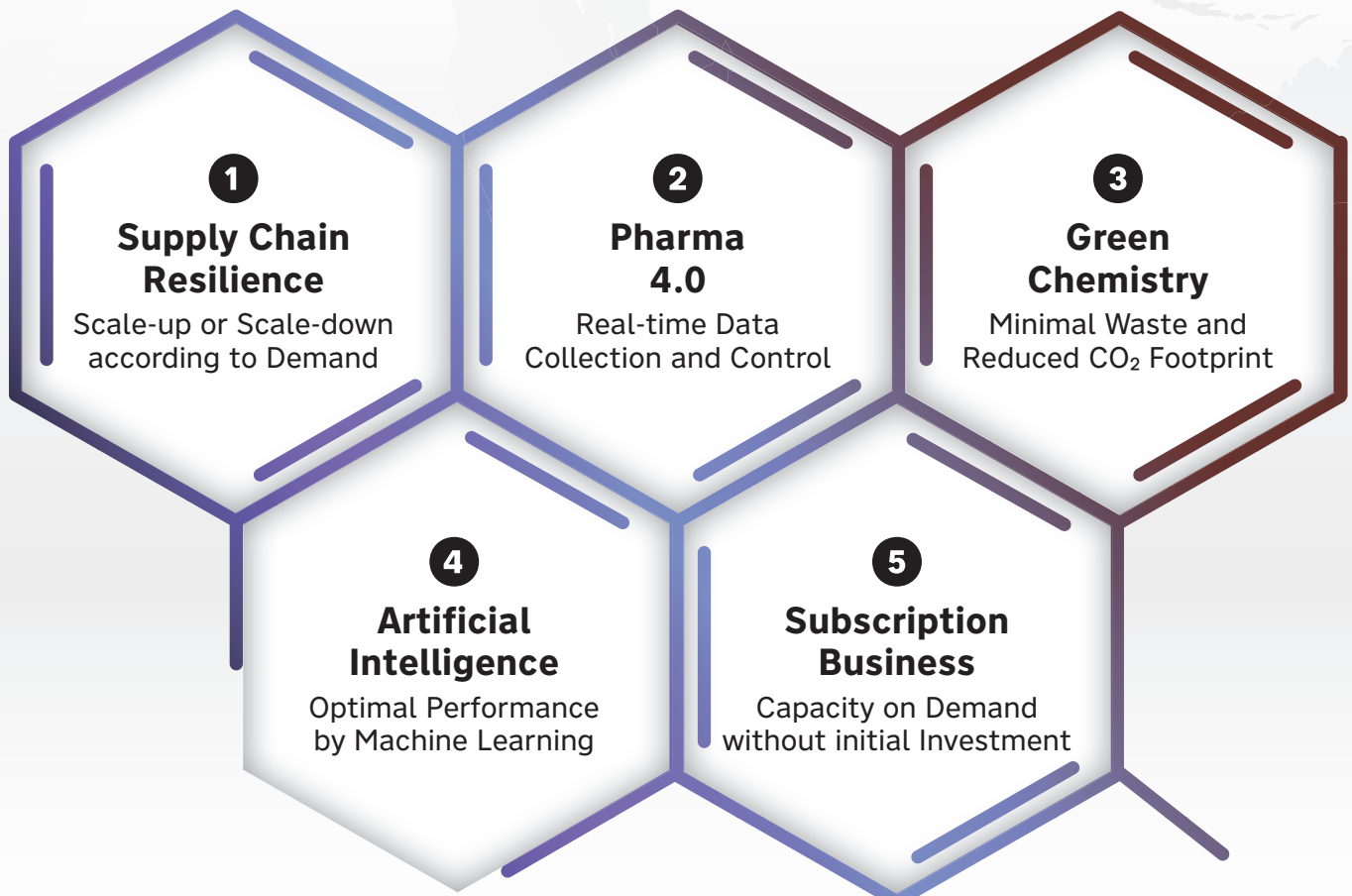
The global pharmaceutical market has experienced significant growth in recent years. According to Statista, the total global pharmaceutical market is estimated to be worth around **USD 1.6 trillion in 2023**. This corresponds to an increase of over USD 100 billion compared to 2022. Regardless of the key economic data, the industry faces enormous challenges, some of which are literally home-made.

Build your own resilient supply chain!



80%
INGREDIENTS
FROM CHINA

5 Megatrends in Pharma



The Power of Habit

This is particularly true with regard to the **batch production (99% usage)**, which dominates the process chain for the production of raw materials and active pharmaceutical ingredients (APIs). In view of the limitations and restrictions of the process and the visions of green chemistry, this is an almost **unacceptable dominance**. Once again, this seems to confirm that hardly anything can be changed more slowly than old habits - especially when the market is characterized by high political and regulatory requirements, as in the case of pharmaceuticals.

A Time of Change

For around 15 years, however, there has been increasing movement in the encrusted structures. The COVID-19 pandemic in particular highlighted the weaknesses of a centralised supply chain and paved the way for a critical examination of the status quo. In addition, calls for more sustainable chemical production became ever louder. **China's dominance with 80% market share** in the area of raw materials and APIs is also causing headaches in many places.

Out of the Dead End

The conclusion is clear: The path of the **batch past with a 99% share** will lead to a dead end. It became equally clear that batch production cannot really solve any of the criticised problems due to its inherent limitations and restrictions. But at least there was and is a perspective called "Flow Chemistry".

Bright Prospects

Flow chemistry has already proven to be effective, efficient and more sustainable in the laboratory. In addition, Flow Manufacturing is considered safe in risk areas, the entire process can be monitored with appropriate sensors, can be displayed transparently via the data and is therefore also suitable for AI/ML analyses. The modularity of the Flow Reactors would also make it possible to design the production facilities as smaller, more flexible units and thus position production close to the end consumer. It was obviously only a matter of time before the industrial revolution arrived in the pharmaceutical industry. And this is happening right now!

FLOWNETICS Engineering, a high-tech start-up from India, is currently setting the course for change and at the same time opening a window of fascinating opportunities for **Pharma 4.0 and green chemistry**. The company impresses with a consistent end-to-end offering from a single source and on a subscription basis - from process development and system engineering through to scale.

"Democratize Chemical Manufacturing"

The origins of industrial progress are basically always motivated by elementary questions about known problems of companies or even entire industries. At FLOWNETICS, we have asked ourselves two closely interwoven questions:

- 1. How can we enable pharmaceutical companies to free themselves from the supply chain risks of largely centralized purchases of raw materials and APIs in China?*
- 2. How can we enable pharmaceutical companies to overcome the restrictions and limitations of the batch process?*

*The answer to both questions is: with a subscription to **End-to-End Flow Manufacturing** from FLOWNETICS. Our holistic platform offering a single source heralds a new era of chemical synthesis. **Leave the batch era behind.** Eliminate the pain points of strategic constraints, inefficiencies and incalculable risks.*

Enter the digital age of maximum control, flexibility, scalability and sustainability and produce in a decentralized and scalable way where your customers and consumers are.

*"Problems can never be solved
with the same way of thinking
that created them"*

– Albert Einstein

The tipping point for change has been reached. Flow Manufacturing has now proven its industrial maturity and even regulators support Flow Manufacturing as a process with a future.

From Pain to Gain, waiting is no longer an option!



SRIVIDHAR BALARAM

FOUNDER &
MANAGING DIRECTOR

director@flownetics-engg.com

solving your pain points

Utilise the innovative potential of Flow Manufacturing and get the **best “medicine” for your pain points.**



FLOWNETICS Engineering is positioning itself at the forefront of transformation in the pharmaceutical industry with its pioneering **end-to-end Flow Manufacturing Platform**. The aim is to democratise production and pave

“Flow Technology enhances product quality, lowers costs, reduces waste, shrinks inventory and boosts flexibility”
– US FDA

a reliable path for independent and decentralised supply chains in the field of fine chemical raw materials and active pharmaceutical ingredients (APIs). In addition to the necessary scalability and flexibility, the end-to-end

offering also impresses with increased cost-effectiveness and resource efficiency. It also offers controlled and monitored process conditions for maximum quality and reliability. All in all, FLOWNETICS promotes the departure from traditional production paradigms and the breaking up of encrusted industrial structures. As a transformation accelerator, FLOWNETICS relies on the advantages of a subscription model. Users can choose between **Performance-as-a-Service (PaaS)** for contract manufacturing and **Factory-as-a-Service (FaaS)** for in-house production at the customer site. Both variants avoid the risk of a high initial investment, enable needs-based conditions and offer the convenience of continuous improvement, predictive maintenance and efficient resource management thanks to an integrated Pharma 4.0 architecture.

8 Benefits of Flow Manufacturing

BATCH	FLOW
SINGLE MARKET DEPENDENCY	A 100% INDEPENDENCE
INVENTORY & OPERATIONAL COSTS	B 100% COST EFFICIENCY = NO RISK
DIFFICULT PRODUCTION SCALABILITY	C 100% FLEXIBLE UP TO SCALE
LESS PROCESS AND PRODUCT QUALITY	D 100% PROCESS AND PRODUCT QUALITY
NO DIRECT PROCESS DATA INSIGHTS	E 100% DATA TRANSPARENCY AND CONTROL
HIGH SPACE & ENERGY REQUIREMENTS	F 100% COMPACT MANUFACTURING FOOTPRINT
INCREASED RISKS & INEFFICIENCIES	G 100% HIGH HUMAN AND PROCESS SECURITY
HIGH ENERGY AND RESOURCE CONSUMPTION	H 100% PARADIGM SHIFT TO GREEN CHEMISTRY

A Independence

Independent and decentralized Flow Manufacturing promotes sustainable and resilient pharmaceutical supply chains by enabling local production. This reduces transportation emissions and logistics costs. It also increases the resilience and reduces dependence on individual supplier countries.

B Cost Efficiency

Flow Manufacturing increases cost efficiency by reducing waste, minimizing downtime and constantly improving yield. Thanks to the faster throughput, it is also possible to react more quickly to market changes.

C Scalability

Flow Manufacturing is highly customizable from development to scale-out. The modular design enables flexible expansion or reconfiguration to scale production volumes. This responsiveness increases overall competitiveness while also ensuring high productivity.

D Reliability

Flow Manufacturing offers **maximum end-to-end reliability**. Equipped with robust, fail-safe mechanisms and manufactured from high-quality materials, FLOWNETICS' systems operate continuously and deliver consistent, high-quality products. Users can rely on the processes to deliver consistent results every time.

E Data Value

Flow Manufacturing offers transparency with AI/ML at the highest level. This increases operational efficiency and improves decision-making. By using **data and AI analyses**, FLOWNETICS optimises production processes, reduces downtime and ensures consistent quality.

F Space Saving

The FLOWNETICS end-to-end systems are compact and massively reduce the space required in production. This space efficiency not only reduces overheads, but also enables greater flexibility in plant design and decentralisation, which increases strategic operations.

G Safety & Security

Flow production **increases safety, especially for hazardous substances** and critical reactions. In addition, the precise control and automation of flow systems minimises human error and improves reaction safety resulting in safer working conditions and more consistent, reliable production processes.

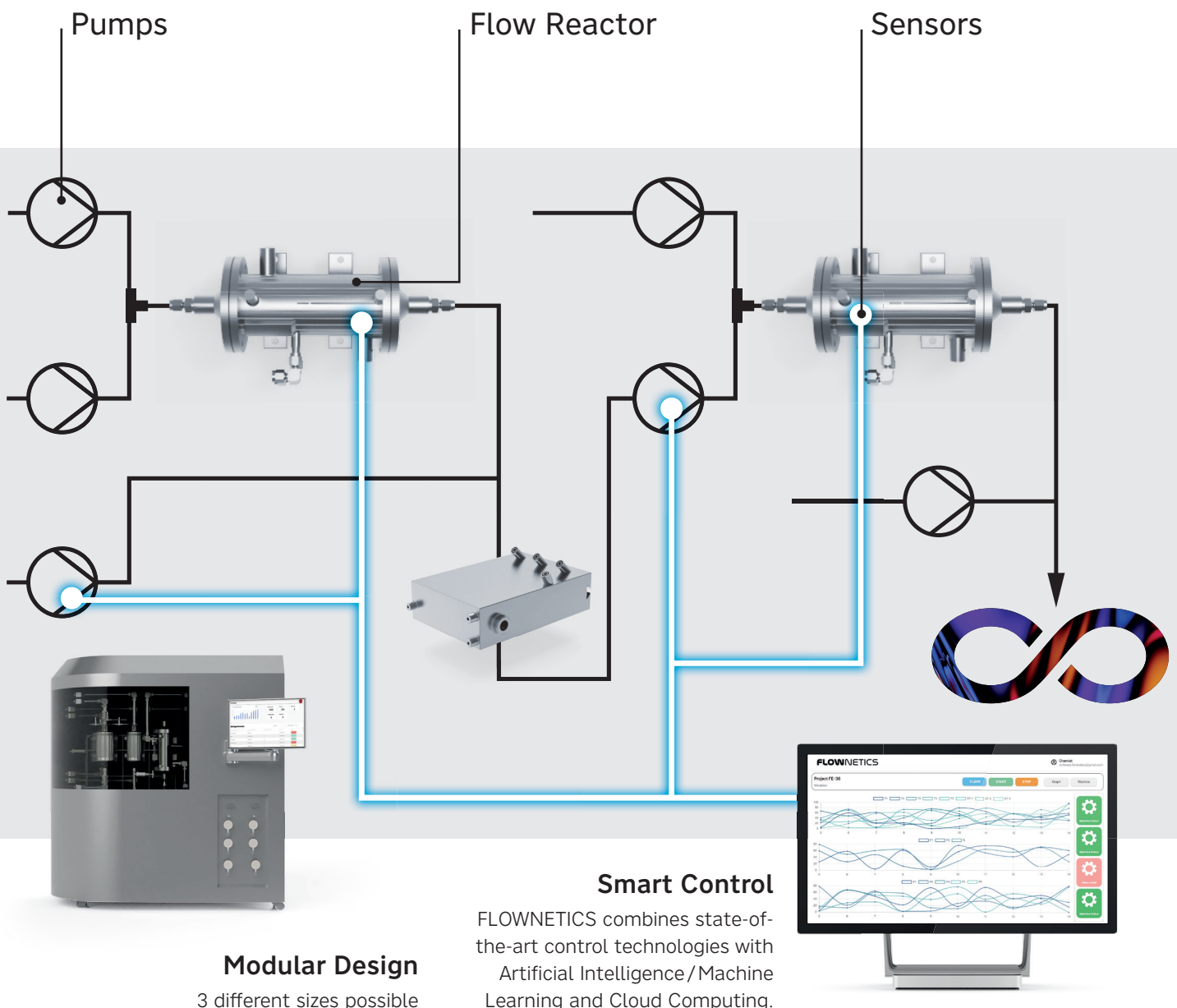
H Green Chemistry

In direct comparison with traditional batch synthesis, Flow Manufacturing is far more efficient and sustainable, resource-saving and safer for people. As a result, flow technology promotes the implementation of the 12 principles of green chemistry in the pharmaceutical sector.

excellence

FLOWNETICS uniquely combines a **wide range of excellence** in one company (completely vertically integrated). The range of **knowledge and services** combines the **innovative spectrum**

- from **chemical engineering** with **AI-supported process development**
- to **systems engineering** and modern **control technology** through to
- **mechanical engineering**, including advanced **manufacturing processes**.



Fully Vertically Integrated

FLOWNETICS offers its customers various equipment and size classes. It all starts with a lab-scale reactor system as a generalized R&D platform including a software suite. The platform is specially designed to close the gap between traditional and modern technologies from the very first idea and to pave the way for customers into the digital future of Flow Manufacturing. Because what works on a laboratory scale also works in practice, from the development of the basics to the expansion of variable production capacities that can adapt scalably to dynamic market demand.

All from a Single Source

In the area of software excellence, FLOWNETICS combines state-of-the-art control technologies with Artificial Intelligence and Machine Learning to provide users with a seamless transition and a high level of efficiency and control. Key features of the FLOWNETICS system include individual user access, DoE (Design of Experiments) software for optimized experiments and a high-tech control

system with a uniquely intuitive human-machine interface for easy entry into the world of Flow Manufacturing.

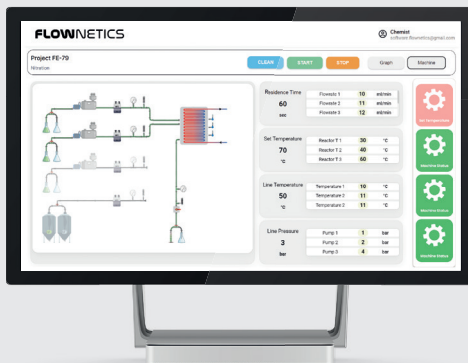
The system is also capable of interpreting the results and displaying complex interactions between variables. Users get a quick introduction to flow technology and often shorten the experimentation phase by up to 50%.

Highlights End-to-End

- Pre-integrated, modular and automated Flow Manufacturing systems that require no additional skills or effort on the part of the customer to operate.
- Advanced technologies such as Additive Manufacturing, Computational Fluid Dynamics, Machine Learning/Artificial Intelligence and Cloud Computing for efficient design, sculpting and manufacturing.
- Eliminate high upfront investments through subscription models for Performance-as-a-Service and Factory-as-a-Service.

FLOWSCALE

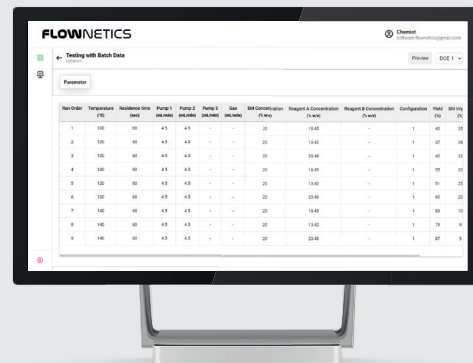
A user-friendly interface to explore and adapt to the principles of flow chemistry



- High performance HMI for stable operation
- Intuitive UI/UX to assist in DoE
- Dynamic and real-time process monitoring
- Data logging and report generation
- Remote access & IoT-enabled

FLOWSCALE

Harnesses the power of AI-driven data analytics to facilitate smooth transition and development of flow process



- Automatic DoE Generator
- Project planning and record keeping
- Built-in computational tools
- Data-driven process intelligence
- Human-in-loop model

“What is your most critical ingredient?”

In this post-COVID era, significance of resilient supply chains has become apparent, especially in critical sectors like pharma and healthcare where key ingredients are sourced from a few suppliers, increasing costs and vulnerability. It is very well known that governments and concerned bodies are now encouraging the local manufacturers to elevate their capabilities in R&D and commercial operations.

The Key Starting Materials (KSMs) and Intermediates are foundational components serving as the backbone of pharmaceutical manufacturing and therefore are arguably the most critical component in the supply chain. They are the essential building blocks from which complex pharmaceutical compounds are derived. The global shortage of important ingredients and the high dependency on China with 80% coverage are the key problems in the industry.

“Democratize Chemical Manufacturing” is our vision – FLOWNETICS enables you with the necessary tools for Progressive Manufacturing to make your supply chain more resilient and sustainable.

Therefore please check what is your most critical ingredient in your supply chain.

At FLOWNETICS, we are committed to enhancing the capabilities of the small, medium and large chemical product owners and brands as well as manufacturers and importers with advanced technologies.

We believe, to truly incorporate a resilient supply chain, the transformation has to start from the early stages of the pharmaceutical value chain now.

Please contact us to optimize your supply chain, either we produce your ingredients (Paas) or we produce your product locally at your factory (FaaS)!



CHETHAN RAJU SUNDAR

Engineering/
Research & Development
crsundar@flownetics-engg.com

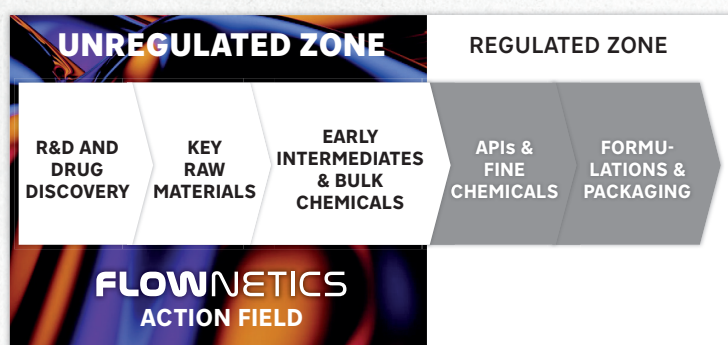
USE CASES

Get our **solution** for your biggest **pain points**. Contact us and send us your **problem case**.

FLOWNETICS have a continuous R&D program to cover and establish flow processes for several functional segments in the chemical space. A few examples that comprise **over a 100 molecules validated** by us over the last few years.

1. **Aryl amines** – Nitration followed by reduction
2. **PEG molecules** – Protection, condensations followed by deprotections
3. **Quinolines & Indoles** – Multistep synthesis
4. **Pyrimidines & Piperidines** – Multistep synthesis
5. **Amides and amines** – High pressure reactions
6. **Protected amines & alcohols** – Selectivity reactions
7. **Esters** – Substitution reaction
8. **Saccharides** – Multistep synthesis
9. **Alkylation** – Friedel craft alkylation, Grignard reaction
10. **Catalysis** – Cyclopropylation and hydrogenation
11. **Pyrophoric chemistry** – Butyl lithium, Grignard, LDA, Ethyl diazoacetate and LAH
12. **Carbon-carbon bond formation** – Palladium catalyzed reaction
13. **Cyclization** – Diels Alder reaction

...

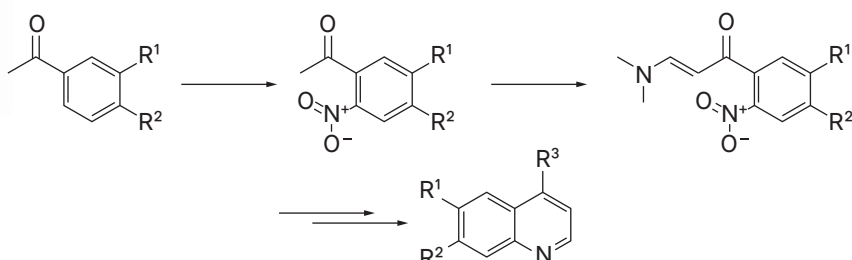


COMMERCIAL VALUE

ROI on initial investments in under 6 months

3 stage synthesis of a hydroxyquinoline intermediate

Early intermediates for anti-malarial, anti-viral, anti-inflammatory and anti-cancer applications.



65%

REDUCTION IN
RAW MATERIAL
COSTS

85%

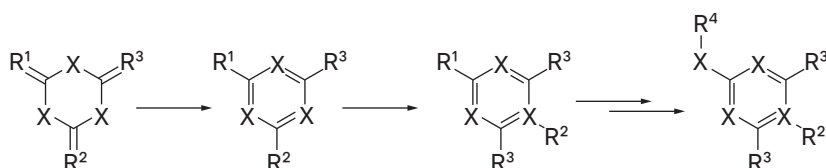
REDUCTION IN
ON OPERATIONAL
COSTS

SUSTAINABILITY FOCUS

8 out of 12 principles of green chemistry

4 stage synthesis of a pyrimidine intermediate

Common ingredient in personal care and cosmetic products.



70%

LESS EFFLUENT
GENERATED THAN
BATCH

90%

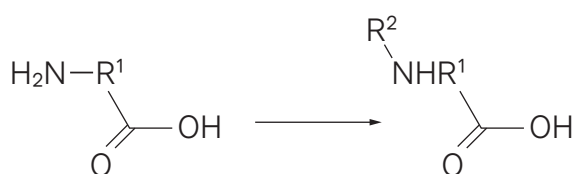
LESS POWER
CONSUMPTION

SUPPLY CHAIN OPTIMIZATION

Resilient supply chain and localized production

N-protected amino acids

Key raw materials for a new class of peptide-based drugs for diabetes and weight loss.



50%

HIGHER PROFIT
MARGIN WITH BACK
INTEGRATION

50%

SAVINGS ON
IMPORTED RAW
MATERIALS

customer

*FLOWNETICS offers **2 different subscription models** that enable customers to **benefit from the advantages** of this technology without having to bear the burden of high investments.*

Flow Manufacturing systems are complex systems consisting of control systems, reactors, pumps, sensors, valves and many other components. Until now, companies have had to develop the necessary skills for this, then identify and procure the right components in order to finally implement the home-made system with various partners. This takes a lot of time, but above all it costs a lot of money and additional maintenance and servicing costs during operation.

All-as-a-Service

With FLOWNETICS, customers get all this from a single source and the necessary knowledge as a service. With FLOWNETICS, companies can therefore concentrate on their core competencies: On Research and Development at the beginning of the value chain and finally on Marketing and Sales. In between, production flows automatically from the idea to the product.

And the best thing about it: FLOWNETICS offers this “Flow”, including Technology and Hardware development, as complete All-inclusive-as-a-Service. The customer only needs to install the process-specific or customized end-to-end platform systems in their company. From this point, FLOWNETICS’ end-to-end service begins: starting with the day-to-day operation of the systems, through comprehensive remote services to maintenance and servicing, including spare parts. The customer only has to provide the raw materials, take care of waste disposal and accept the finished products.



“7 Benefits of our Full-Service-Approach”

FLOWNETICS as a Service Solutions offer a **cost-effective, scalable and technologically** advanced manufacturing solution that allows companies to focus on innovation while minimizing risk and maintaining strong customer relationships. The highlights in the overview are more than convincing:

- 1. Focus on Core Competencies:** Manufacturers can concentrate on Research & Development as well as Marketing & Sales
- 2. Cost Efficiency:** By adopting a servitization model, manufacturers can shift from capital expenditure (CAPEX) to operational expenditure (OPEX), allowing for a more flexible and predictable financial model.
- 3. Scalability and Flexibility:** XaaS enables manufacturers to scale production up or down based on demand without the need for heavy upfront investment in machinery, facilities and personnel.

4. Advanced Technologies: XaaS ensures access to the latest manufacturing technologies in engineering, process, hardware and software.

5. Risk Reduction: XaaS reduces the risk associated with equipment obsolescence and unexpected breakdowns

6. Improved Customer Relationships: XaaS can enhance overall customer relationships by providing a better customer experience, longer customer lifetime value and a wider choice of products with the flexibility to upgrade or downgrade as needed.

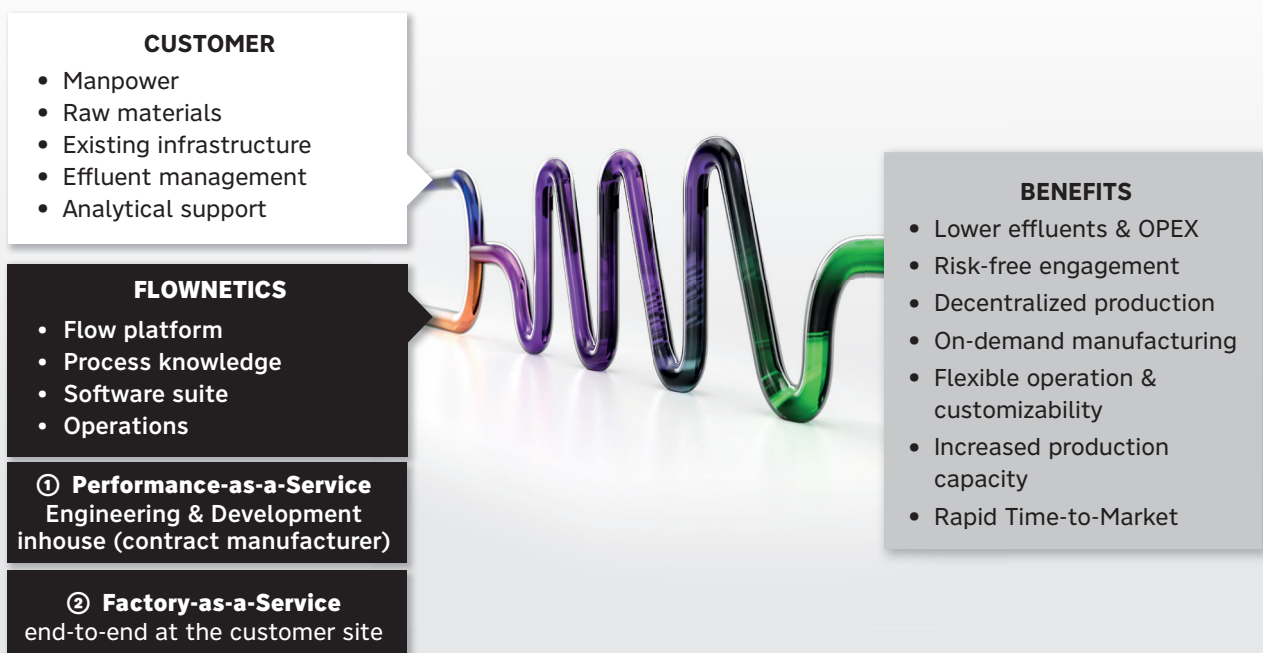
7. Predictive Maintenance: The integration of IIoT and cloud based advanced analytics enables predictive maintenance, ensuring equipment longevity and reducing downtime.

① Performance-as-a-Service - Contract manufacturer (Engineering and Development)

FLOWNETICS Performance-as-a-Service represents a highly specialized and robust lab platform that accelerates the adoption of this technology and provides a competent rental rate that still guarantees an ROI on equipment and development costs in less than 12 months.

② Factory-as-a-Service at the customer site (End-to-End at customer site)

The introduction of Flow Manufacturing in pharmaceutical production undoubtedly involves a high initial investment. In this context, a Factory-as-a-Service (FaaS) approach is an innovative solution to facilitate the transition to this advanced manufacturing technology, even for small and medium-sized companies.



Follow the Flow from Pain to Gain

- “Democratize Chemical Manufacturing”
- **Status quo:** Dominance from **China** with **80% market share** and **globally 99% batch production** in the industry
- “**Make your supply chain more resilient and sustainable**”
- **FLOWNETICS offers a fully vertically integrated end-to-end** Flow Manufacturing platform with **AI-supported** process development
- **Customers can choose between 2 business models (risk-free engagement)**
 - ➊ **Performance-as-a-Service for Contract Manufacturing**
Engineering and Development
 - ➋ **Factory-as-a-Service for inhouse production**
End-to-End at customer site
- **10x Benefits:**
independence, Yield, OPEX/CAPEX, Space, Green, Data Driven & Safety...

“What is your most critical ingredient?”
Contact us right now to solve your problems!

FLOWNETICS Engineering
Private Limited, India

+91 9035 021 855
sales@flownetics-engg.com

www.flownetics-engg.com

