ER2FOOD

Strategic support for facilitating the adoption of Energy and Resources efficiency as drivers for the technical and business development of Egyptian SMEs and start-ups of the FOOD sector

Process in the value chain

This project has received funding from Europe Aid /
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Agenda

- **Introduction to the module: scope and goals**
- Examples of typical flour milling components
- The current R&D scenario in the sector - mills
  - Industrial research
  - Key global players
  - Case studies
- Key areas of innovation and sustainability – mills
- Conclusion - mills
- Food Packaging Roles and Materials
- The current R&D scenario in the packaging
  - Industrial research
  - Key global players
  - Case studies
  - Research Trends
- Conclusions - packaging

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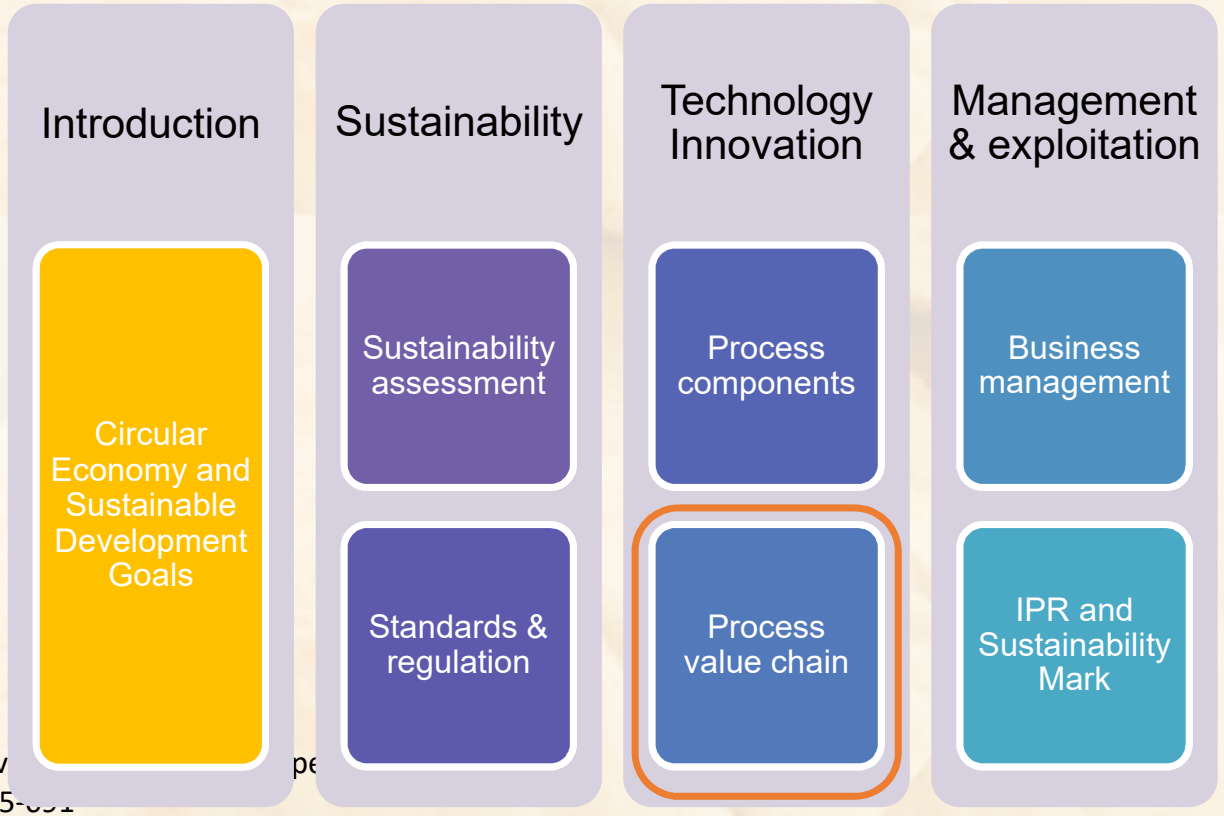
Introduction to the module: scope and goals

This is one of the training modules defined for the group: “Technology Innovation”



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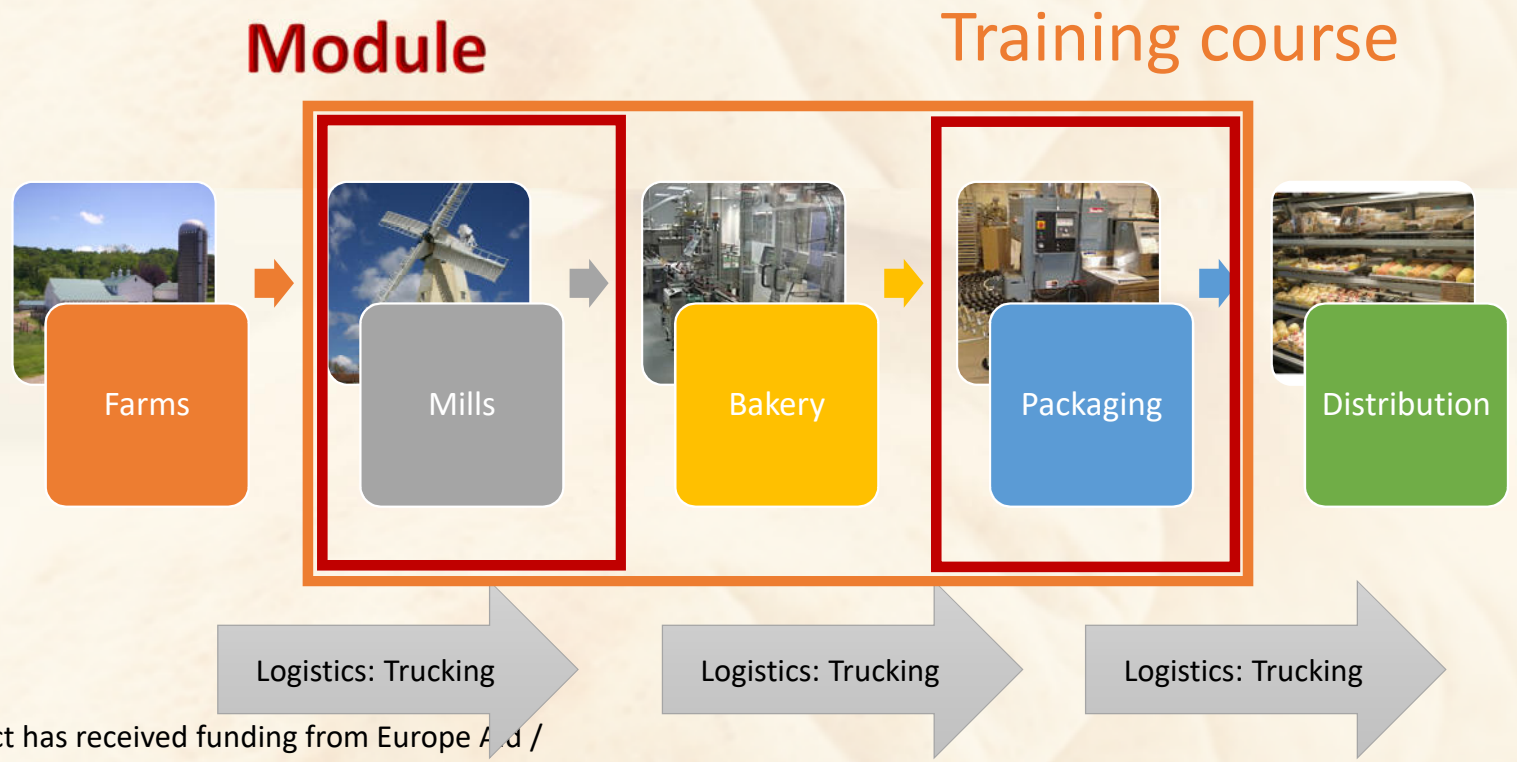
SCOPE and GOALS

The scope of the present training course is part of the wider perimeter of industrial bakery value chain, while the module itself focuses on bakery processes:



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SCOPE and GOALS

The goal of the project:

- ER2FOOD project aims at providing strategic support and expert consultancy services to Egyptian MSMEs and start-ups from the value chain of industrial bakery, for facilitating the adoption of Energy and Resources efficiency as drivers of their technical and business development

The goals of the module:

- To describe the scenario of R&D in the field of energy and resources efficiency
- To identify the best available technologies for a typical industrial bakery line
- To identify who are the key players (machinery suppliers) in the sector
- To identify the success cases that could be taken as reference by the Egyptian community

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Why this module?

This module is aimed to better clarify how the typical processes of milling and packaging affect the energy consumption of a company and, in general, it wants to stimulate the evaluation of the different possible alternatives a company has to achieve a higher level of sustainability and competitiveness

- For each of the key component of the milling and packaging processes, the module provides a list of actions that can be done, to achieve a higher efficiency and reduce the energy bill and improve sustainability
- The module also provides figures about the typical return on investment for the suggested actions, leveraging on past experiences and recent publications and use cases
- The use cases here provided give not only a benchmark but also a further evidence of the possible results and improvements that a company can achieve

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Flour milling

- Milling is an energy-intensive sector and energy is the largest operating expense item after raw material costs
- In order to get an overview of costs, we can assume the investment cost of a flour mill of 200t/day capacity reaches about 2M EUR with a lifetime of 20 years on average. In this case, the annual depreciation cost will be 100k EUR
- On average, it has been calculated that the process uses 50% electric energy for milling and grinding, 30% is used for pneumatic conveying, 11% for mechanical conveying
- In total, the annual energy cost of such a company will be around 200k EUR, that is twice the depreciation cost of the flour mill
- According to these numbers, it is clear that the easiest and fastest way to reduce production costs is to invest in energy efficiency solutions, right after the efficient management of raw materials

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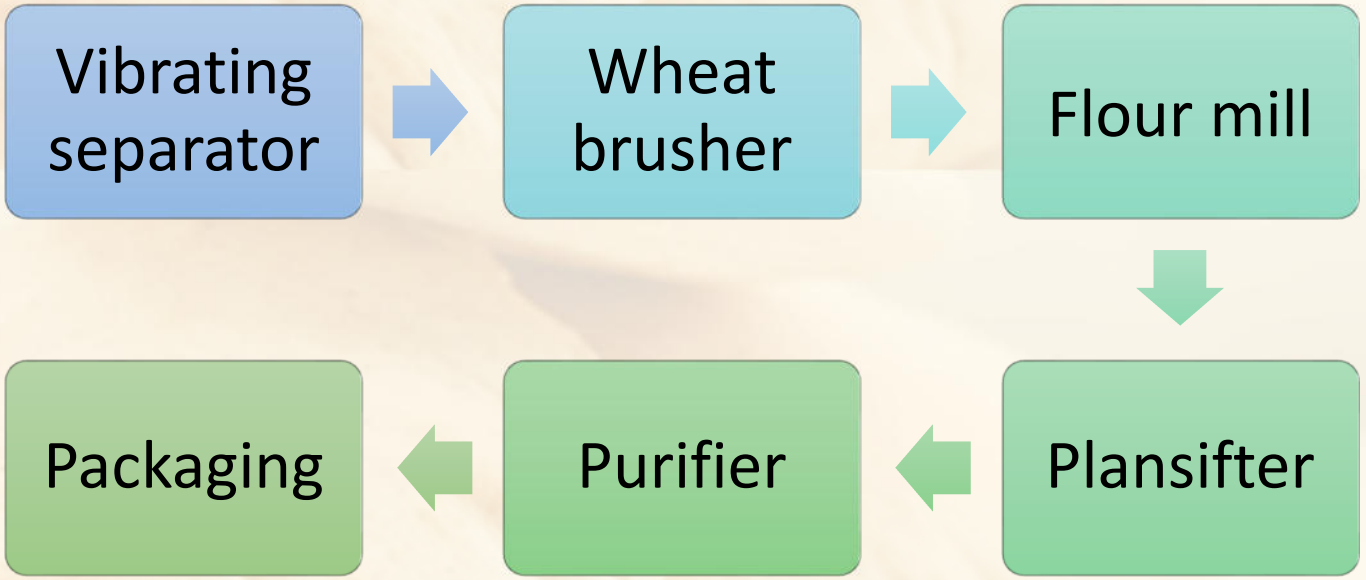
Typical milling line and its components

During the first stage, wheat is separated from little rocks, stones, seed or other material that may cause damage to the flour mill machine.

After processing of the wheat through the flour mill, we can get different classes of wheat flour thanks to the steps of plansifting and purification



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Flour milling – energy consumption vs value chain

Description	Energy consumption (MJ/ton flour)	Share of energy consumption
Wheat flour production	2.092 – 2.194	11 – 12%
Transport	31	0%
Collector	77 -79	0%
Transport	297 – 370	2%
Milling	**361 – 1.186**	**2 – 7%**
Transport	90 – 92	0 – 1%
Bakery	5.377 – 8.513	30 – 45%
Transport	207 – 460	1 – 3%
Outlet bread	3.105 – 3.693	16 – 21%
Shopping	1.721	9 – 10%
Consumer	2.497	13 – 14%

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Patent Analysis

Usually, a patent analysis is used for:

- ✓ **Clearance & state-of-the-art search:** the analysis confirms if you have the freedom to operate in a particular technology area and avoid potential risk of infringement.

But the patent scenario is also a valuable source of information for:

- ✓ **Competitive, technical & market intelligence searching.** The analysis helps in performing strategic, technical, and competitive intelligence, with the support of an artificial intelligence.

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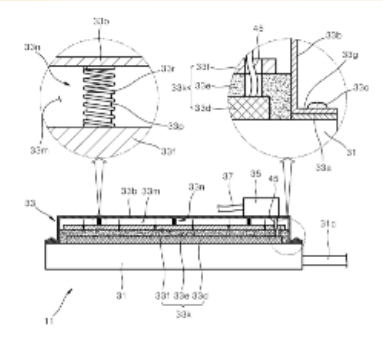
Information stored in a patent (example)

- **Title:** ELECTRIC HEATING DEVICE FOR BAKING BREAD
- **Assignee:** Park
- **Inventor:** Park
- **Patent legal status:** Alive
- **Publication date:** 2016-09-08
- **Publication number:** KR1655252B1
- **International Patent Classification code (IPC):** A21B 5/02
- **Abstract:** The invention relates to the electrical type bakery mold heater for the bread baking. This includes the presser portion in which it pressurizes the pressing plate to the gasket, sealing the internal space of the airtightness cover by the state inserted between the airtightness cover, and flange portion and bakery mold and the state supported in the airtightness…….
- **Drawings**



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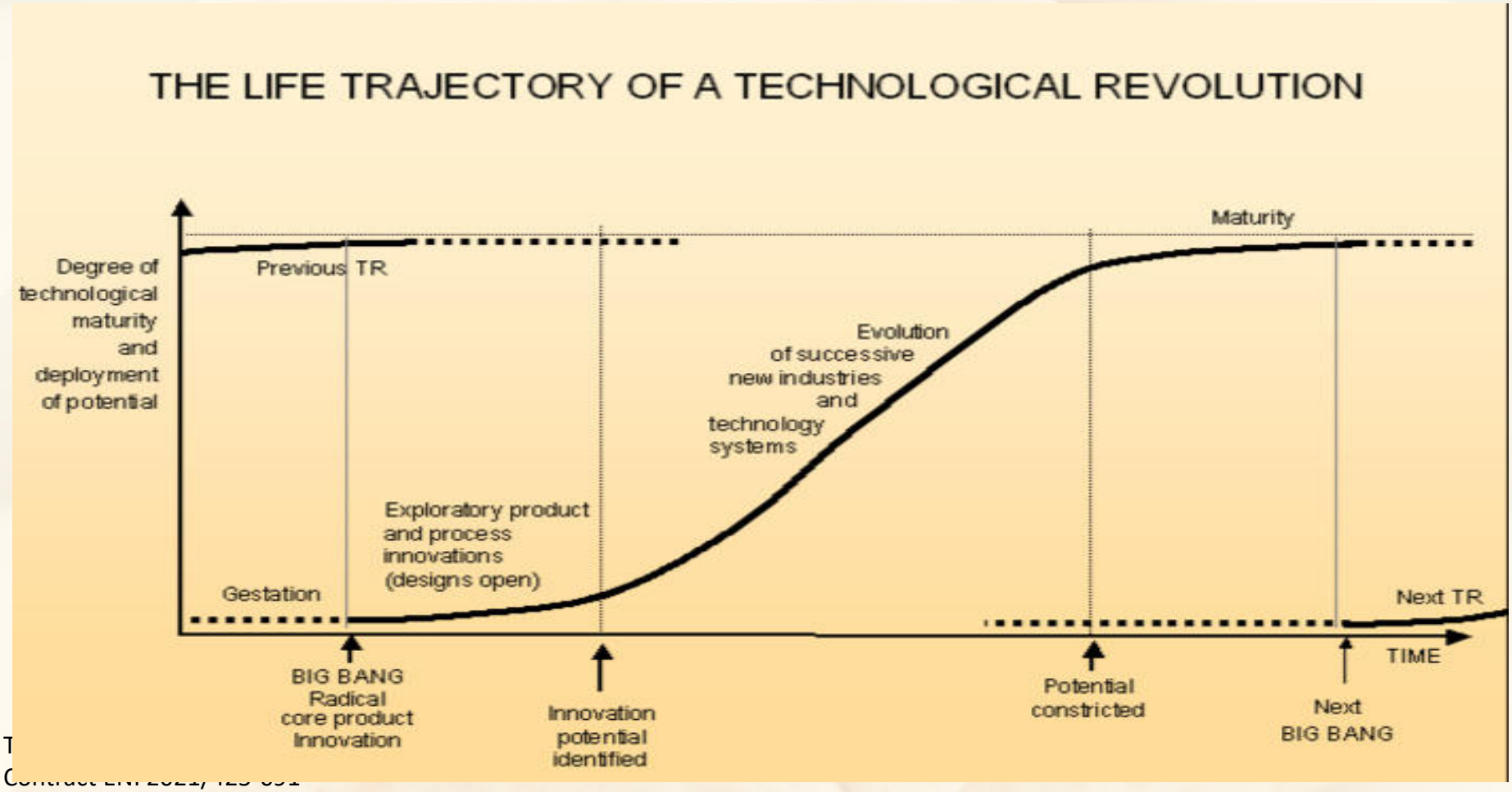
Evolution of systems



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International Patent Classification code

- A HUMAN NECESSITIES
- B PERFORMING OPERATIONS; TRANSPORTING
- C CHEMISTRY; METALLURGY
- D TEXTILES; PAPER
- E FIXED CONSTRUCTIONS
- F ENGINEERING IN GENERAL
  - F15 FLUID-PRESSURE ACTUATORS; HYDRAULICS OR PNEUMATICS IN GENERAL
  - F16 ENGINEERING ELEMENTS OR UNITS; GENERAL MEASURES FOR PRODUCING AND MAINTAINING EFFECTIVE FUNCTIONING OF MACHINES OR INSTALLATIONS; THERMAL INSULATION IN GENERAL
  - F17 STORING OR
  - LIGHTING; HE
  - F21 LIGHTING
  - F22 STEAM GENE
  - F23 COMBUSTIO
  - F24 HEATING; RA
  - F25 REFRIGERAT SYSTEMS; M
  - F26 DRYING
  - F27 FURNACES;
  - F28 HEAT EXCHA
- G
- H

- F24B DOMESTIC STOVES OR RANGES FOR SOLID FUELS; IMPLEMENTS FOR USE IN CONNECTION WITH STOVES OR RANGES [6]
- F24C OTHER DOMESTIC STOVES OR RANGES; DETAILS OF DOMESTIC STOVES OR RANGES, OF GENERAL APPLICATION (radiator stoves of the fluid-circulating type F24H)
- F24D DOMESTIC- OR SPACE-HEATING SYSTEMS, e.g. CENTRAL HEATING SYSTEMS; DOMESTIC HOT-WATER SUPPLY SYSTEMS; ELEMENTS OR COMPONENTS THEREFOR (using steam or condensate extracted or exhausted from steam engine plants for heating purposes F01K 17/02)
- F24F AIR-CONDITIONING; AIR-HUMIDIFICATION; VENTILATION; USE OF AIR CURRENTS FOR SCREENING (removing dirt or fumes from areas where they are produced B08B 15/00; vertical ducts for carrying away waste gases from buildings E04F 17/02; tops for chimneys or ventilating shafts, terminals for flues F23L 17/02)
- F24H FLUID HEATERS, e.g. WATER OR AIR HEATERS, HAVING HEAT-GENERATING MEANS, IN GENERAL (heat-transfer, heat-exchange or heat-storage materials C09K 5/00; tube furnaces for thermal non-catalytic cracking C10G 9/20; devices, e.g. valves, for venting and aerating enclosures F16K 24/00; steam traps or like apparatus F16T; steam generation F22; combustion apparatus F23; domestic stoves or ranges F24B, F24C; domestic- or space-heating systems F24D; furnaces, kilns, ovens, retorts F27; heat-exchangers F28; electric heating elements or arrangements H05B)

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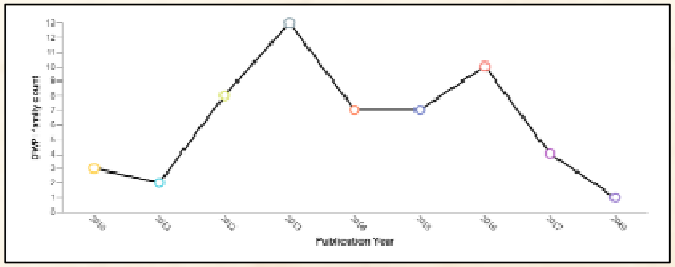
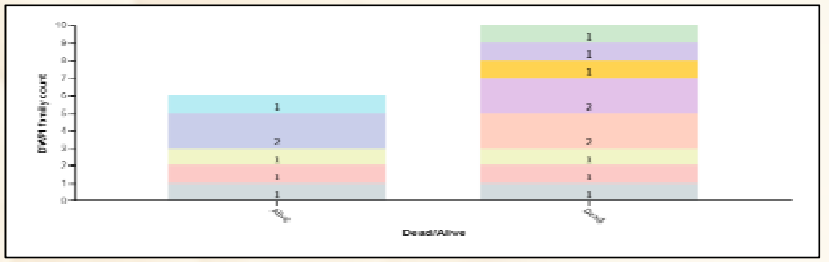
Patent Analysis

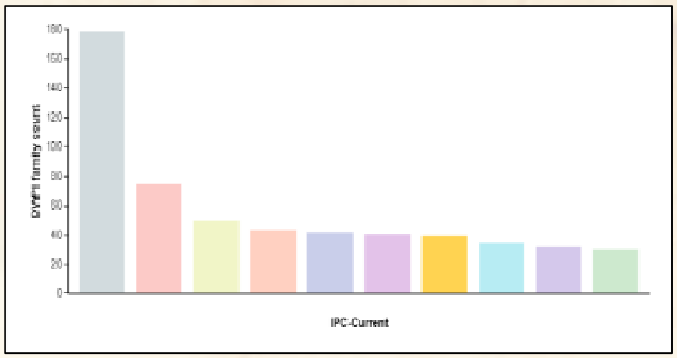
Patent publishing trend



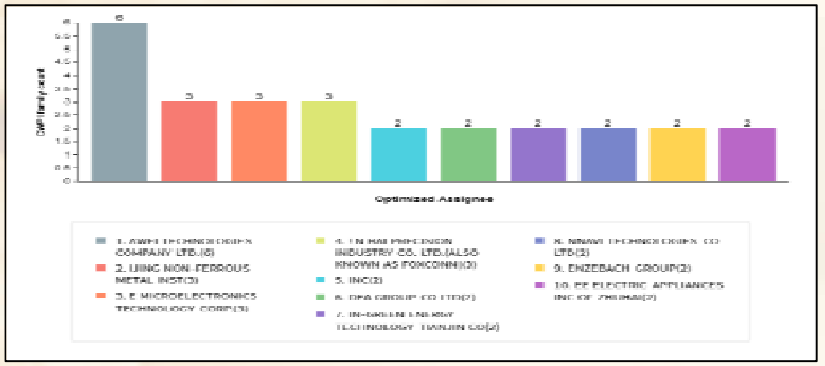
Dead vs Alive patents



Top IPC – International Patent Classification

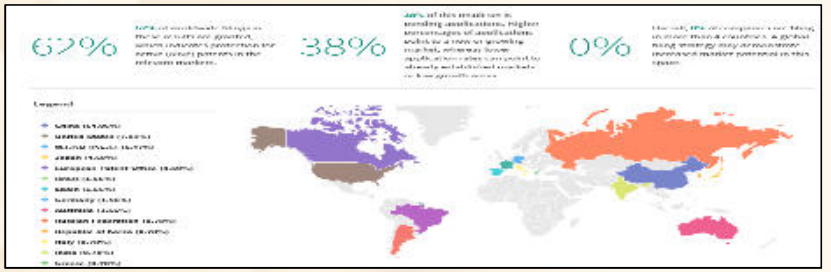


Top applicants



Technology Areas and A.I. Insights

Alive international market



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Energy Efficiency in milling – patent analysis

Data and tools

- Derwent Innovation (www.derwentinnovation.com)
- Espacenet (www.espacenet.com)
- Time interval: from 2010 to 2020

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Energy Efficiency in milling – patent analysis

Results

- **~1.480** records
- **~ 1.240** INPADOC families. A **patent family** is a collection of **patent** documents covering a technology. The technical content covered by the applications is similar, but not necessarily the same

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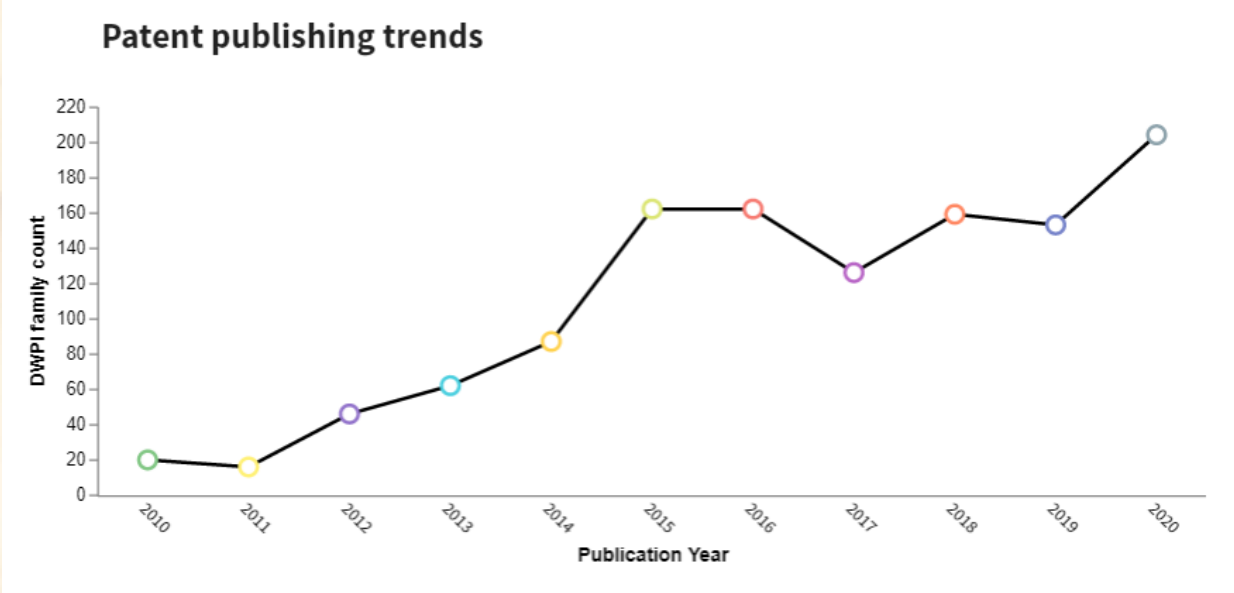
Energy Efficiency in milling - trend

The analysis of publishing trend in the period 2010-2020 shows a robust positive trend that appears to accelerate in the last years. In 2010 about 20 patents/year were published, dealing with efficient solutions for milling. In 10 years, the quantity has grown 10 times, with more than 200 patents submitted in 2020.

According to this, we can confirm that industrial products have reached a very high maturity level, but more innovations are expected in the coming years i.e., obsolescence has not been reached yet.



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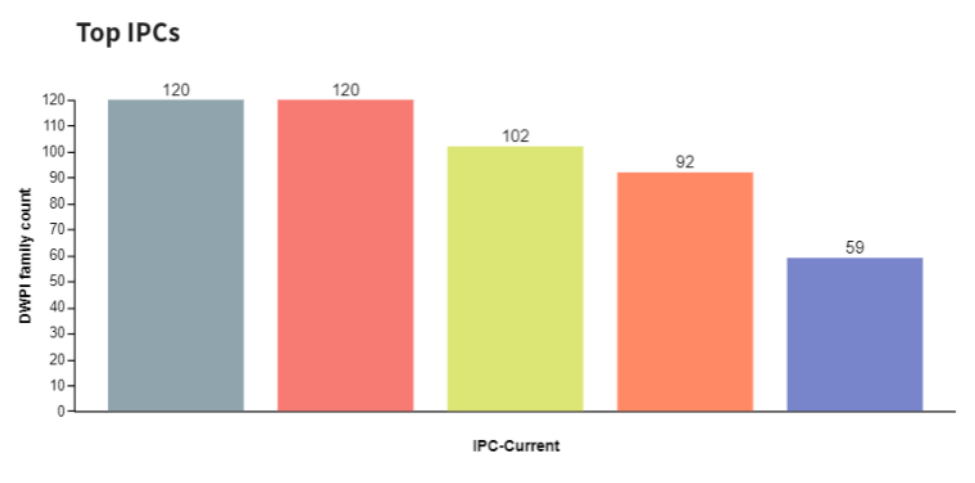
Energy Efficiency in milling – top IPC



IPC	Description	Records
B02C 21/00	Disintegrating plant with or without drying of the material	120
B02C 23/02	Auxiliary methods or auxiliary devices or accessories specially adapted for crushing or disintegrating – Feeding devices	120
B02C 23/00	Auxiliary methods or auxiliary devices or accessories specially adapted for crushing or disintegrating in general	102
B02C 23/16	Auxiliary methods or auxiliary devices or accessories specially adapted for crushing or disintegrating with separator defining termination of crushing or disintegrating zone, e.g. screen denying egress of oversize material	92
B02C 23/08	Separating or sorting of material, associated with crushing or disintegrating	59

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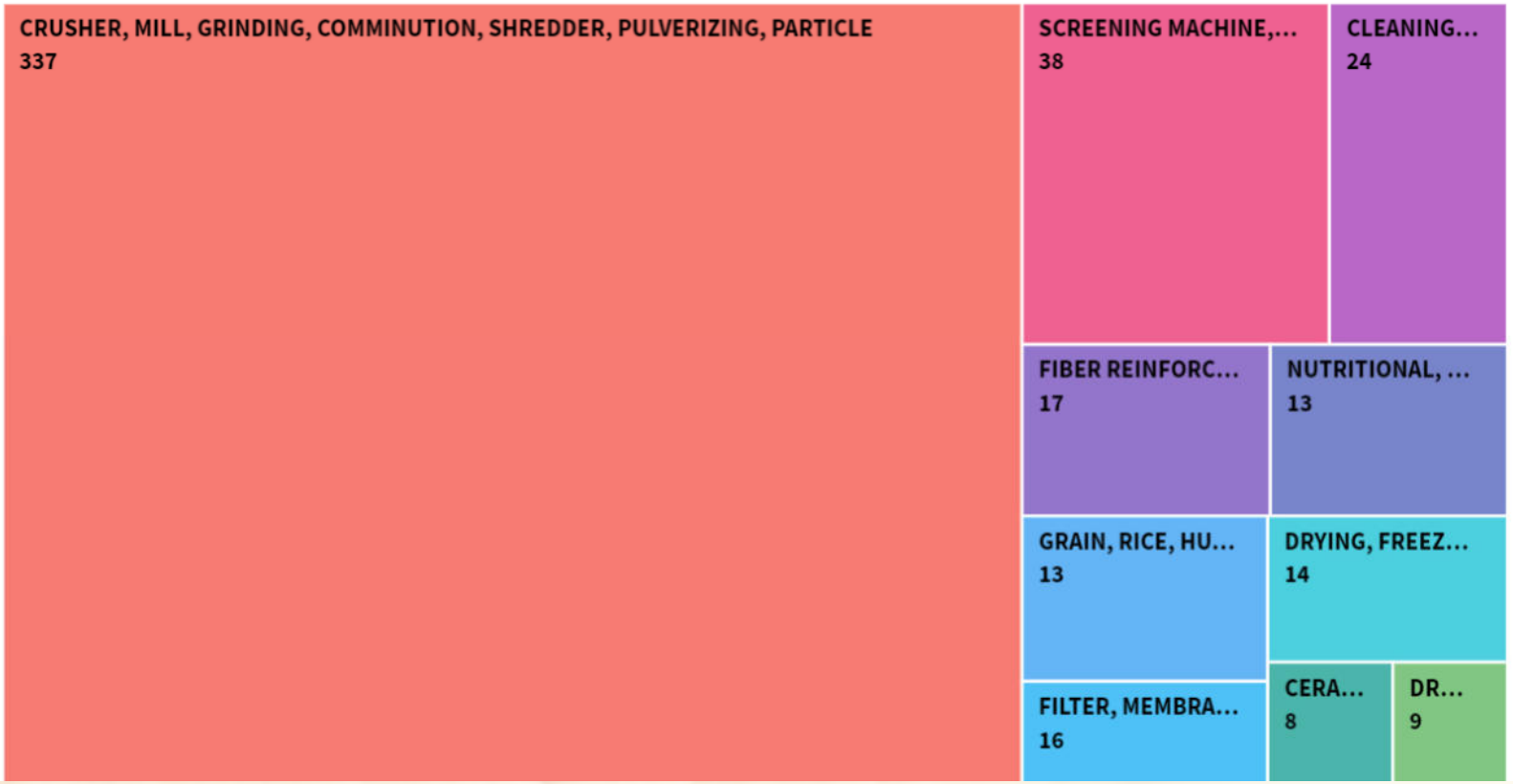
Energy Efficiency in milling – keywords

- CRUSHER, MILL, GRINDING, COMMINUTION, SHREDDER, PULVERIZING, PARTICLE
- SCREENING MACHINE, SIEVE, VIBRATORY SEPARATOR, SORTING, SHALE SHAKER, SIFTER, PARTICLE
- CLEANING, WASHING
- FIBER REINFORCED RESIN, PREFORM, MOLDED ARTICLE, EXTRUDER, PREPREG, COMPOSITE MATERIAL, PLASTIC
- NUTRITIONAL, EXTRACT, SUPPLEMENT, DIETARY, LACTOBACILLUS, PROBIOTIC, TASTE
- GRAIN, RICE, HULLING, HUSKING, CEREAL, BRAN, FLOUR
- FILTER, MEMBRANE, SEPARATION, GAS, FILTRATION, CARBON DIOXIDE, SORBENT
- DRYING, FREEZE, DRIED, HOT AIR, MOISTURE, HEATING
- CERAMIC, PARTICLE, CALCIUM, COMPOSITE, SINTERED BODY, BORON NITRIDE, ZIRCONIA
- DROPLET, BUBBLE, FLUID, LIQUID, MICROFLUIDIC, BIOREACTOR, GAS

2017-2021

642 new records in this time period.



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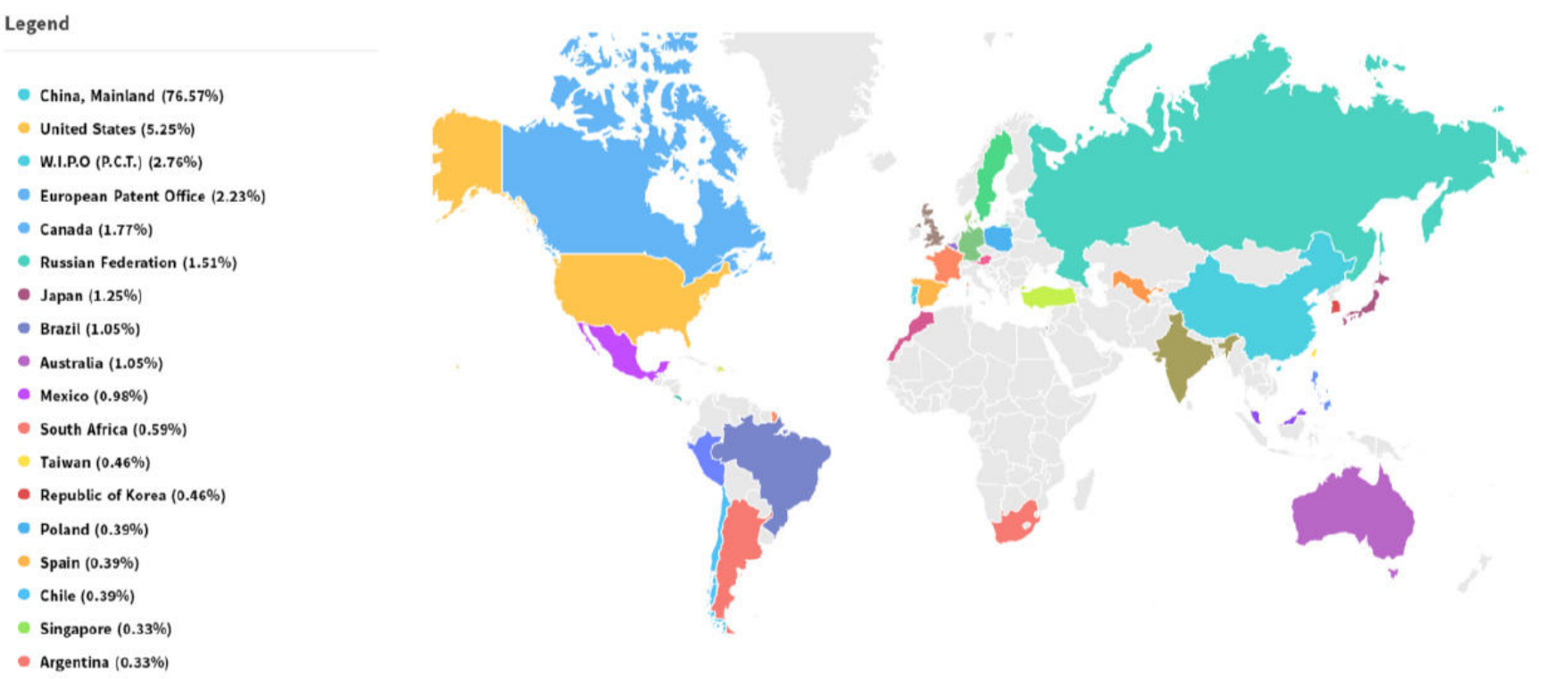
Energy Efficiency in milling – top markets

67% 67% of worldwide filings in these results are granted, which indicates protection for active (Alive) patents in the relevant markets.

33% 33% of this result set is pending applications. Higher percentages of applications point to a new or growing market, whereas lower application rates can point to already established markets or low growth areas.

0% Overall, 0% of companies are filing in more than 4 countries. A global filing strategy may demonstrate increased market potential in this space.



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Cont

Case study - Energy audit of Crown Flour Mill, Nigeria

- An interesting paper* assesses an energy audit of the 2015 production year of Crown Flour Mill Plant A and Plant B.
- Data was collected from the processing mills to determine the energy consumption rate
- From the results, it was determined that the roller mill machines consume the largest quantity of energy (32,078,200MJ/year and 20,808,191.27MJ/year respectively)
- This accounts for 91.8% and 62.6% respectively of energy consumed in the plants.
- The calculated amount of diesel fuel energy consumed was about 18.4GWh/year and 29.5GWh/year for Mill A and B respectively, which is a total of 47.9GWh/year.

- However, the energy demand of the process machines and consumption capacities for Mills was **a total of 14.1GWh/year which is far lower than the energy generated by the diesel fuel generators**

- **This implies that a lot of energy is being wasted in the flour production plants.**

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Case study - Energy audit of Crown Flour Mill, Nigeria

Flour manufacturing process machines specific energy consumption (MJ/kg) for Mill A

Manufacturing process Machines	Energy consumption (kWh/yr.)	Energy consumption (MJ/yr.)	Production Output (kg/year)	Specific Energy Consumption, SEC, (MJ/kg)
Tempering Bin	73632.28	265076.25	64258600	0.0041
Roller Mills	3978405.00	32078200	64258600	0.4992
Plansifter	70415.80	253496.88	64258600	0.0039
Minisifter	22481.11	80999.82	64258600	0.0013
Purifier	10480.44	45992.12	64258600	0.0007
Bran Finisher	76776.58	276395.65	64258600	0.0043
Detacher	328019.68	1180870.77	64258600	0.0184
Sterilator	52410.05	188337.62	64258600	0.0029
Air Lock Cyclone	29844.89	107117.50	64258600	0.0017
High Pressure fan	127170.64	457813.15	64258600	0.0071
Total	4769636.47	34934299.76		0.5436

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Case study - Energy audit of Crown Flour Mill, Nigeria

Flour manufacturing process machines specific energy consumption (MJ/kg) for Mill B

Manufacturing process machines	Energy consumption (kWh/yr.)	Energy consumption (MJ/yr.)	Production Output (kg/yr.)	Specific Energy Consumption (MJ/kg)
1st Tempering Bin	29380.31	105769.12	102820400	0.0010
Aspirator	22475.85	80913.06	102820400	0.0008
Damper	110011.61	39641.79	102820400	0.0004
2nd Tempering Bin	43985.39	158347.40	102820400	0.0015
Elevator	14139.45	50902.02	102820400	0.0005
Roller Mills	5780053.13	20808191.27	102820400	0.2023
Plan Sifter	217043.61	781356.00	102820400	0.0076
Purifier	13888.14	49997.30	102820400	0.0005
Bran Finisher	230837.75	831015.90	102820400	0.0081
Detacher	825167.20	2970601.92	102820400	0.0289
After Cyclone Air Lock	57200.25	205920.90	102820400	0.0020
High Pressure Fan	1116678.75	4020043.50	102820400	0.0039
Filter Fan	92998.50	334794.60	102820400	0.0033
Sterilator	333740.00	1201464.00	102820400	0.0117
Blower	61622.43	221840.75	102820400	0.0022
Blower Standby	13796.76	49668.34	102820400	0.0005
Low Pressure Fan	235666.91	848400.88	102820400	0.0083
Rinsing Air Machine	140079.03	504284.51	102820400	0.0049
Total	9338765.07	33263153.26		0.2884

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ENERGY AUDIT OF A FLOUR MILL PLANT: A CASE STUDY OF CROWN FLOUR MILL PLC
Aliu S.A., Onochie U.P., Itabor, N.A. and Adingwupu, A.C.

Case study - Energy audit of Crown Flour Mill, Nigeria

The energy audit of Crown Flour Mill, Apapa, Lagos State was carried out in order to determine the energy consumption rate and the pattern through which the consumption rate and cost of energy can be minimized

From the findings, the study came to these main conclusions:

1. Large quantity of energy consuming equipment, like the electric motors that are used to drive most of the machines in the flour Mill Manufacturing Plant, were operating below their installed capacity thereby wasting energy. This is primarily due to the fact that most of the electric motors are old and have been rewound twice or more.

2. Notable amount of electrical energy could be saved by developing an overall motor inventory and replacement plan in the plant. By so doing, there would be a reduction in energy wastage and production cost.

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Energy Efficiency in milling

From the analysis of the current research scenario it emerges that:

- the fastest way to reduce production costs is to have focus on energy costs right after raw material cost.
- It has been calculated that it would be possible to get energy saving by:
  - having maximum capacity usage in overall process (5-10%)
  - using high efficiency motors and increase efficient maintenance by 2-5 percent, optimising air flow and avoiding leaks in conveying systems by 10-20 percent.
- The energy saving opportunities in grain mills focus on best practices and available new technologies in the areas of:
  - Electric motors
  - Conveyors and compressed air
  - Hot water and steam boilers
  - Lighting
  - HVAC installations

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"Energy saving" by The european flour millers, Energy Experts International B.V. (https://flourmillers.eu/)
ENERGY SAVING IN FLOUR MILLING, Mr Tuncay Lamci, Integrated Machinery Systems, Turkey – for Grain & Feed Milling Technology magazine

Energy Efficiency Opportunities – Electric motors

Opportunity	Payback time
Reducing the external load on motors, such as reducing air volume absorbed by the pneumatic system or preventing leaks from compressed air system would thereby reduce motor load, which must be considered as the first step for the saving	6 months
Selection of efficient motors, precisely sized according to the production volume, are used at full capacity and this would reduce additional loads in motors and gears A high efficiency motor of 90kW EFF1 type running 18 hours per day and 300 days per year at a plant, would yield 2500TL (1000 EUR) of energy saving in a year with actual energy costs	1-2 years

"Energy saving" by The european flour millers, Energy Experts International B.V. (https://flourmillers.eu/)
ENERGY SAVING IN FLOUR MILLING, Mr Tuncay Lamci, Integrated Machinery Systems, Turkey – for Grain & Feed Milling Technology magazine

Energy Efficiency Opportunities – Electric motors

Opportunity	Payback time
Chain transfer systems require regular oiling, whereas belt transfer requires regular check, setting and replacement	Immediate
Variable speed drive motors: as an example, in pneumatic systems required air quantity for the transport of stock product varies with the ambient and seasonal conditions; setting motor speed by using variable speed drive would provide energy savings and would therefore return the investment cost	1-2 years

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Energy Efficiency Opportunities – Conveying systems

Opportunity	Payback time
In mechanical conveyors (e.g. bucket elevators, screw and chain conveyors) some saving opportunities are use of products with proper bearings where the friction in these machines are at minimum, regular protective maintenance, product choice at right capacity	Immediate
In pneumatic systems, removing vibration by mechanic balance, setting product and stock speed by a right system design, optimising air volume to be absorbed by clacks, setting fan speed can bring a 10-20% saving	6-12 months
Switching from a screw pump to a rotary airlock can bring about significant **energy savings** and greater flexibility.	2-3 years

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Energy Efficiency Opportunities – Conveying systems

Opportunity	Payback time
Install electronic controlled solenoid valve to automatic switch off compressed air supply when not necessary	6-12 months
Integrate air flow and power meters to monitor the power consumption and used air	6-12 months
Install an air pre-cooling system and a heat recovery unit	1-2 years
Use frequency control (inverters) systems for compressors	2-3 years

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Energy Efficiency Opportunities – Conveying systems

Opportunity	Payback time
Plan inspection often, at least once a year. Monitor the efficiency of steam production monthly	Immediate
Check boilers and exchangers for fouling	Immediate
In case of multiple boilers, apply load management to optimize the overall efficiency	Immediate
Measure the excess of O2 in the exhaust to check the efficiency of combustion and replace the burner or improve control	1-2 years
Check and repair the insulation of boilers and piping	1-2 years
Recover heat (if possible)	2-3 years

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"Energy saving" by The european flour millers, Energy Experts International B.V. (https://flourmillers.eu/)
ENERGY SAVING IN FLOUR MILLING, Mr Tuncay Lamci, Integrated Machinery Systems, Turkey – for Grain & Feed Milling Technology magazine

Energy Efficiency Opportunities – Cross-cutting

Lighting:

- Replacement of bulbs with efficient and long-lasting LEDs
- Increase use of daylight - Increasing levels of daylight within rooms can reduce electrical lighting loads by up to 70%
- Automatic control of lighting - Occupancy sensors can save 10% to 20% of a facility's lighting energy use

HVAC (heating, ventilation, and air conditioning) system:

- energy monitoring and control systems. An energy monitoring and control system supports the efficient operation of HVAC systems by monitoring, controlling, and tracking system energy consumption.
- Adjust non-production hours set-back temperatures. Setting back building temperatures during periods of non-use, such as weekends or non-production times, can significantly reduce energy consumption.
- Consider new high-efficient systems, including heat pumps
- Consider heat recovery systems, e.g. using waste heat from process, compressed air
- Improve the building overall efficiency (e.g. insulation)

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  - Case studies
- Key areas of innovation and sustainability – mills
- **Conclusion - mills**
- Food Packaging Roles and Materials
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Conclusions - mills

- According to recent experiences and to the collected use-cases, industrial bakeries have a good potential for improvement, especially in terms of energy efficiency
- It has been highlighted how the sustainability improvements can positively affect the competitiveness of a company, opening new opportunities for its market
- All the typical processes included in bakery lines can be investigated and, possibly, made more efficient with solutions that have different costs, returns on investments and final effects
- Also solutions that require no or livery limited investments are possible. These are typical best practices to be customized by the company and shared internally to be fully adopted by staff
- In the next slides, a summary of measures that can be implemented in industrial bakeries is provided, starting from those that require the lowest investments

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Summary table

Efficiency measures	No (or low) capital investment
Electric motors	Improved maintenance plan, regular checks
Conveyors and compressed air	Lower operating pressure, check settings regularly to monitor leaks, improved maintenance plans of mechanical components,
Hot water and steam boilers	Improve visual inspection, correct sizing, check fouling
Lighting	Automatic control of lights
HVAC installations	Automatic control of the HVAC system, plan for adjusting temperature during the day or during production stops

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Summary table

Efficiency measures	Short payback period
Electric motors	Re-calibrate external loads
Lighting	Full automatic lighting control, replacement of bulbvs with LED
HVAC	Energy manitoring system, variable air volume and adjustable speed drives, more efficient fans, building insulation, roof coating
Boilers and steam	Process control, improve insulation, condensate return, recover waste heat, reduce excess air, Improve insulation, monitor steam traps
Conveyors and compressed air	Install a monitoring and control system

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Summary table

Efficiency measures	Higher capital investments
Electric motors	Upgrade motors and drive controls (e.g. inverters)
Lighting	increase daylight
HVAC	Heat recovery systems, solar air heating, roof gardens
Boilers	Upgrade of boilers, Improve insulation, monitor steam traps, recover flash steam
Conveyors and compressed air	Upgrade the system with new efficient components (e.g. rotary airlock)

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Packaging - overview

- The International Packaging Institute (IPI) defines packaging as the enclosure of products, items or packages in a wrapped pouch, bag, box, cup, tray, can, tube, bottle or other container form to perform one or more of the following functions: containment, protection, preservation, communication, utility and performance.
- Functions of Packaging: protection & preservation, product information, promotion of corporate identity, form part of sales promotion and adds to the appeals of the product
- There are three types of packaging materials: primary, secondary and tertiary packaging.
    1. Primary packaging: materials in direct contact with the product (e.g. plastic bags)
    2. Secondary packaging: contains primary packaging (e.g corrugated boxes, paperboard)
    3. Tertiary packaging: contains secondary packaging (e.g shipping containers, baskets, pallets)

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Packaging – the importance of food packaging

- The global food packaging market size was estimated at **USD 303.26 billion in 2020**;

- On the basis of application, the market is categorized into fruits & vegetables, bakery & confectionery, dairy products, meat, poultry & seafood, sauces, dressings and condiments, and others. Among these applications, the **bakery & confectionery account the 37,4% of global food packaging in 2020, by application**;

- Current food production and consumption practices generate a lot of packaging, and new forms of packaging are constantly being developed. **The packaging of food places the largest demand on the packaging industry, with approximately two thirds of all the material produced going to package food**.

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Food Packaging Market Size – Fortune Business Insights – Published on November 2021 – Base year 2020

Packaging Roles

- **Protection/preservation:** retard product deterioration, retain the ben-eficial effects of processing, extend shelf-life, and maintain or in-crease the quality and safety of food
- **Containment and food waste reduction:** Inadequate preservation/protection, stor-age, and transportation have been cited as causes of food waste
- **Marketing and information:** package is the face of a product and often is the only productexposure consumers experience prior to purchase.
- **Traceability**: to improve sup-ply management, to facilitate trace-back for food safety and quality purposes, and to differentiate and market foods with subtle or unde-tectable quality attributes
- **Tamper indication:** Willful tampering with food and pharmaceutical products hasresulted in special packaging features designed to reduce or elim-inate the risk of tampering and adulteration.
- **Other functions:** Packaging may serve other functions, such as a carrier for pre-miums (for example, inclusion of a gift, additional product, orcoupon) or containers for household use.

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Food packaging—roles, materials, and environmental issues K Marsh, B Bugusu - Journal of food science, 2007 - researchgate.net

Packaging Materials

Paper & Card

Glass

Metals

Plastic

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Packaging Materials - Paper & Card

Paper & Card

Paper is a very cheap, **lightweight product with excellent printing capacity.** Although it is very sensitive to moisture, it can be corrected with a combination of paper and other materials such as plastic or paraffin.

Cardboard is a material made up of several superimposed layers of paper, making it **thicker, harder and more resistant than paper**. Its main use is for packaging and containers in the form of boxes.

In recent years, paper and cardboard manufacturers are paying special attention to issues related to **health and the environment by working with recycled products that increase the useful life of these raw materials**.

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Packaging Materials - Paper & Card

Advantages	Disadvantages
➢ Widely recycled. ➢ Compostable. ➢ Does not break down into microplastics.	➢ Reduced barrier qualities in comparison to plastic resulting in a shorter shelf life. ➢ Easier to tear or damage than other materials. ➢ Not always made out of recycled materials, new paper requires cutting down trees. ➢ Paper often costs more than the plastic equivalent. ➢ The material is not transparent which does not allow for viewing the product.

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Packaging Materials - Glass

Glass is an inert material that is impermeable to gases and vapors. It is an **excellent and completely neutral oxygen barrier** when in contact with food. However, it is a f**ragile, heavy material that requires a lot of energy to be manufactured**.

Glass uses one of the most abundant raw materials on the planet, silica, but it is not renewable. Despite this, it is a **recyclable product**, since it can be used as a container repeatedly.

Glass containers can be bottles (the most used), jars, glasses, ampoules, jars, etc. However, this material is not used for frozen products due to the risk of breakage.

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Packaging Materials – Glass

Advantages	Disadvantages
➢ Widely recycled – some companies invest in labels which do not leave behind adhesive and label residue, to ensure the glass packaging can be easily recycled. ➢ It is easy to repurpose and reuse. ➢ Great barrier qualities which are good for shelf life. ➢ Products can be pasteurised within glass packaging making it suitable for long life products. ➢ Glass can be transparent and clear which allows the customer to view the product in the packaging.	➢ Does not biodegrade quickly. ➢ Very energy intensive to produce and recycle. ➢ Glass cannot be made with 100% recycled glass to ensure it keeps its strength. ➢ Glass can break if damaged, which will compromise the safety of the food. ➢ It is often more expensive than a plastic alternative. ➢ It is bulkier and heavy to transport which will increase fuel consumption and costs.

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Packaging Materials - Metal

Metal is the most **versatile of all packaging forms**. It offers a combination of excellent physical protection and barrier properties, formability and decorative potential, recyclability, and consumer acceptance. The 2 metals most predominantly used in packaging are steel and aluminum.

Steel and tin: tin cans are made of steel sheet coated with tin as a measure of protection against corrosion of steel, especially when they contain products with low pH.

Metals

Aluminum: is increasingly used for canning due to its lightness, low cost and capacity to be recycled. It can be found in packaging, bottle closures and wraps and laminates. It has the same barrier properties as steel but with the advantage of being resistant to corrosion.

Aluminum foil is formed by layers of laminated aluminum. It is a highly flexible product that allows to preserve or protect food in the domestic environment. However, it is difficult to use in modern fast packaging equipment due to wrinkles, rips and marks.

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Packaging Materials - Metal

Advantages	Disadvantages
➢ Widely recycled. ➢ Great barrier qualities which are good for shelf life. ➢ Products can be pasteurised within the metal packaging making it suitable for long life products.	➢ Does not biodegrade quickly. ➢ Very energy intensive to produce and recycle. ➢ Is often more expensive than the plastic alternative. ➢ The material is not transparent which does not allow for viewing the product. ➢ This material is open to possible corrosion.

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Packaging Materials - Plastic

Plastics are organic polymeric materials that can be molded into the desired shape. The **lightness and versatility** of these have been confirmed over decades in the processing and packaging of food. **Plastic containers and packaging** protect against the contamination of food and offer **adequate mechanical strength**.

Due to a lower cost and lower energy consumption during manufacturing, **plastics have replaced traditional packaging materials**. In addition, they are able to preserve and protect the food for longer, minimizing the use of preservatives.

In relation to the consumer, they are easy to handle and open, and offer an effective surface for printing labels or brands. However, although plastics are recyclable materials, they are **pollutants**.

Plastic

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Packaging Materials - Plastic

Advantages	Disadvantages
➢ Good barrier qualities. ➢ Products can be pasteurised within some types of plastic packaging making it suitable for longer life products. ➢ Plastic can be transparent and clear which allows the customer to view the product in the packaging. ➢ Plastic is one of the cheapest packaging materials to use. ➢ It is more flexible than glass, making it easier to mould and shape. ➢ It requires less energy to recycle compared to glass, and is lighter to transport.	➢ Does not biodegrade quickly and breaks down into microplastics (as opposed to its original compounds) which can enter the food supply chain. ➢ Not all types of plastic can be recycled and repurposed or reused. WRAP, a not-for-profit organisation encourages companies to move away from colours of plastic which cannot be identified in recycling centres. For example, black trays could be replaced with colours that can be identified, such as clear or grey. ➢ There is a negative public perception of the material. ➢ Plastic is often used for single-use throw away items, such as cutlery, which is an unsustainable practice.

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Bakery packaging – patent analysis

Results

- **~1.600** records
- **~ 1.298** INPADOC families. A **patent family** is a collection of **patent** documents covering a technology. The technical content covered by the applications is similar, but not necessarily the same

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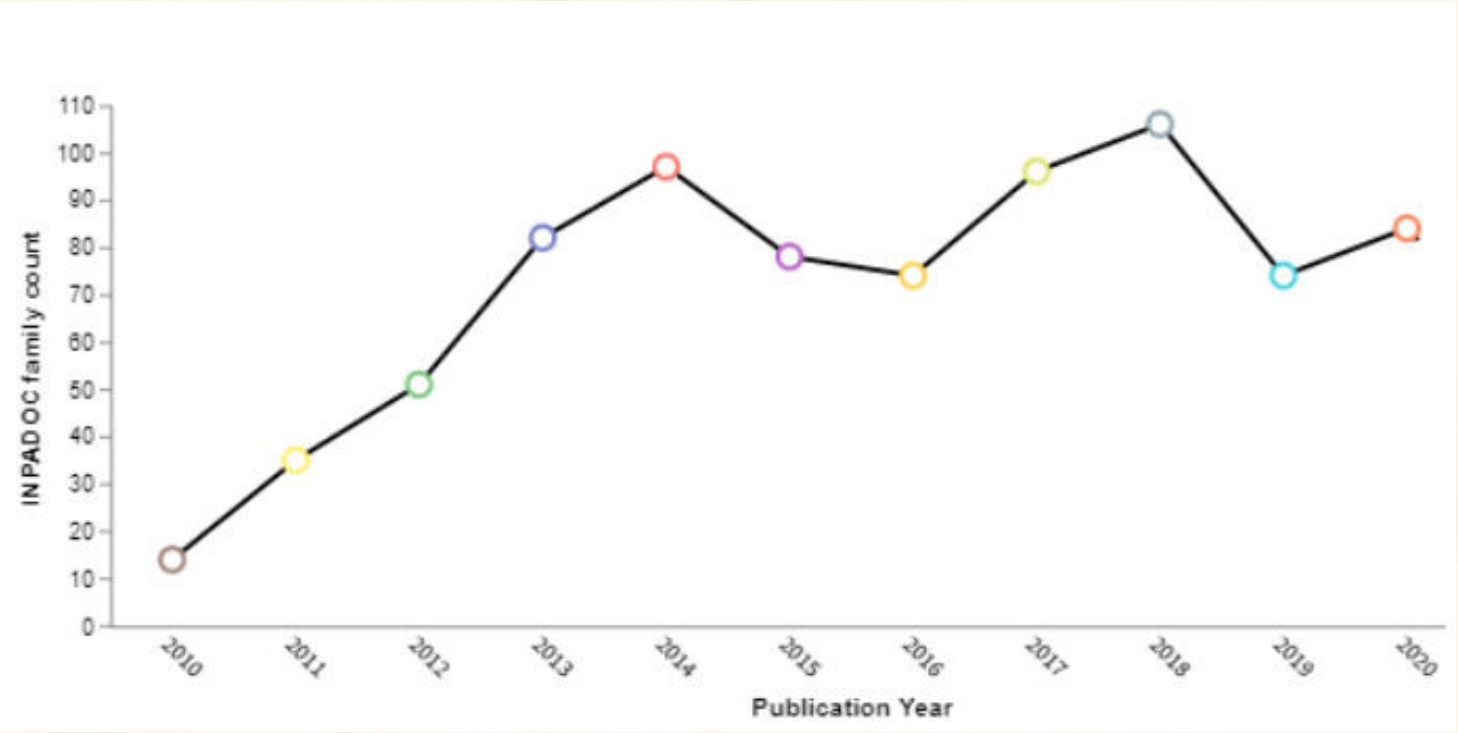
Bakery packaging – patent analysis

The analysis of publishing trend in the **period 2010-2020** shows a constant growth in the beginning of the decade.

In the last years, the level of patenting is stabilizing.

The topic is of interest and companies have started investing in this field of research. The increase of the trend is recent, which means that there is still room for improvements.



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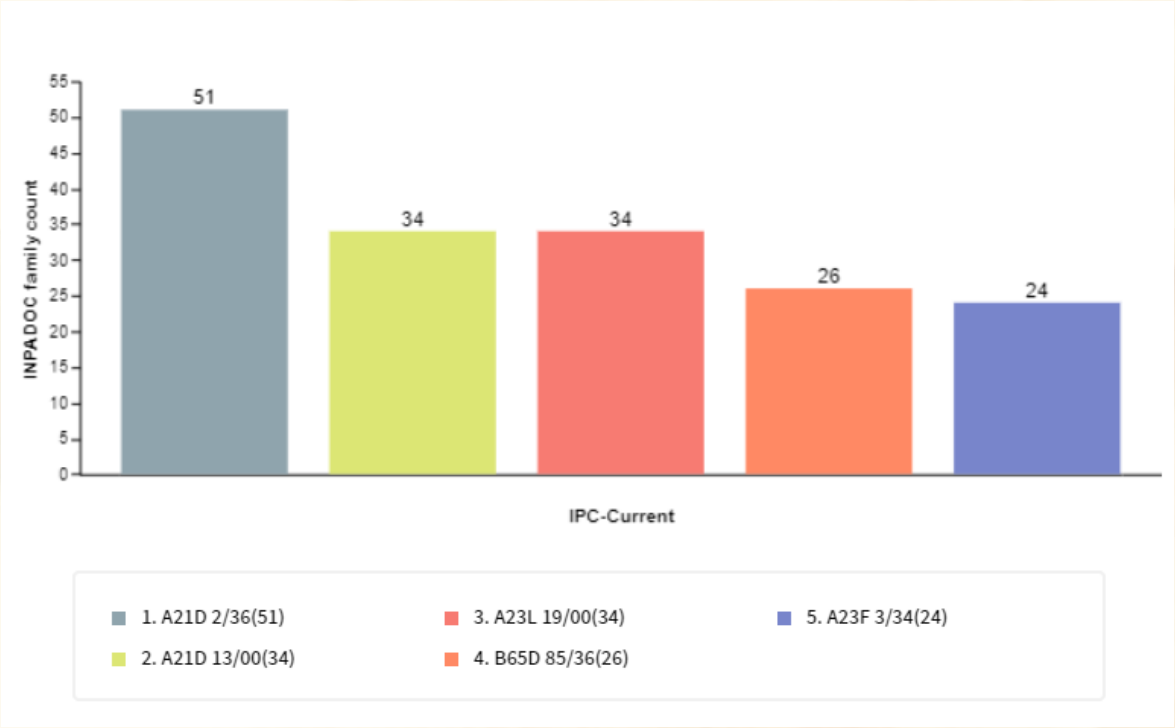
Bakery packaging – top IPC



IPC	Description	Records
A21D 2/36	Vegetable material	51
A21D 13/00	Finished or partly finished bakery products	34
A23L 19/00	Products from fruits or vegetables; Preparation or treatment thereof	34
B65D 85/36	for bakery products, e.g. biscuits	26
A23F 3/34	for bakery products, e.g. biscuits	24

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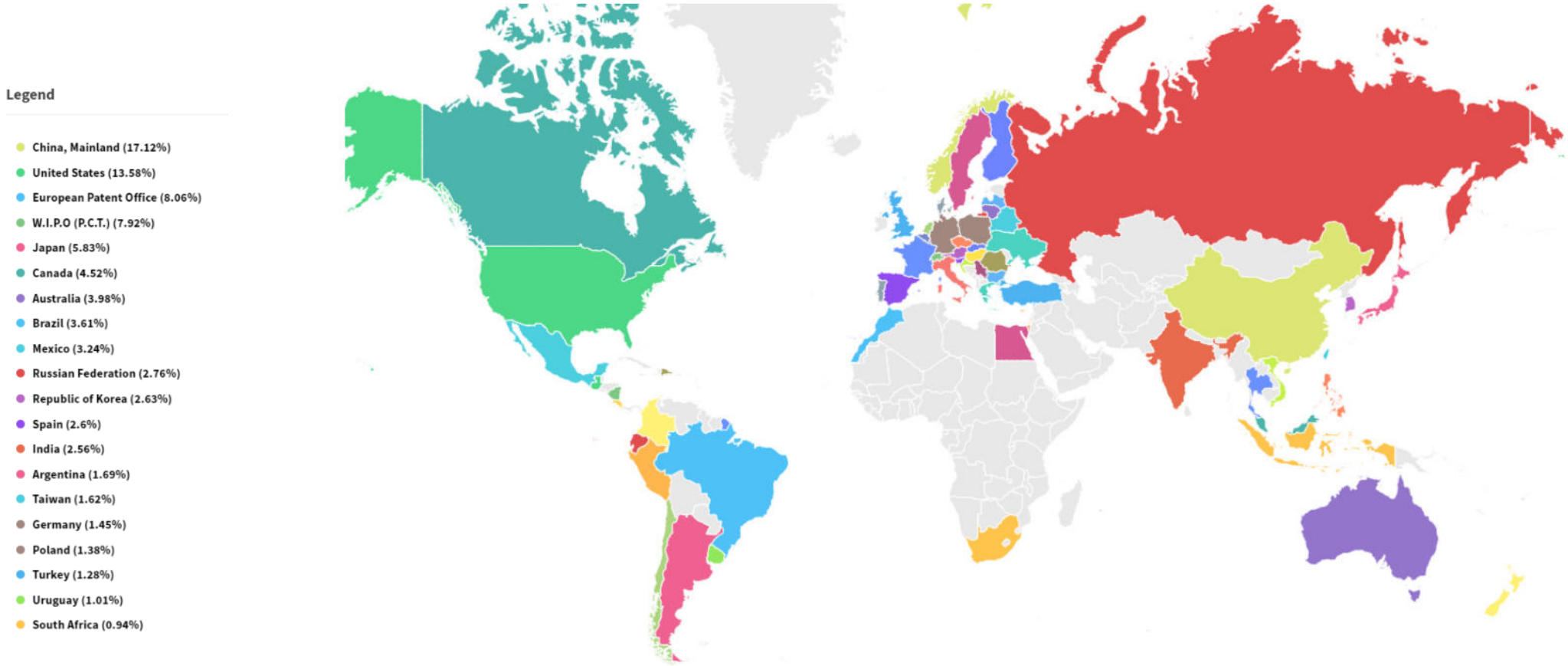
Bakery packaging – keywords

Bakery packaging – top markets

41% **41%** of worldwide filings in these results are granted, which indicates protection for active (Alive) patents in the relevant markets.

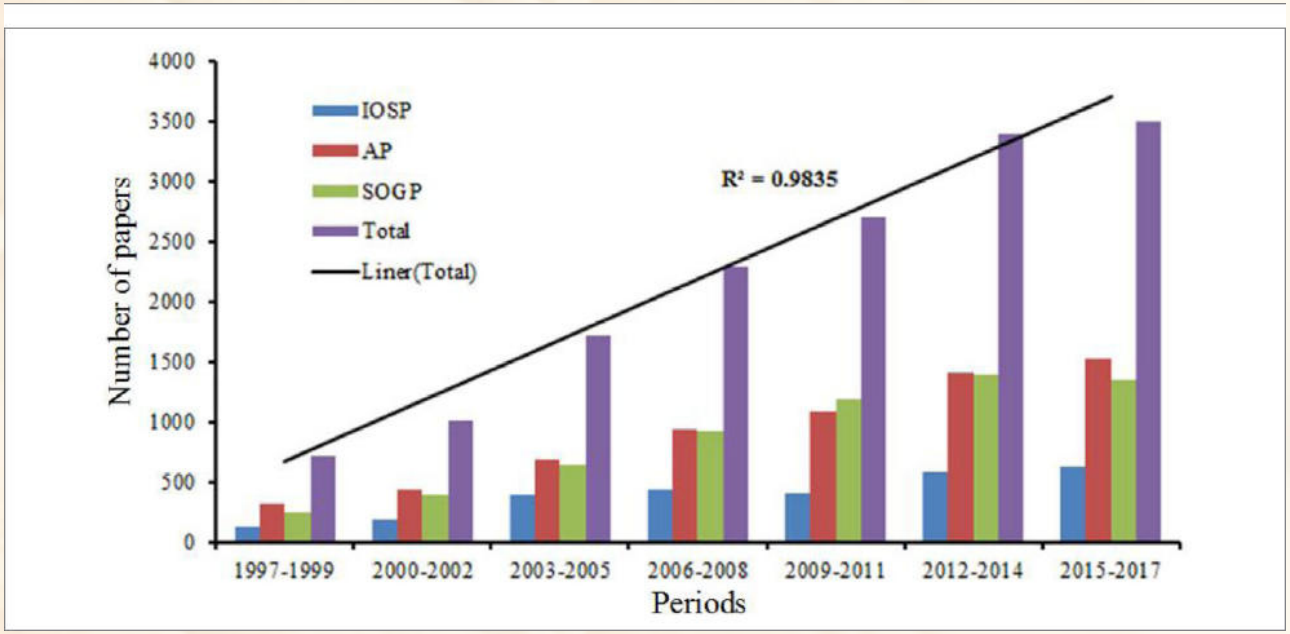
59% **59%** of this result set is pending applications. Higher percentages of applications point to a new or growing market, whereas lower application rates can point to already established markets or low growth areas.

0% Overall, **0%** of companies are filing in more than 4 countries. A global filing strategy may demonstrate increased market potential in this space.



Packaging - Future Trends

The graphic shows the yearly trend of the total number of publications on IOSP, AP, and SOGP over the past 20 years (1997-2017). **The number of peer-reviewed publications on food packaging innovations has increased steadily**. For the past two decades, the research interest in IOSP has lagged far behind the interest in AP, which can be attributed to AP providing protection beyond traditional protection and inert barriers to the external environment; it offers a relatively large number of possible methods of decreasing food waste and loss.



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Food packaging: A comprehensive review and future trends
JW Han et al. - Reviews in Food, 2018 - Wiley Online Library

Packaging - Intelligent or smart packaging

IOSP intelligent or smart packaging provides a total packaging solution that on the one hand monitors changes in a product or its environment (intelligent) and on the other hand acts upon these changes (active).

HARPAK ULMA, a packaging equipment manufacturer, realized its **packaging platforms smarter and more connected** would drastically improve Operation Technology and Information Technology staff operations. The company created a multi-phase, multi-year plan to digitally transform its portfolio and meet heightened customer expectations by delivering individual technologies and end-to-end packaging line automation, such as inspection, robotics, instrumentation, loading and conveyance, and palletizing equipment.

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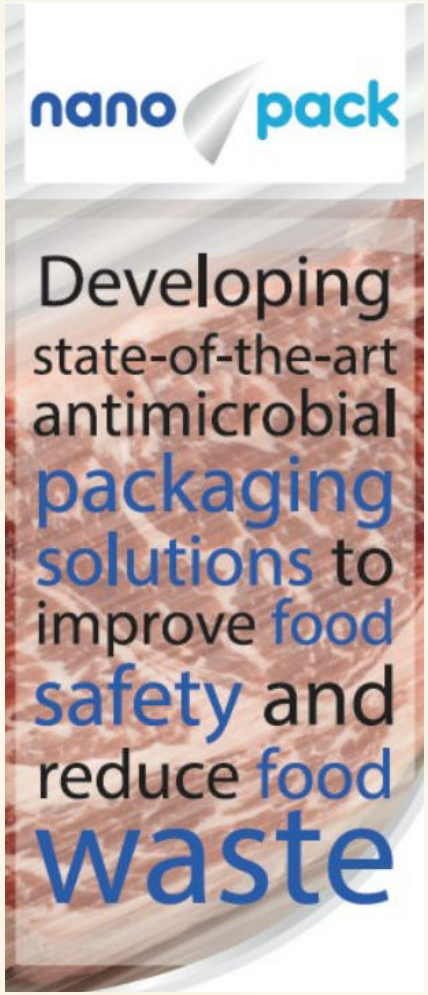
Vanderroost, M., Ragaert, P., Devlieghere, F., De Meulenaer, B., (2014). Intelligent food packaging: The next generation. Trends in Food Science & Technology, 39(1): 47-62
https://www.snackandbakery.com/articles/97205-case-study-harpak-digitally-transforms-smart-packaging-solutions

Packaging - active packaging

Process in the value chain

AP Active Packaging refers to the incorporation of additives into packaging systems with the aim of maintaining or extending meat product quality and shelf-life. One of the key areas of research for packaging of bread, cakes and biscuits is into the **antimicrobial properties of nanocomposites**. This is particularly important as consumers turn away from products containing preservatives. NanoPack is a 3-year EU funded project (www.nanopack.eu) aimed at developing and demonstrating a solution for extending food shelf life by **using novel antimicrobial surfaces applied in active food packaging products**. Several partners from across Europe and Israel are involved.

The Nanopack technology consists in the encapsulation of essential oils with a naturally-occurring antimicrobial activity into Halloysite Nanotubes (HNTs), which are subsequently mixed with polymers to make packaging films. As the antimicrobial agents are released as a vapor from the packaging materials into the headspace, they can sanitize both the product surface and the headspace.



A critical review on intelligent and active packaging in the food industry: Research and development MS Firouz, K Mohi-Alden, M Omid - Food Research International, 2021 – Elsevier
https://www.nanopack.eu/

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Packaging – SOGP sustainable or green packaging

What is sustainable packaging?

Simply put, it is packaging that, over time, reduces its environmental footprint.

This can happen in a number of ways:

- **Ingredients:** Using raw 100% recycled or raw materials
- **Production process:** By minimising the production process, supply chain and carbon footprint
- **Reusability:** Creating a circular economy around the packaging, extending its life cycle and usability.

Unfortunately, most packaging is designed as single-use, and is typically thrown away rather than reused or recycled. According to the US Environmental Protection Agency (EPA), food and food packaging materials make up almost half of all municipal solid waste. Sabic, St. Johns Packaging and Kingsmill Launch World's First Ever Bread Packaging Based on Recycled **Post-Consumer Plastic**.

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https://packhelp.com/sustainable-packaging/
https://www.snackandbakery.com/articles/97445-case-study-sabic-st-johns-packaging-and-kingsmill-launch-worlds-first-ever-bread-packaging-based-on-recycled-post-consumer-plastic

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Conclusions - Packaging

- Food packaging technologies are improving continuously in response to lifestyle changes and the ever-increasing demand for high-quality and safe foods.

- According to patent scenario analysis the packaging in the bakery sector id a topic of interested and the companies have started investing in this field of research.

- Innovation and research are focused on three main types of packaging: intelligent or smart packaging; active packaging and sustainable or green packaging. It emerges that additional effort should be focused on overcoming the technical constraints and high costs associated with these technologies, which have been the main factors preventing wider implementation and the development of additional commercial applications for new types of packaging materials in the food packaging industry.

- It has been highlighted how the sustainability improvements can positively affect the competitiveness of a company, opening new opportunities for its market.

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