



The economic impact of NanoCellulose

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ArboraNano
The Canadian Forest NanoProducts Network

International Symposium on Assessing the Economic Impact of Nanotechnology

27 – 28 March 2012, Washington DC

Outline

- ArboraNano
- What is NanoCellulose?
- Suppliers of NanoCellulose
- What can we make from it?
- Incentives for using NanoCellulose
- Production capacity and demand
- Health, safety, environment, certification
- Potential Benefits of NanoCellulose
- Conclusions

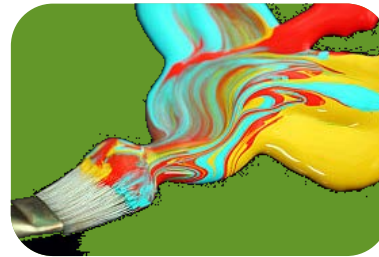
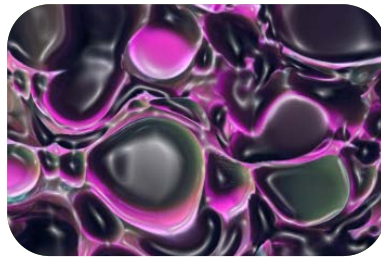
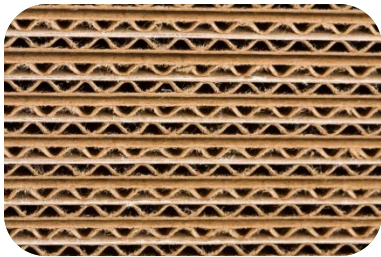


ArboraNano

The Canadian Forest NanoProducts Network

We are a Business-Led Network of Centres of Excellence, funded by Canadian Federal Government with matching funding from Industry and Provincial Governments.

We stimulate innovation of high-value nanoproducts making use of Canada's renewable forest resources.



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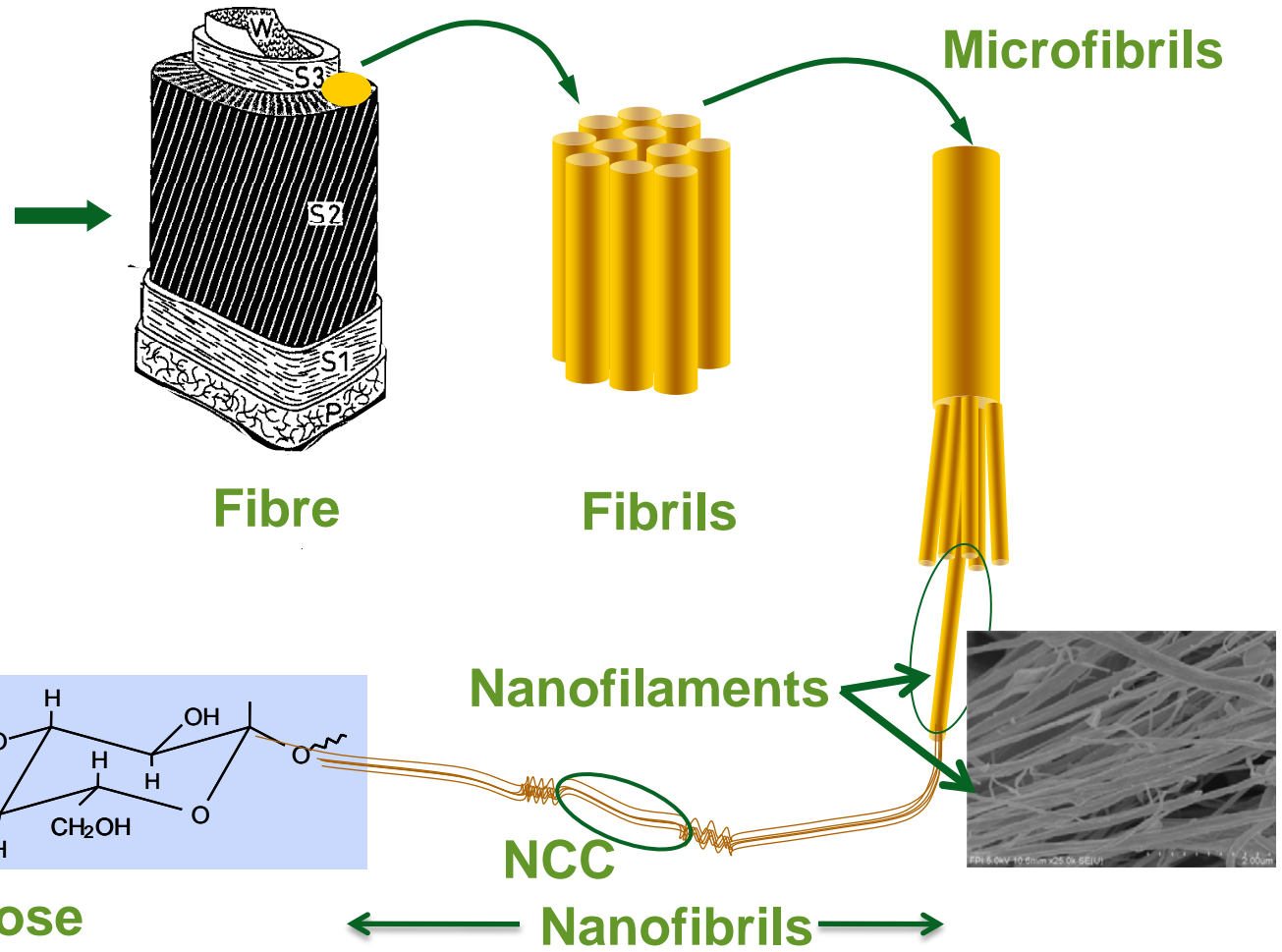
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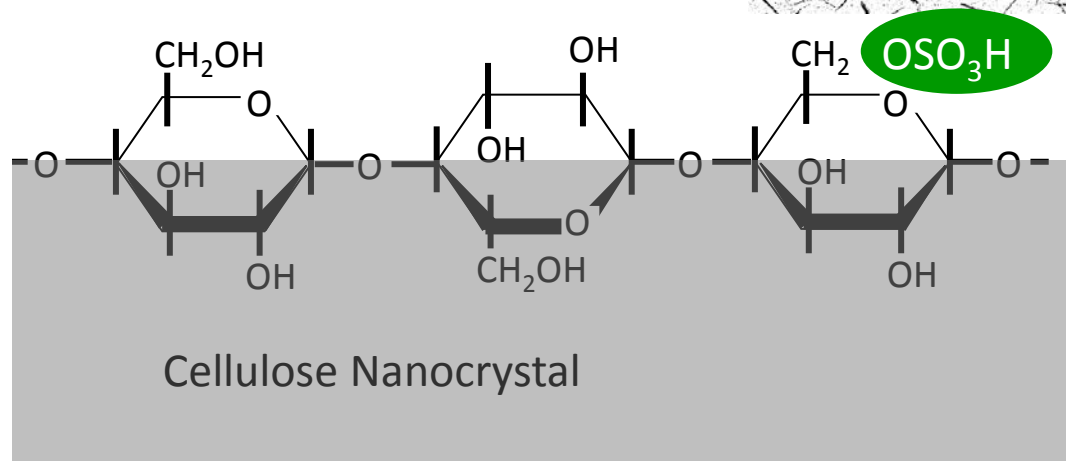
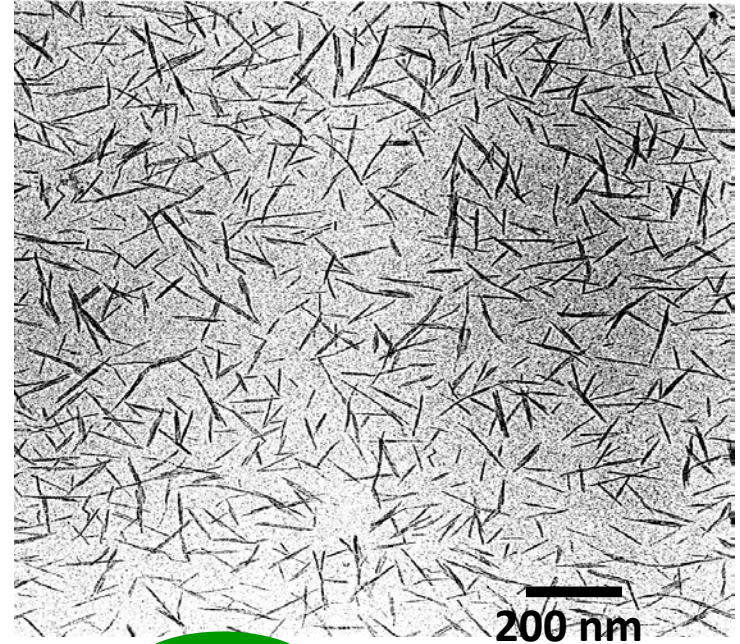
What is NanoCellulose?

Fibres: A Goldmine of Suprastructures



NanoCrystalline Cellulose (NCC)

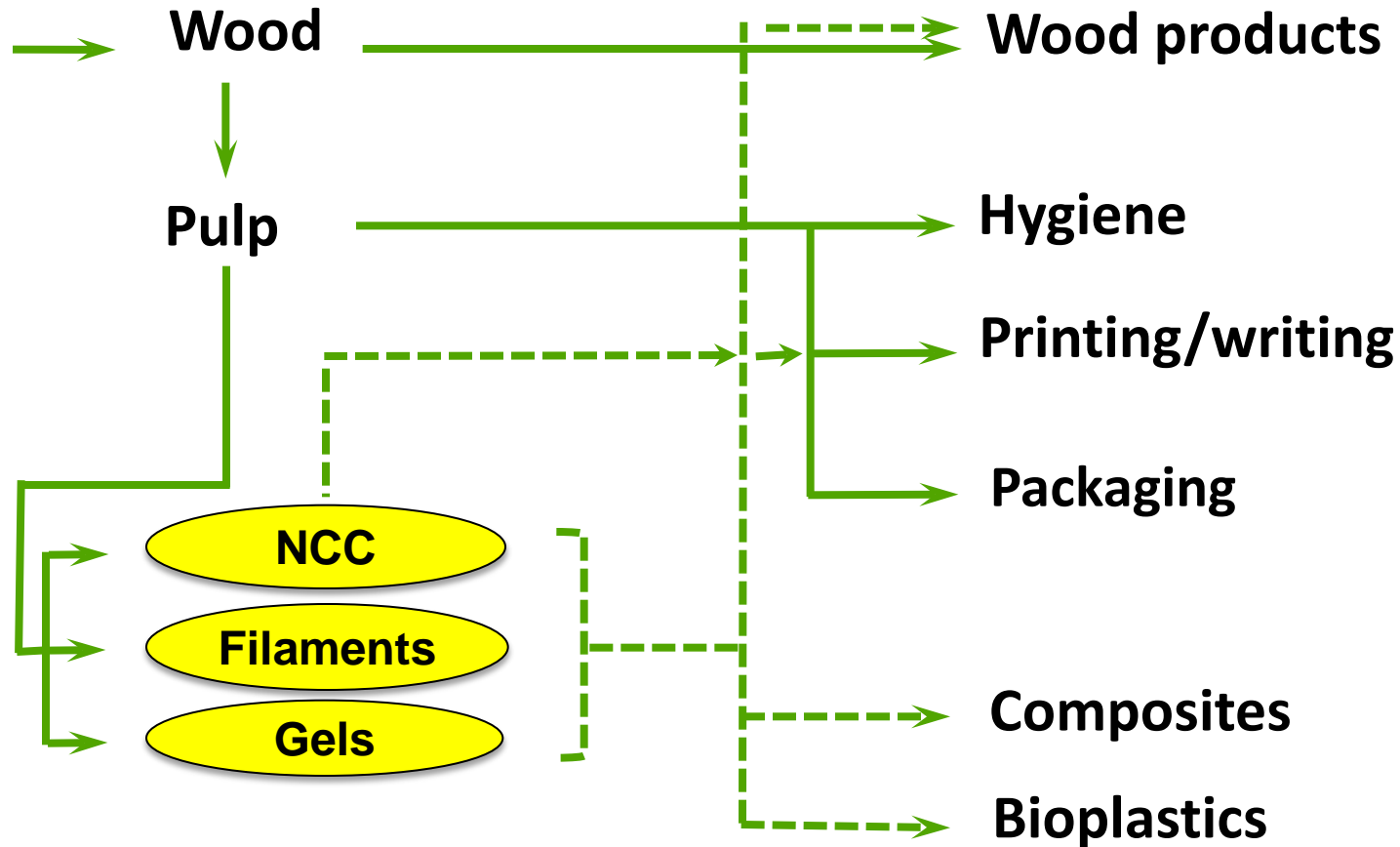
- Elementary unit of crystalline cellulose
- Dimensions: 110 nm x 5 nm
- Unique Properties:
 - **Strength**
 - **Surface Area**
 - **Optical Properties**
 - **Self-assembly**



High Reinforcement Potential

	<i>Density (g/cm³)</i>	<i>Tensile strength (MPa)</i>	<i>Young's modulus (GPa)</i>	<i>Elongation at break (%)</i>
NCC	1.5	10,000	150	6.7
SWCNT	1.2	30,000	1054	6
MWCNT	2.6	30,000	1000-1280	12.5
Carbon	1.7	4,000	230-240	1.4-1.8
Kevlar 29	1.44	2,800	183	4
Aramid	1.4	3,000-3,150	63-67	3.3-3.7
E-glass	2.5	2,000-3,500	70	2.5
302 Stainless steel	7.7-8.1	1,280	210	
Kraft softwood	~1.5	~700	~20	~2-4
Cotton	1.5-1.6	287-800	5.5-12.6	~7-8
Jute	1.3-1.45	393-773	13-26.5	1.16-1.5
Flax	1.50	345-1,100	27.6	2.7-3.2

Focus on Three New Product Families





Suppliers of NanoCellulose

NCC Production Capacity

- **University Laboratories**
 - g /week
- **FPIinnovations**
 - pilot plant capacity of 10 Kg/week of NCC (current rate)
 - <http://www.newswire.ca/en/story/795699/fpinnovations-inaugurates-its-new-research-facilities-for-nanocrystalline-cellulose>
- **The US Forest Service's Forest Products Laboratory**
 - pilot plant capacity of 35-50 kg /day of NCC (projected rate)
 - <http://www.tappi.org/content/events/11NANOSTDS/paper/ireland.pdf>
- **Alberta Innovates – Technology Futures**
 - pilot plant capacity of 100 kg/week of NCC (projected rate)
 - <http://www.frogheart.ca/?p=3886>
- **Bio Vision Technologies Inc.**
 - NCC (carboxylated) – Pilot plant capacity of 4 tonnes/year (current rate)
 - <http://www.biovisiontech.ca/technology.html>
- **Celluforce Inc.**
 - NCC Demonstration plant capacity of 1 tonne/day (Projected rate)
 - <http://www.newswire.ca/en/story/911413/celluforce-celebrates-the-inauguration-of-the-world-s-first-nanocrystalline-cellulose-demonstration-plant>
- **Melodia, Israel**

CelluForce Inc. – Windsor, Qc, Canada



NFC Production Capacity

- **Inventia** (Stockholm, Sweden)
 - NFC demonstration plant capacity of 100 kg/day
 - <http://www.tappi.org/Downloads/Conference-Papers/2011/2011-TAPPI-International-Conference-on-Nanotechnology-for-Renewable-Materials/11NANO44.aspx>
- **The US Forest Service** in collaboration with the University of Maine
 - building a demonstration plant with a design capacity of 500 kg/day of NFC
 - <http://www.tappi.org/content/events/11NANOSTDS/paper/ireland.pdf>
- **J. Rettenmaier & Söhne GmbH** (Germany)
 - <http://www.jrs.de/wEnglisch/index.shtml>



Other Sources of NanoCellulose



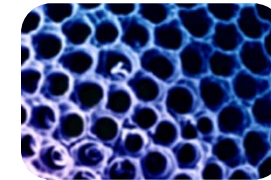
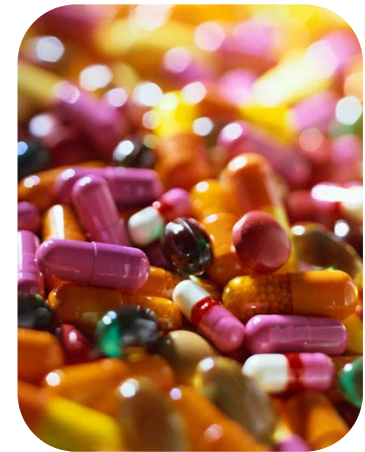
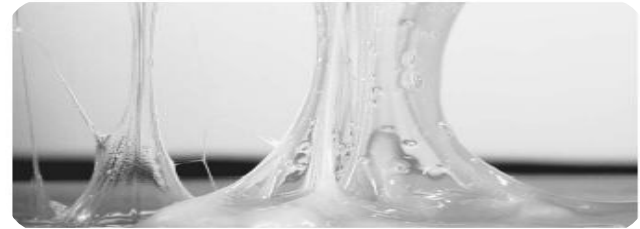
- **Borregaard**, Norway
- **DaiCel** , Japan
- **Nippon Paper**, Japan
- **Stora Enso**, Finland
- **UPM-Kymmene**, Finland
- **Verso Paper**, USA



What Can We Make from NanoCellulose?

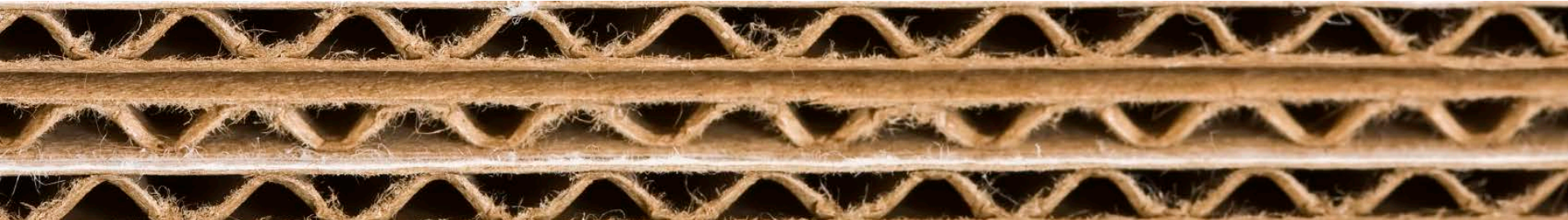
Intermediate products from NanoCellulose

- Paints, varnishes, coatings
- Films
- Adhesives
- Thermosets
- Thermoplastics
- Reinforced Bio Polymers
- Synthetic fibres and textiles
- Nanocomposites
- Cosmetics and pharmaceuticals
- Optical devices
- Viscosity modifiers and flow aids
- Mesoporous films and membranes
- Catalysts
- Flexible displays
- Printed films
- Hydrogels
- Building products



Products from CNF

- Films and flexible packaging
- Compostable replacement for plastic film
 - Trash bags and grocery bags
- High-quality paper and board products
- Super-strong pulp
- Mineral paper
- Strong tissue products
- Wood fibre composites
- Wood panels



ArboraNano Distribution of Funding



7% aerospace



20% automotive



21% forest products



11% oil & gas



3% health



38% varia

Distributed by Targeted Development

- 
- Acrylics
 - Composites
 - Paints
 - Coatings/ Sealants
 - Epoxies/ Adhesives

7% aerospace

- 
- Cushions
 - Headliners
 - Headlamps

20% automotive

- 
- Mechanical Paper
 - Packaging
 - LWC Paper
 - Wood Adhesives

21% forest products

- 
- Drilling Mud

11% oil & gas

- 
- Pharmaceuticals
 - Personal Care

3% health

- 
- Coatings/Paint/Ink
 - Textiles
 - Films
 - Membranes
 - Construction

38% varia



Incentives for Using NanoCellulose

Incentives for:

Producer:



Forest Industry

Consumer:



Public

User:



Manufacturing Industry

Incentives for the Producer

- **Producer – Forest Industry**

- Availability of Forest Biomass
- Well developed harvesting, handling & processing technologies
- Declining demand for traditional products in traditional markets
- Need to derive greater value from harvested biomass



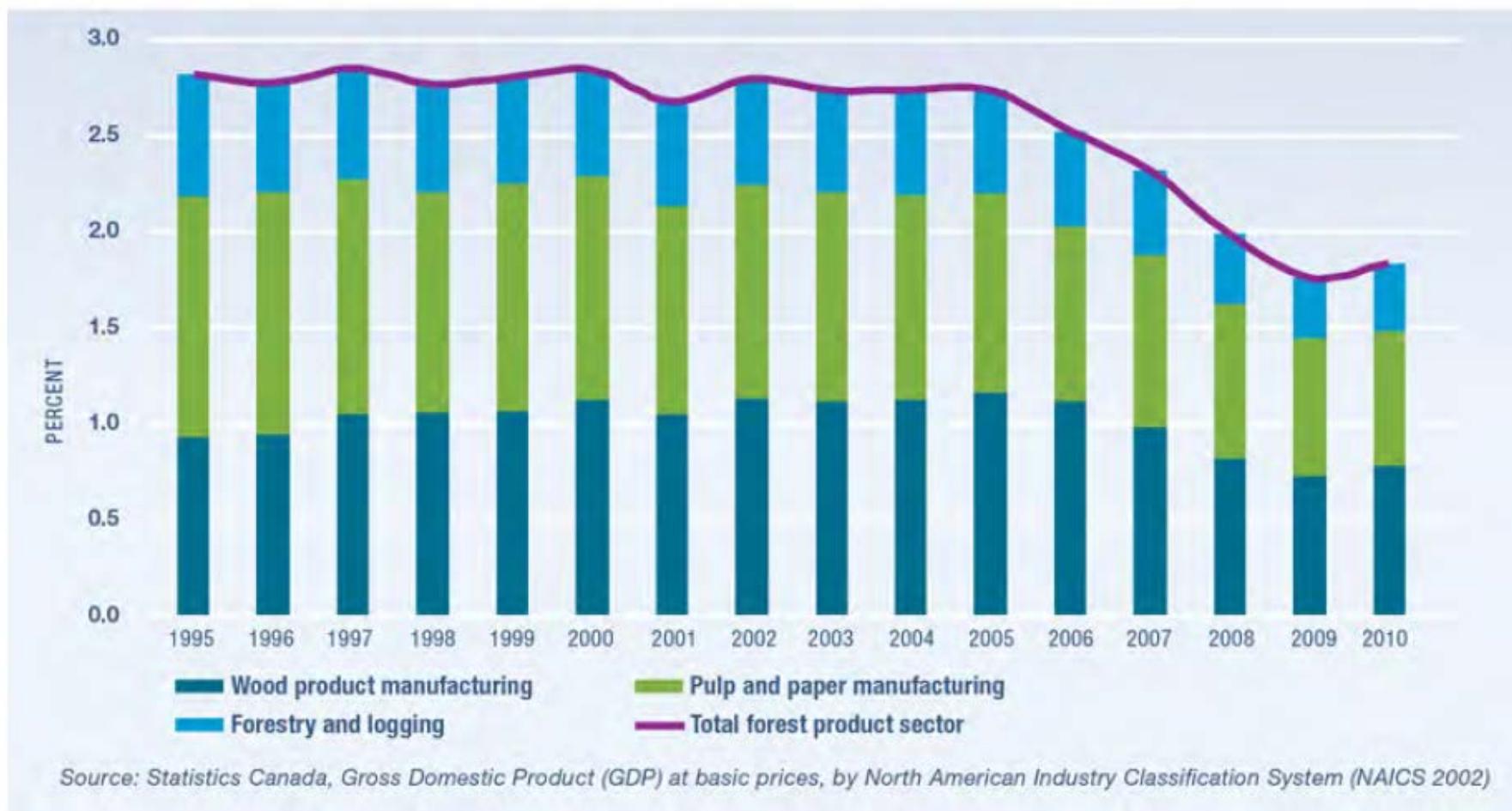
Availability of Forest Biomass



A Canadian perspective

- **Supply**
 - Canada has ~400 million hectares of forests
 - 10% of the world's forest
 - 30% of the world's boreal forests
 - Annually ~1% of Canada's forests harvested
- **Reduced demand for traditional Canadian forest products**
 - Loss of employment
 - Availability of excess forest biomass

Forest Product Sector Contribution to GDP



The State of Canada's Forests – Annual Report 2011 – Natural Resources Canada

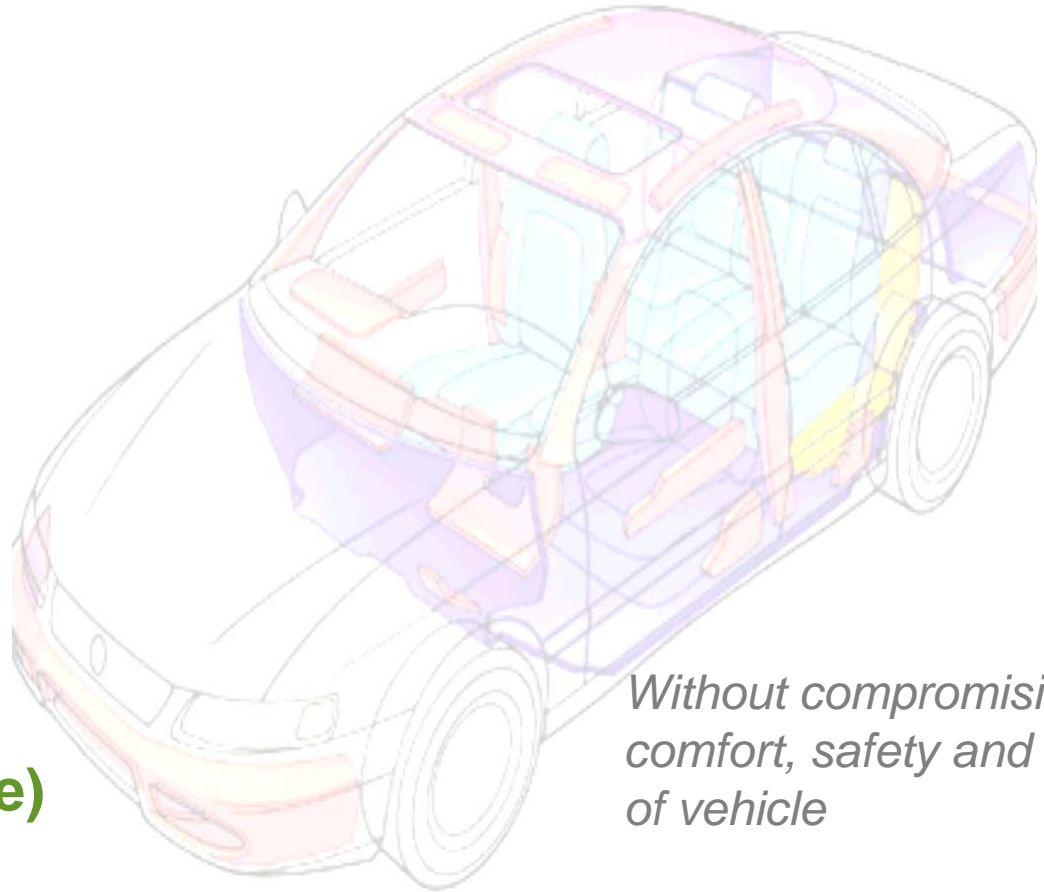
Incentives for Manufacturing Industry

- New source of raw material with wide, largely unexplored range of applications
 - New products
 - New business opportunities
- Security of supply
 - Sustainable renewable resource
 - Availability and price stability
- Source of “green” materials
 - Reduced carbon footprint
 - Recyclable
 - Reusable
 - Compostable



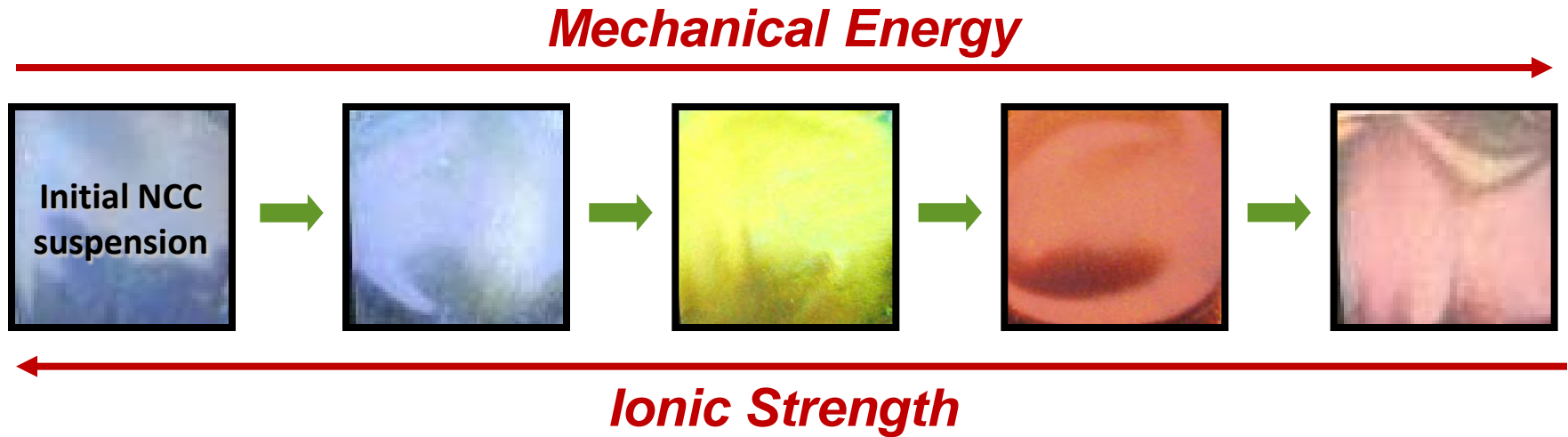
Automotive Industry's 10 Commandments

1. **Lighter**
2. **Stronger**
3. **Thinner**
4. **Durable**
5. **Acoustical**
6. **Greener**
7. **Cleaner (VOC free)**
8. **Recyclable**
9. **From renewable/secure resources**
10. **Cost effective**



*Without compromising
comfort, safety and appeal
of vehicle*

Control of Iridescence Colour Reflection



- Strong and flexible film
- From UV to Infra-Red Reflection
- Coated on glass, plastic, metal, etc.
- No additives required



Iridescent NCC Films

- Deposition on glass, plastics, etc.
- Applications in cosmetic and architectural industries
- Security paper
- Inks, varnishes and coatings
- IR reflectance: Thermal barriers
- UV reflectance: UV barriers

Incentives for the Consumer & Public

- **Environmental stewardship**

- Sustainable renewable resources
- Reduced carbon footprint
- Recyclable
- Reusable
- Compostable



- **Security of supply**

- Price and price stability

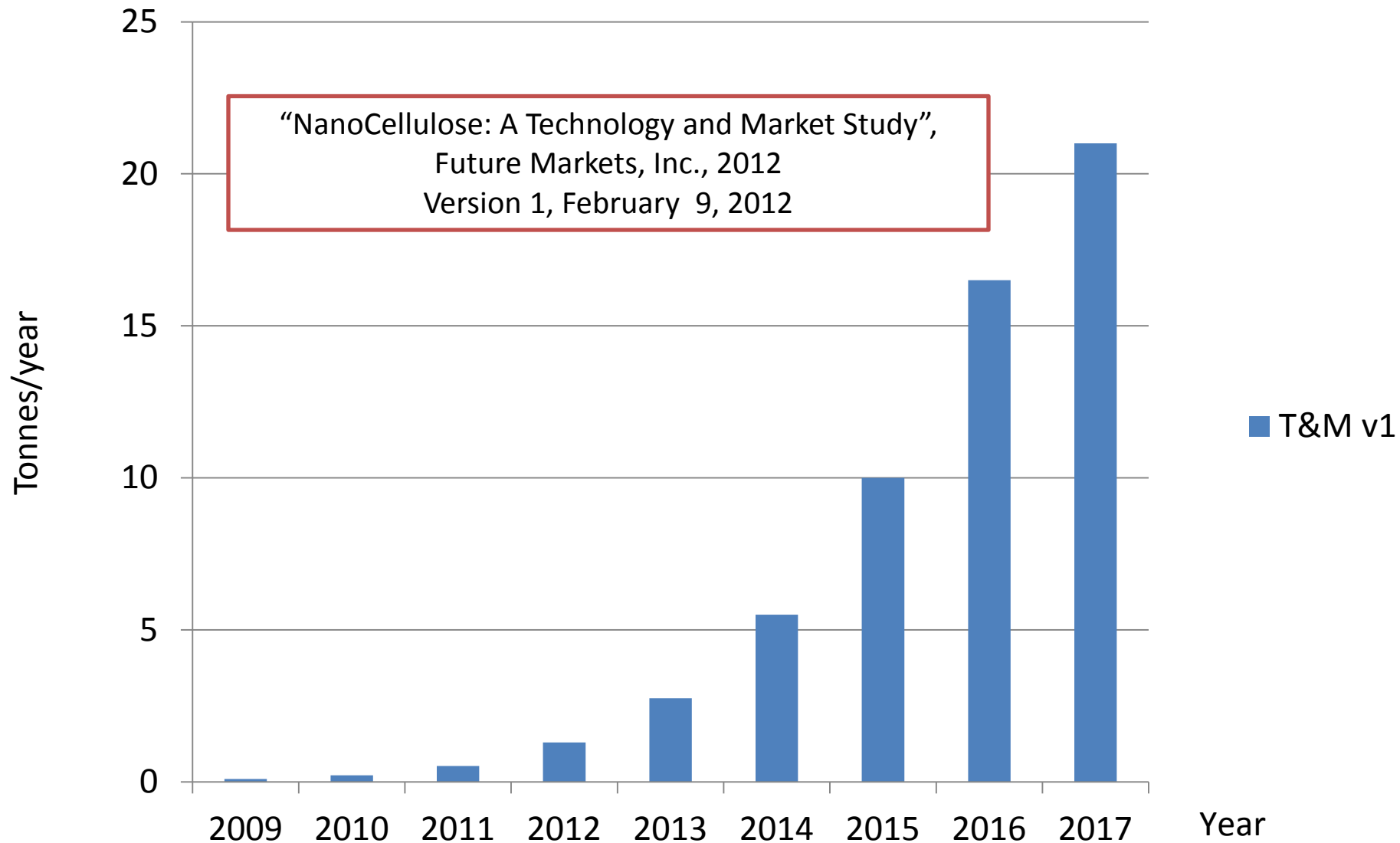
- **Exciting new products**

- **Employment**

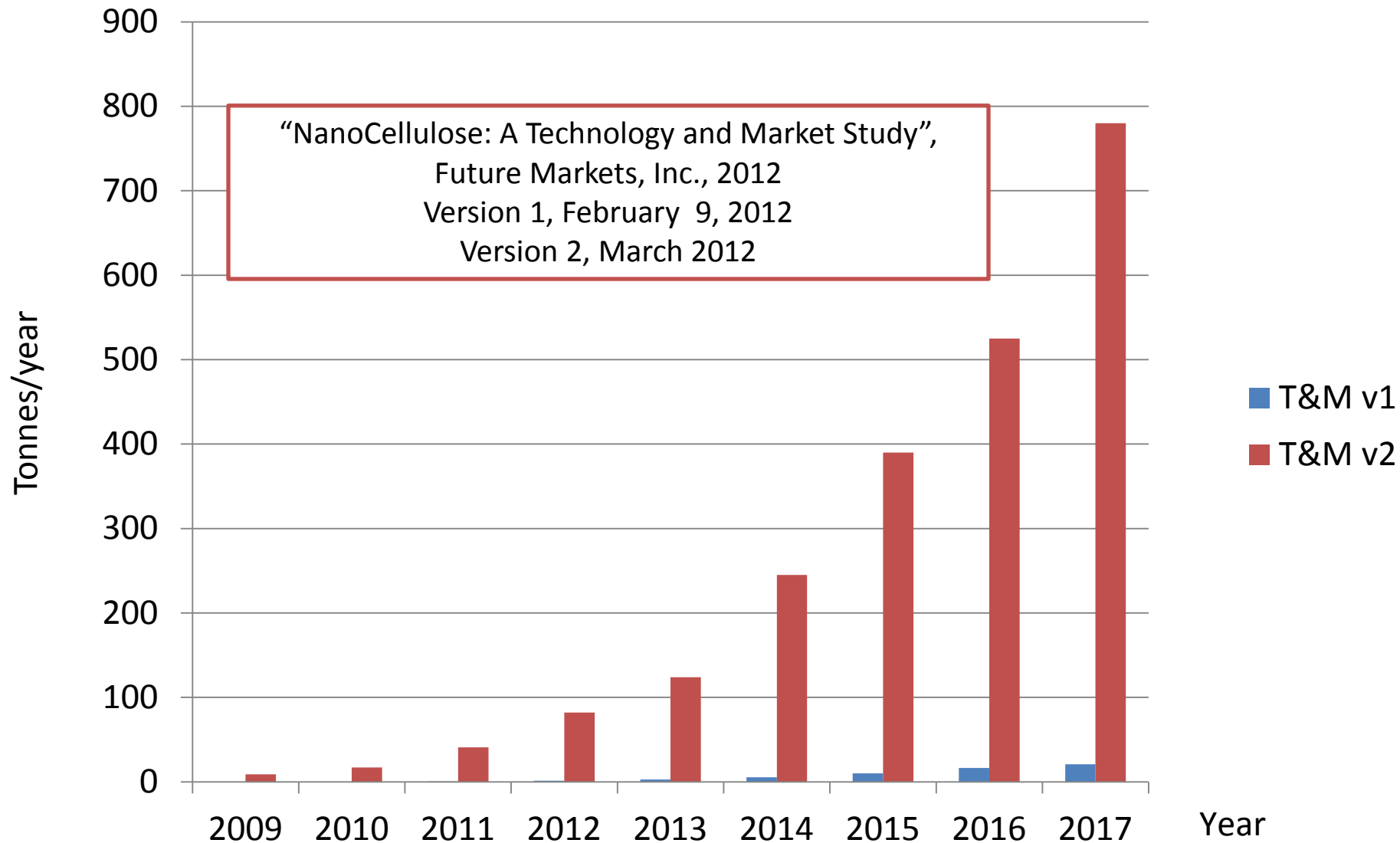


Production Capacity and Demand

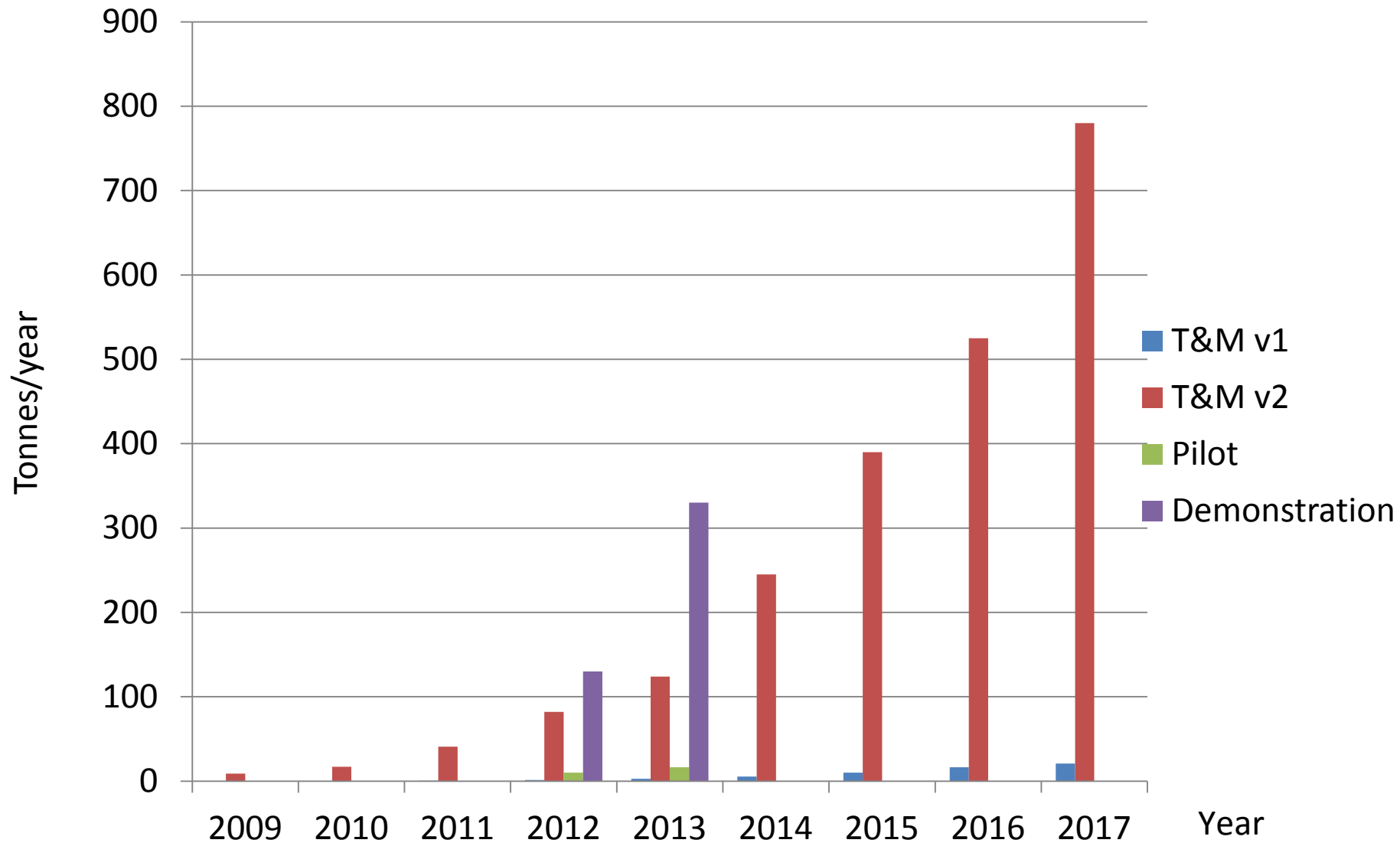
NanoCellulose Production Capacity



NanoCellulose Production Capacity



NanoCellulose Production Capacity



Summary of Potential Markets

NCC Application Summary (2007)	Size (000 tonnes)	Assumed NCC content	Assumed Market Penetration	NCC demand (000 tonnes)	Geography	Growth
Paints and Coatings	3,980	2%	5%	4	US	2%
Composites	2,000	2%	5%	2	US	3%+
Films & Barriers	1,730	50%	5%	43	NA	5%
Paper (Retention and Binder)	43	100%	5%	2	NA	-4%
Excipients	3,903	10%	5%	20	global	4%
Natural Textiles (wool cotton)	28,330	2%	5%	28	global	4%
Manufactured Textiles	46,280	2%	5%	46	global	4%
Cosmetics	large (US shipments \$40 billion)				global	4%
Total	86,265			145		



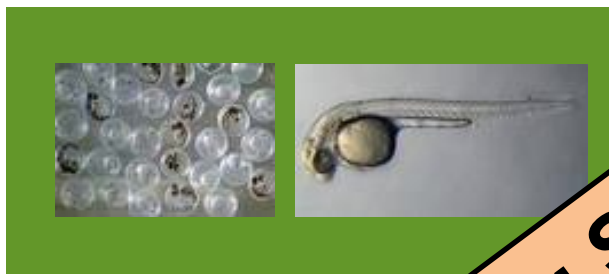
Health & Safety, Environment, and Certification

Ecotoxicological Assessment



FPInnovations:

Acute and chronic testing with fish and water



University of Ottawa:

atching and survival tests with Zebra fish



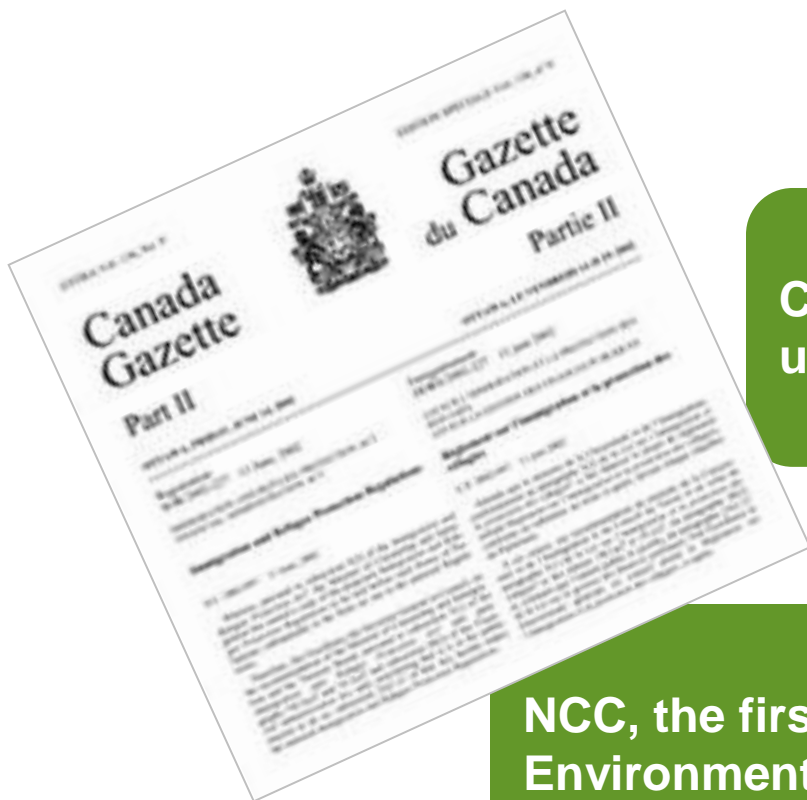
Environment Canada:

Tests with various aquatic species

NON-TOXIC: Similar to MCC and Table Salt

Certification of NCC

**NanoCrystalline Cellulose is covered by the
Canadian Environmental Protection Act**



**Canadian regulatory authorities approve the
use of NCC “without restrictions” — *January 2012***

**NCC, the first nanomaterial to be included on
Environment Canada's Domestic Substances List (DSL)**

Standardization

- **International NanoCellulose Standards Committee (INSCC)**
 - TAPPI workshops
 - Arlington VA, June 9, 2011
 - Roadmap for the Development of International Standards for NanoCellulose, Draft 4 – October 24, 2011
 - Montreal QC, June 7, 2012
- **ISO Technical Committee 229 (TC229)**

Potential Impact of NanoCellulose

- NanoCellulose has a substantial potential for **economic growth**
- Development of new products will lead to **retention of high-value industries and employment** in manufacturing sector
- NanoCellulose can contribute to **improved citizen health** through the development of new health care products
- **Social and economic benefits** will be seen as a consequence of innovation leading to new business opportunities
- NanoCellulose is a significant component of the drive towards the development and adoption of environmentally sound manufacturing technologies needed to address **climate change**
- **Global challenges** include the development of sound international standards to facilitate global trade, quality assurance and the maintenance of high environmental and safety standards

Conclusions

- **NanoCellulose is here to stay**
 - Quickly becoming available commercially world wide
- **Manufacturing technologies improving quickly**
 - Strong emphasis on rapid scalability
- **NanoCellulose now available in large quantities**
 - Suitable for industrial scale development
- **Health and safety**
 - Strong efforts made to ensure safety of these new materials in the environment, the workplace and the products

Conclusions (cont'd)

- **Application opportunities**
 - Virtually unlimited
- **Petrochemical industry will not disappear**
 - Nearly a century of development experience
 - Strong competition for NanoCellulose materials
 - Forest products industry will not commercialize on their own
 - Partnerships with manufacturing industries are key to the successful introduction of NanoCellulose
- **“Green” is a fragile advantage for NanoCellulose**
 - Cost and performance are paramount
 - “Green” is a bonus



Thank you for your attention!