NEA NI2050 Initiative

Global Survey Outcomes

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ADV PANEL and NDC Meetings
September 2017

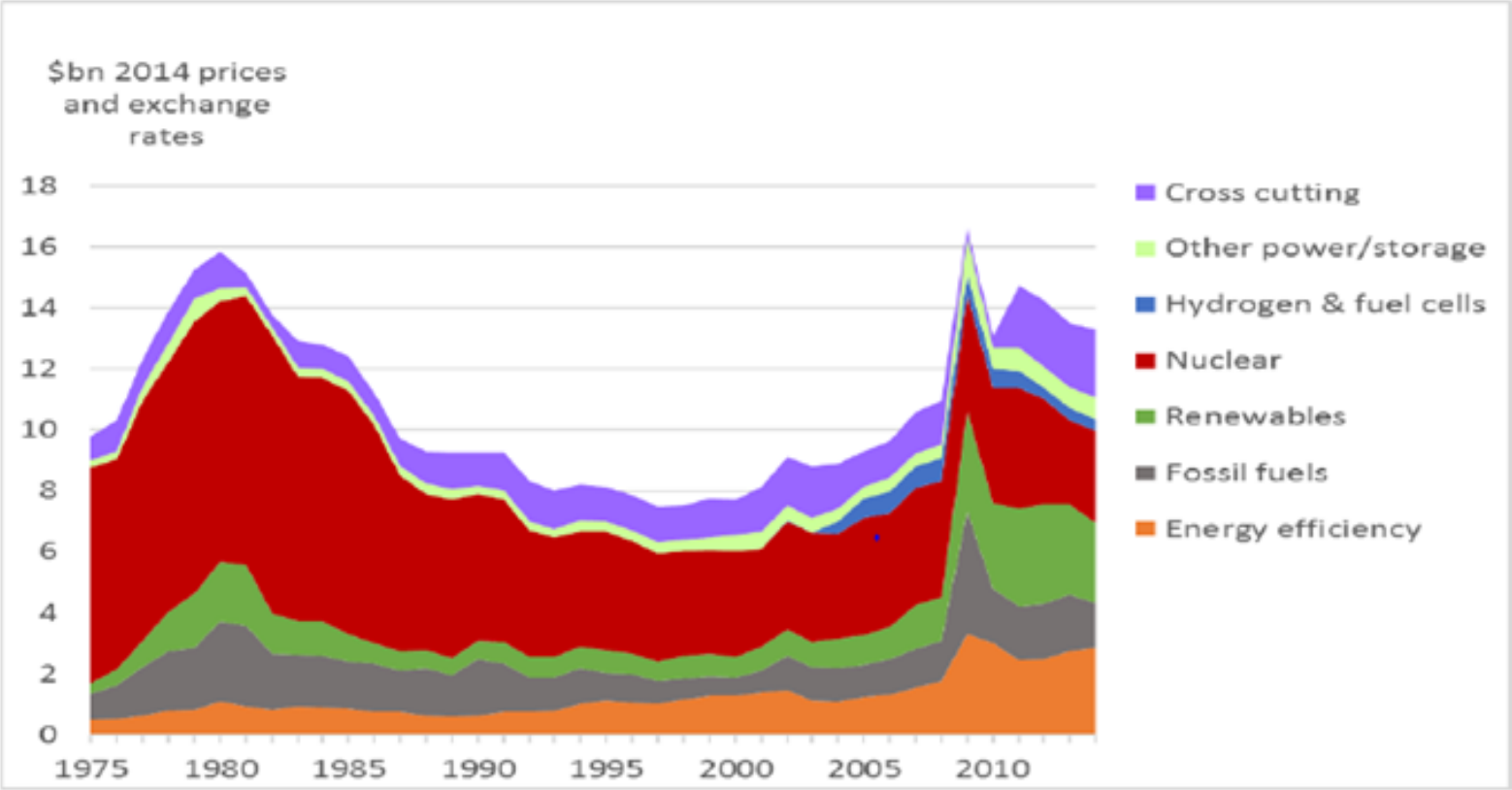
ELEMENTS of the SURVEY

- Discussed and agreed at the NI2050 Launch Conf in 07/2015
- Objective : picture of actual state of nuclear research
- Technical and Budgets (Public + Private *(not successfull)*)
- By country, via a nominated contact point (through NDC)
- Period 2010-2015 (6 years)
- 9 Categories (and subcategories)
- Survey sent out September 2015
- Initial deadline November 2015

Comments:

- Many delays, large variety of returns (both in scope and budgets)
- Comparison with IEA yearly surveys since 1975 – using other categories
- Request from AP to look at trends – done using IEA 2000-2015

GLOBAL: ALL Energy R&D Public BUDGETS



Source: Energy Technology RD&D, IEA (2015).

POST COP21 Mission Innovation: R&D x 2

	AUSTRALIA	BRAZIL	CANADA	CHILE	CHINA	DENMARK	EUROPEAN UNION	FINLAND	FRANCE	GERMANY	INDIA	INDONESIA	ITALY	JAPAN	KINGDOM OF SAUDI ARABIA	MEXICO	NETHERLANDS	NORWAY	REPUBLIC OF KOREA	SWEDEN	UNITED ARAB EMIRATES	UNITED KINGDOM	UNITED STATES
INDUSTRY & BUILDINGS	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
VEHICLES & OTHER TRANSPORTATION	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●		●	●	●	●			●
BIO-BASED FUELS & ENERGY	●	●	●			●	●	●	●	●	●	●	●			●	●	●	●	●	●	●	●	●
SOLAR, WIND & OTHER RENEWABLES	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
NUCLEAR ENERGY	●	●	●		●											●			●		●	●	●	●
HYDROGEN & FUEL CELLS	●	●	●		●	●	●	●	●	●	●			●	●	●	●	●	●			●	●	●
CLEANER FOSSIL ENERGY		●	●		●	●		●		●	●	●			●		●		●					●
CO_2 CAPTURE, UTILIZATION & STORAGE	●	●	●		●	●	●		●	●	●	●		●	●	●	●	●	●		●	●	●	●
ELECTRICTY GRID	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●
ENERGY STORAGE	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
BASIC ENERGY RESEARCH	●		●			●	●		●	●	●	●	●	●	●		●	●		●	●			●

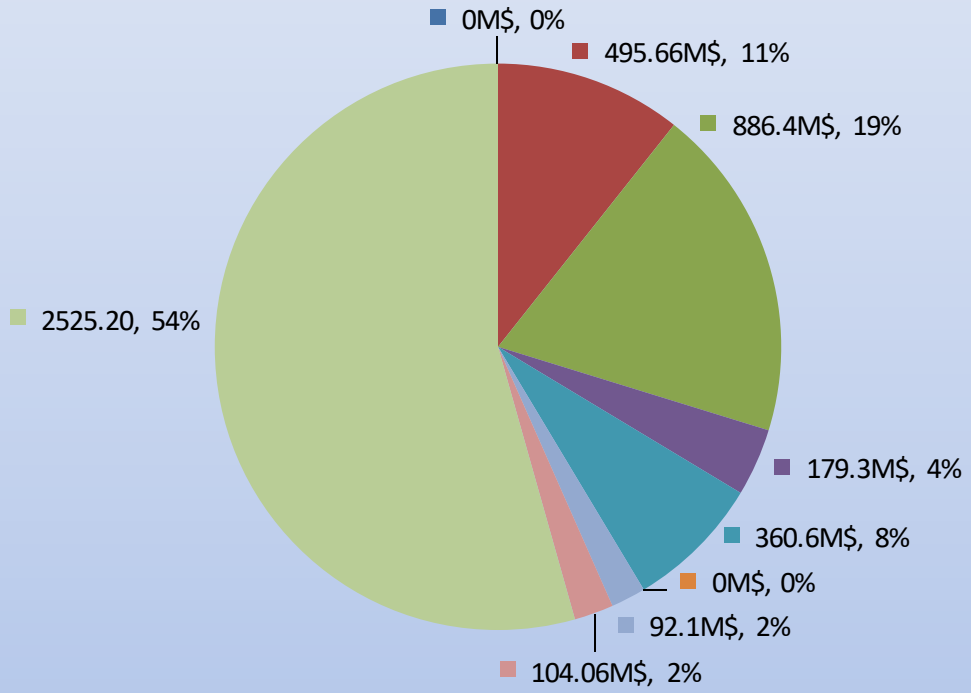
Indicators are for key areas of R&D investment, but do not imply a comprehensive representation of a country's full R&D portfolio.

Source: Mission Innovation

NI2050 SURVEY: Consolidation of BUDGET Numbers

- Large Excel Tables containing all numbers from the survey, per year, categories/subcategories, subtotals and totals,…
- Manual calcs needed
- Conversion National Currencies to yearly USD, using official OECD conversion rates
- Large set of graphs
- We may provide the excel tables if desired for own use

USA: Total Budget Categories 1-9 2010-2015



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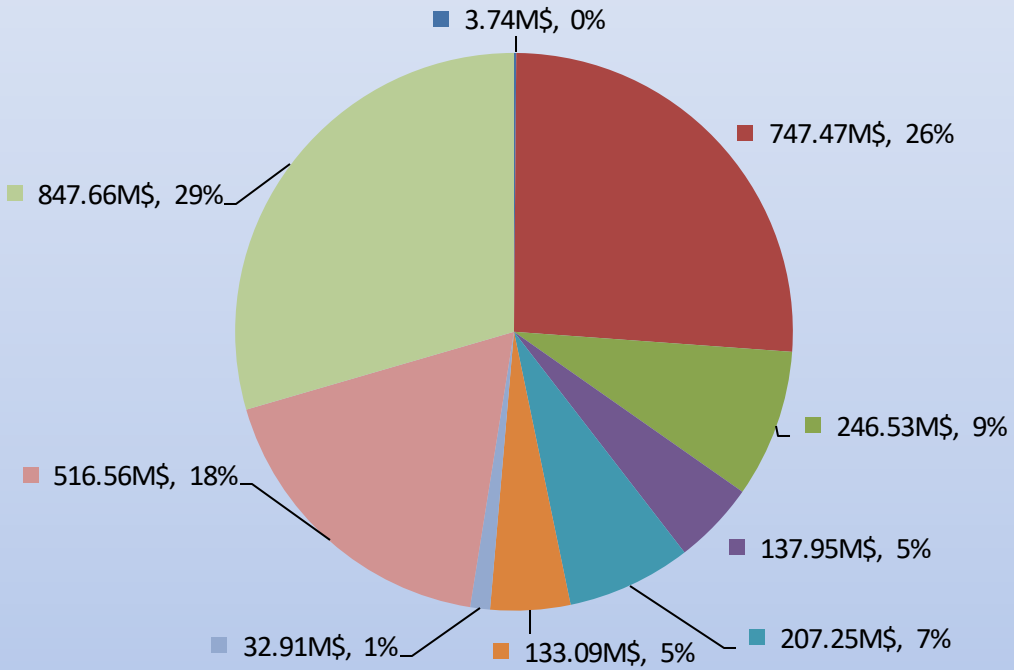
8. Large Research Infrastructures
9. Fusion

Korea: Total Budget Categories 1-9 2010-2015



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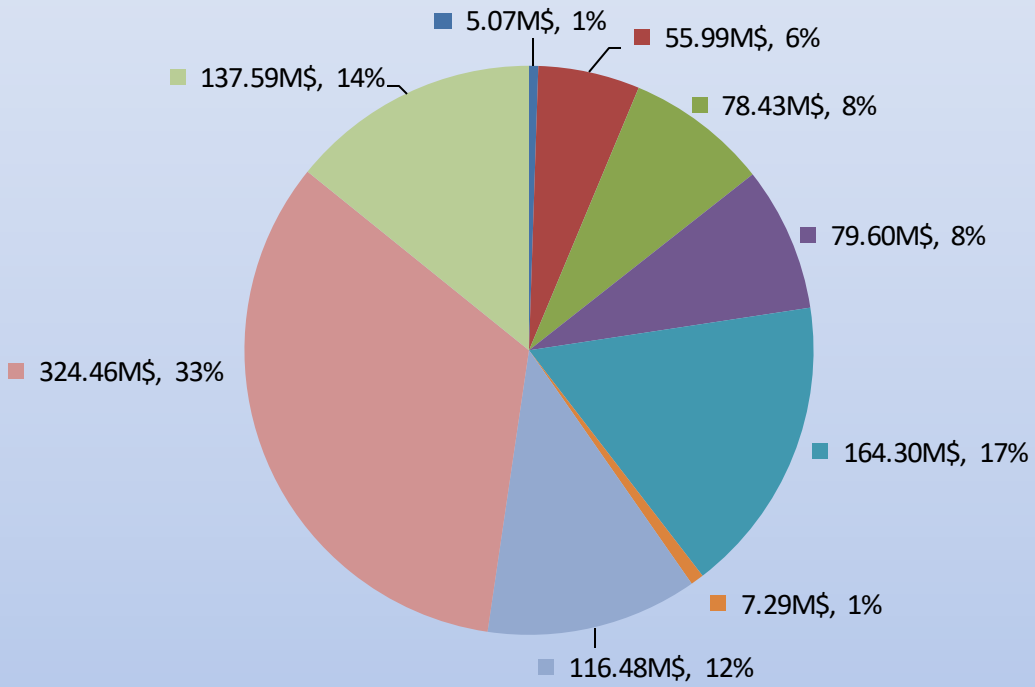
UK: Total Budget Categories 1-9 2010-2015



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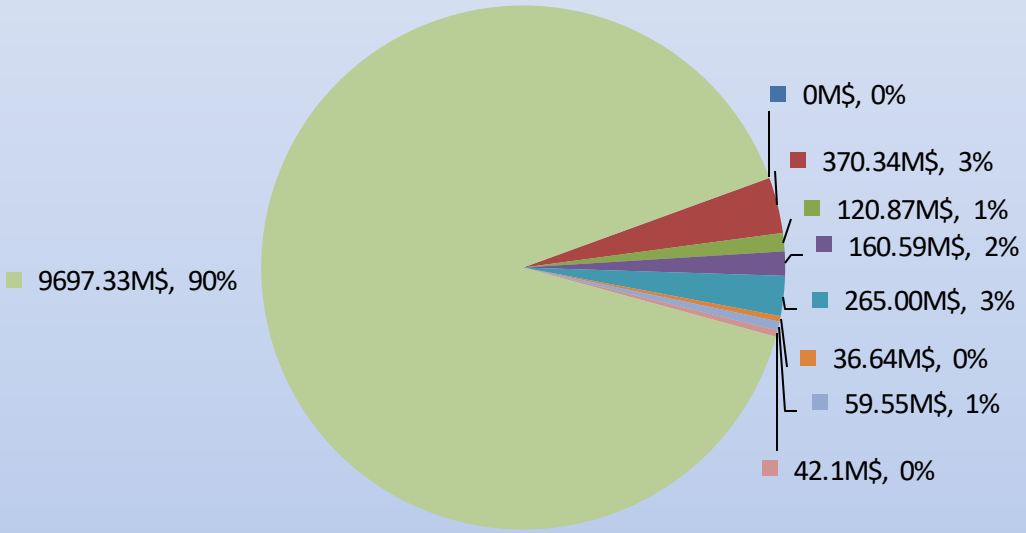
EURATOM: Total Budget Categories 1-9 2010-2015



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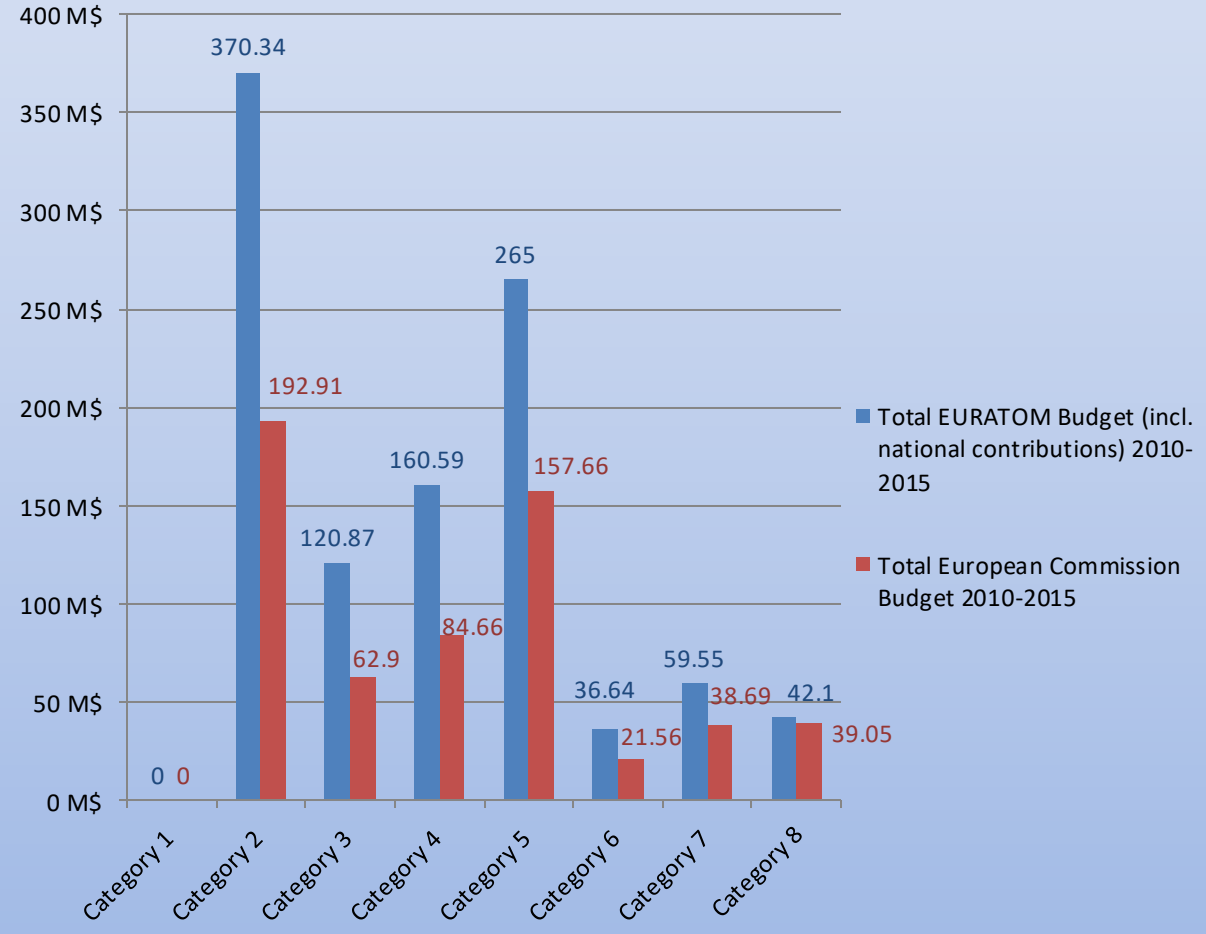
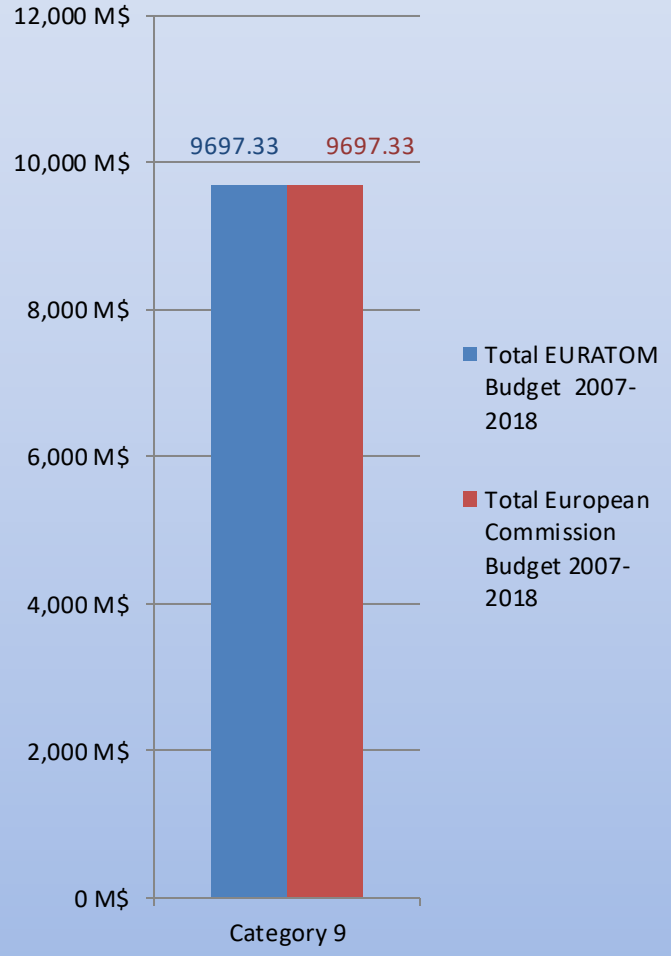
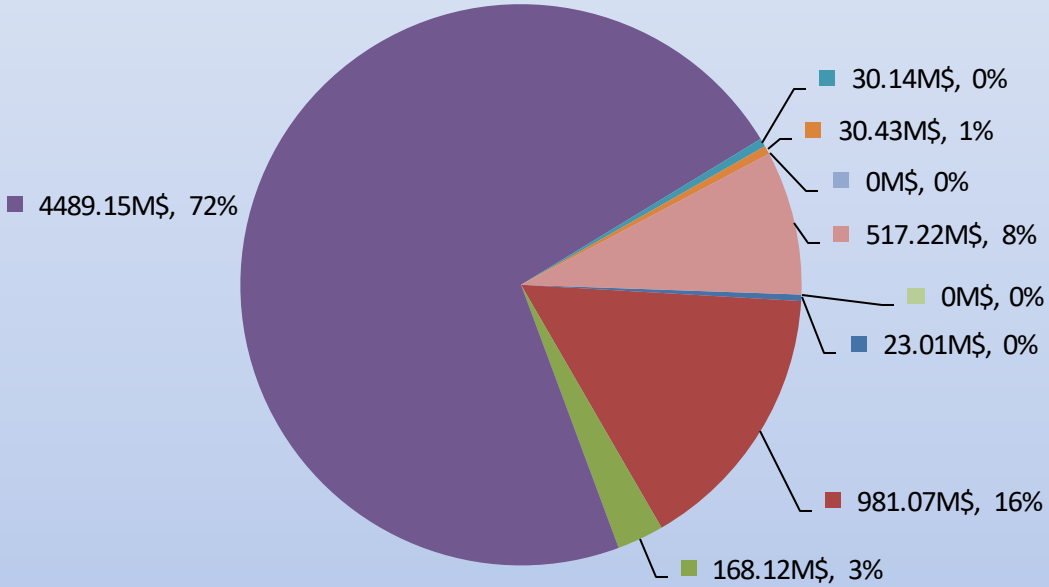
EURATOM: Total Fission Budget 2010-2015



Total Fusion Budget 2007-2018



Japan: Total Budget Categories 1-9 2010-2015



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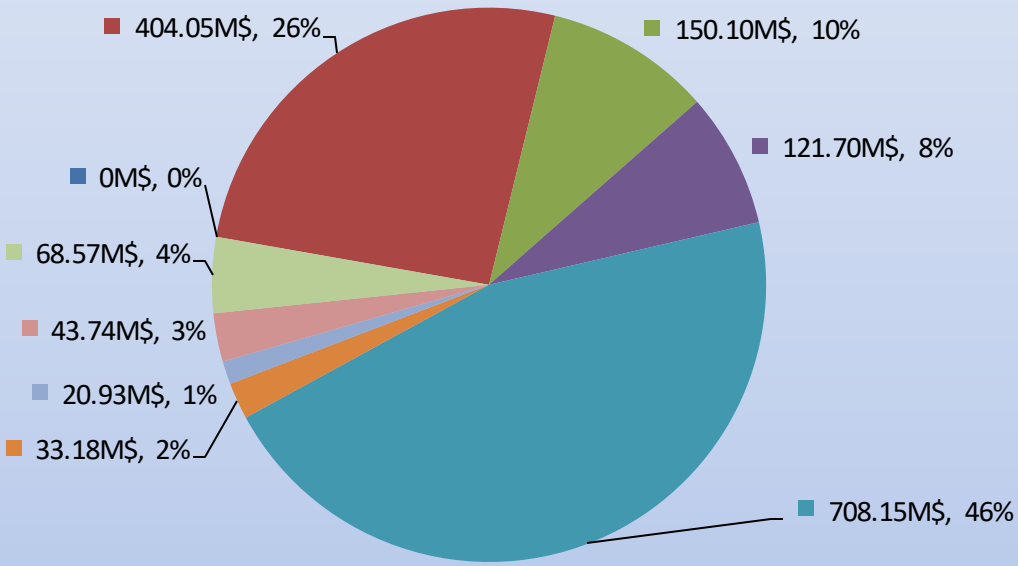
Canada: Total Budget Categories 1-9 2010-2015



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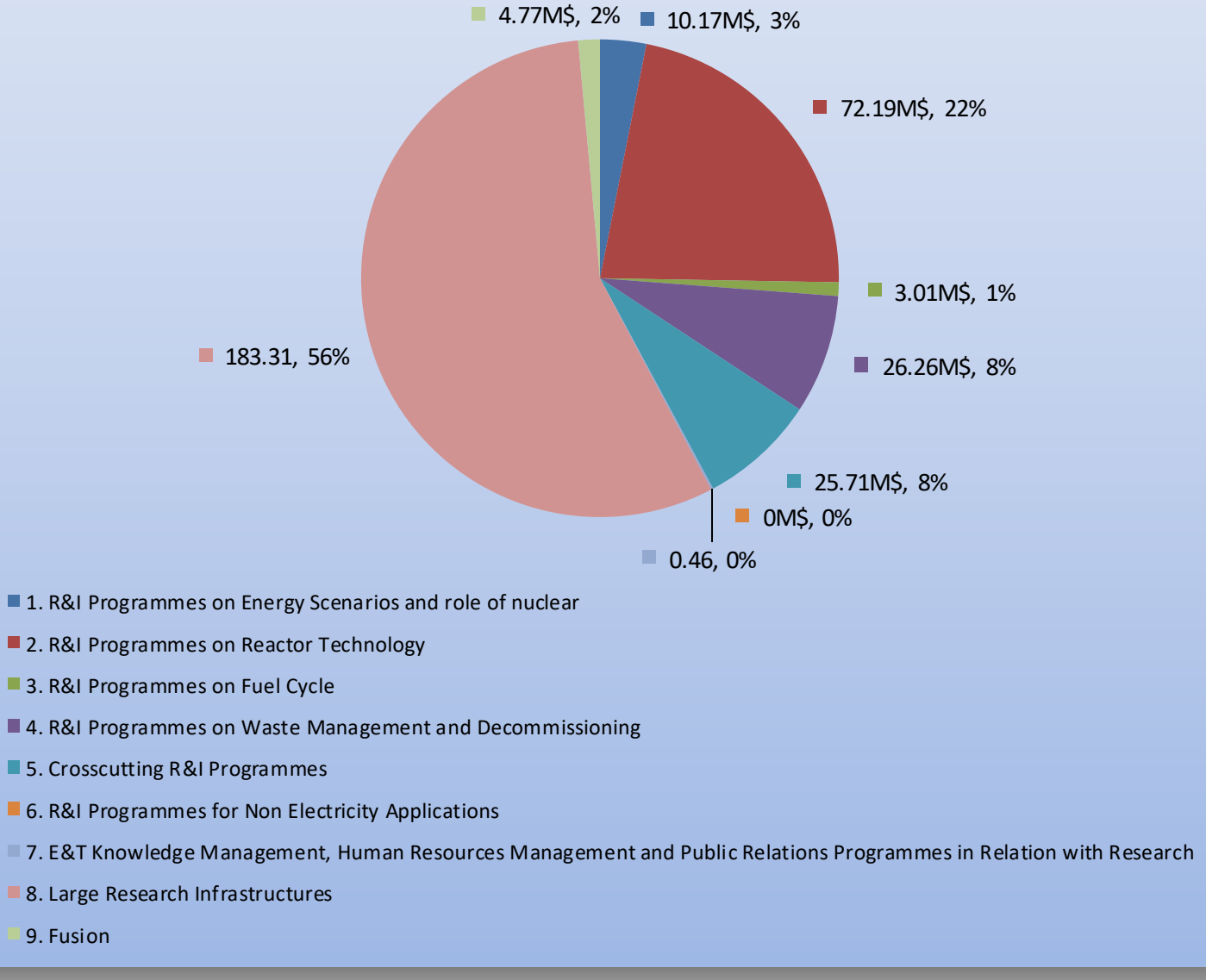
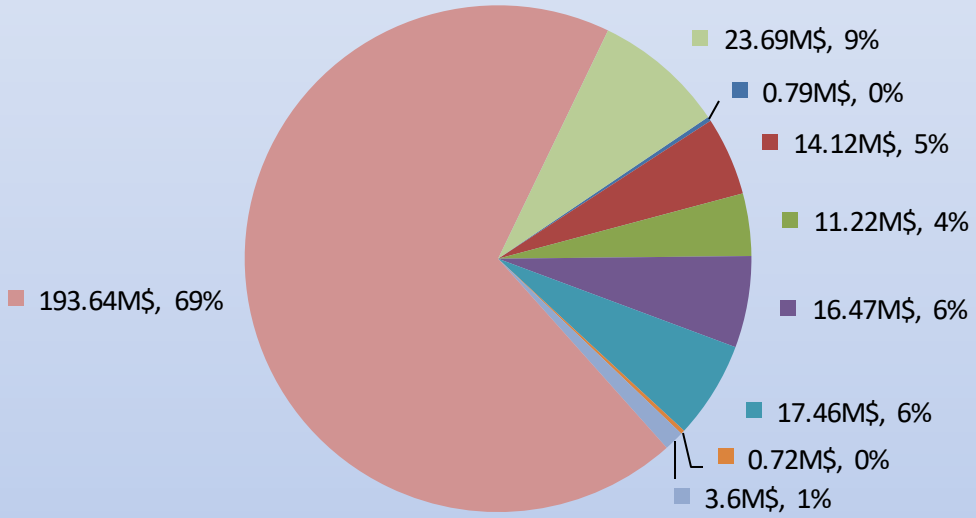
Czech Republic: Total Budget Categories 1-9 2010-2015



Netherlands: Total Budget Categories 1-9 2010-2015



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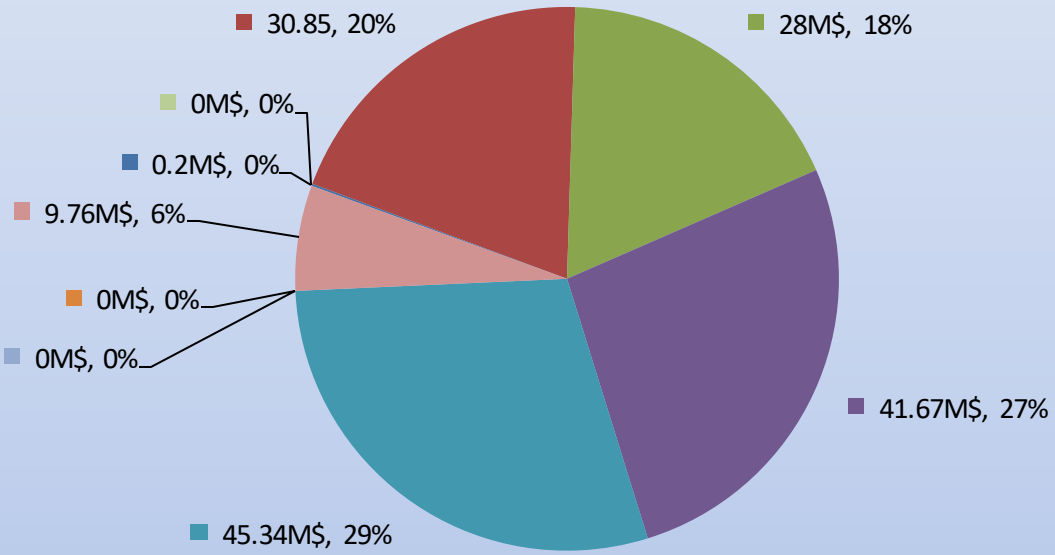
Spain: Total Budget Categories 1-9 2010-2015



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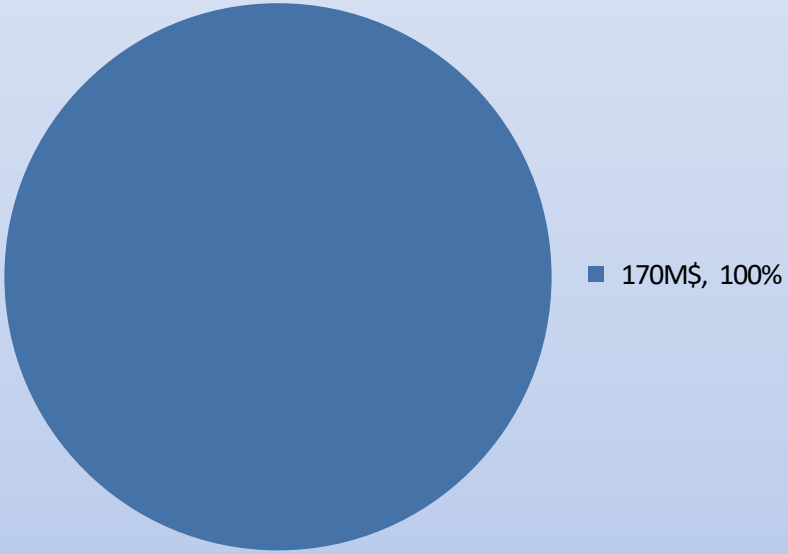
Germany: Total Budget Categories 1-9 2010-2015



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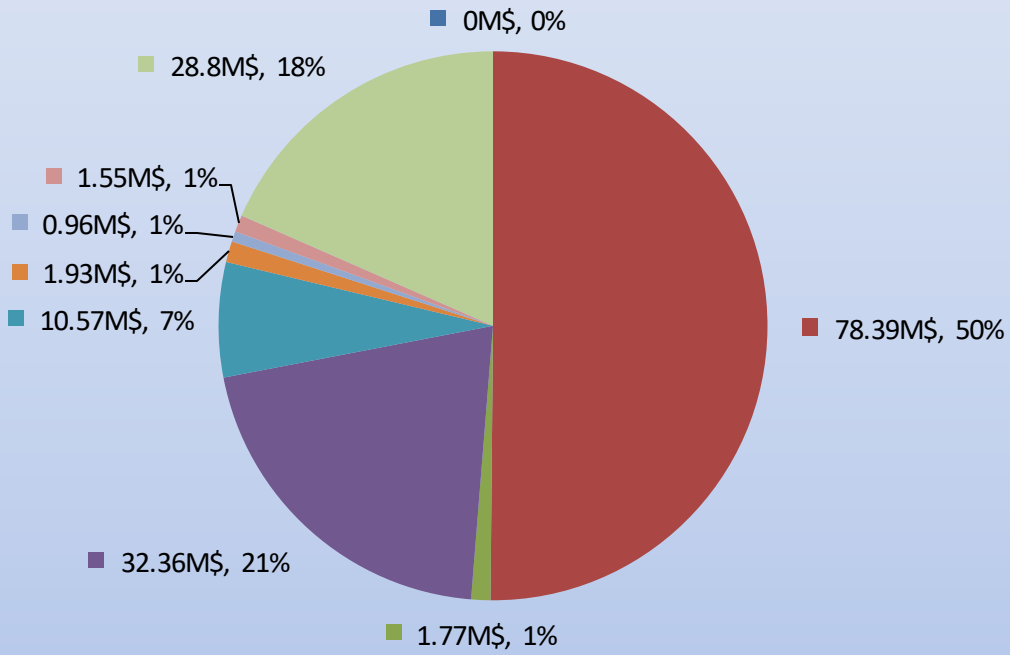
Finland: Total Budget Categories 1-9 2010-2015



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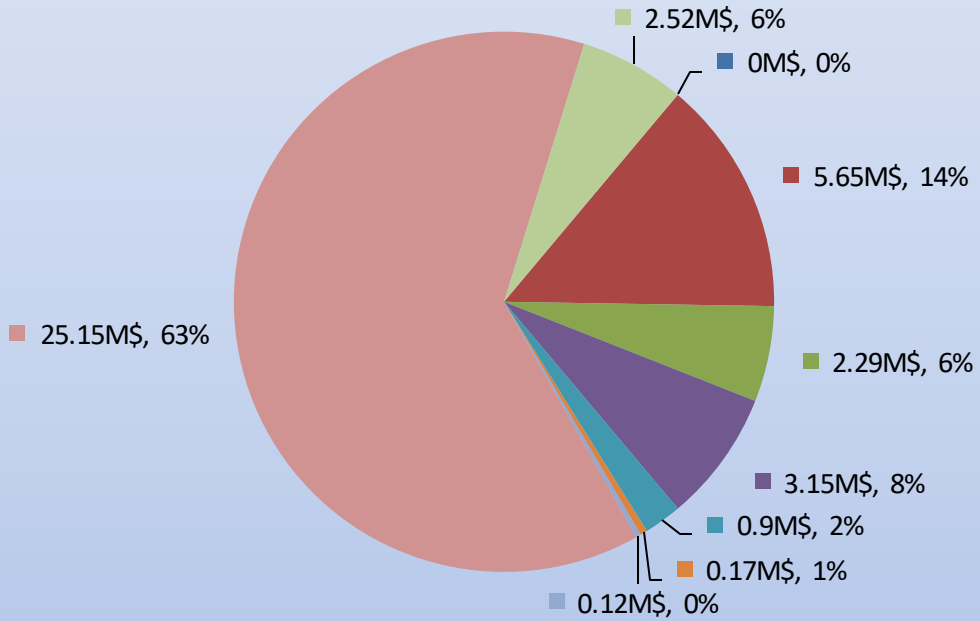
Poland: Total Budget Categories 1-9 2010-2015



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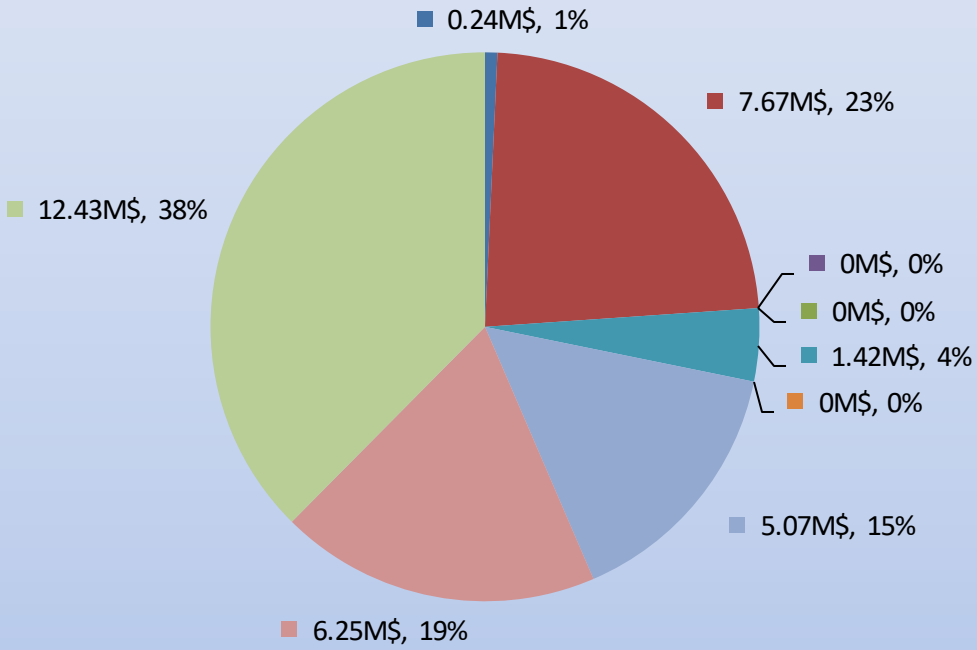
Slovenia: Total Budget Categories 1-9 2010-2015



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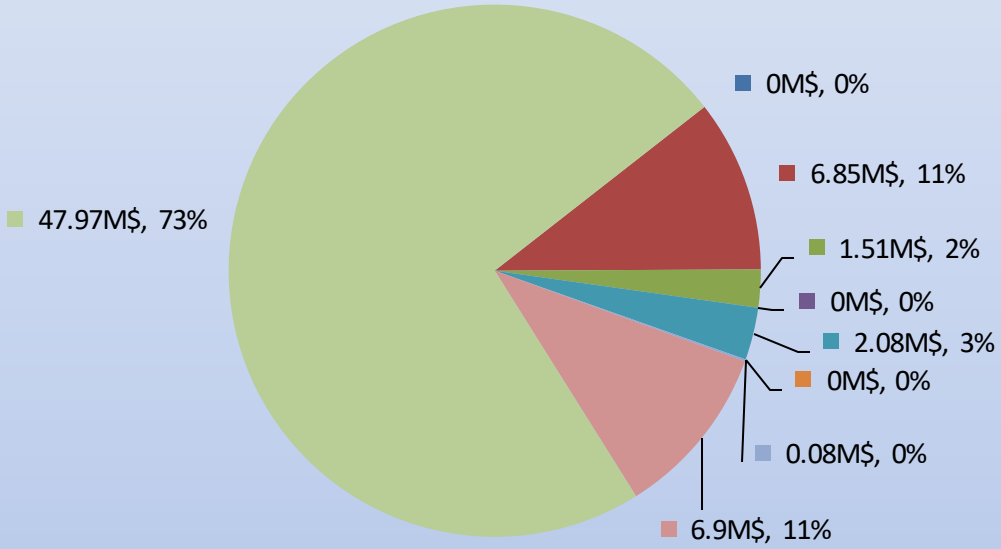
Italy: Total Budget Categories 1-9 2010-2015



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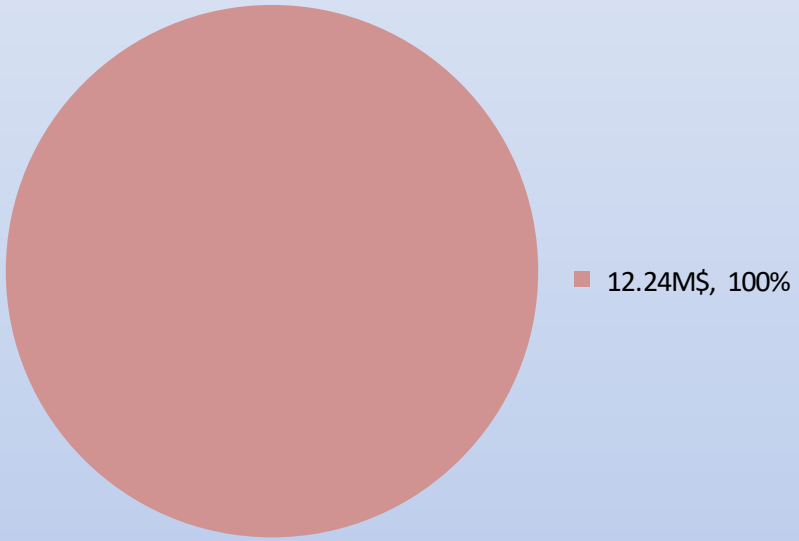
Austria: Total Budget Categories 1-9 2010-2015



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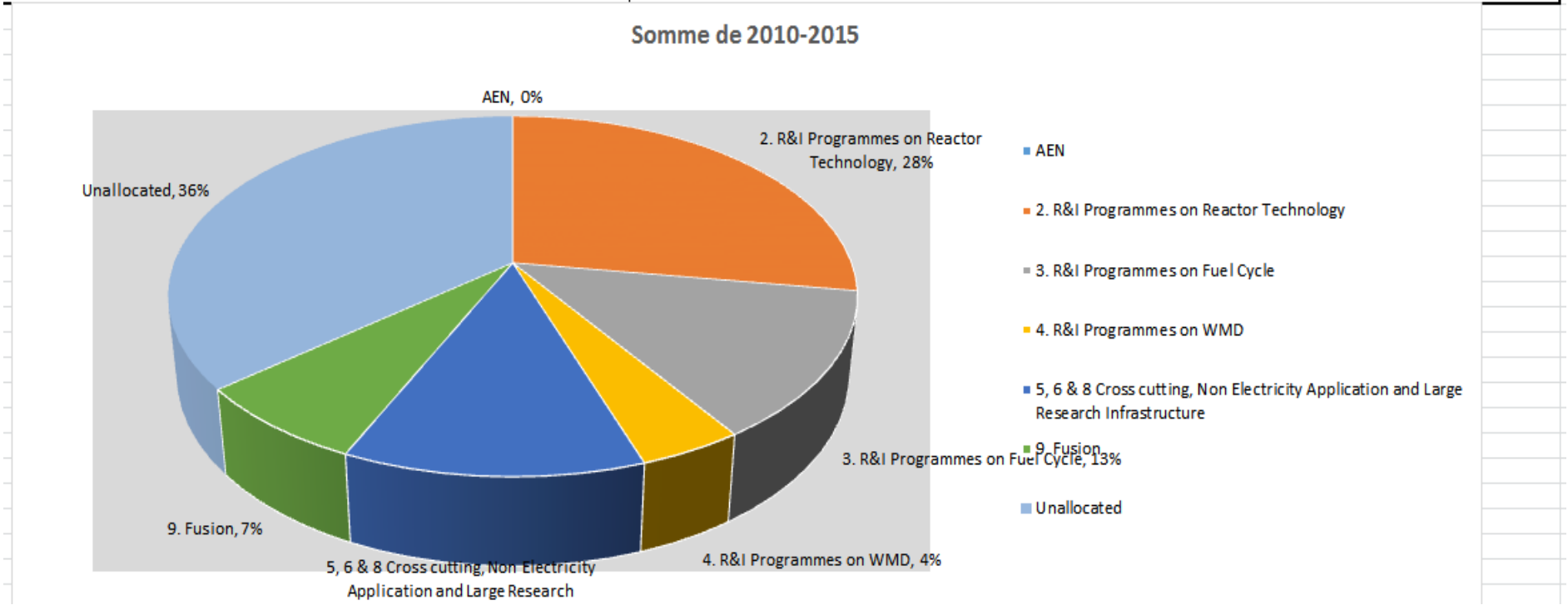
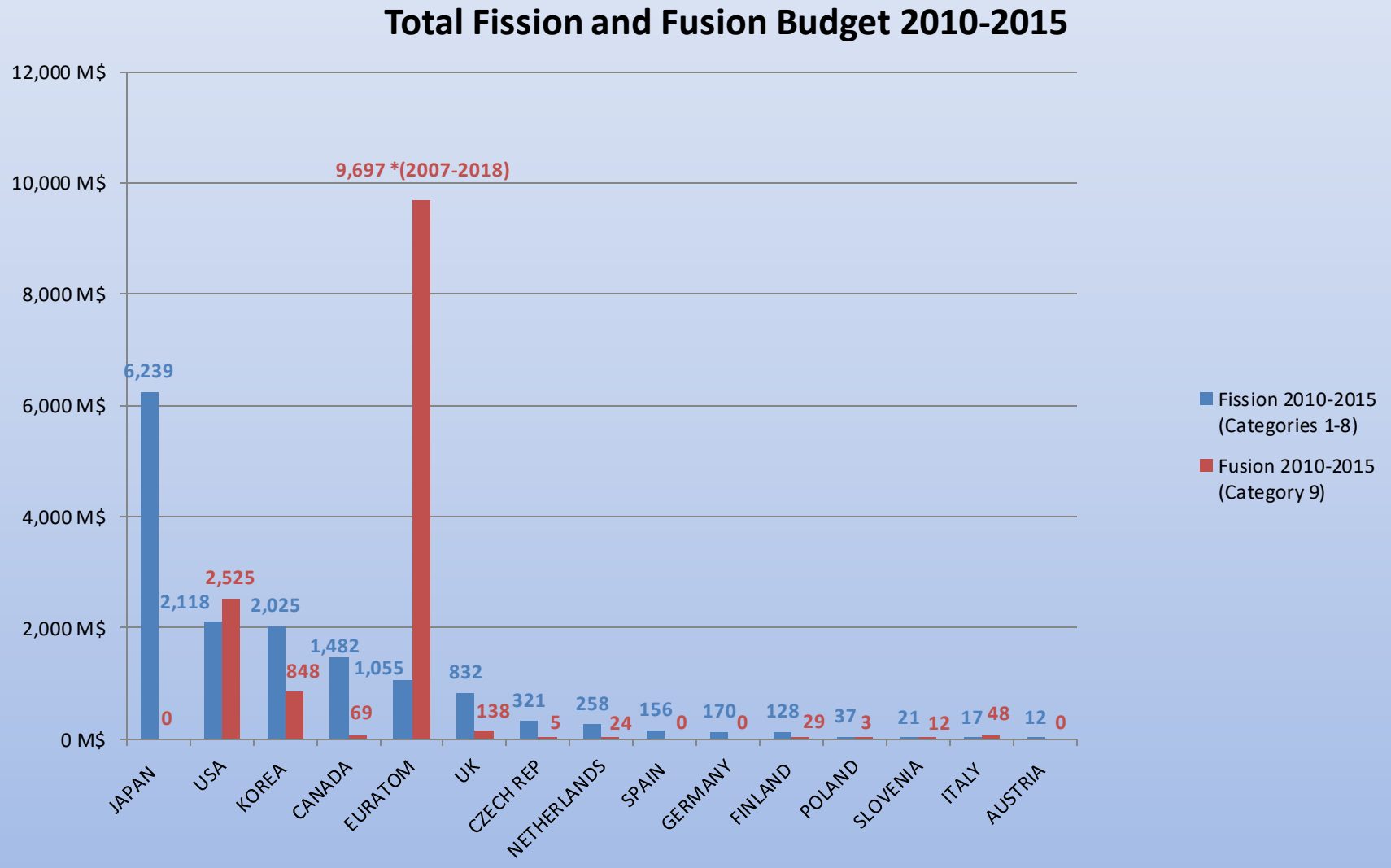
France

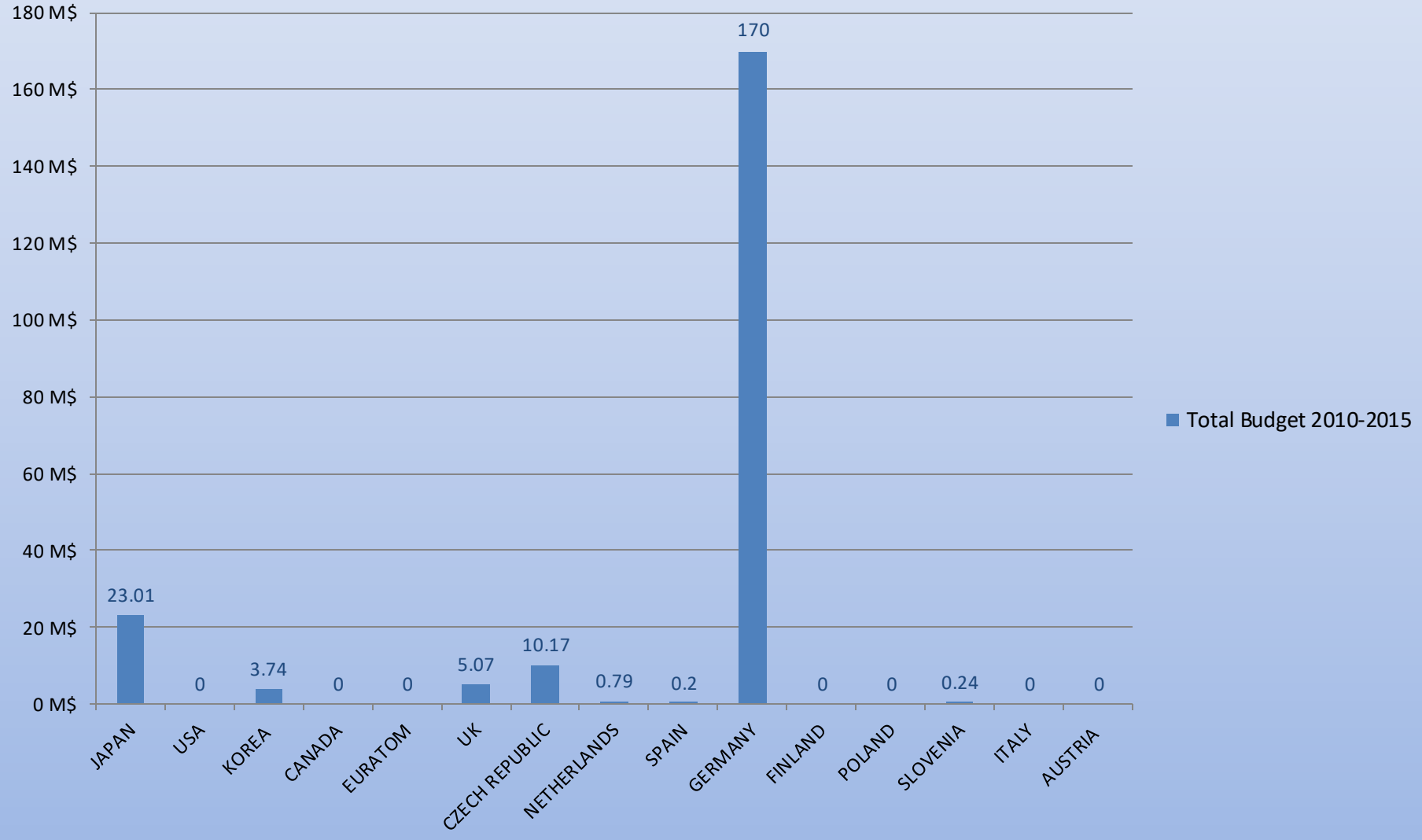
	Données						
AEN	Somme - 2010-2015	Somme - 2010	Somme - 2011	Somme - 2012	Somme - 2013	Somme - 2014	Somme - 2015
2. R&I Programmes on Reactor Technology	793.47	87.00	117.57	147.36	150.16	137.48	153.91
3. R&I Programmes on Fuel Cycle	380.16	22.00	54.88	79.62	77.91	72.01	73.74
4. R&I Programmes on WMD	119.69	48.38	37.53	7.92	9.46	8.64	7.76
5, 6 & 8 Cross cutting, Non Electricity Application and Large Research Infrastruct	343.89	69.75	53.29	56.59	56.83	54.87	52.56
9. Fusion	207.23	34.26	35.00	35.87	35.56	34.42	32.12
Unallocated	1041.80	157.58	175.96	215.14	183.64	174.79	134.70
Total Résultat	**2886.25**	**418.97**	**474.23**	**542.50**	**513.56**	**482.21**	**454.79**



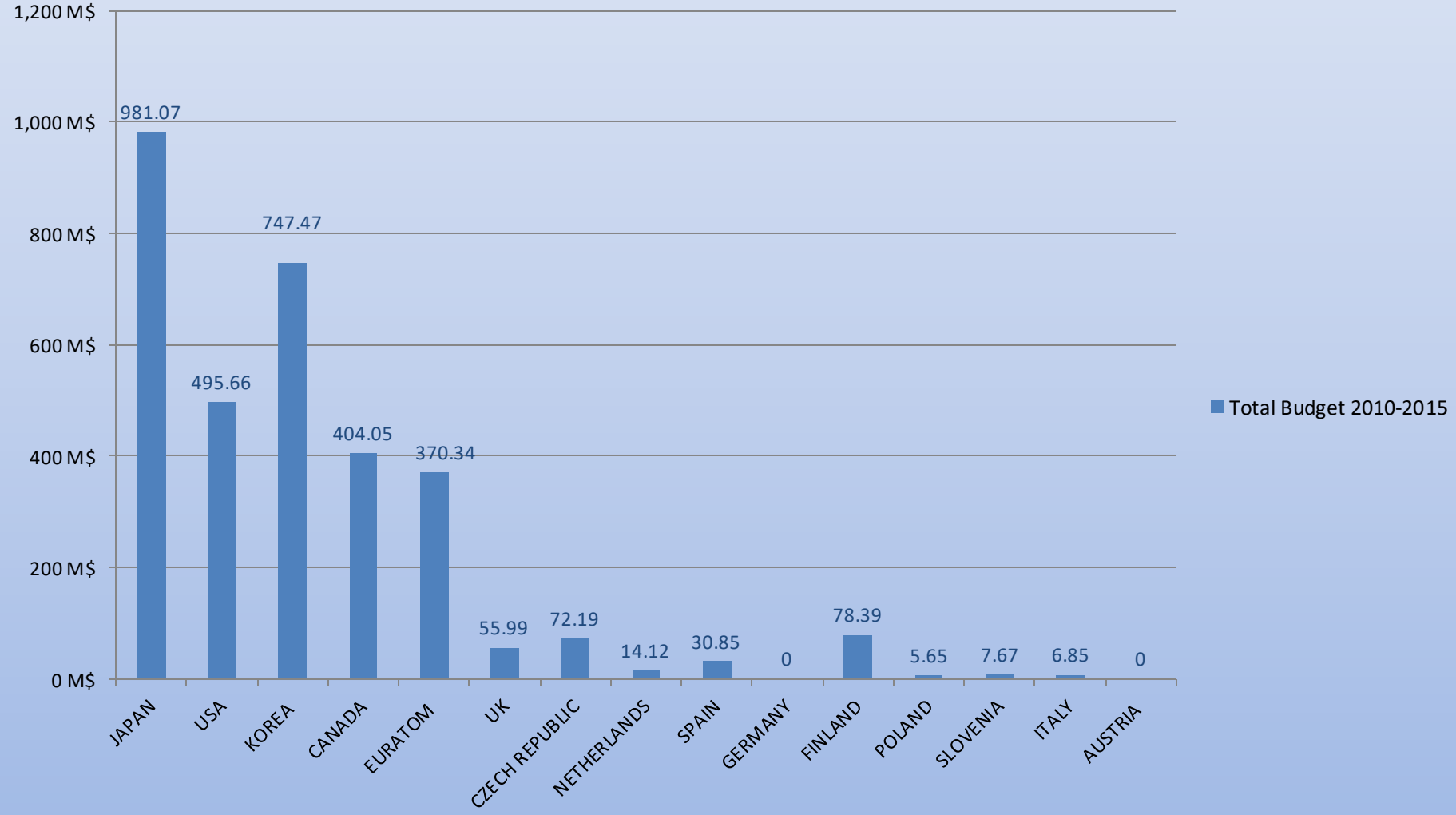


France:
Total Fission: 3,469.43 M$, Total Fusion: 268.69 M$

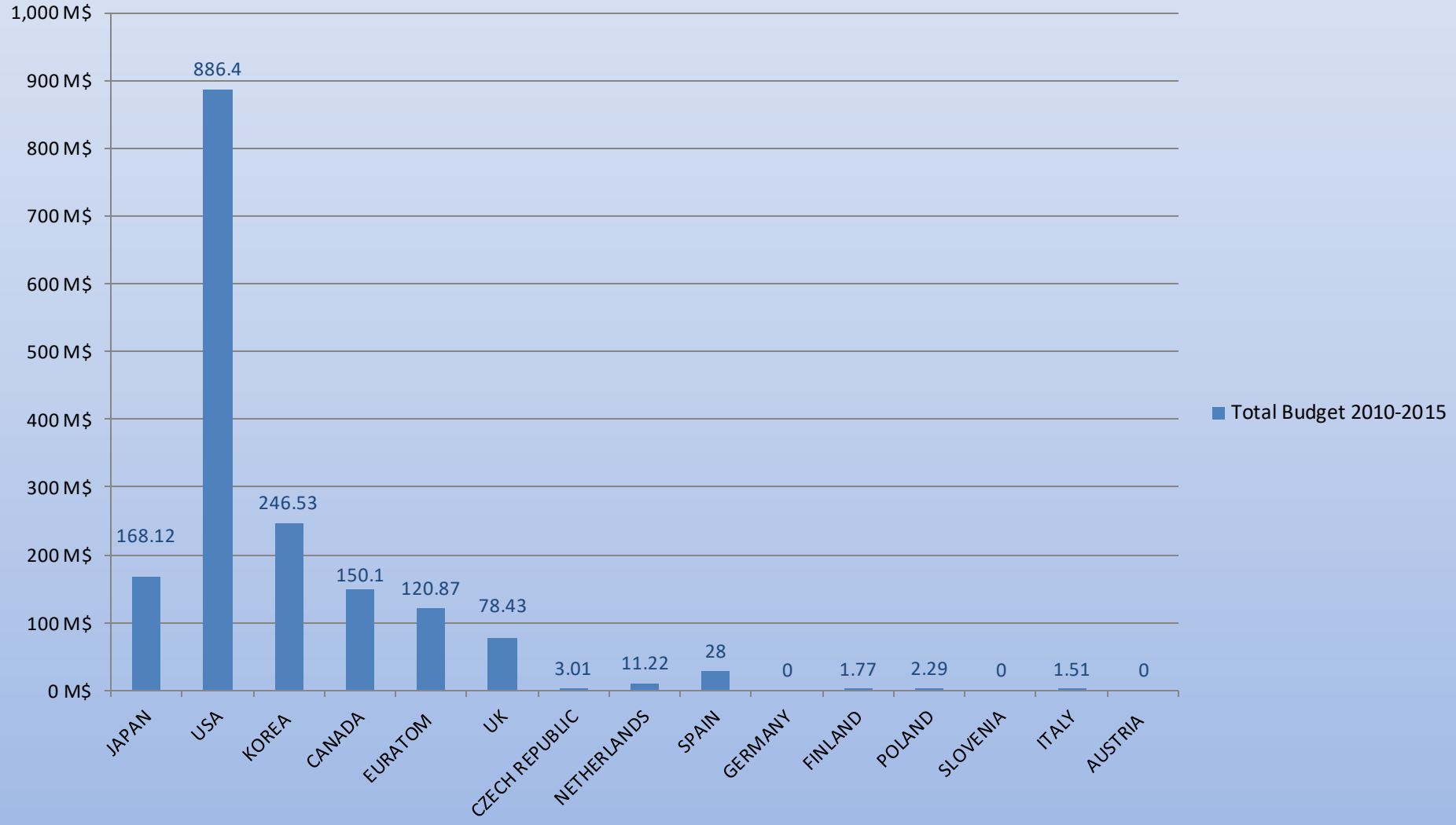
Category 1: R&I Programmes on Energy Scenarios and Role of Nuclear



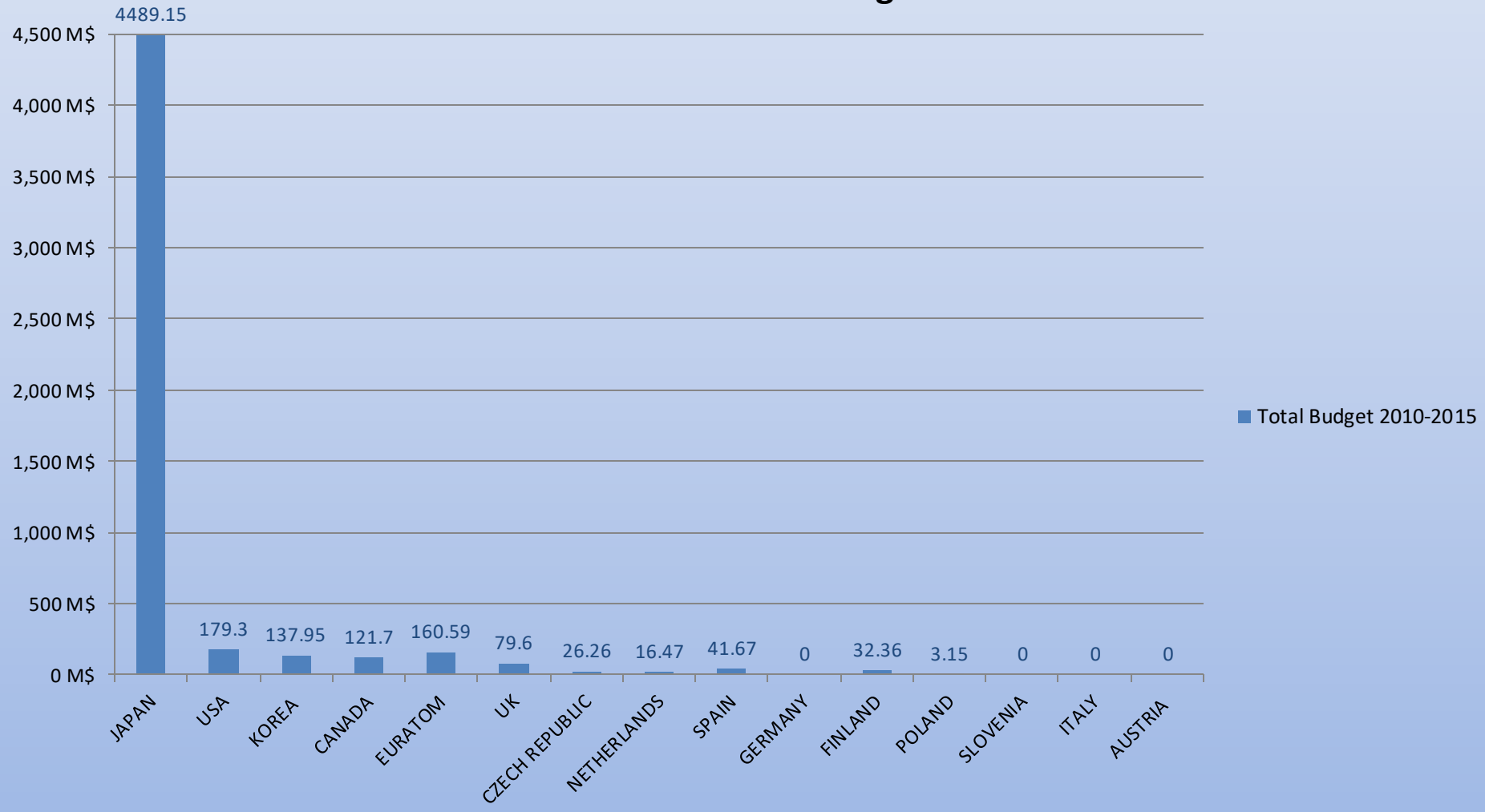
Category 2: R&I Programmes on Reactor Technology



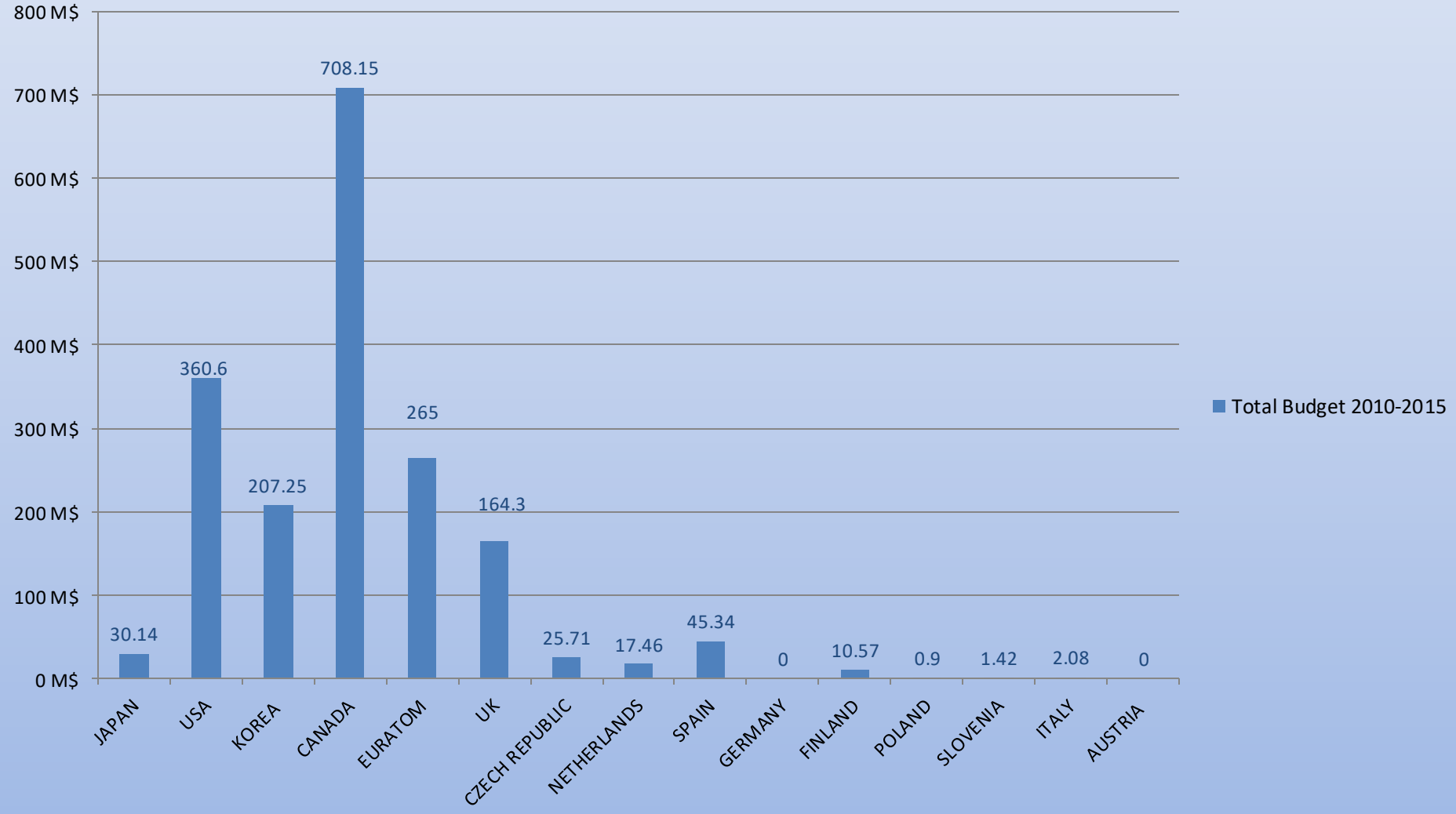
Category 3: R&I Programmes on Fuel Cycle



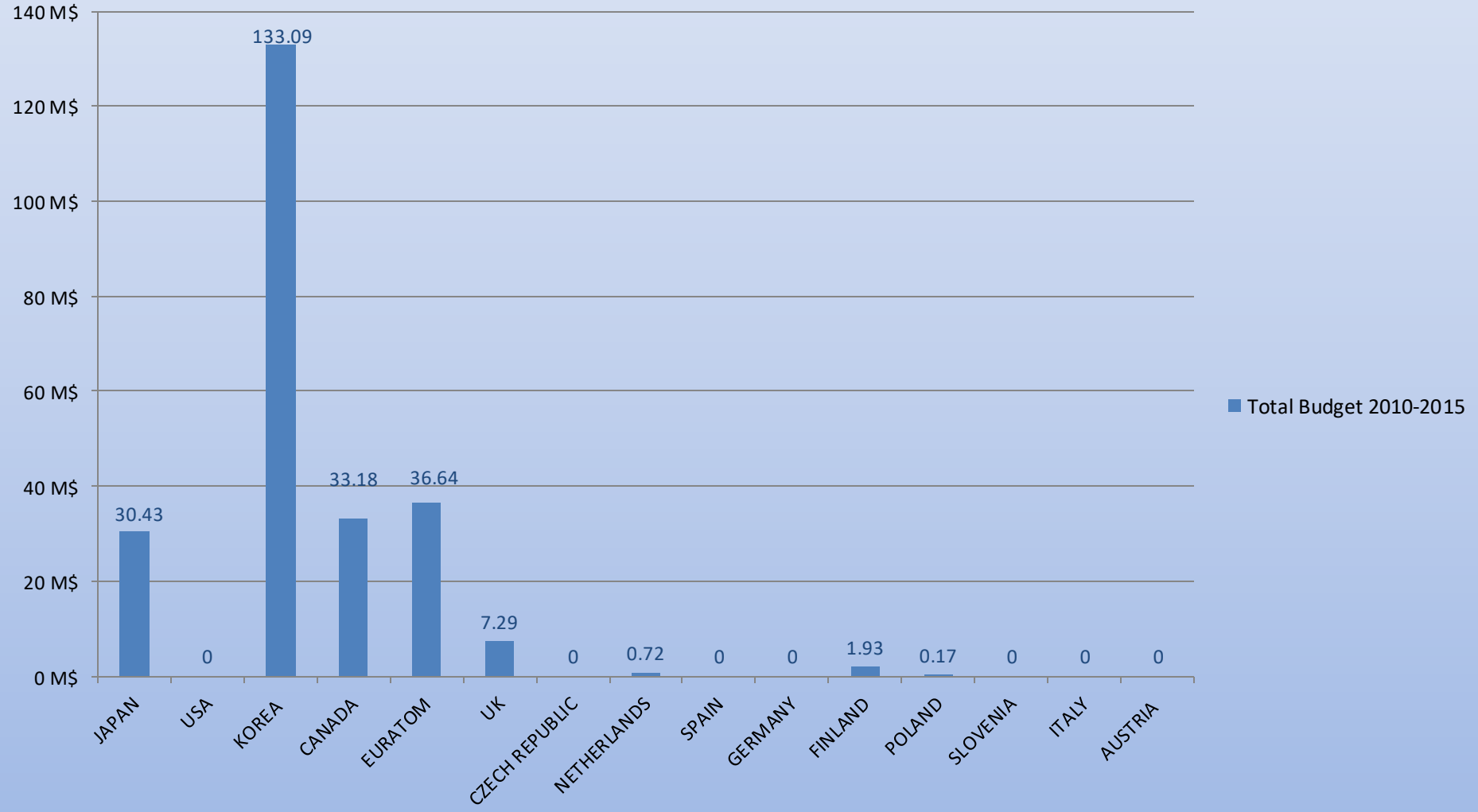
Category 4: R&I Programmes on Waste Management and Decommissioning



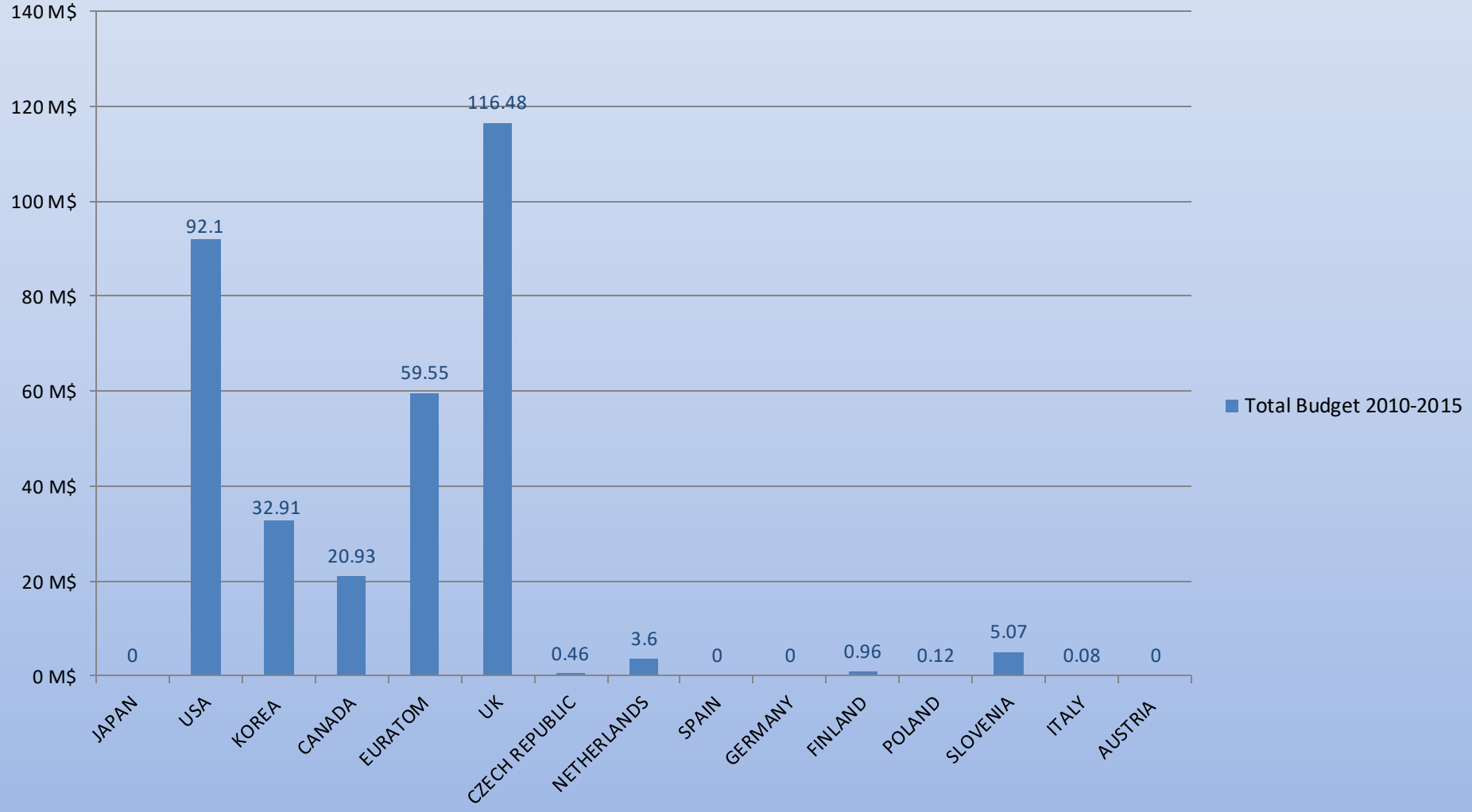
Category 5: Crosscutting R&I Programmes



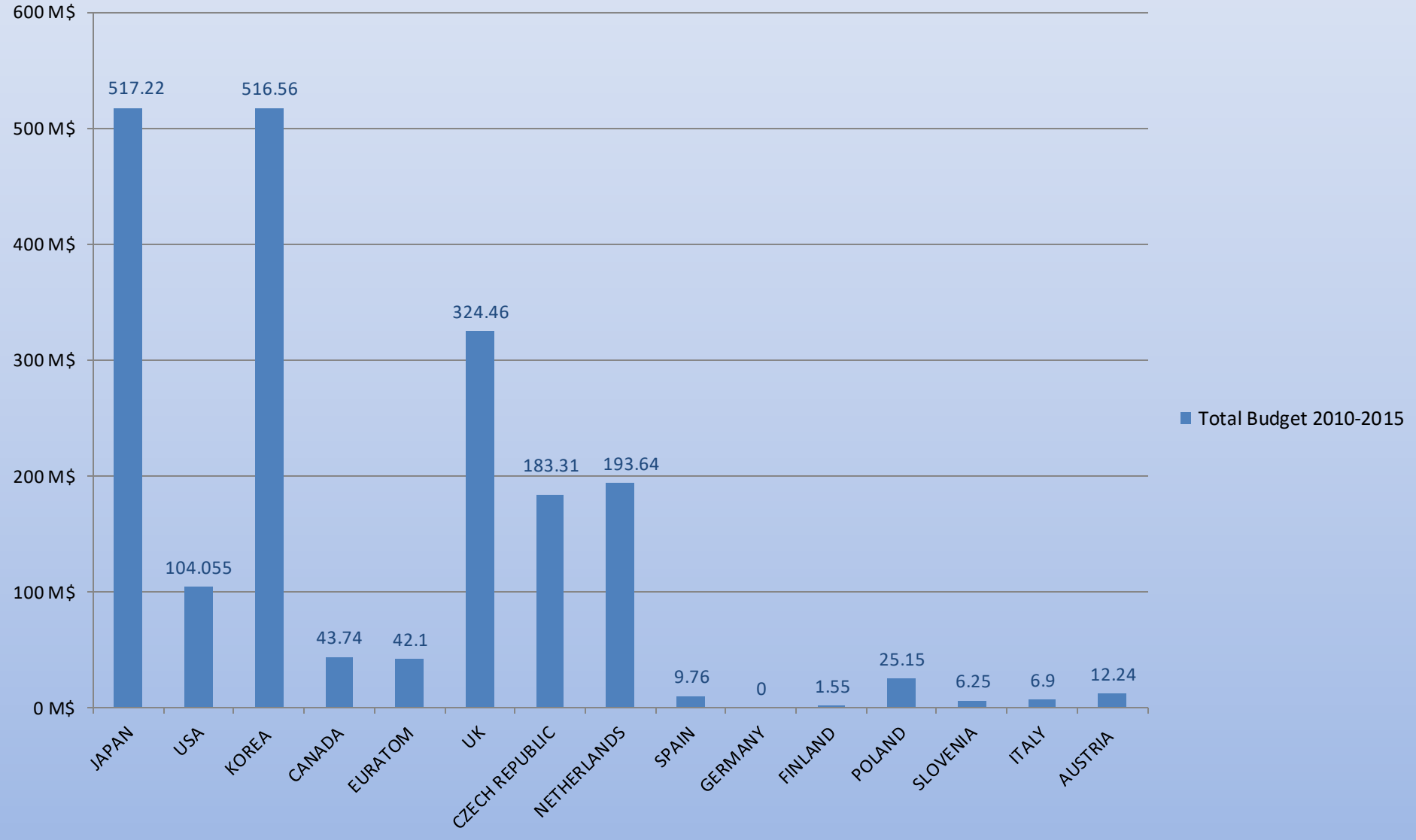
Category 6: R&I Programmes for Non Electricity Applications

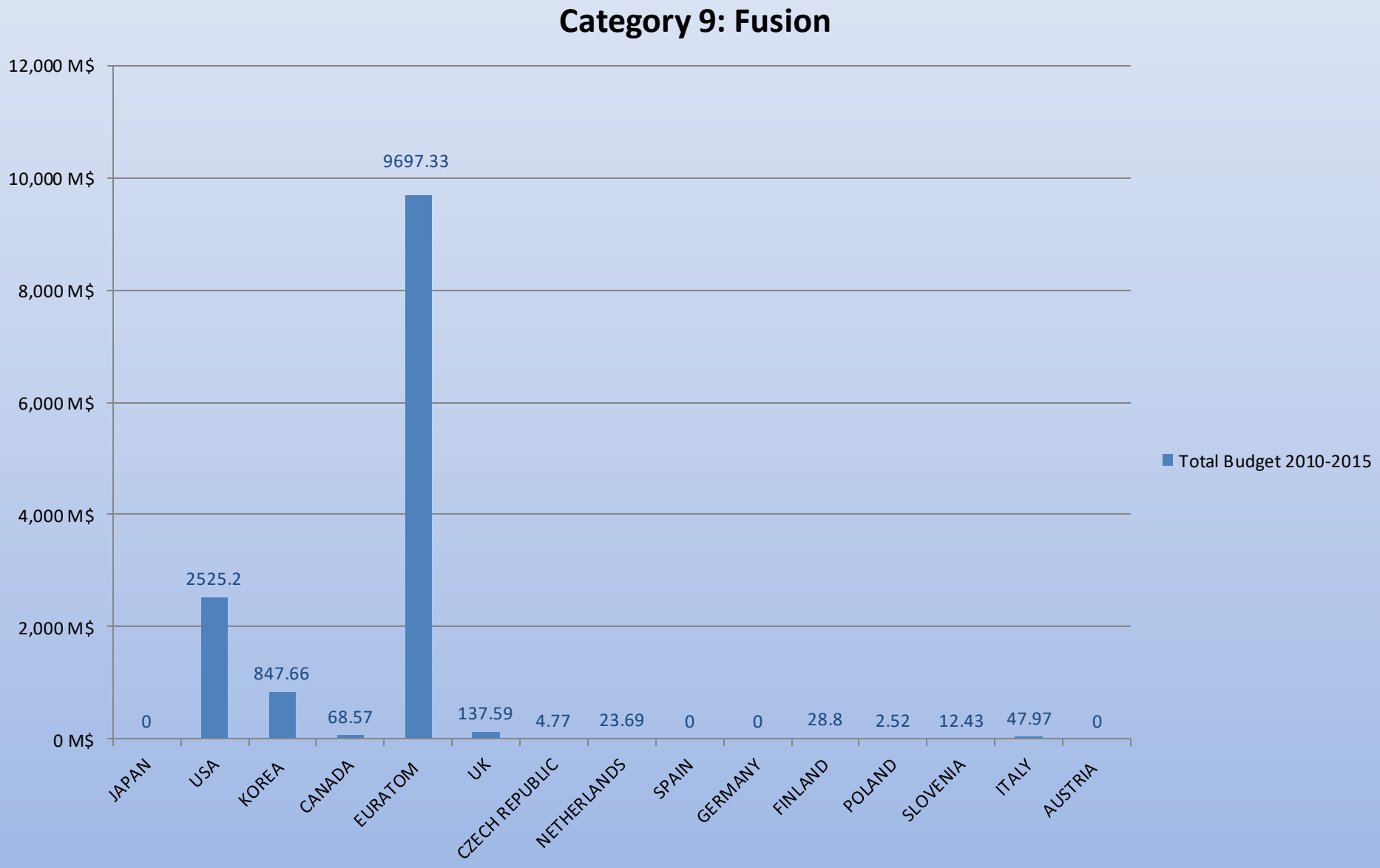


Category 7: E&T, Knowledge Management, Human Resources Management and Public Awareness Programmes in relation with Research



Category 8: Large Research Infrastructures

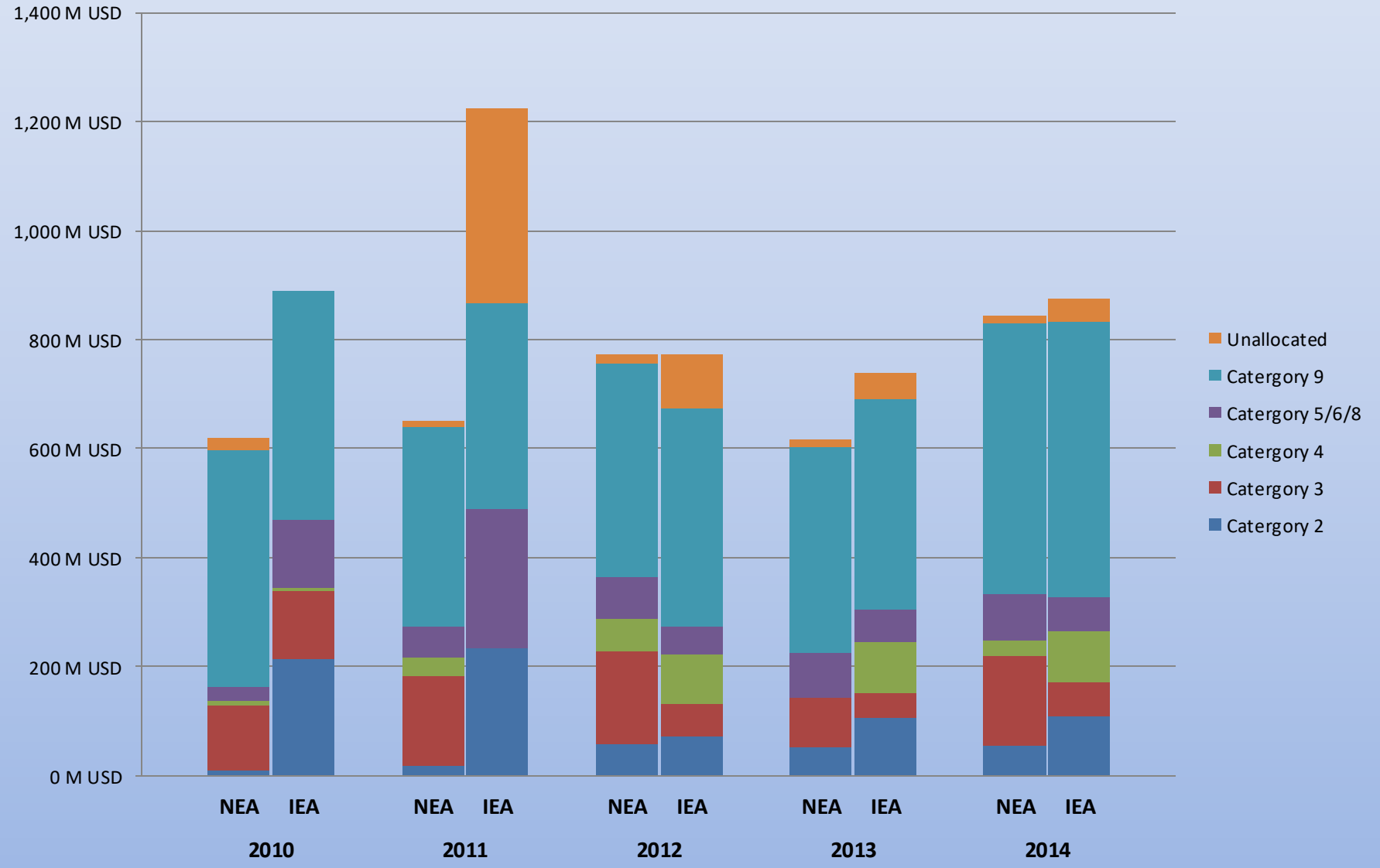


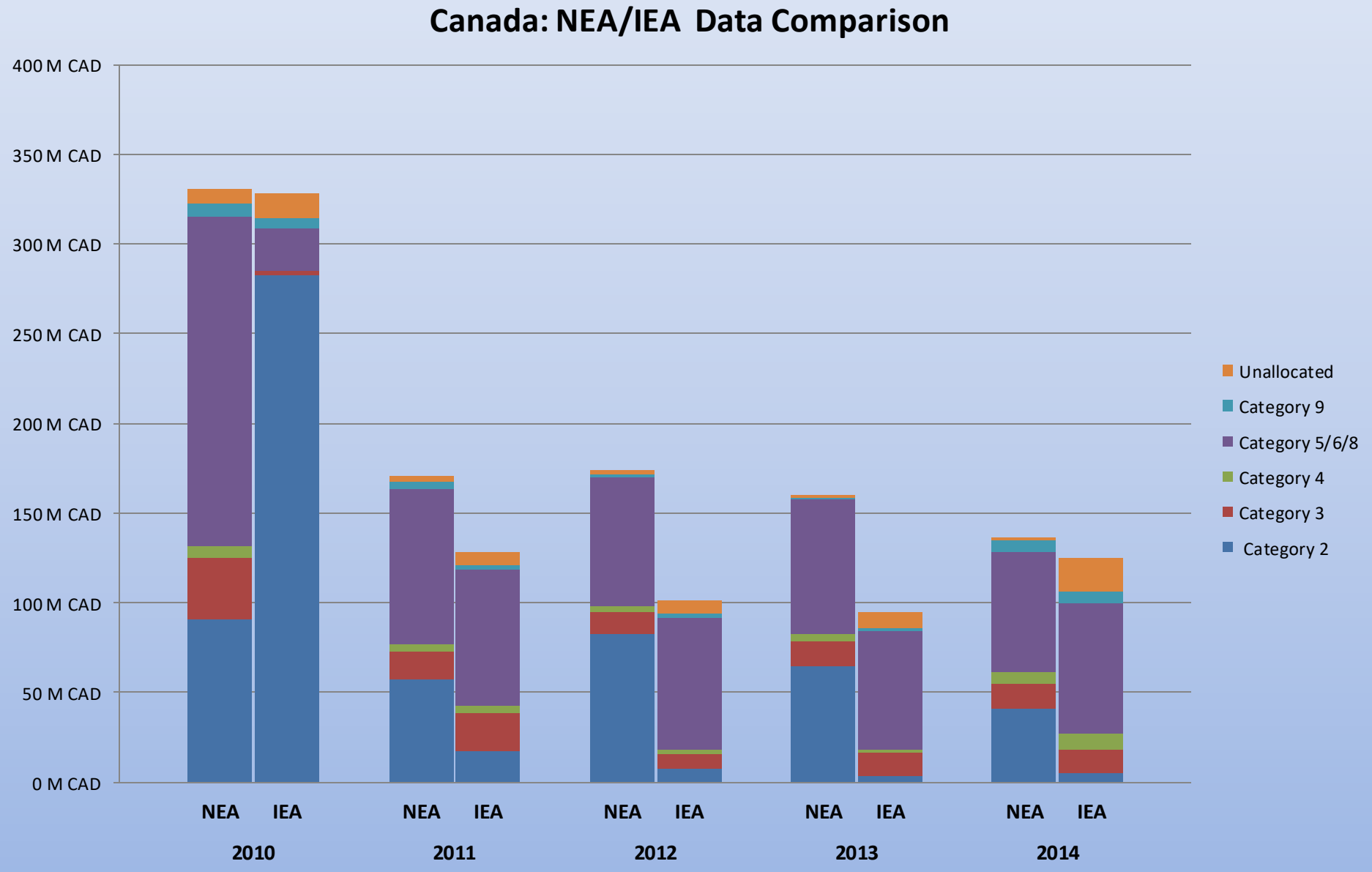


NEA SURVEY vs IEA ??? Over 2010-2015
Suggestions for Category Consolidation

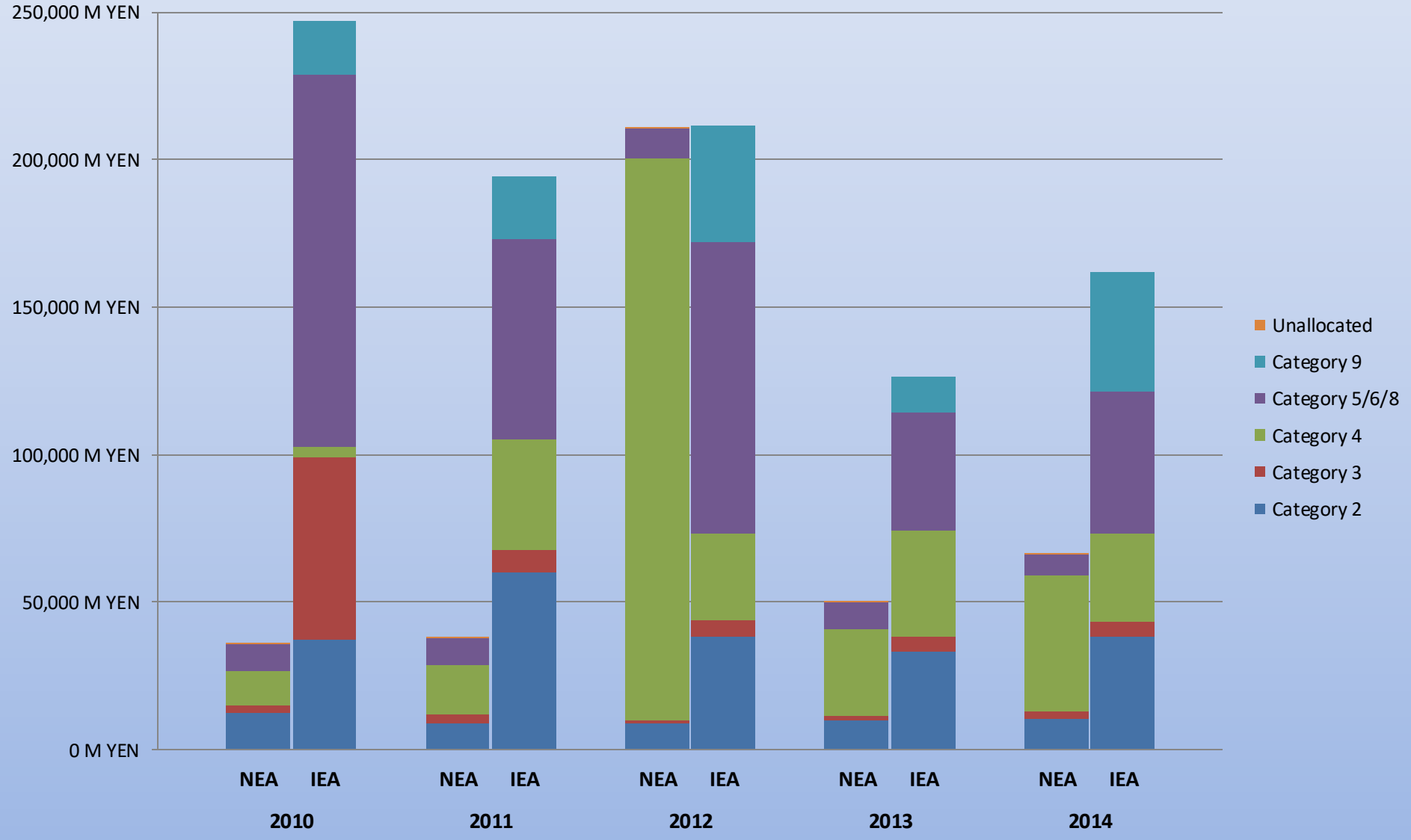
NI2050 Survey	IEA RD&D Survey
Category 2: R&I Programmes on Reactor Technology **2.1** Large GEN II and III Reactors and SMRs	**411** LWRs **412** Other Converter Reactors + **412** Unallocated
2.2 GEN IV Reactors and Advanced SMRs **2.3** Advanced Power Conversion Systems	**415** Nuclear Breeders
Category 3: R&I Programmes on Fuel Cycle & Reactor Technology	**4131** Fissile Material Recycling/Reprocessing **4133** Other Fuel Cycle
Category 4: Programmes on Waste Management and Decommissioning	**4132** Nuclear Waste Manangement **4143** Decommissioning
Category 5: Crosscutting R&I Programmes **Category 6:** R&I Programmes on for Non Electricity Applications **Category 8:** Large Research Infrastructures	**4141** Plant Safety and Integrity **4142** Environmental Protection **4144** Other Nuclear Supporting Techs **416** Other Nuclear Fission
Category 9: Fusion	**421** Magnetic Confinement **422** Inertial Confinement **423** Other Nuclear Fusion **42** Unallocated
Unallocated: Categories 1 & 7	**Unallocated: 413, 414, 41, 4**

USA: NEA/IEA Data Comparison





Japan: NEA/IEA Data Comparison



NI2050 SURVEY: Consolidation of TECHNICAL Scope

- Report per country and following the 9 categories of the survey

- Selection of 10 countries: US, CAN, KR, EC, JP, RF, FR, CZ, FI, NL

- Wide variation in coverage/content of the survey returns

- Report contains most of the information from the survey COMPLEMENTED by additional information from open sources (*in Italic*), providing some level of consistency between the reports

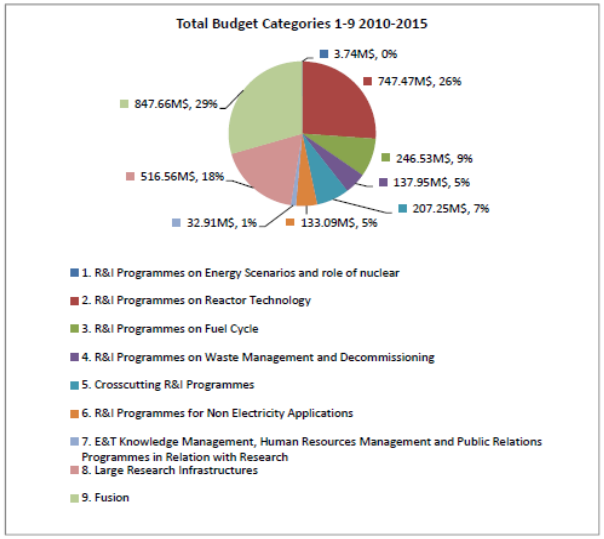
- Sources are cited and numerous weblinks are given

- "State of Play"

- Possibility for further consolidation on infrastructures (category 8)

NI2050 SURVEY: Consolidation of TECHNICAL Scope

COUNTRY REVIEW OF R&D STATE OF PLAY: REPUBLIC OF KOREA



1. R&I Programmes on Energy Scenarios and role of nuclear

The Ministry of Trade, Industry and Energy (MOTIE) released <Second Energy Master Plan> in 2014 to determine its national energy policy until 2035. It aimed at reducing final energy consumption by 13% by 2035, with six basic directions: conversion to demand management policies, establishment of distributed generation system, balance with the environment and safety, enhancement of energy security and stable energy supply, stable supply system of each energy source, and energy policy reflecting public opinion.

Nuclear energy in Korea has been considered as the big contributor to the nation's economic growth as well as Low Carbon Green Growth.[1] In 2004, Nuclear Technology Roadmap (NuTRM) was established, which provides the systematic chains from needs-driven R&D activities, through innovation and industrial performance, to eventual contribution to the society. In 2008, "Long-term Development Plan of Future Nuclear Energy System" was established to secure the solutions for the front- and back-end of the fuel cycle. Sodium-cooled Fast Reactor (SFR) coupled with pyro-processing is expected to provide long-term solution for spent nuclear fuel (SNF) management in Korea. Very High Temperature Reactor (VHTR) is expected to contribute to clean and safe energy with a wide range of applications such as hydrogen production.

A number of studies on the economics of nuclear energy are performed including a SMART (System-integrated Modular Advanced Reactor), SFR, and research reactors for export.

More information:
Ministry of Trade, Industry and Energy (http://english.motie.go.kr/www/main.do)

2. R&I Programmes on Reactor Technology

2.1. Large GEN II and III reactors and SMRs

As a near-term reactor option, the Korean Next Generation Reactor, which is the Advanced Power Reactor (APR1400, Generation III PWR – 1400 MWe), has been developed and is under construction. Building on the APR1400, the Advanced Power Reactor Plus (APR+, Generation III+ PWR – 1500 MWe) with improved economy and safety is under development. It is expected to be ten times safer than APR1400. The standard design of the APR+ was certified by the Korean regulatory agency in 2014.

In the field of core physics, the Korea Atomic Energy Research Institute (KAERI) seeks to develop the Safety and Performance Analysis Code (SPACE) that is the best estimate system analysis code to be used for licensing PWR design, in collaboration with several research institutions. KAERI is in charge of the development of the physical models, correlations packages, and code Verification & Validation (V&V), including integral effect tests and separate effect tests for model development and code validation.

For the design optimization and performance improvement of Generation III+ reactor, APR+ research project focuses on renovating the reactor design and validating the advanced safety system such as Direct Vessel Injection Plus (DVI+), Fluidic Device Plus[2] (FD+), Passive Auxiliary Feedwater System (PAFS), and Control Element Driving Mechanism (CEDM).

Integral and separate effect tests were performed to verify the reactor system response and local thermal hydraulic phenomena by using FESTA facility. In 2013, the 5-year project on the Hybrid Safety Injection Tank (HSIT) performance test was launched. HSIT is a new safety injection system to make up the reactor coolant during the anticipated Design Basis Accidents (DBAs) and beyond Design Basis Accidents (bDBAs) such as Station Black-Out (SBO) in PWR system.

Additionally, for the seismic risk assessment, KAERI is developing the performance criteria of seismic isolation systems and seismic design of umbilical that is defined as the interface crossing over between the seismically isolated and non-isolated structures of nuclear power plants (NPPs).

For the beyond design basis safety analysis, technology development for safe operation of NPPs against man-made hazards and natural disaster are being pursued and is being reflected to APR1400 and APR+. Safety enhancement technologies including passive hydrogen removal systems, exhaust and decompression equipment, and coastal barrier were developed. In addition, several methodologies are under development, which include the development of the Integrated Risk Assessment Technology for Multiple Units, the Base Technology for Integrated Severe Accident Management and Emergency Preparedness, and the Risk Evaluation Methodology for Extreme External Events.

For the development of Small Modular Reactor (SMR), KAERI is developing the System-integrated Modular Advanced Reactor (SMART) which is a 330 MWt PWR with integral system generators and advanced passive

8. Large Research Infrastructures[3]

8.1. Critical Zero Power Facilities

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8.2. Research Reactors

The research reactors mentioned below are selected based on the survey provided by Republic of Korea AND high utilisation rate[4] reactors (>=20EW) from IAEA Research Reactor Database.

- High-flux Advanced Neutron Application Reactor (HANARO) – KAERI, Daejeon

High-flux Advanced Neutron Application Reactor (HANARO) is a 30 MWt open-pool-type research reactor that has been operated since 1995. HANARO is widely utilized in the fields of neutron science, irradiation test, radioisotope (RI) production, and neutron transmutation doping. HANARO is also equipped with a neutron beam facility.

More information: https://www.kaeri.re.kr/english/sub/sub04_04.jsp

- Kijang Research Reactor (KJRR, to be built) – KAERI, Busan

Kijang Research Reactor (KJRR) is the open-tank-in-pool-type research reactor, 15 MWt, using high density, low enriched U-Mo fuel for RI production, which is the First-of-a-kind application, of which qualification test is being performed in cooperation with Idaho National Laboratory, presently under construction. It is expected to start operation by early 2020.

Related document:
OVERVIEW OF KJRR DESIGN FEATURES
(http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/47/065/47065303.pdf)

8.3. Large Demonstrators/Prototypes

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8.4. Accelerators

- Proton Linear Accelerator – KAERI, Daejeon

It is 100 MeV, 20 mA Proton Linear Accelerator at Korea Multi-purpose Accelerator Complex (KOMAC), KAERI.

[1] Nuclear energy has been a strategic priority for Korea, but a new president elected in 2017 is aiming to phase it out over some 45 years. (http://www.world-nuclear-news.org/NP-Moon-urged-to-halt-South-Korean-nuclear-exit-0507174.html)

[2] Fluidic Device (FD) is used for flow control. For example, APR1400 Safety Injection Tank (SIT) design differs from the conventional accumulators in that it incorporates a flow controlling FD at the exit of the tank to provide a means for passive flow control.

[3] The facilities mentioned in this report only cover inputs from survey and NI2050 meeting presentations. For more information on large research infrastructures, please refer to the following websites.
NEA Research and Test Facilities DataBase (https://www.oecd-nea.org/rtfdb/public/)
IAEA Research Reactor Database (https://nucleus.iaea.org/RRDB/RR/ReactorSearch.aspx?filter=0)
IAEA Accelerator Knowledge Portal (https://nucleus.iaea.org/sites/accelerators/Pages/default.aspx)
IAEA Catalogue of Facilities in Support of Liquid Metal Cooled Fast Neutron Systems (https://nucleus.iaea.org/sites/lmfns/Pages/default.aspx)
IAEA Post Irradiation Examination Facilities Database (https://infcis.iaea.org/PIE/PIEMain.asp?Order=1&RPage=1&Page=1&RightP=List)

[4] The utilisation rate is determined by the Effective Weeks (EW=7days*24hours of operation) of utilisation per year.

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- Selection criteria of infrastructure

Research reactor: Survey, IAEA Research Reactor Database (with high utilisation rate*)

* Effective Weeks (7days*24hrs of operation per year) ≥ 20 EW

Others: Survey, AP presentations

- Results: Non-exhaustive lists
ex) Discrepancy between reports and templates: Korea infrastructure – "HELIOS" (LBE thermal hydraulics) from Dr. Kamide's template

- MC (NDC rep/Adv Panel) until end November to review and provide comments/updates/additions – ia on infrastructures…

NI2050 SURVEY: Trends using IEA 2000-2015 data

- For all IEA countries we got all figures per year – all energies, including split nuclear fission and fusion – Excel tables

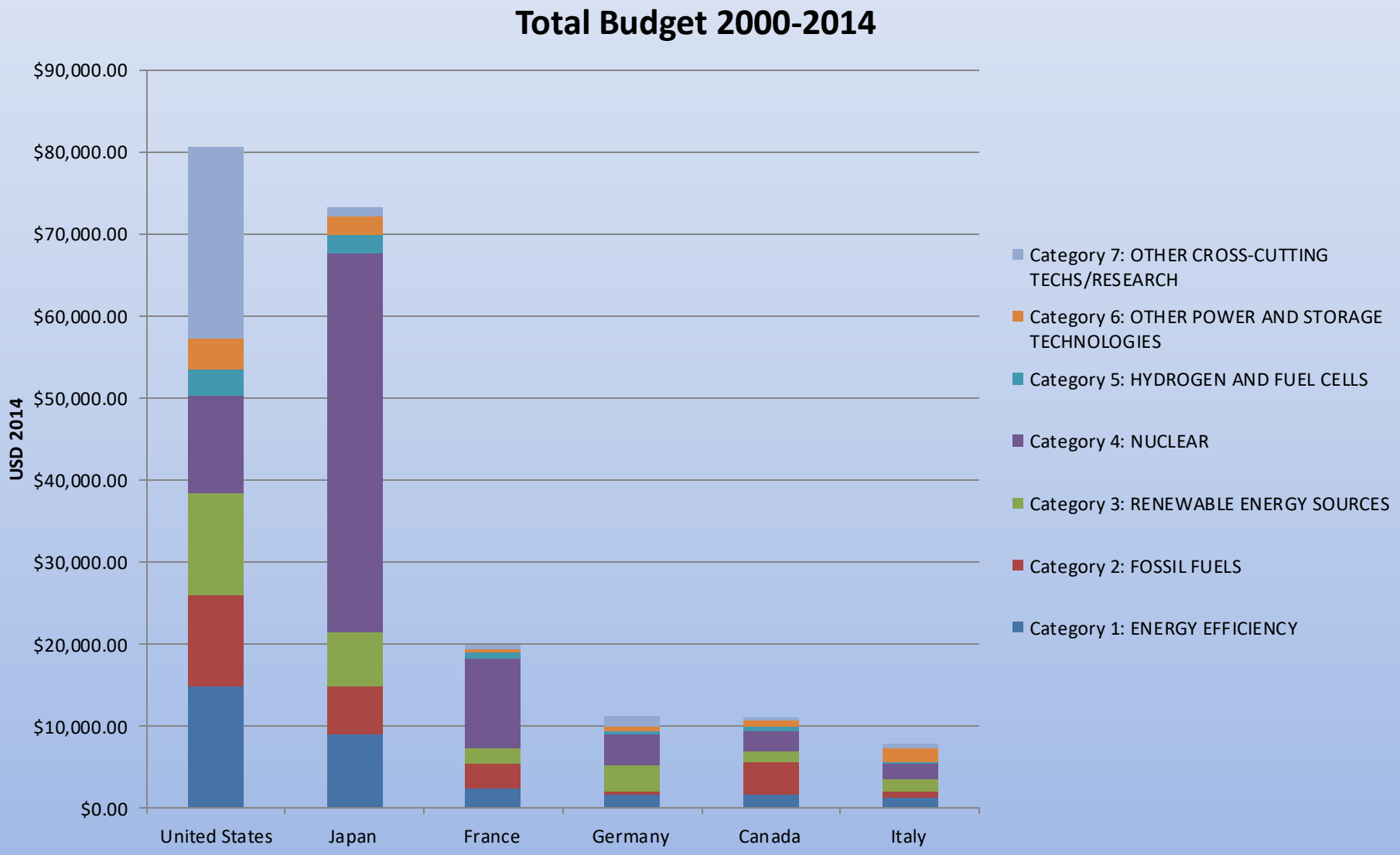
- Graphs:

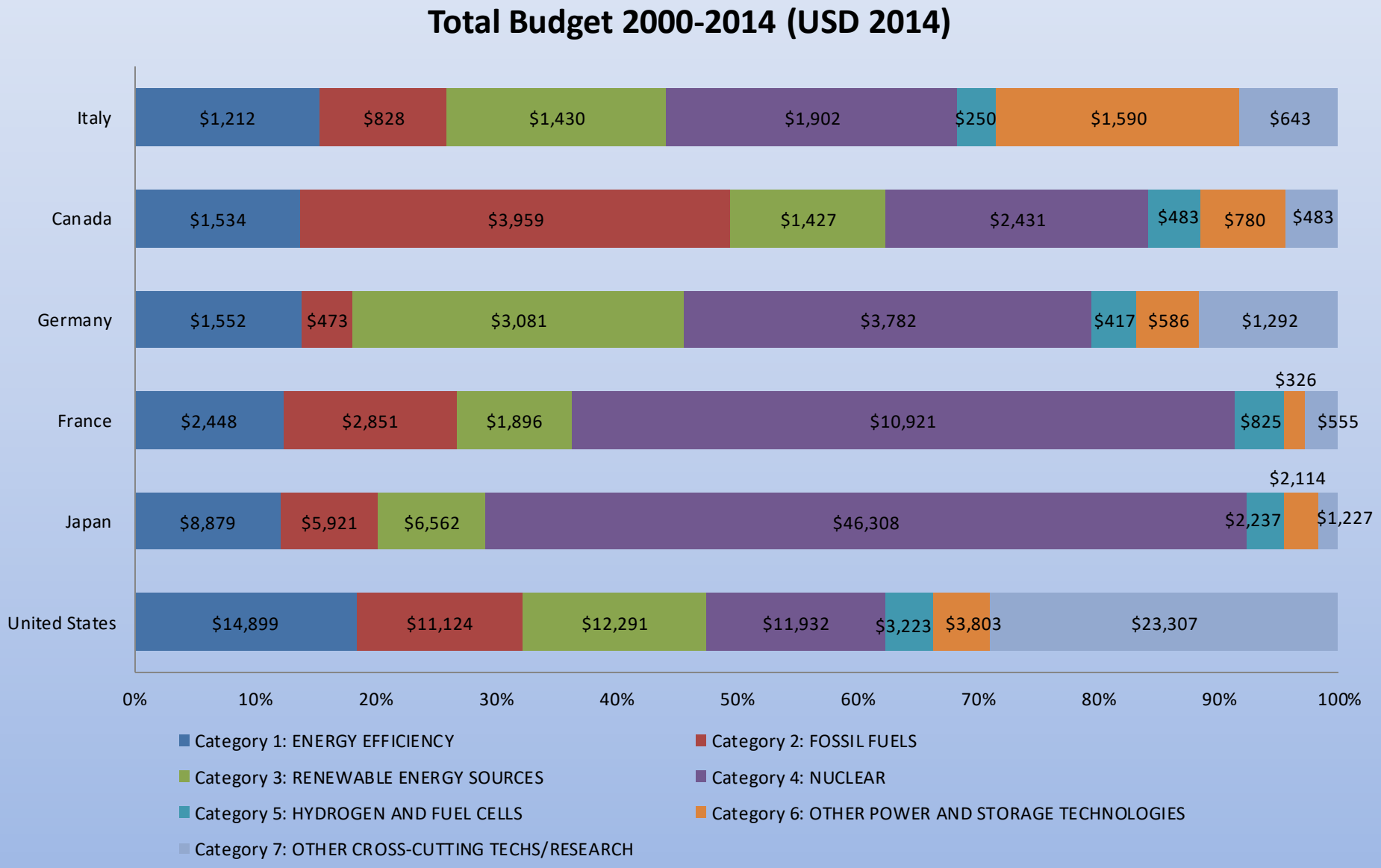
  1/Total cumultative budget per country for the 15 years, and share between different energies

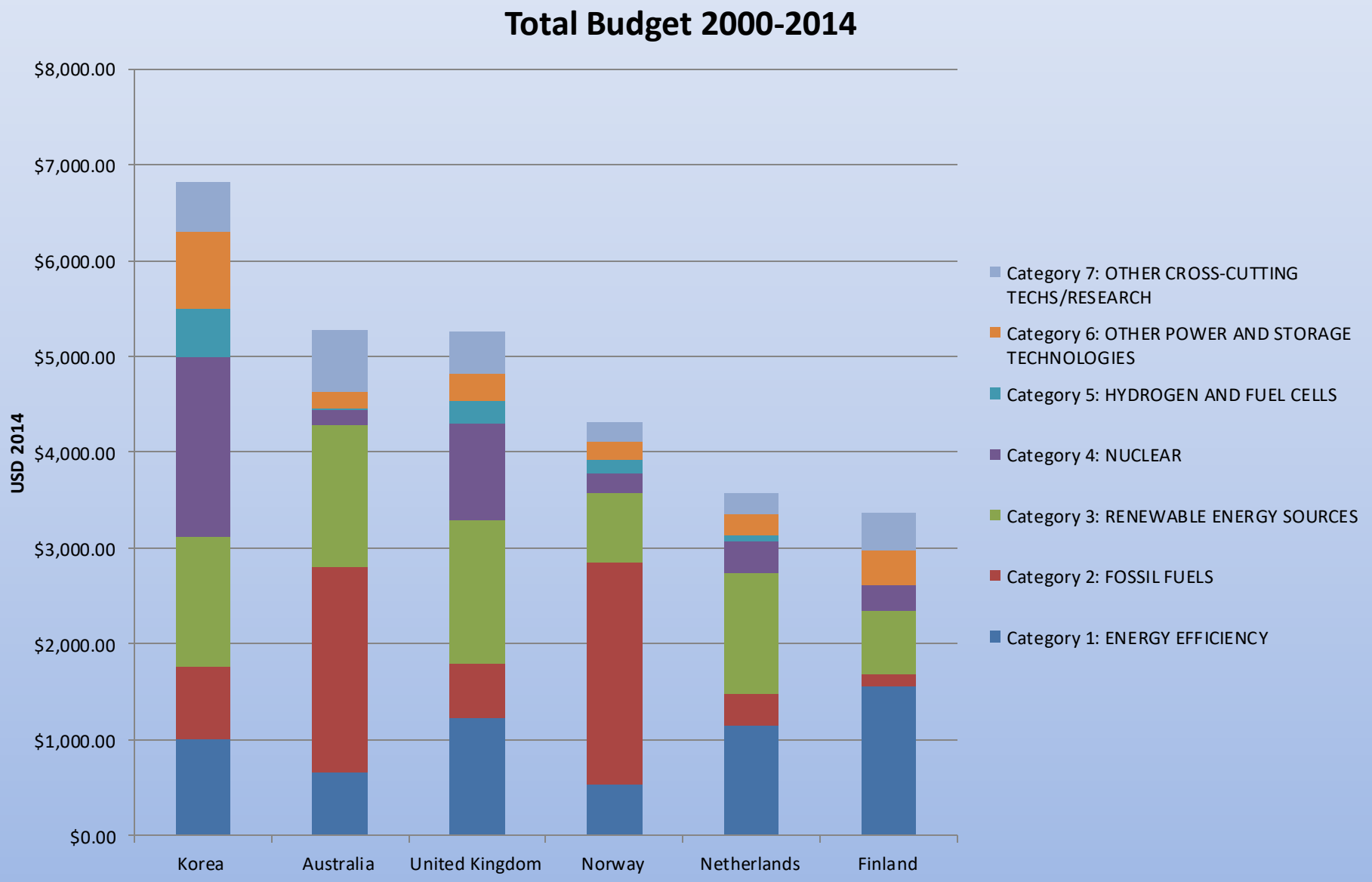
  2/For « top ten » - per country, trend in budget (total and per energy type (in actual USD and USD2014)

  3/For nuclear – total and split FI/FU per country for the 15 years

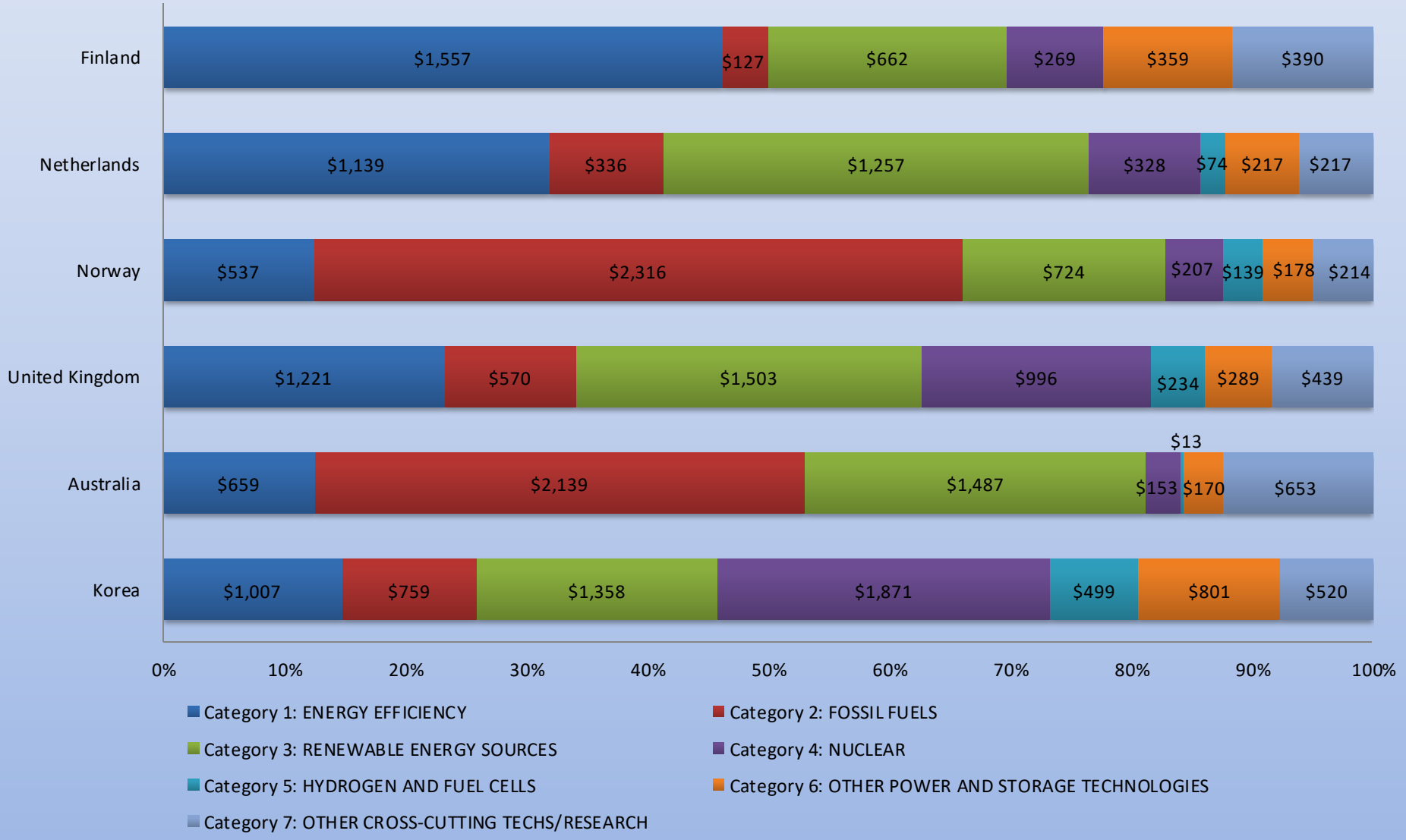
  4/Where possible – per country, trend in budget (total nuclear, and FI/FU)

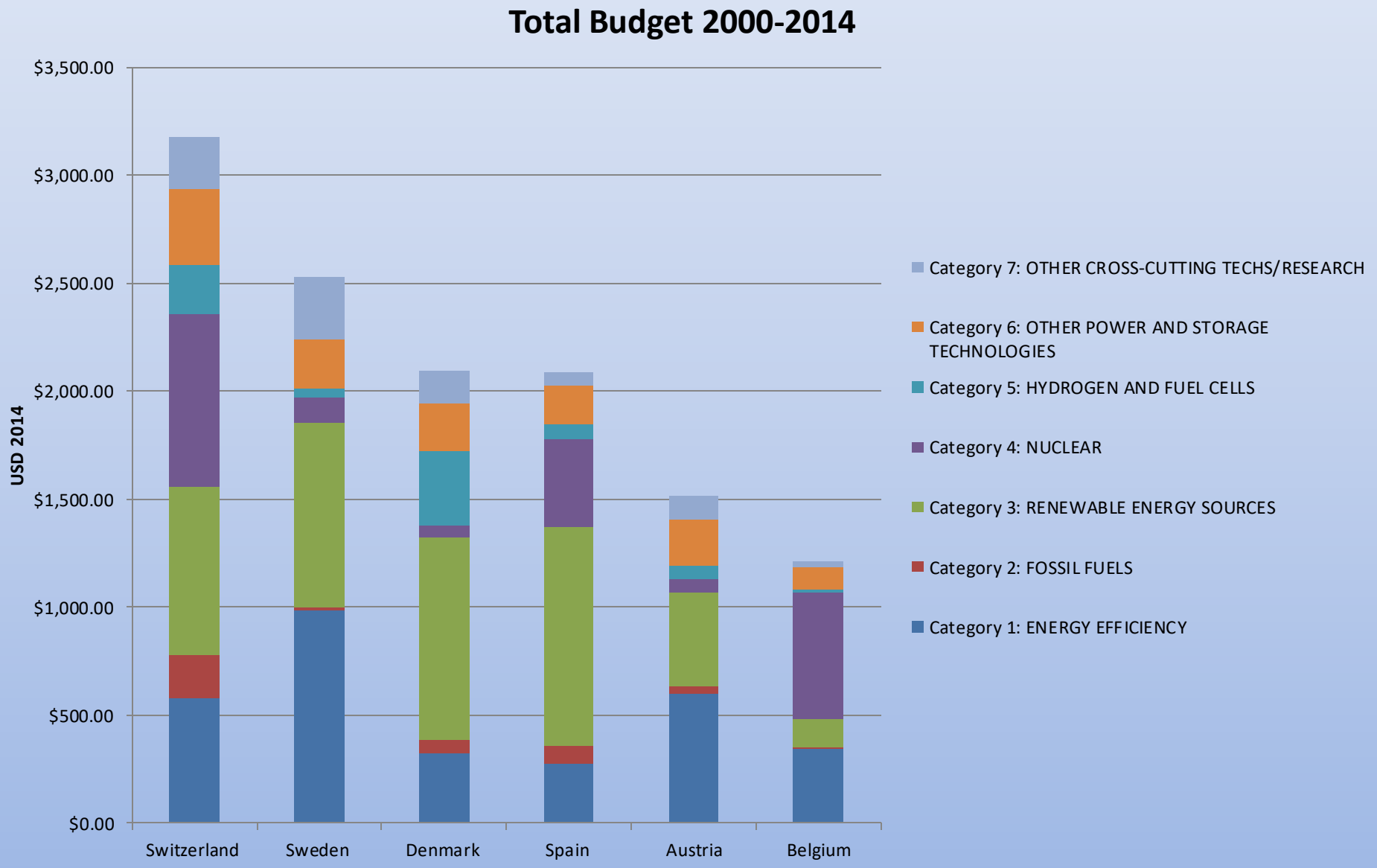


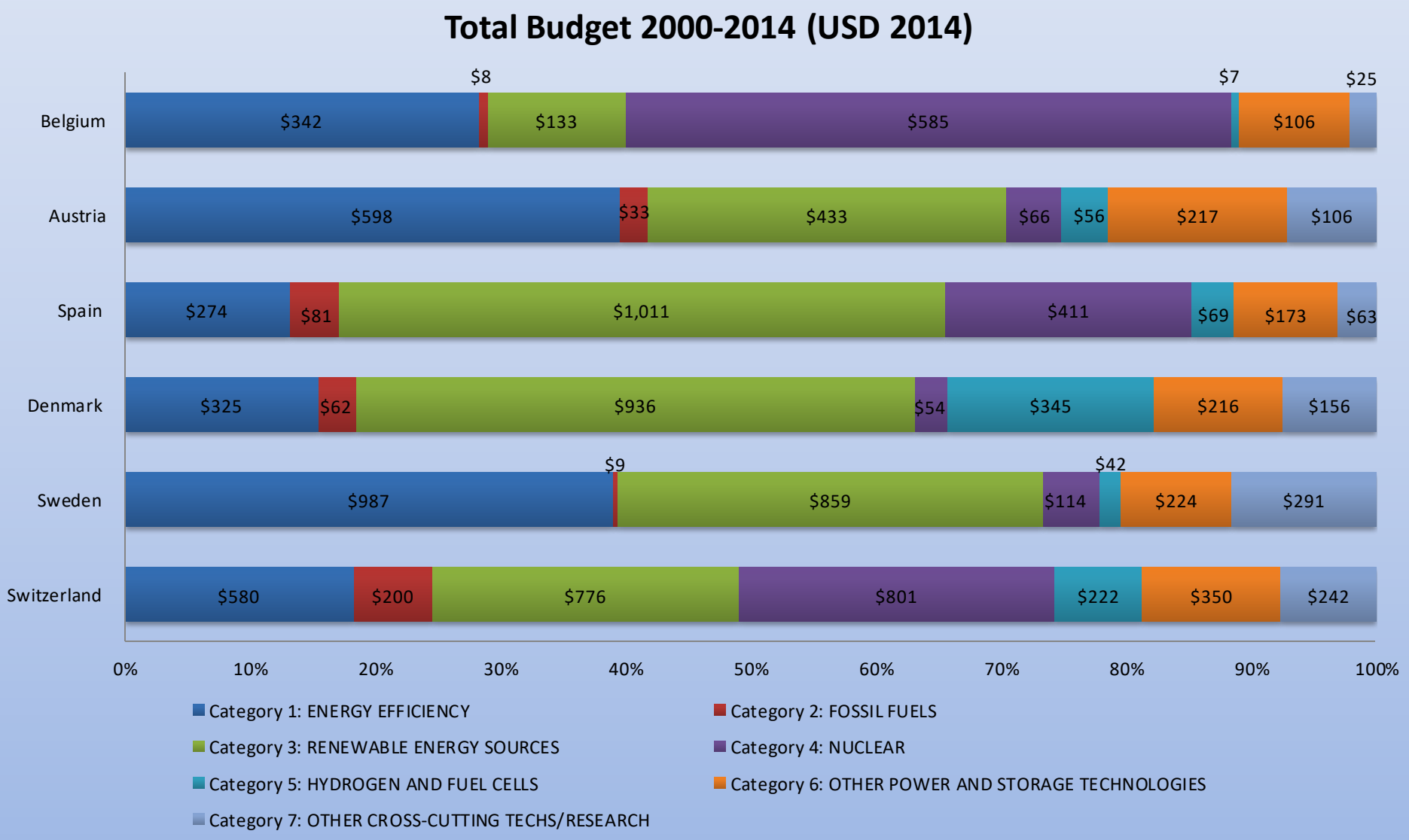


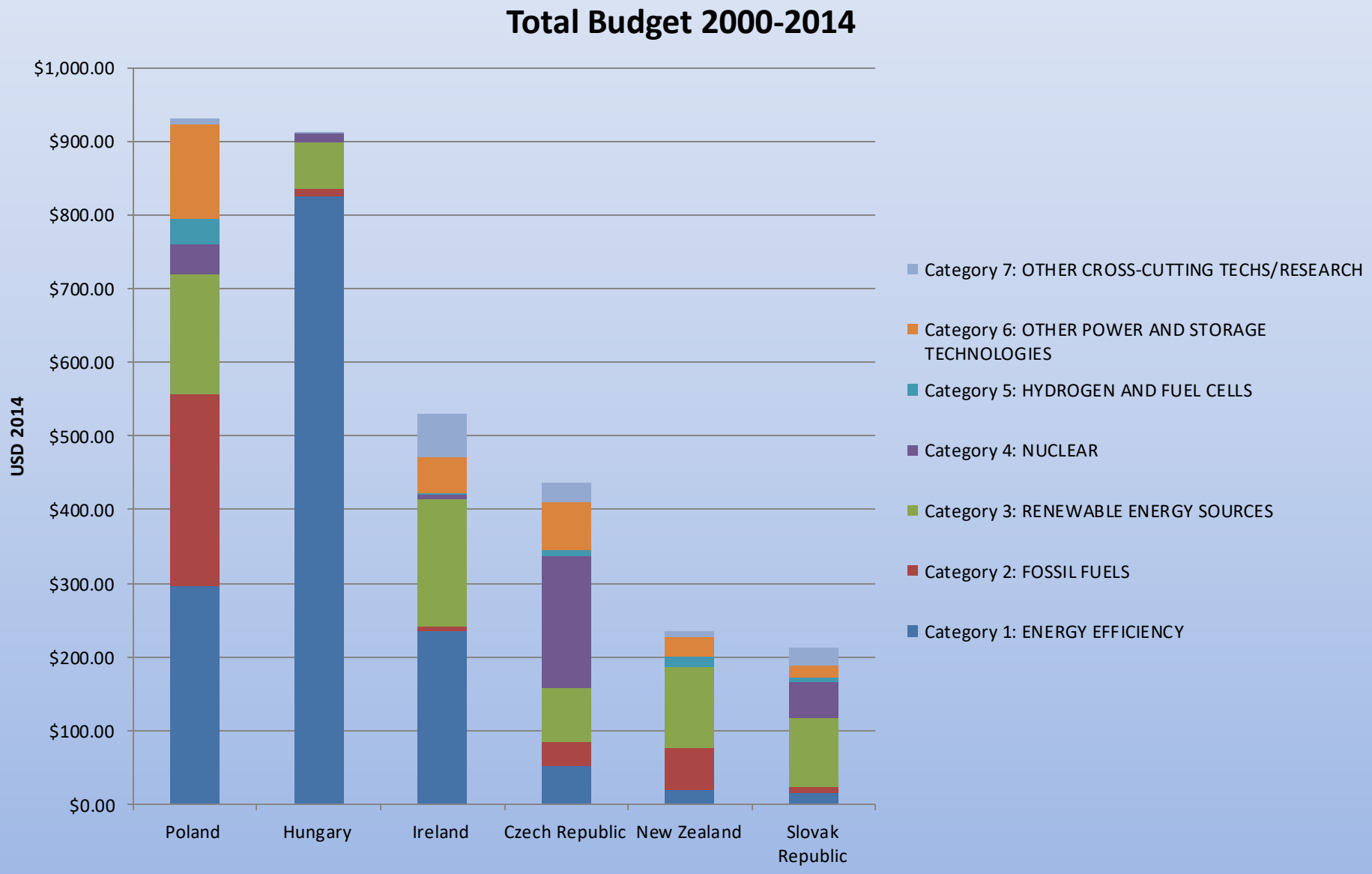


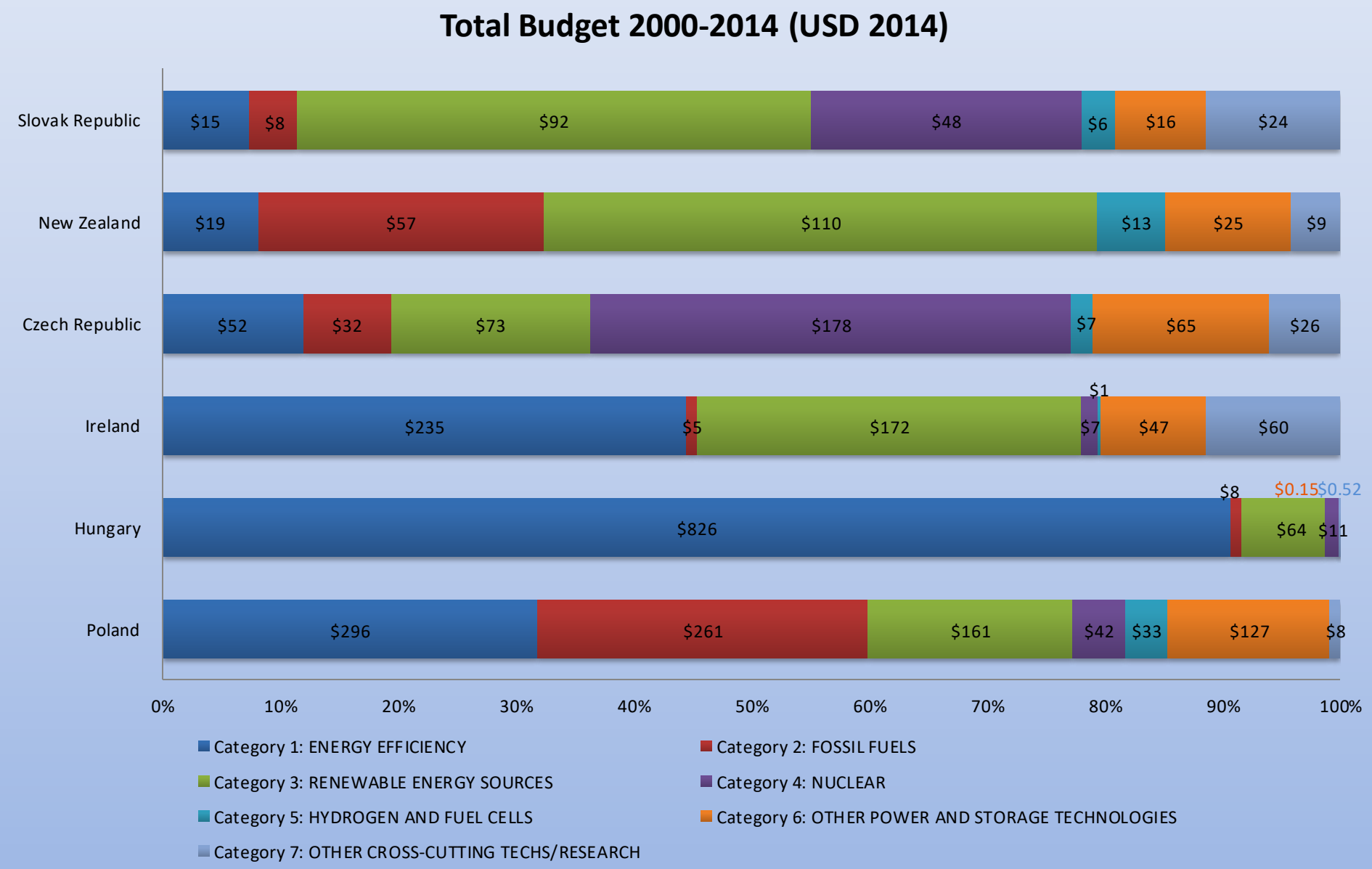
Total Budget 2000-2014 (USD 2014)

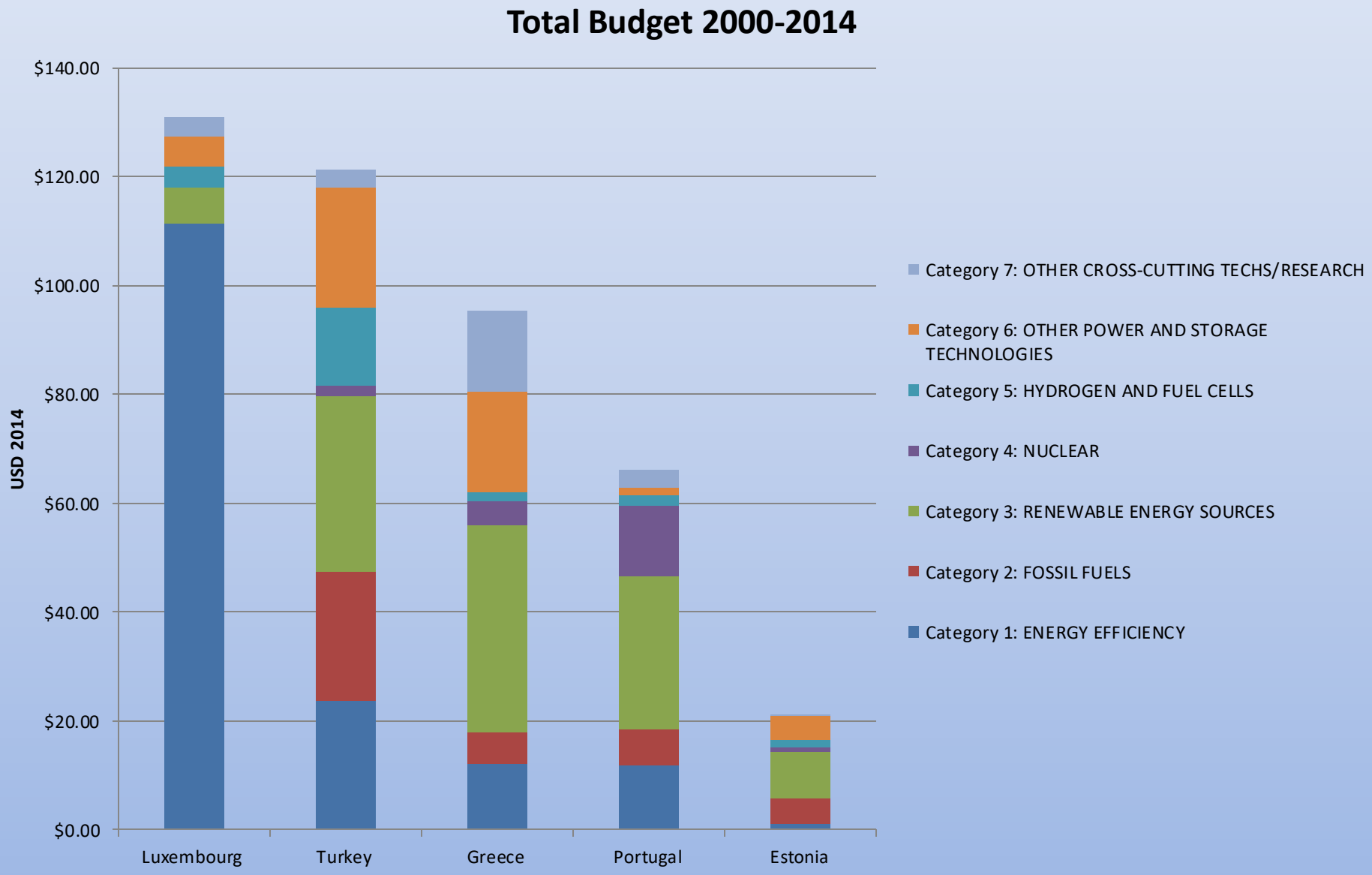


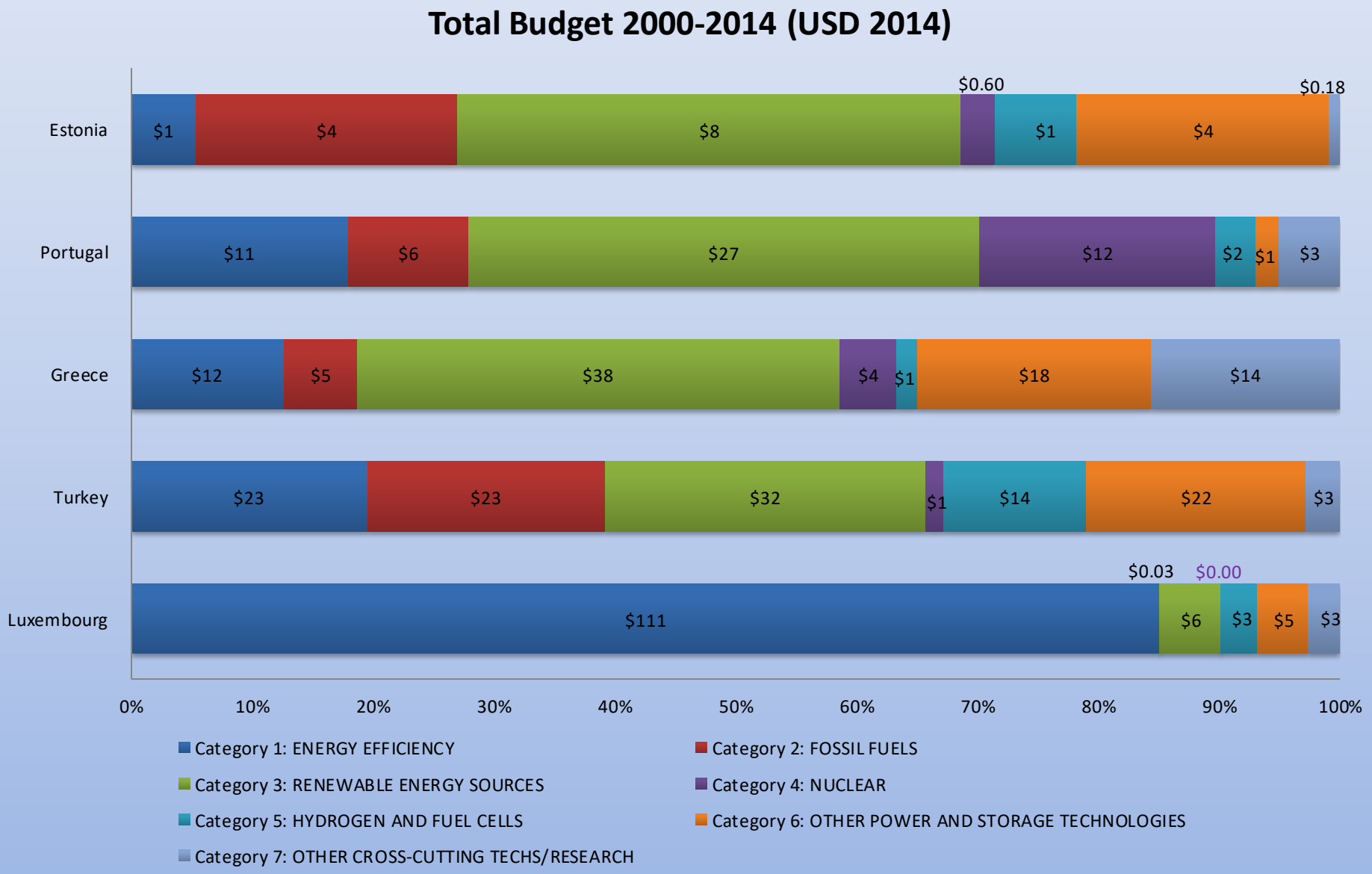


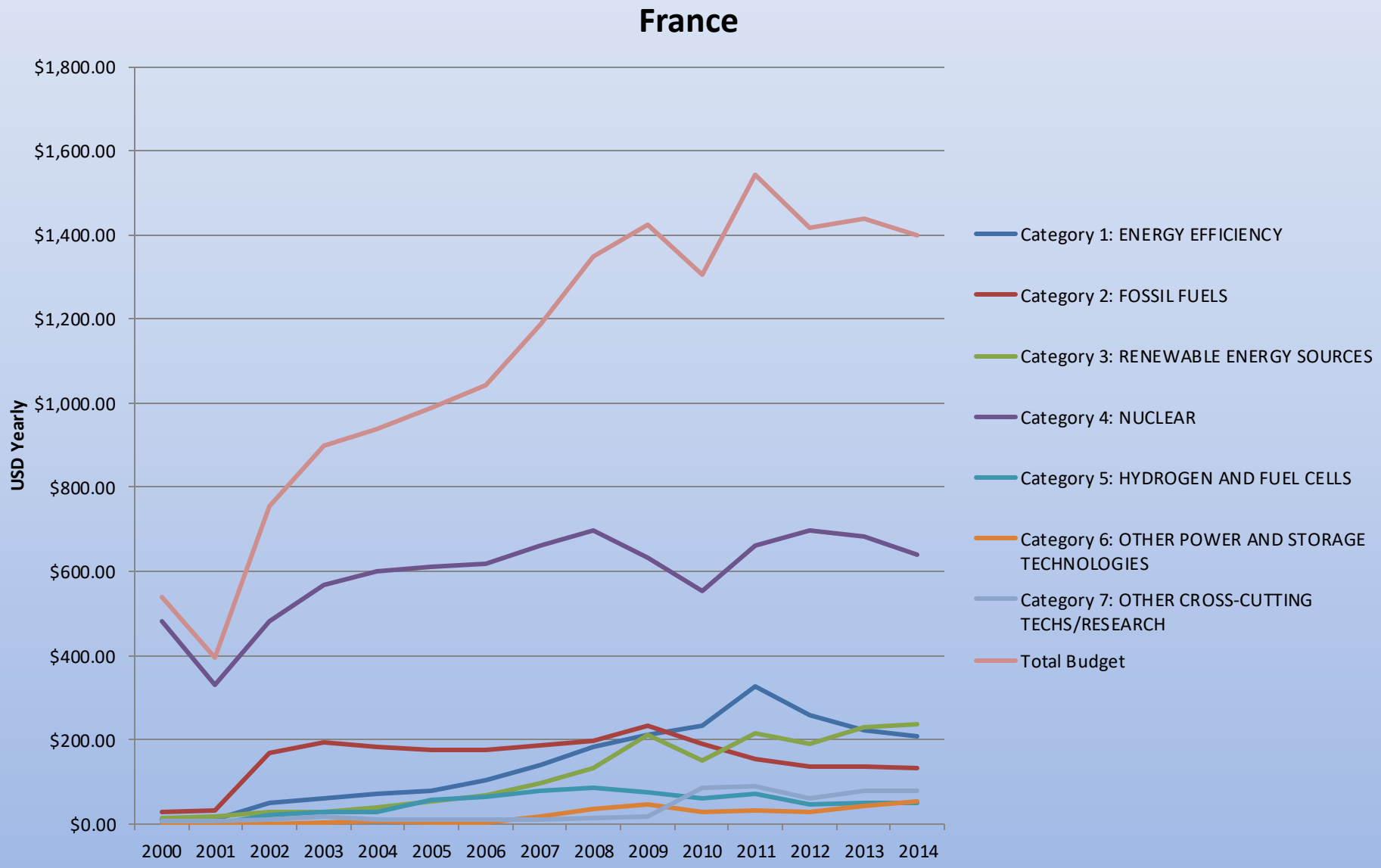


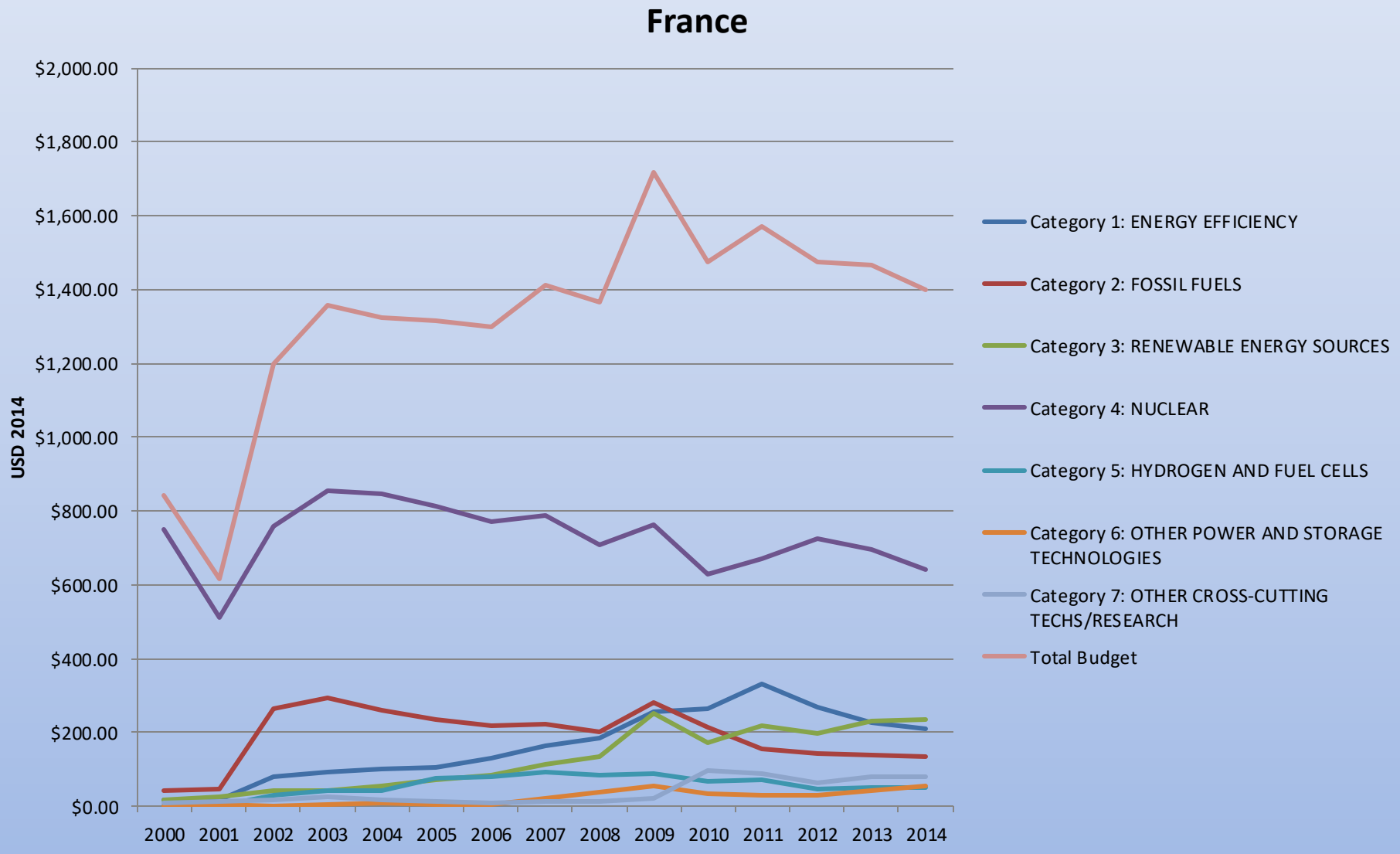


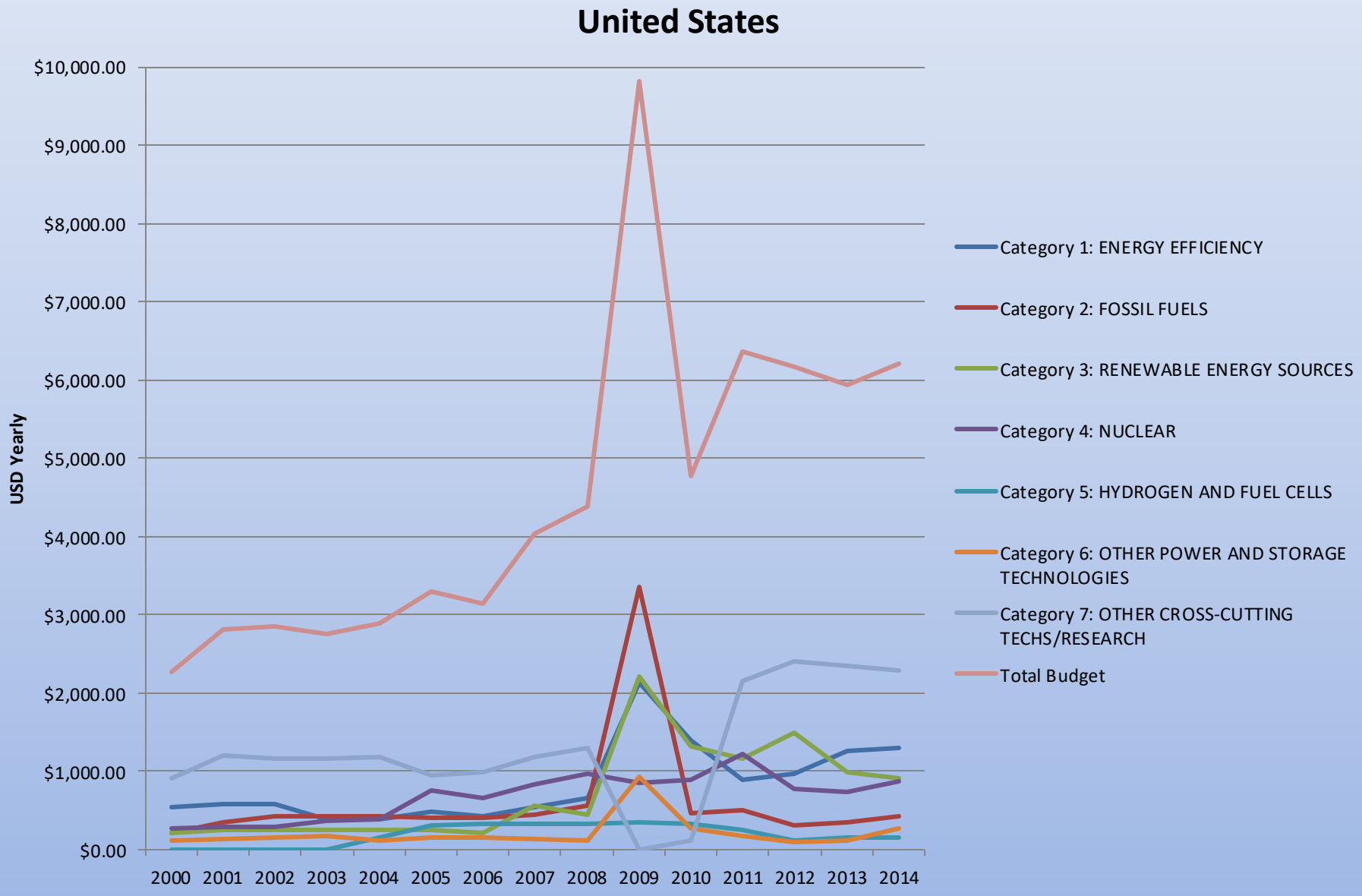


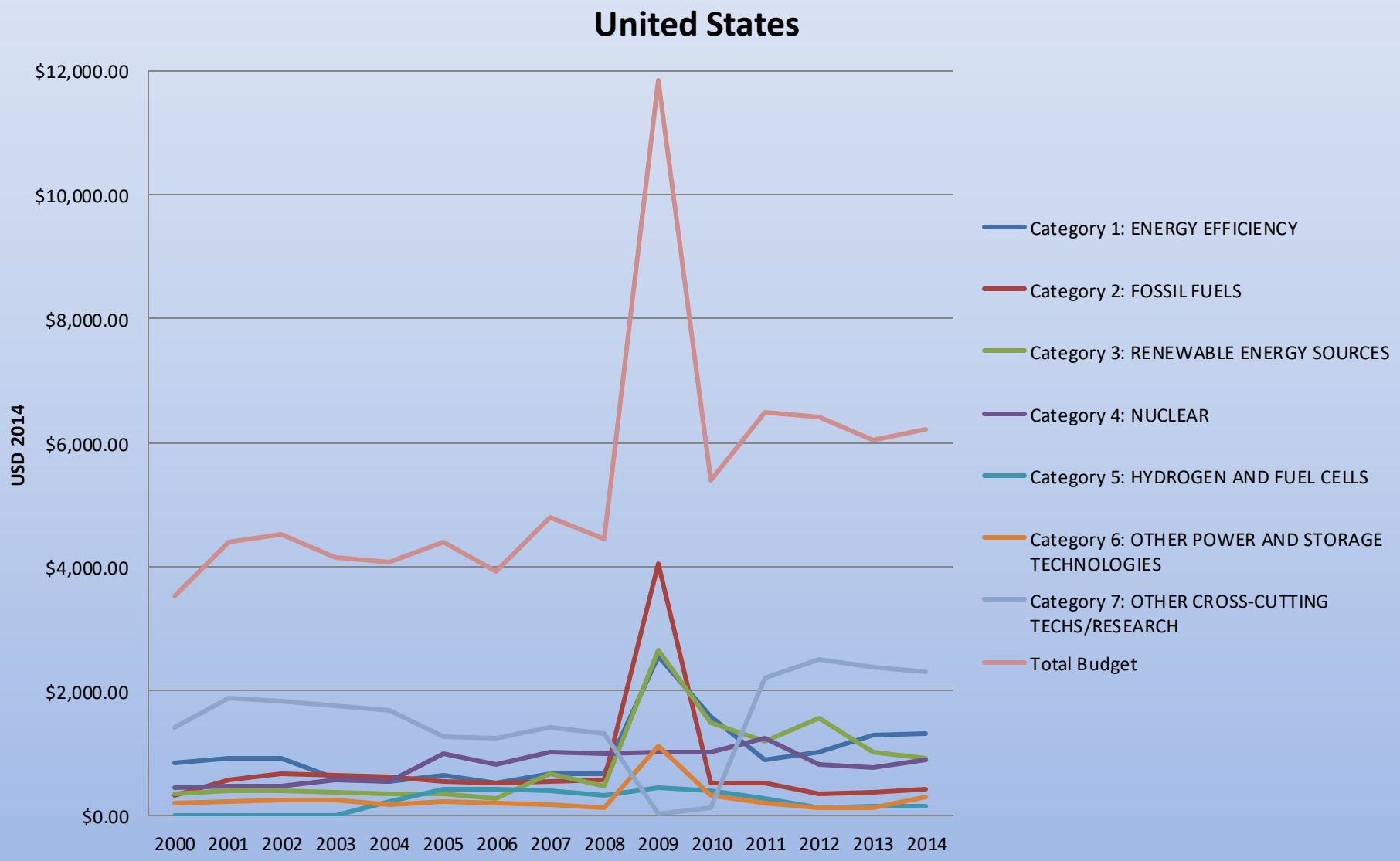


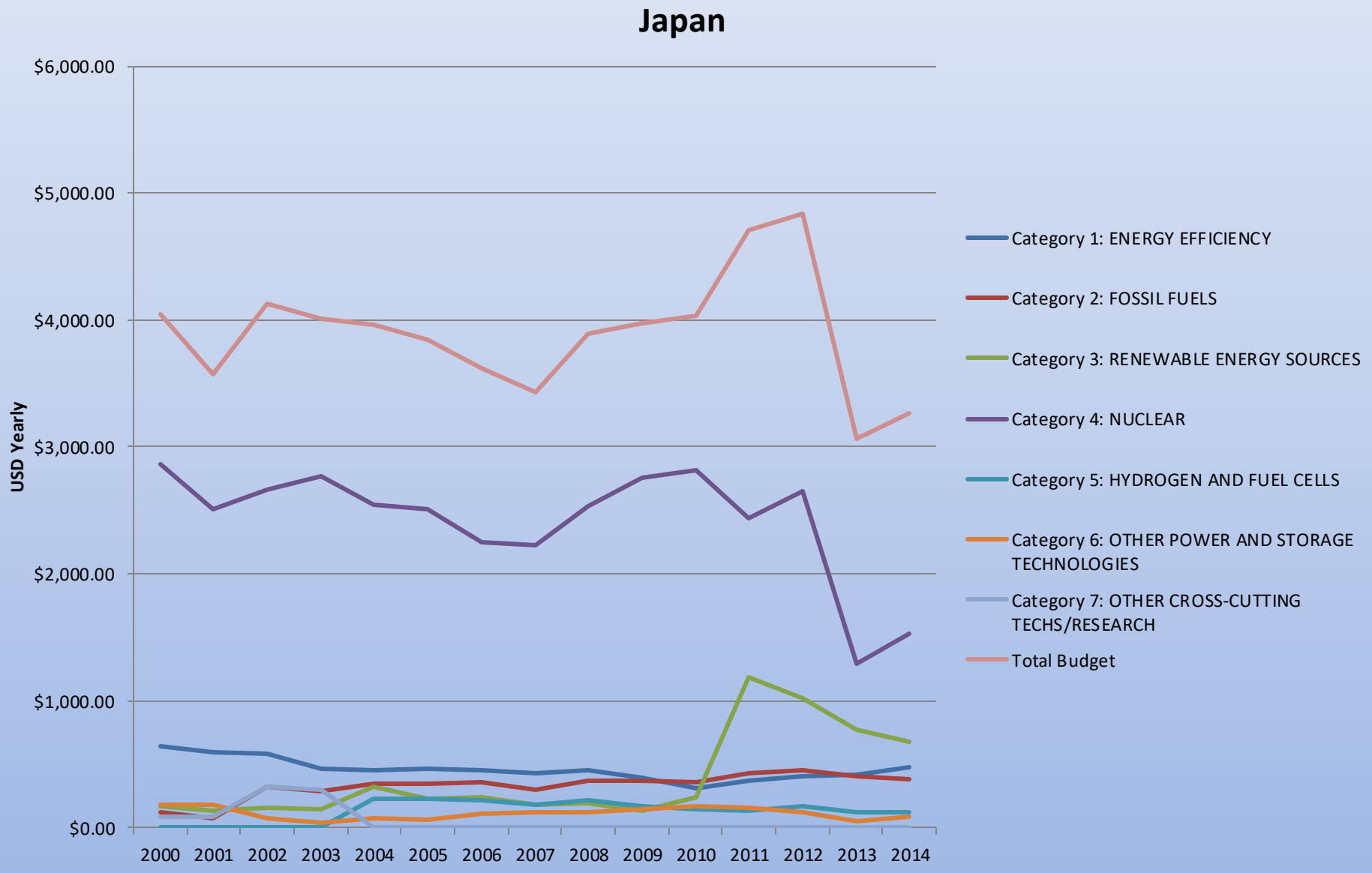


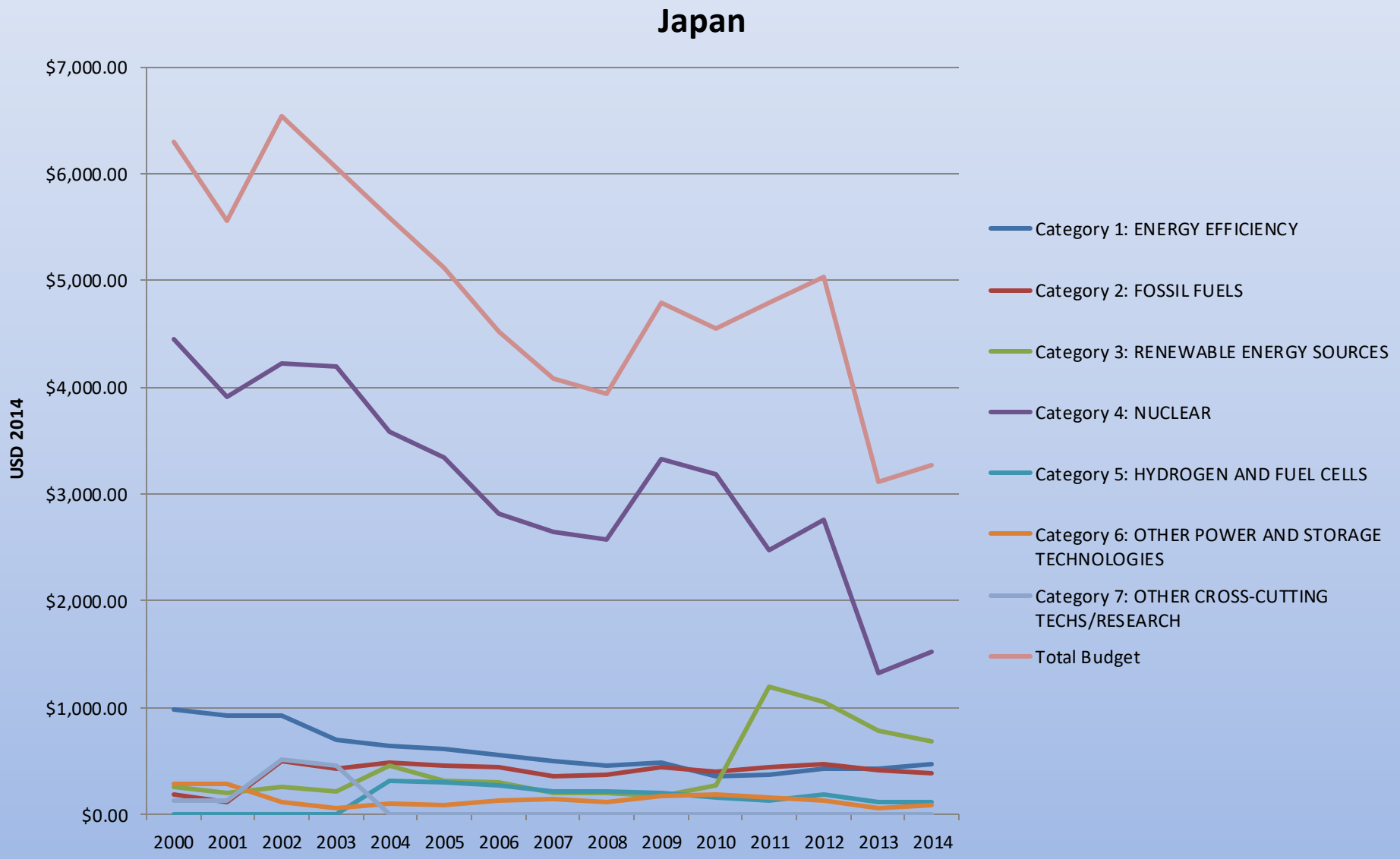


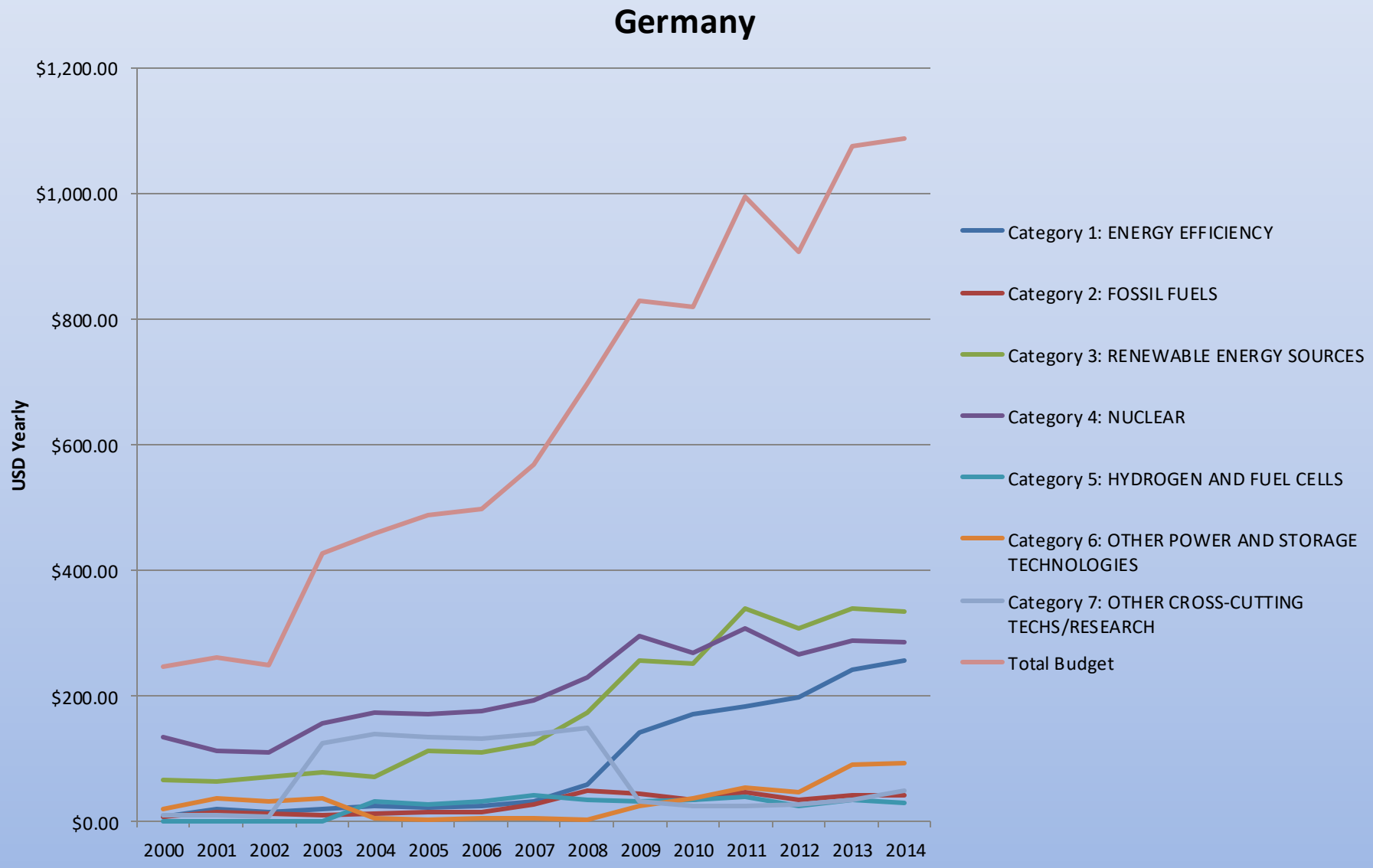


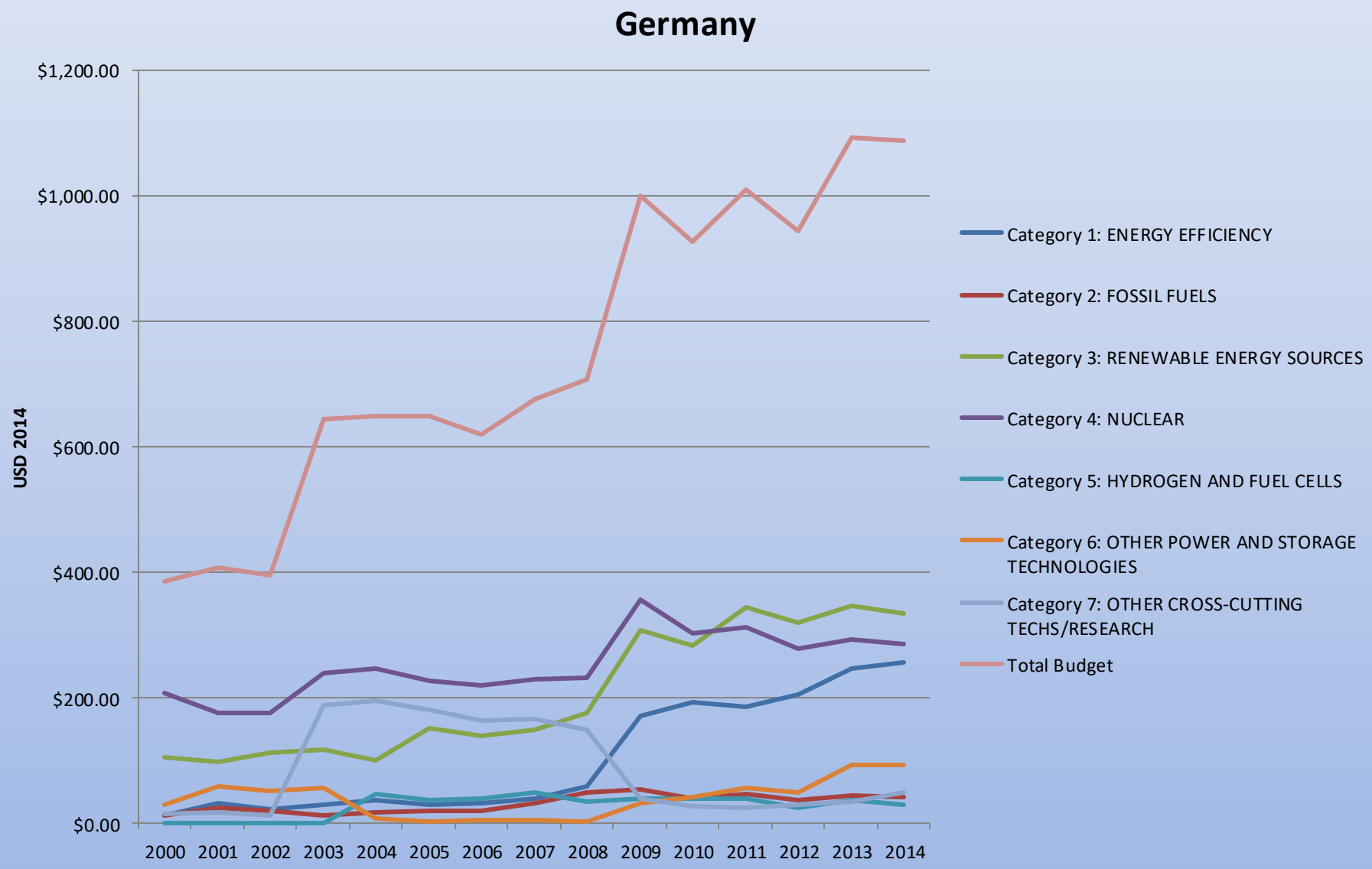


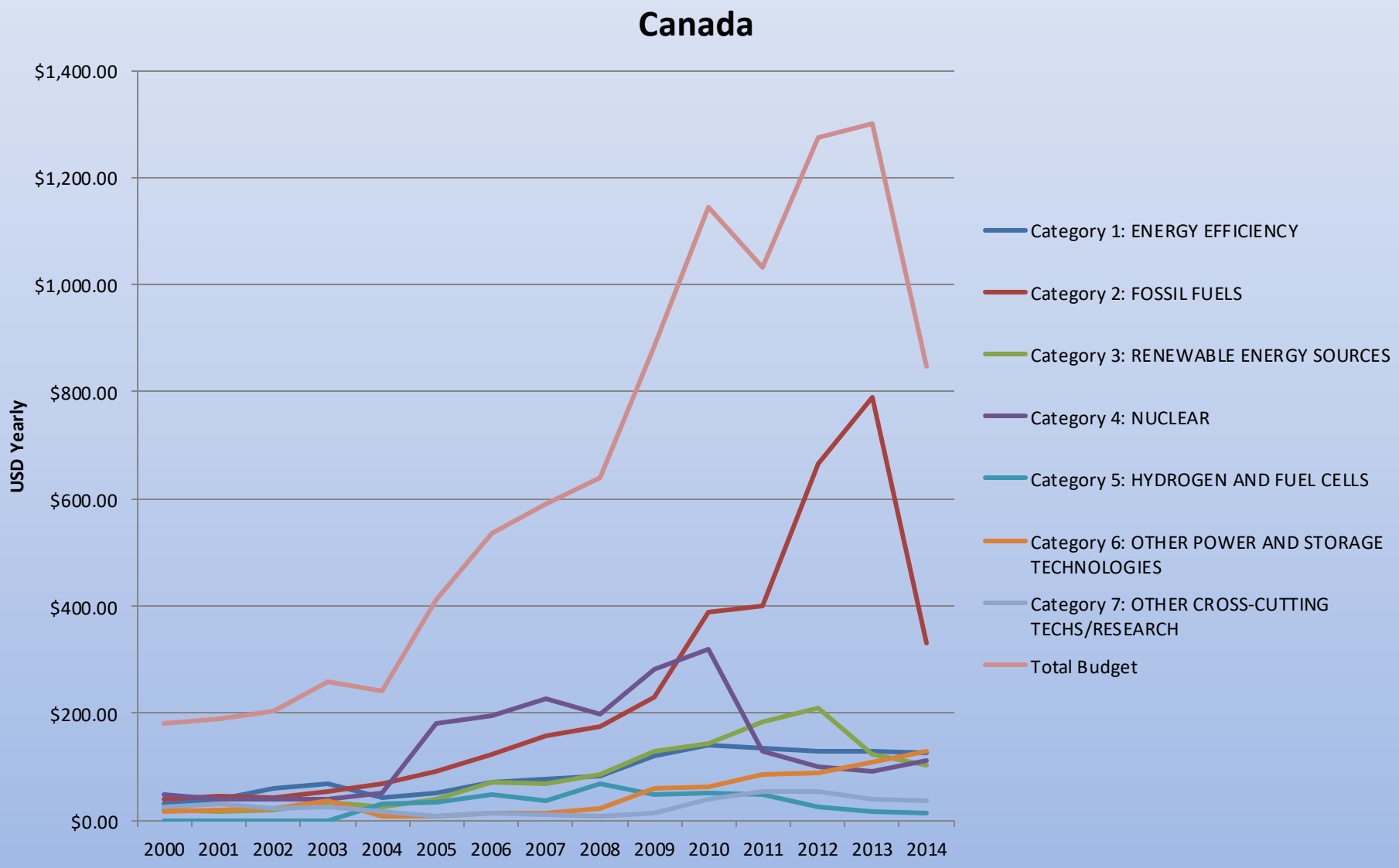


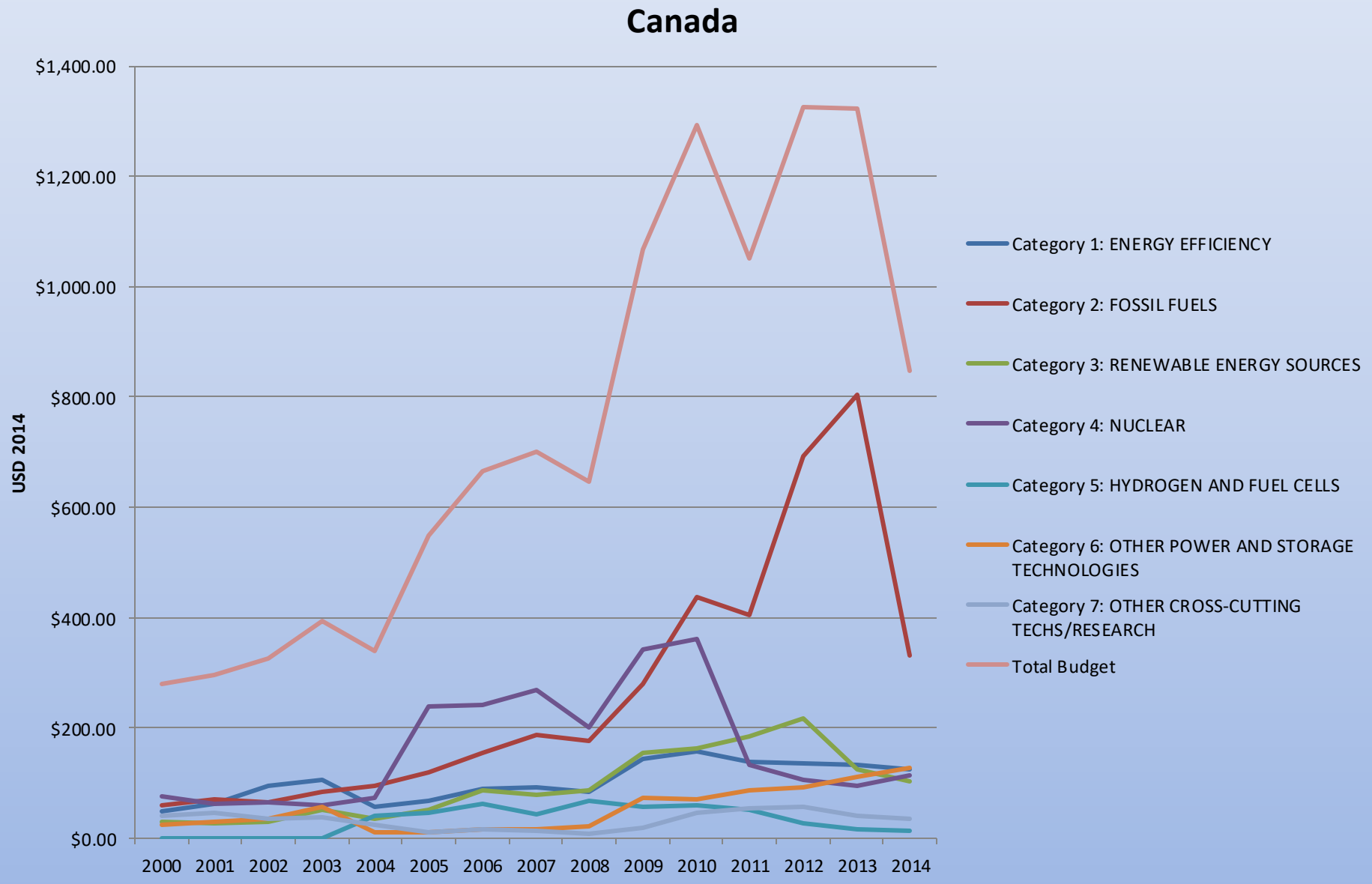


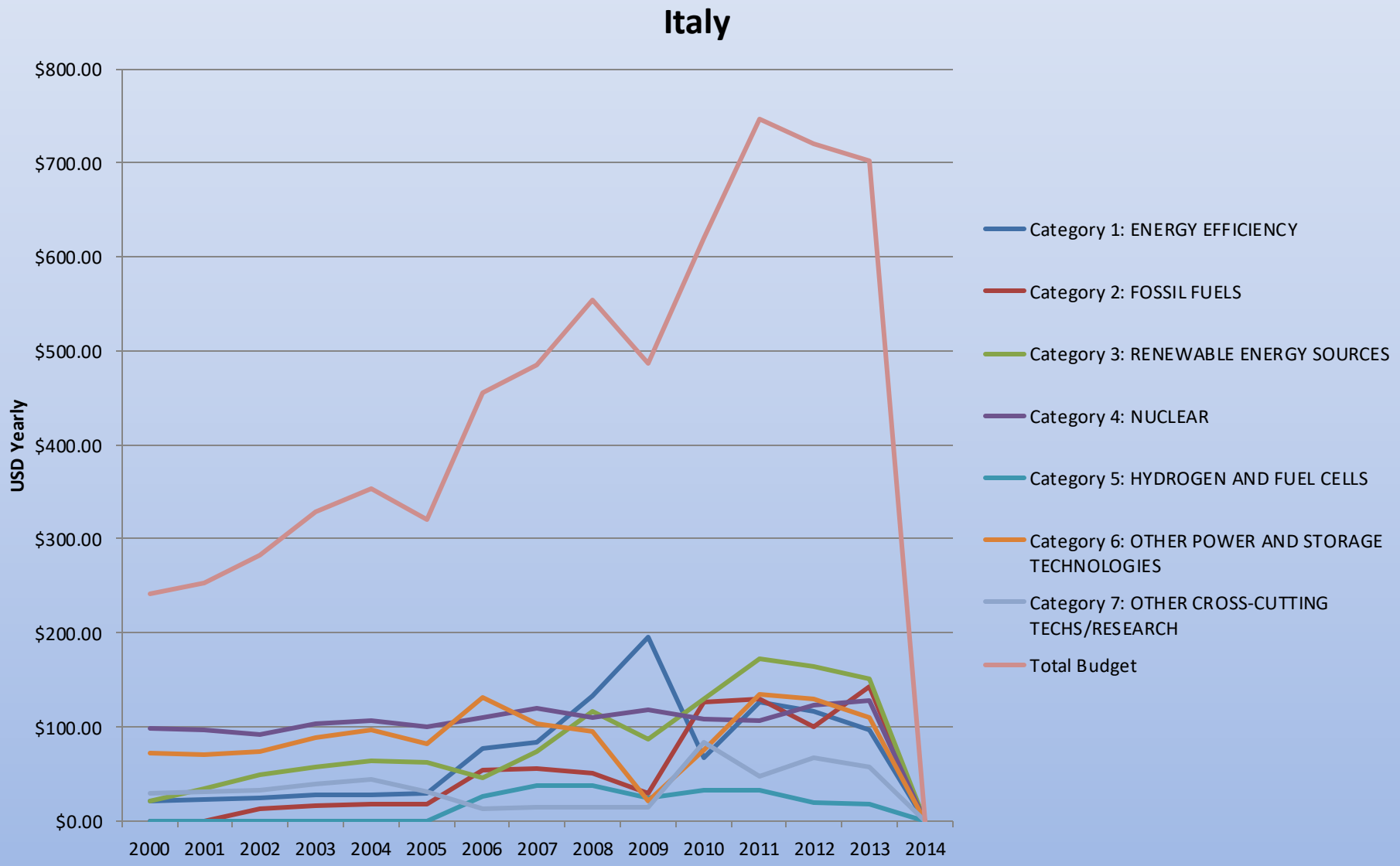


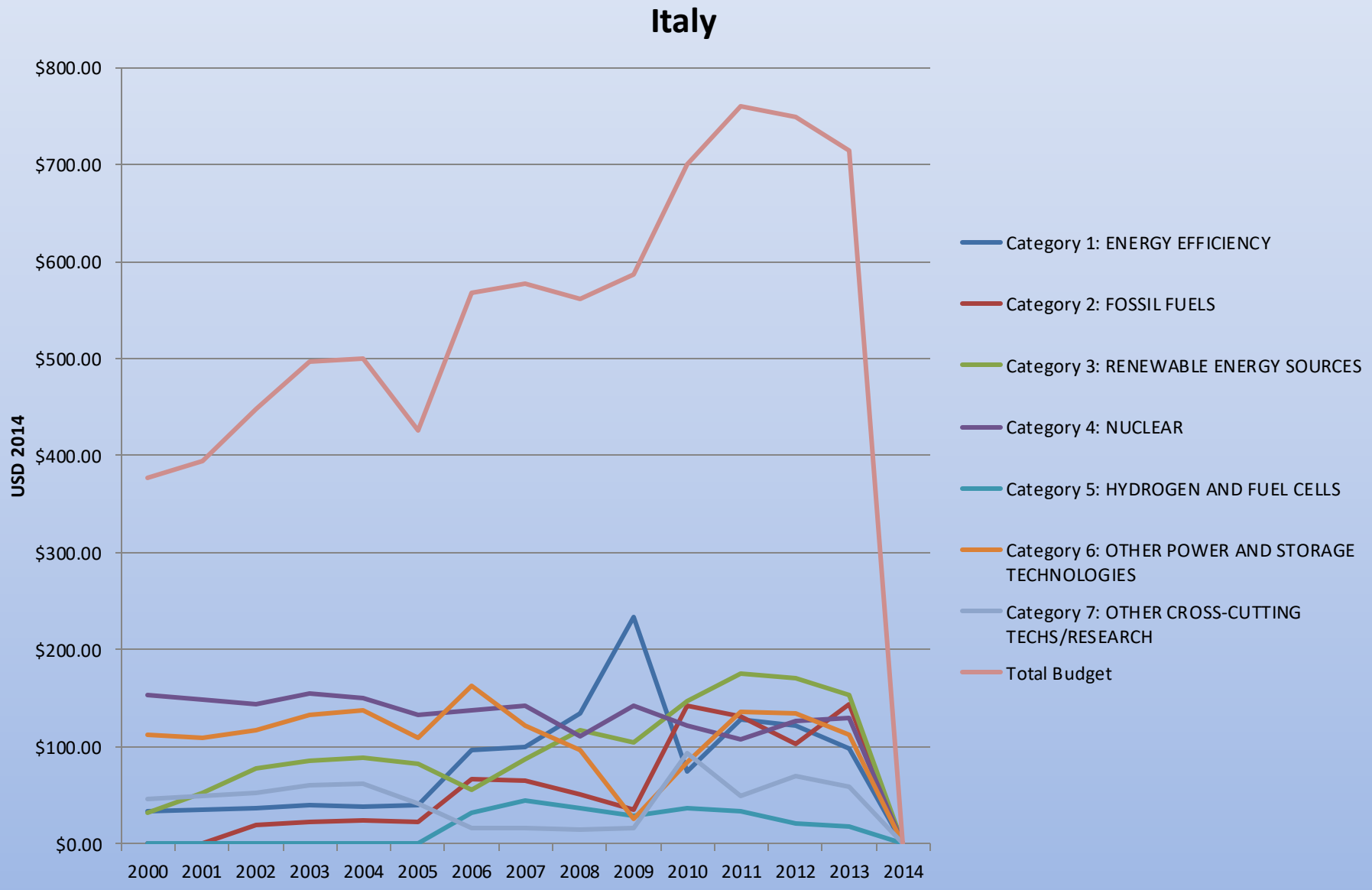


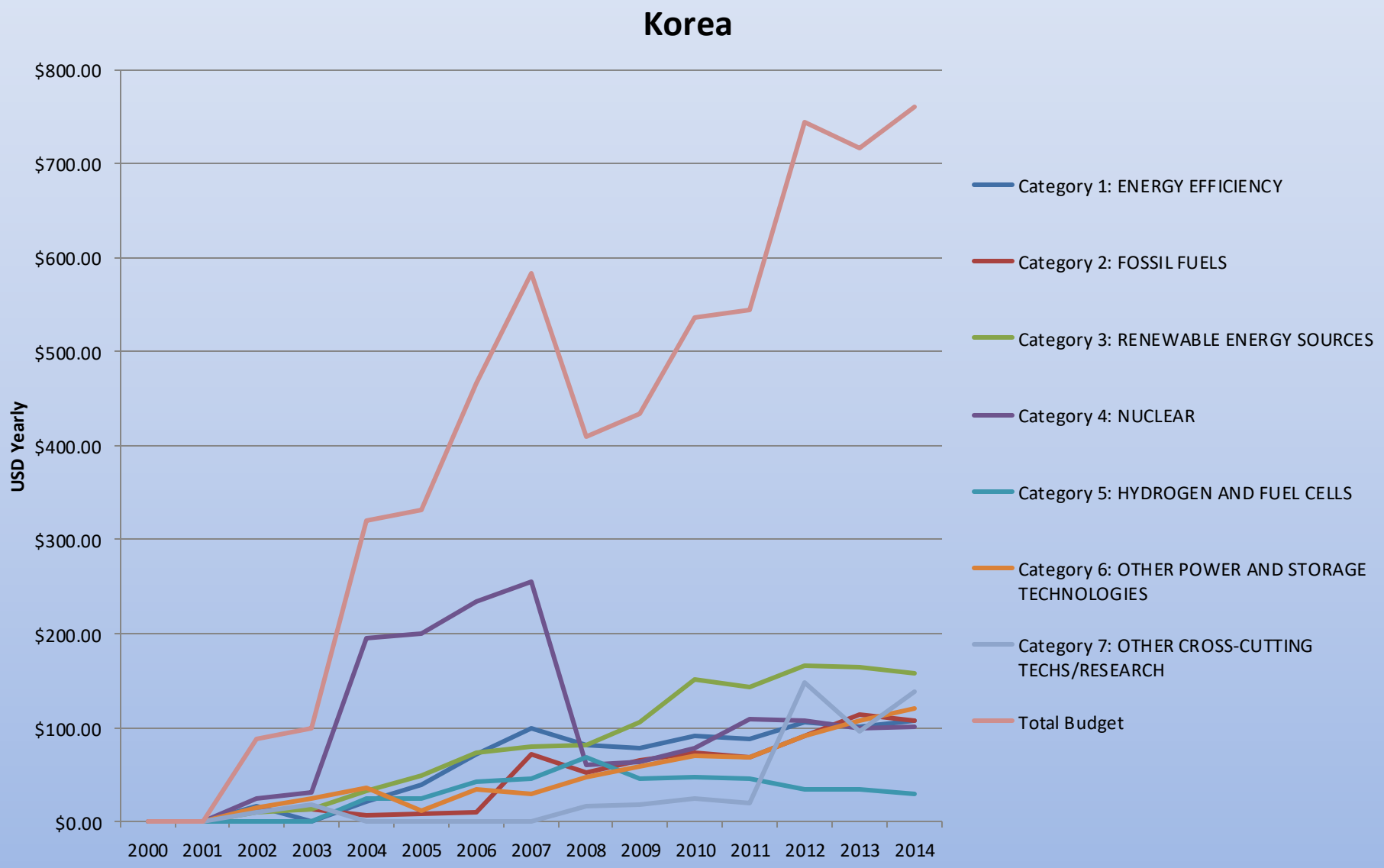


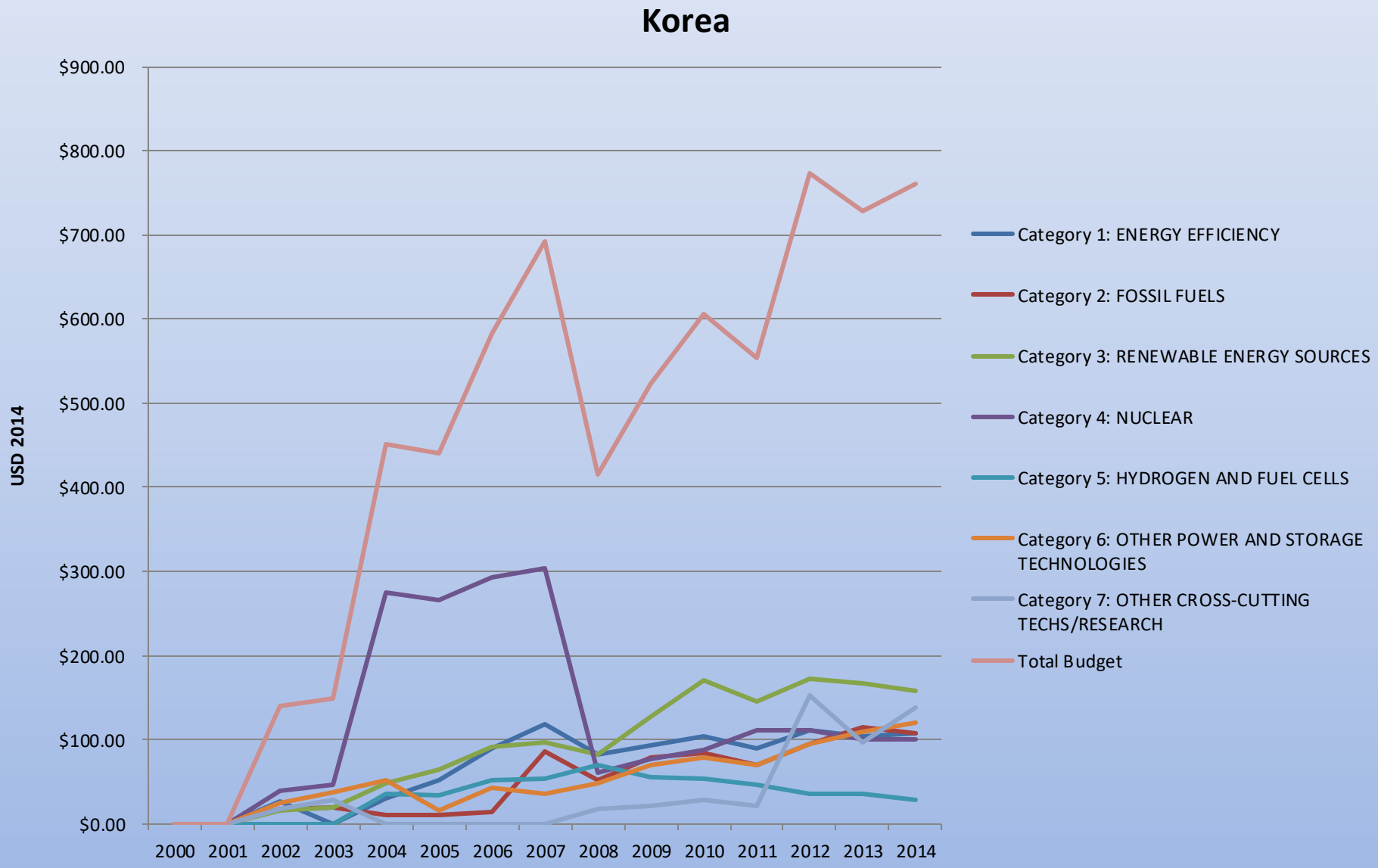


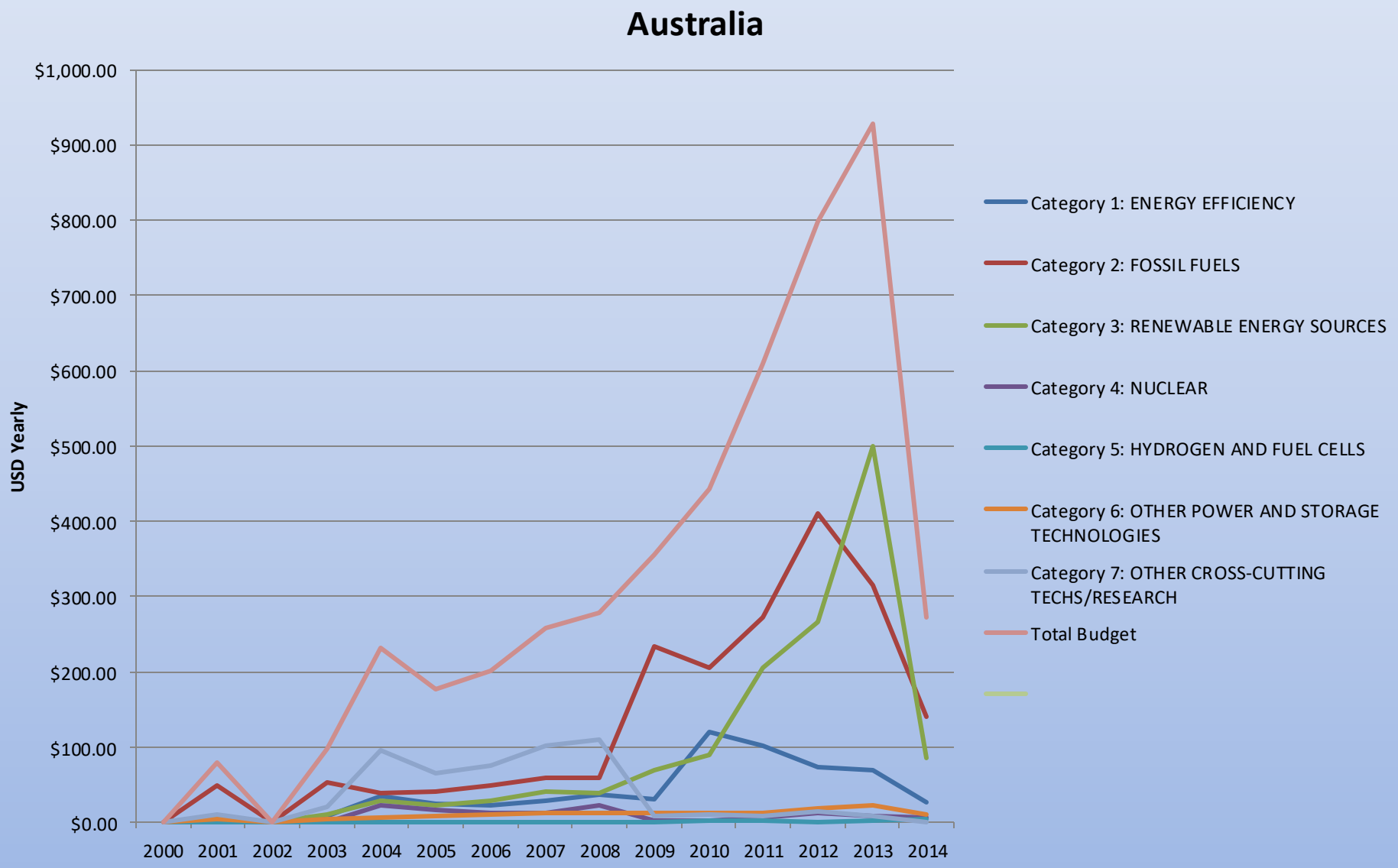


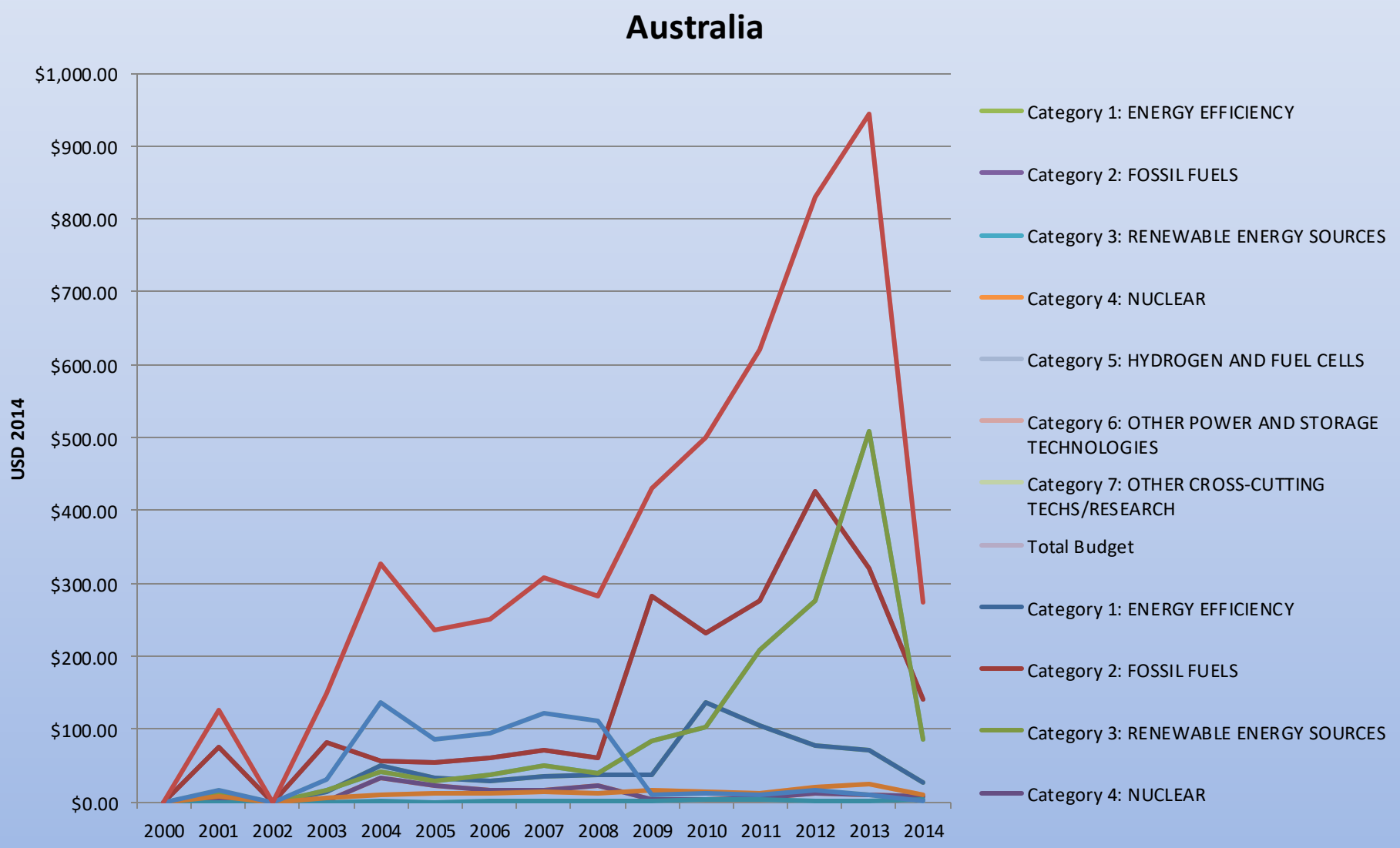


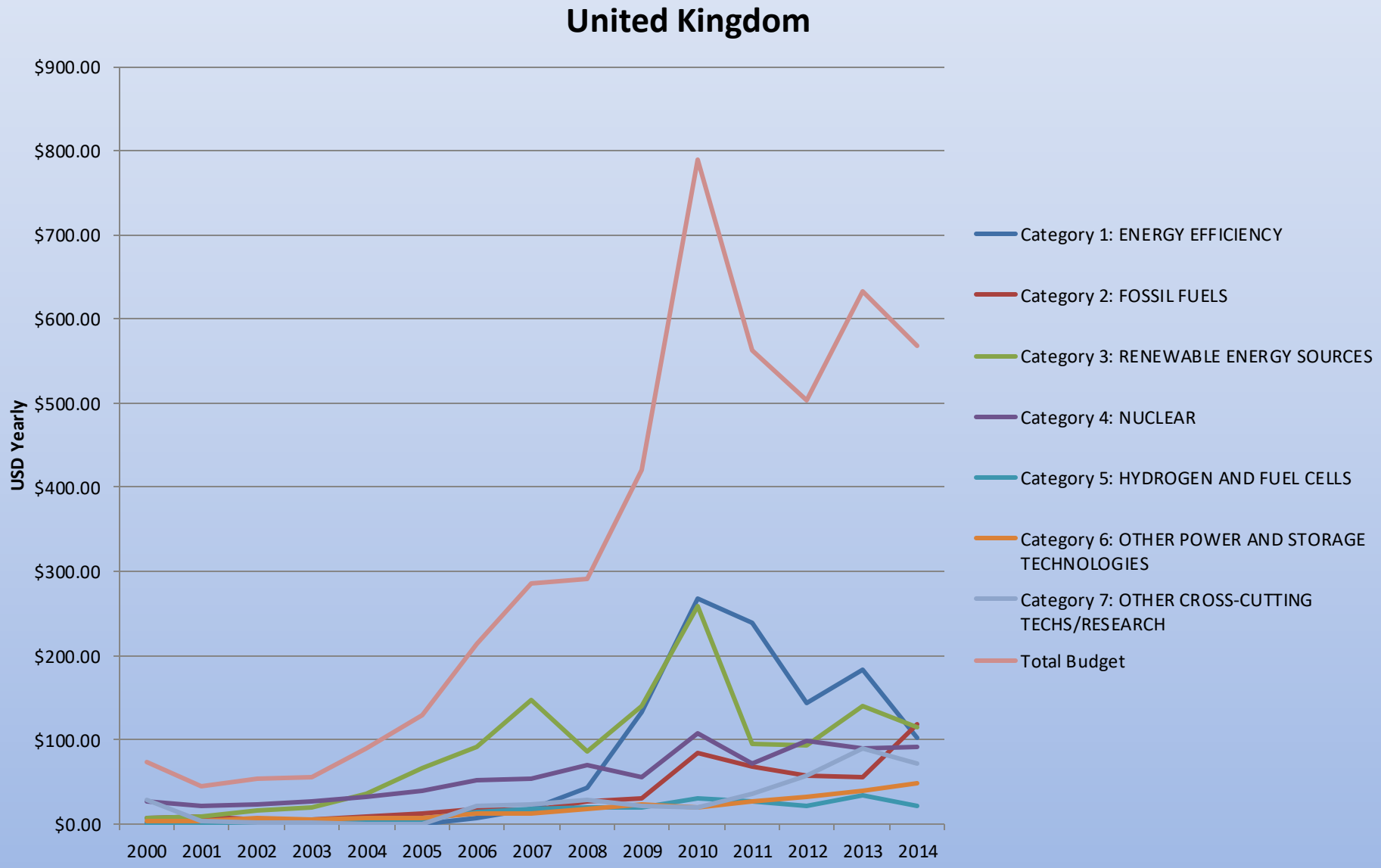


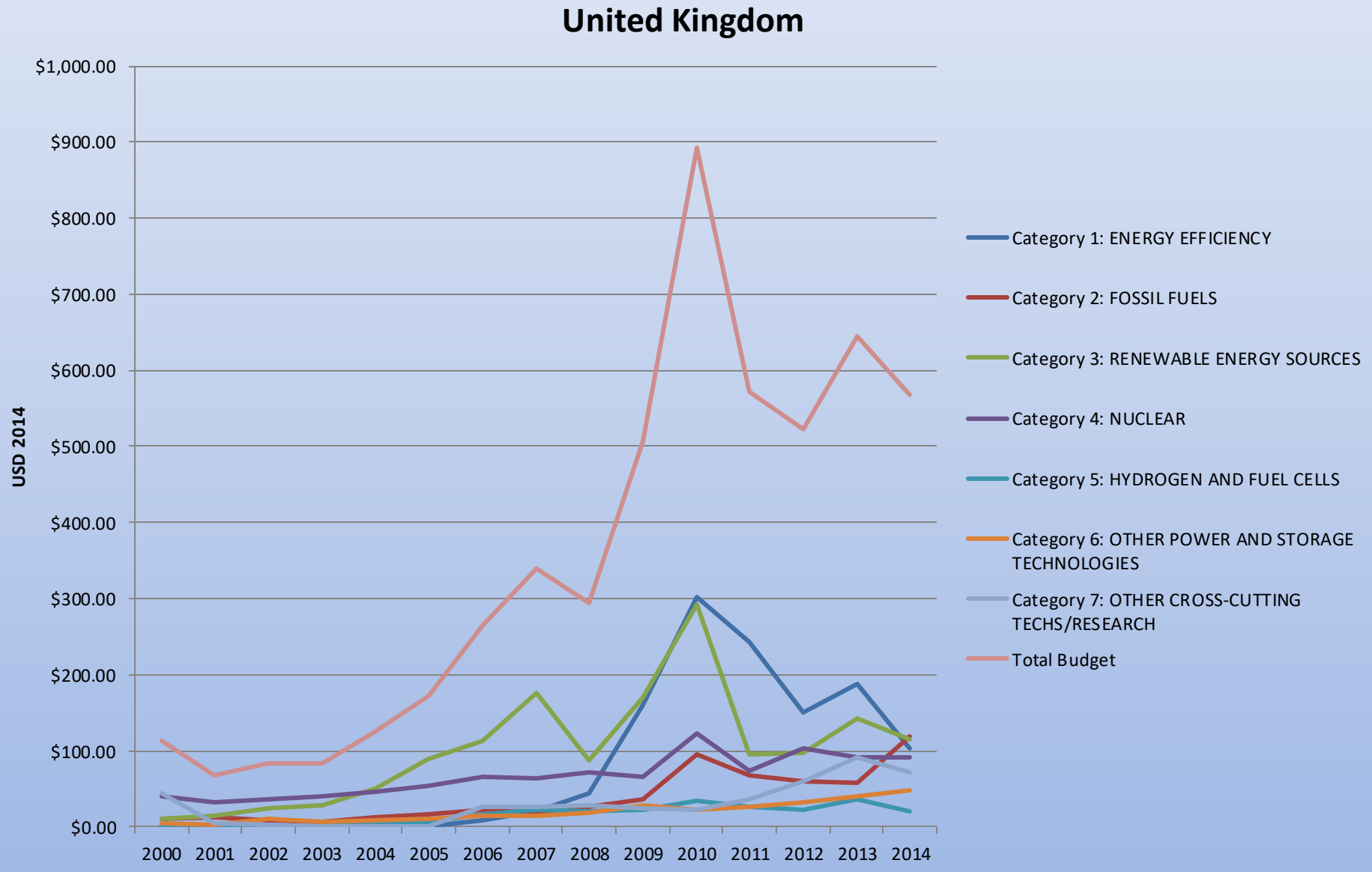


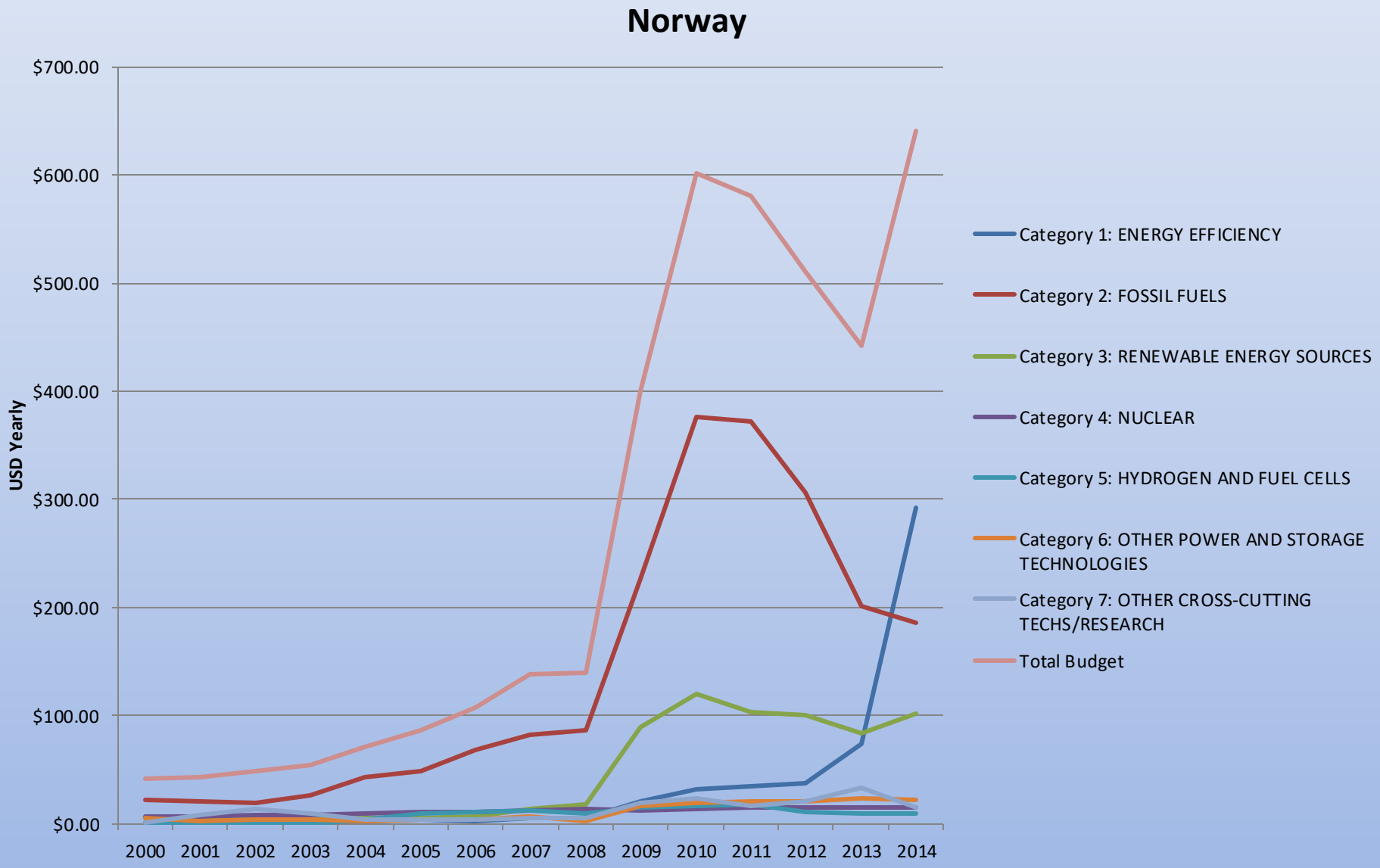


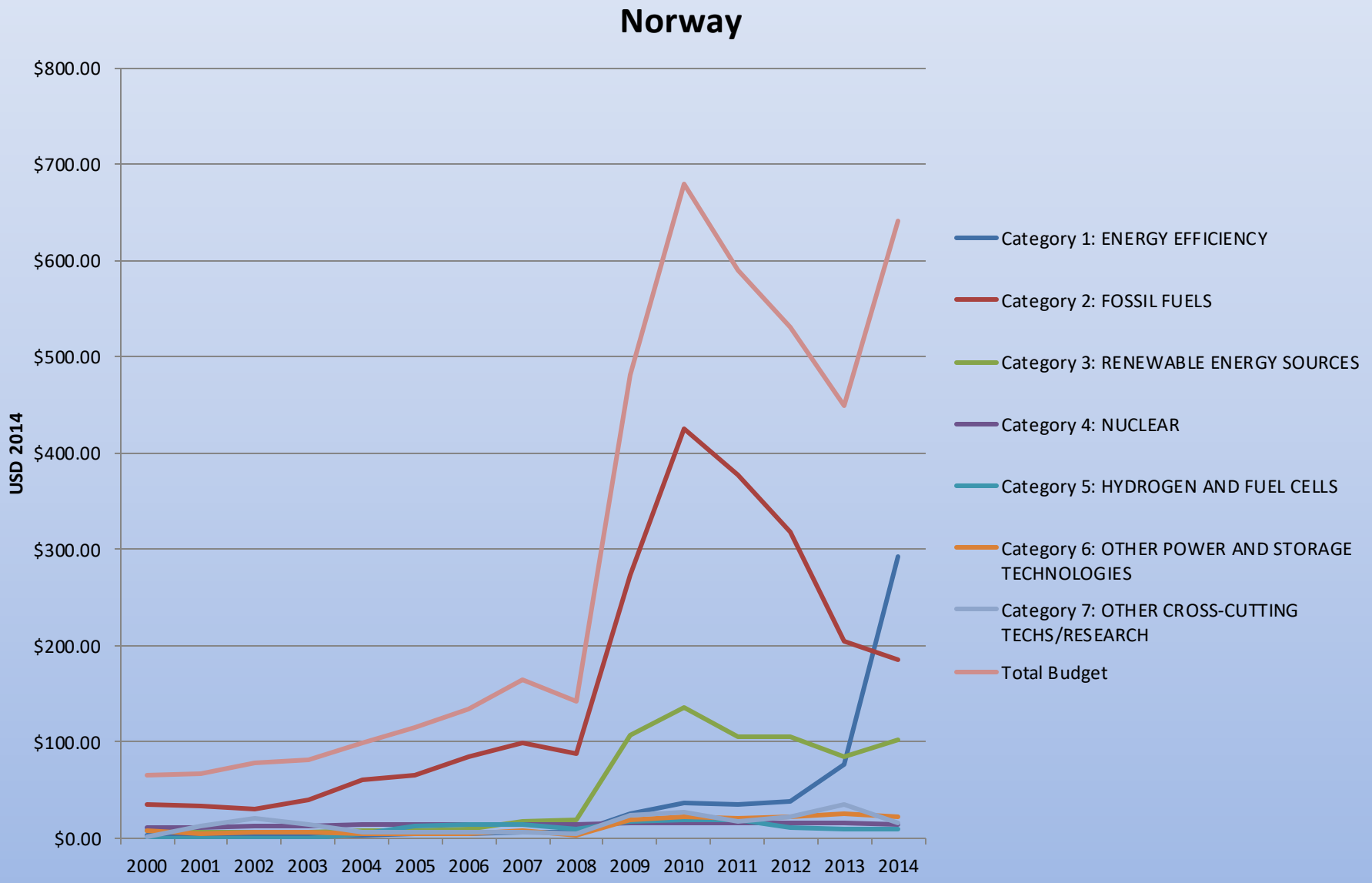


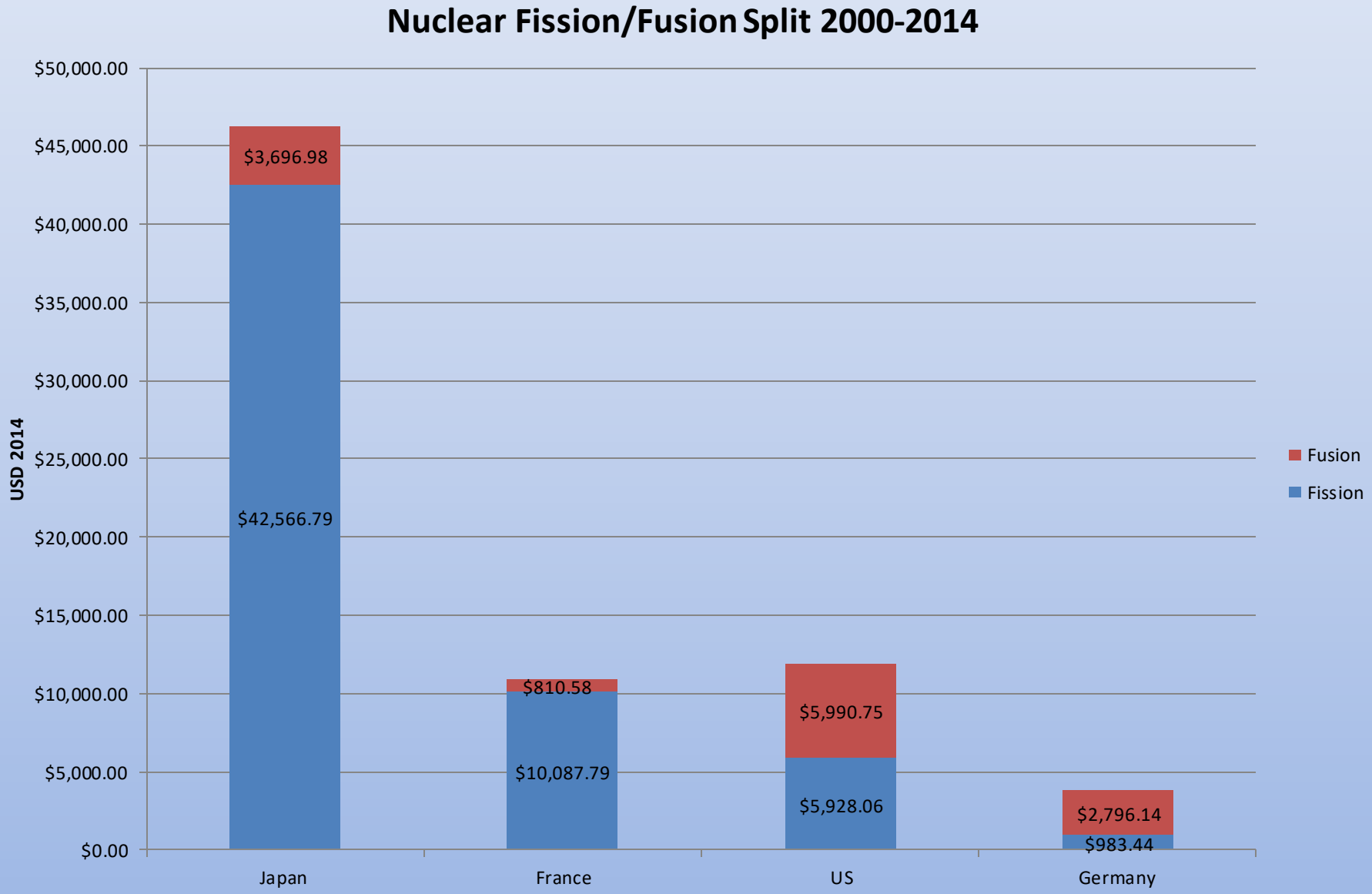


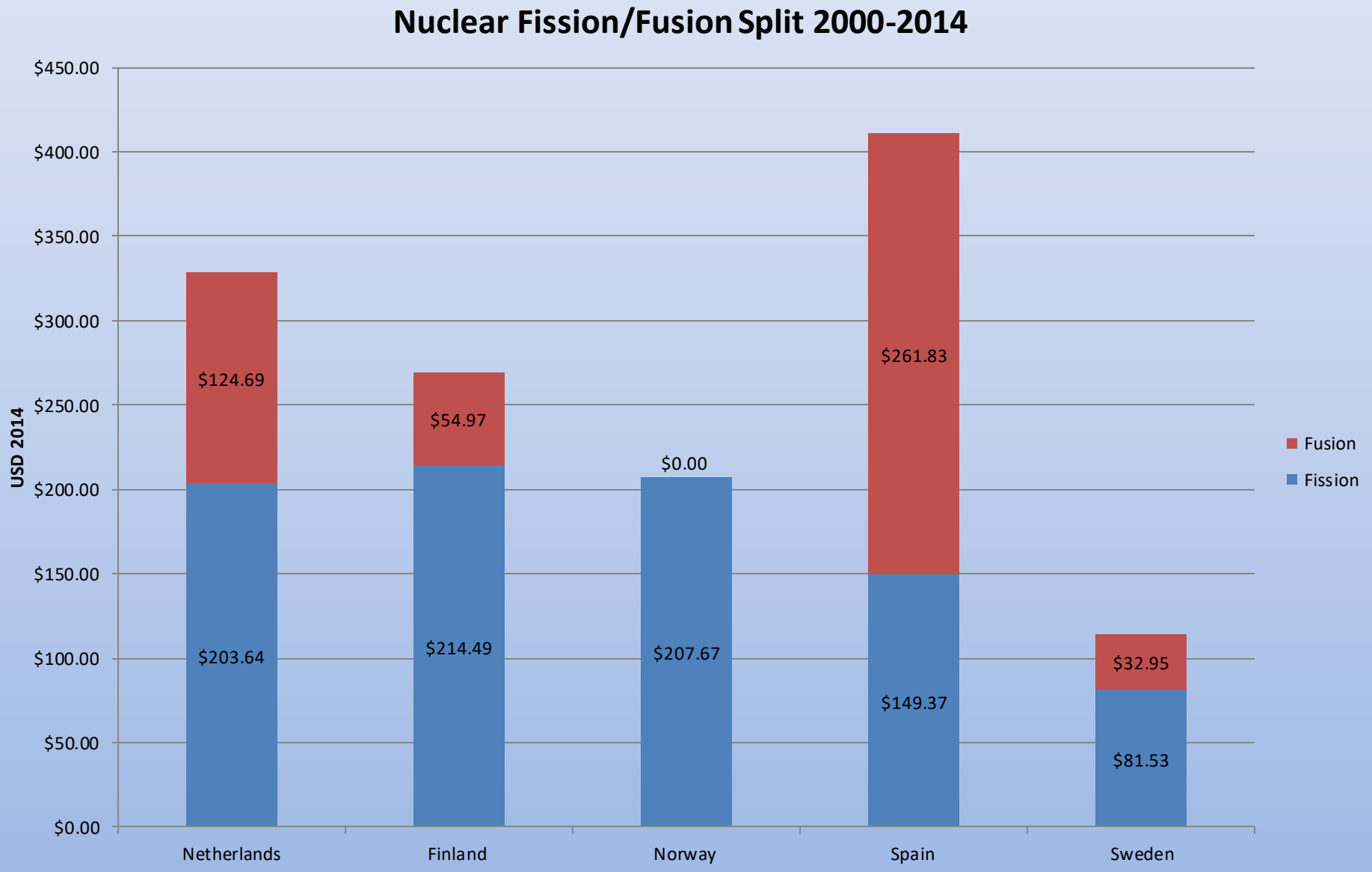




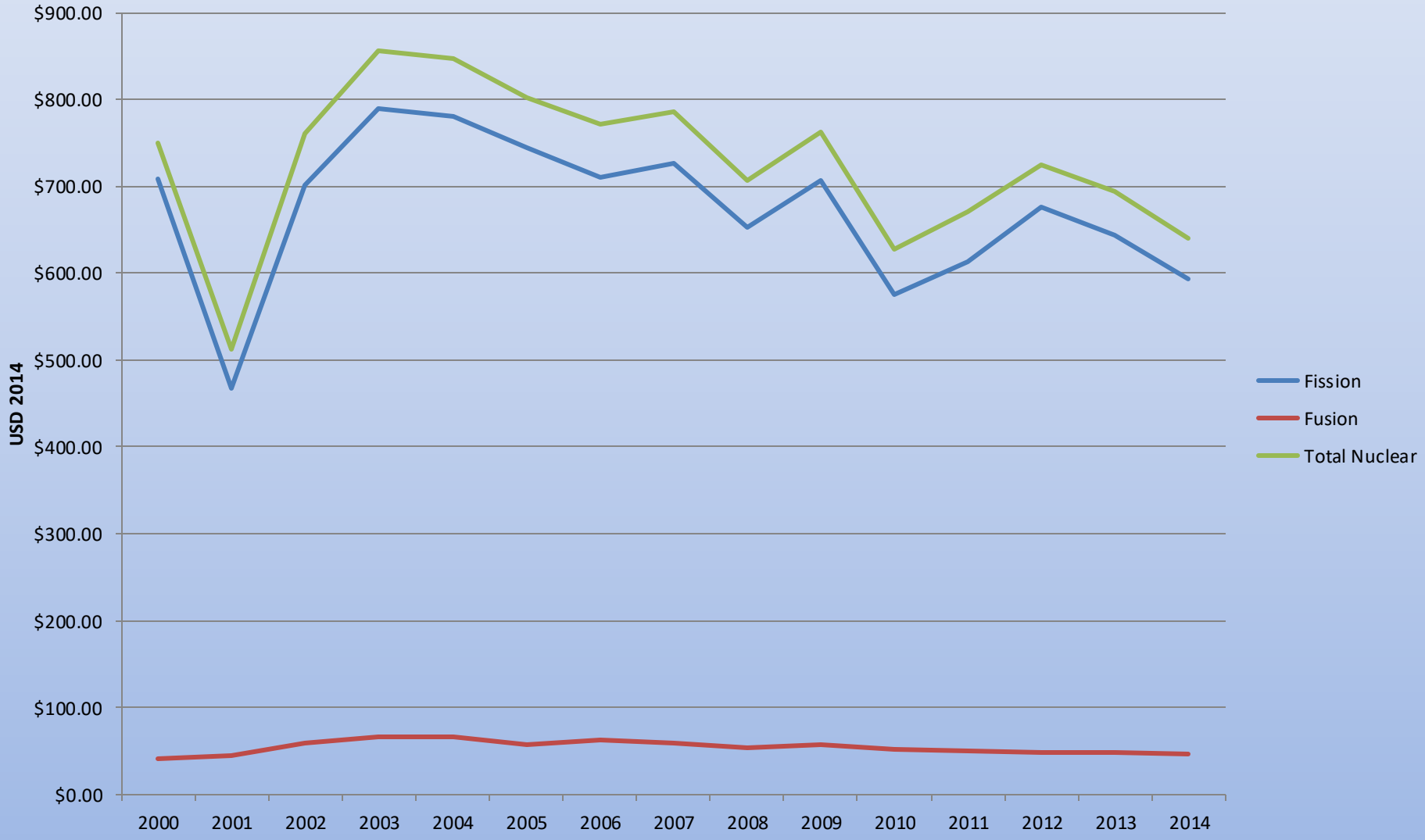


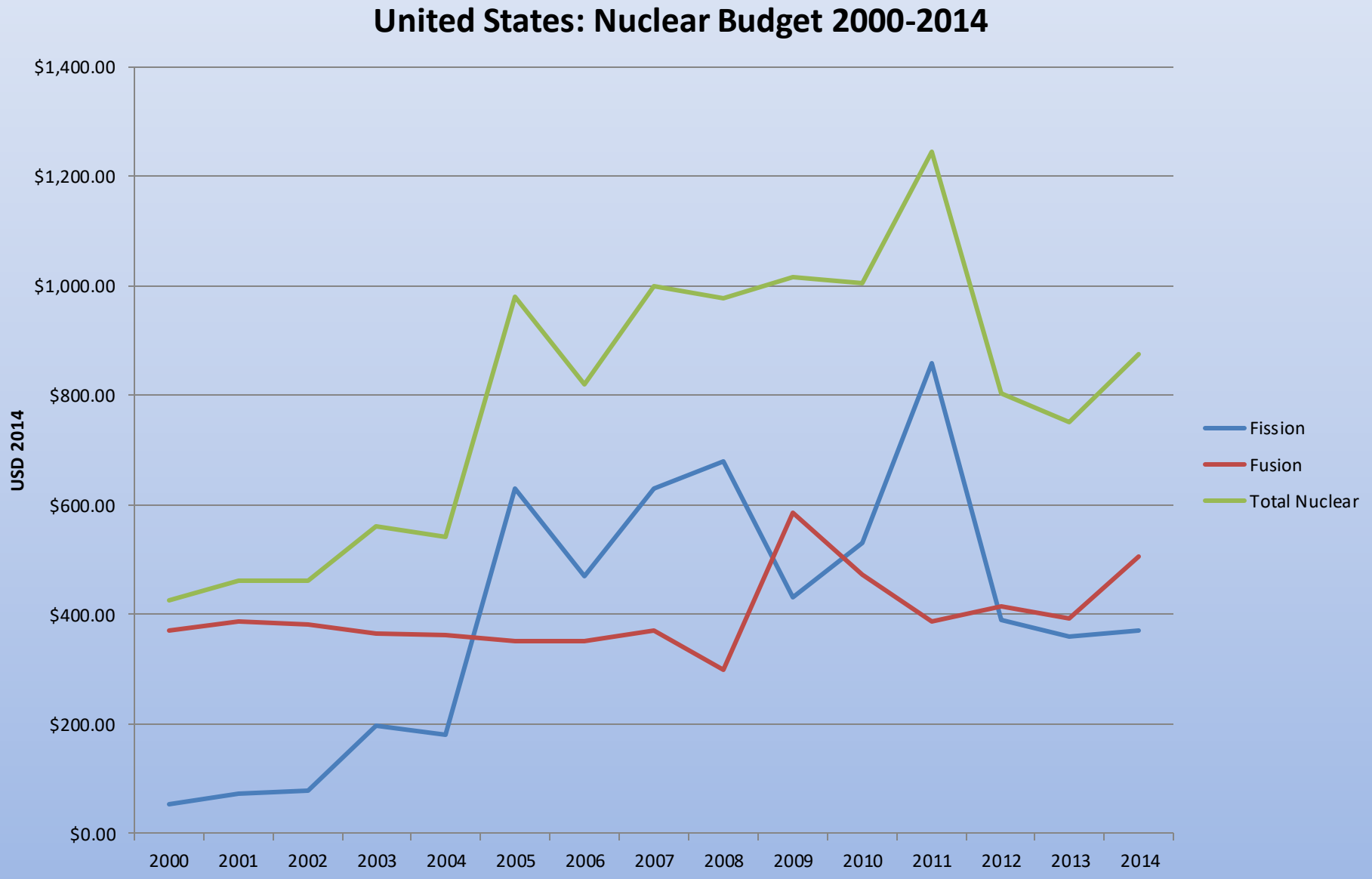


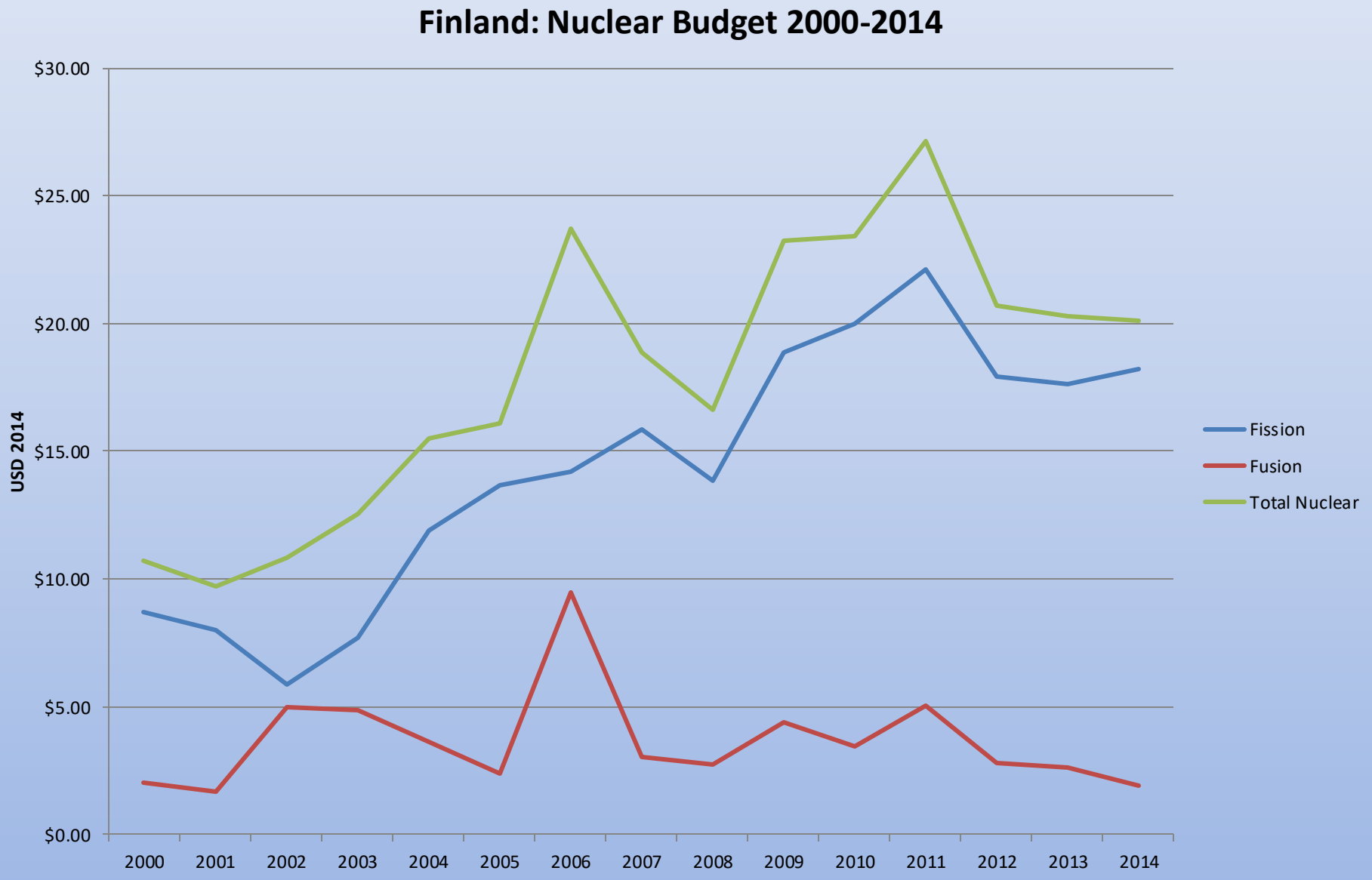


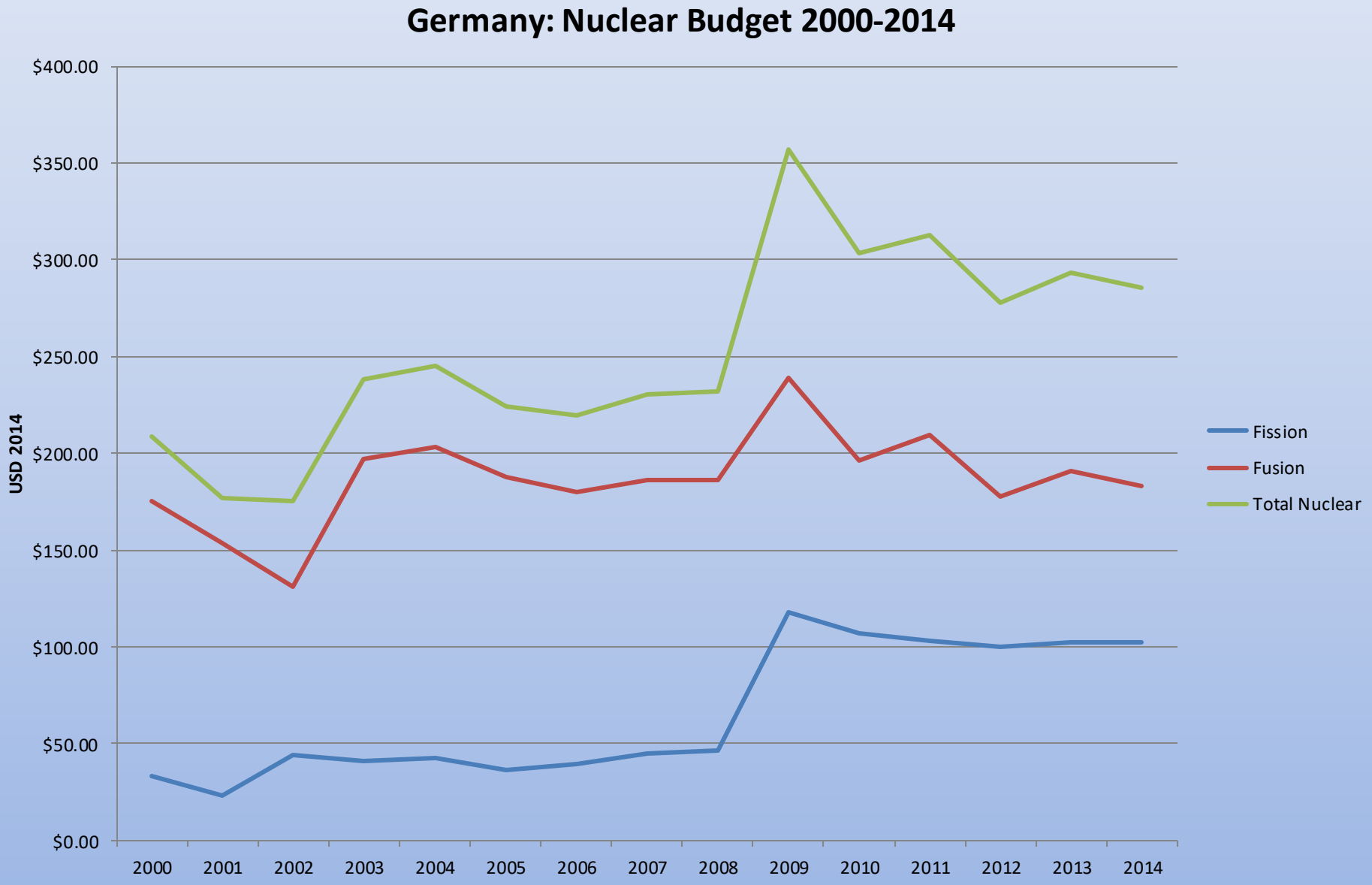


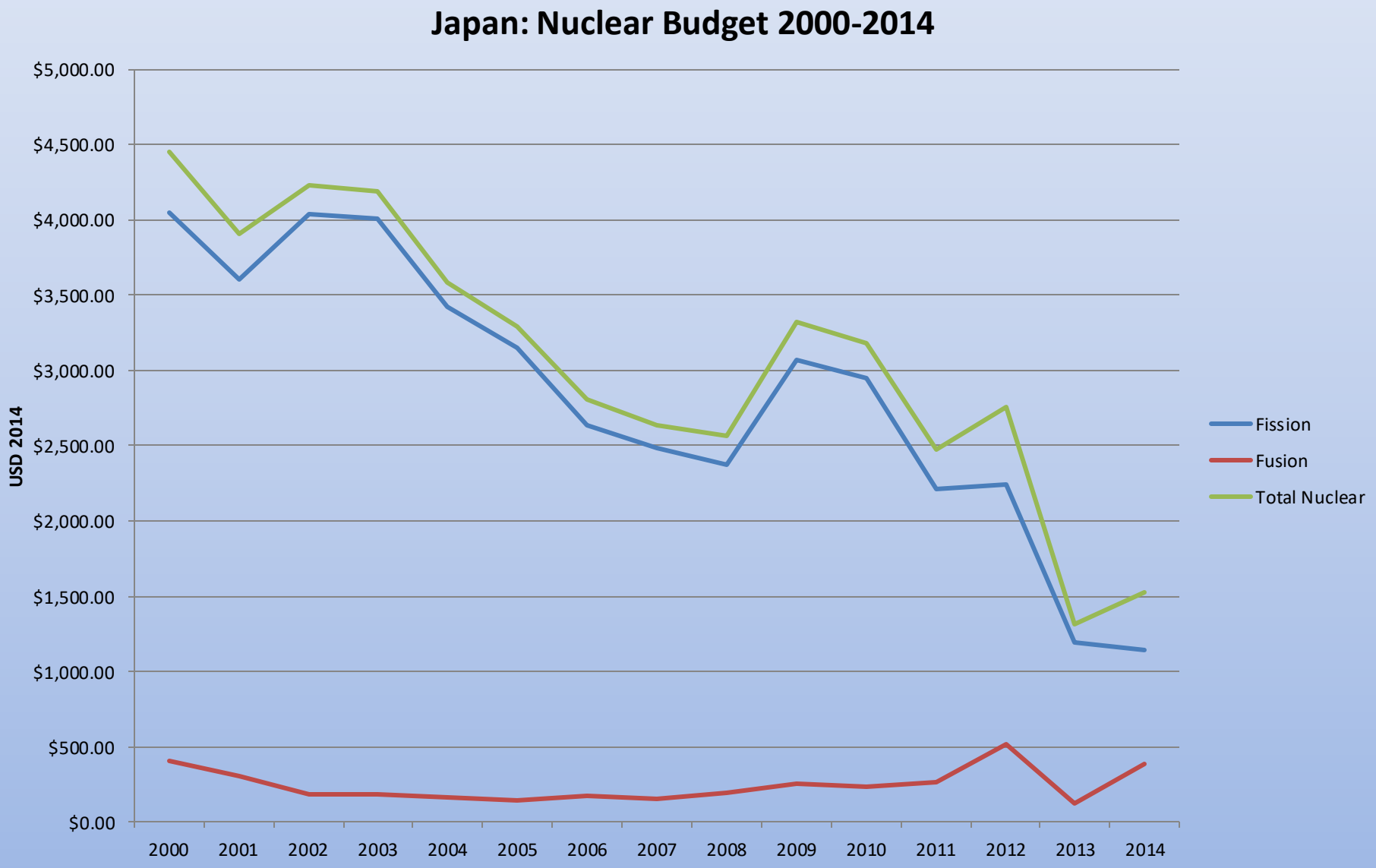
France: Nuclear Budget 2000-2014



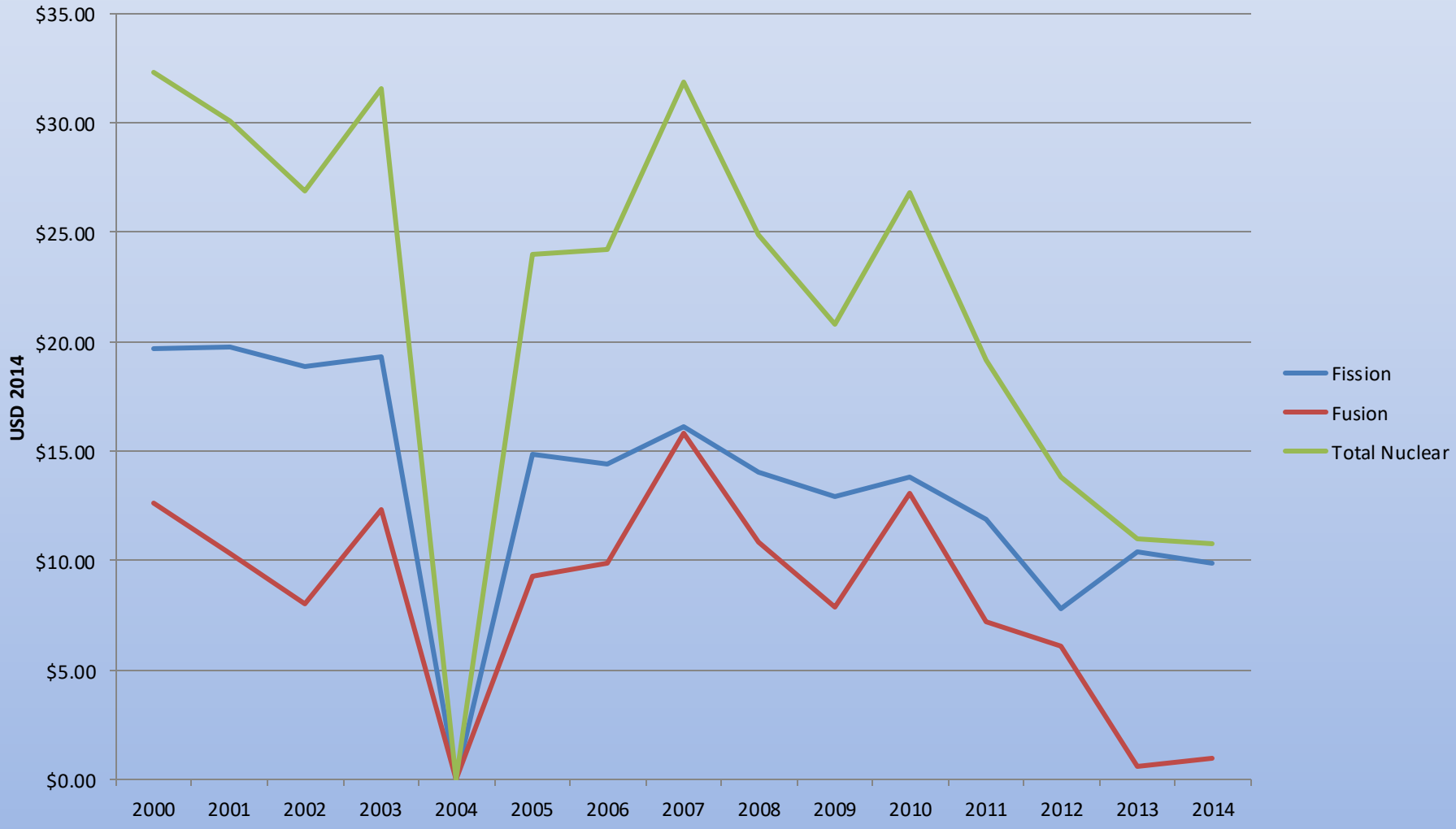




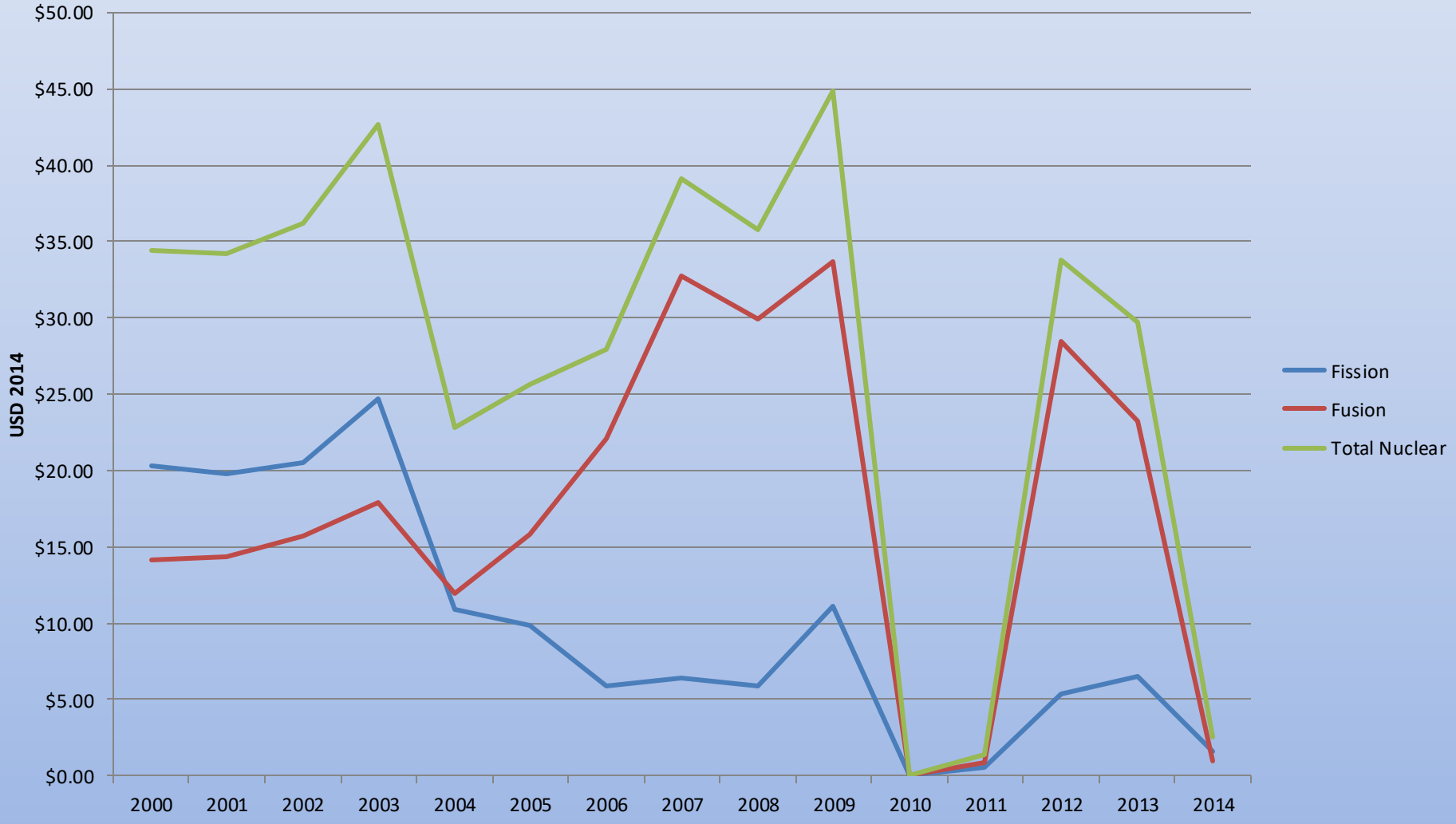


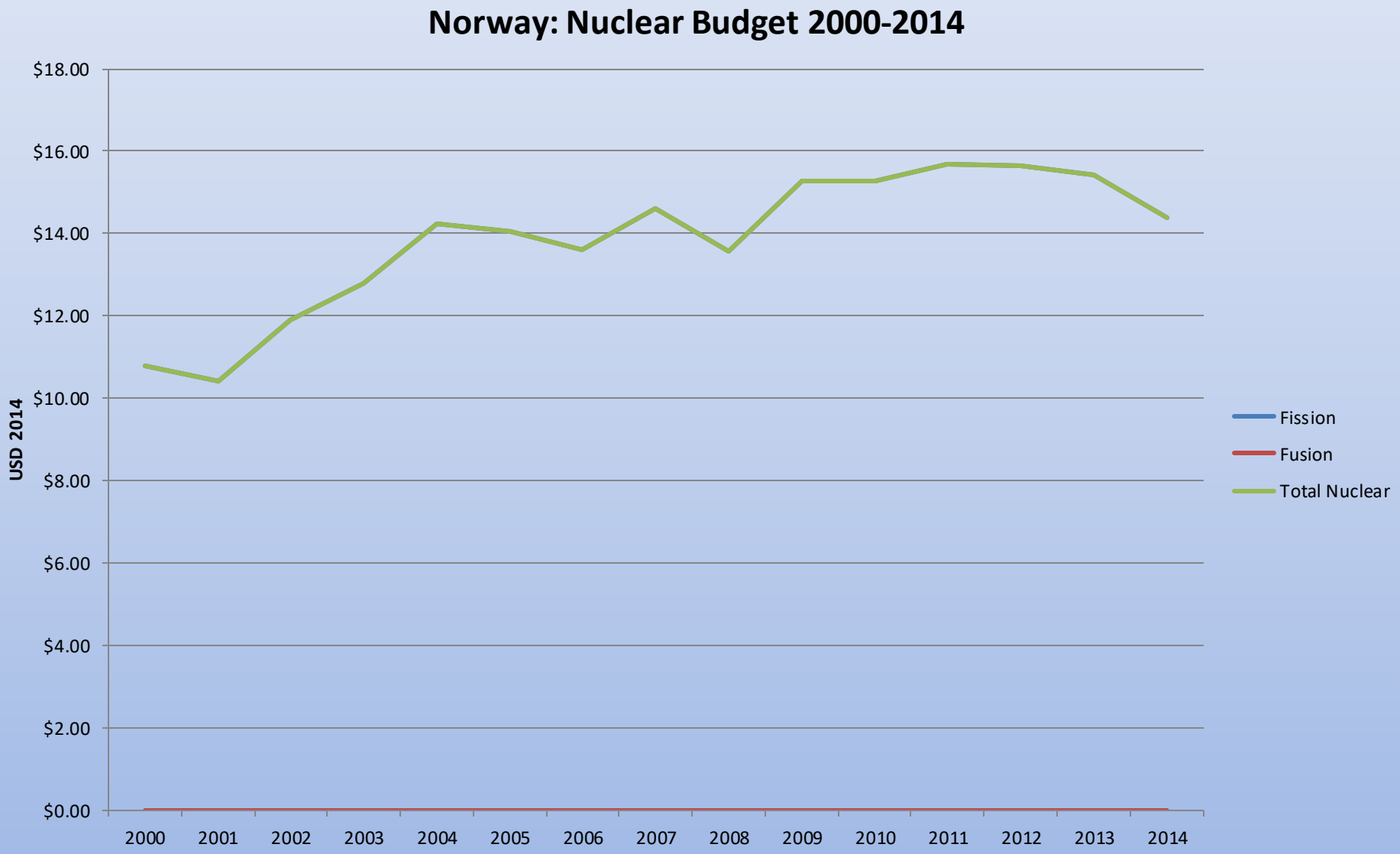


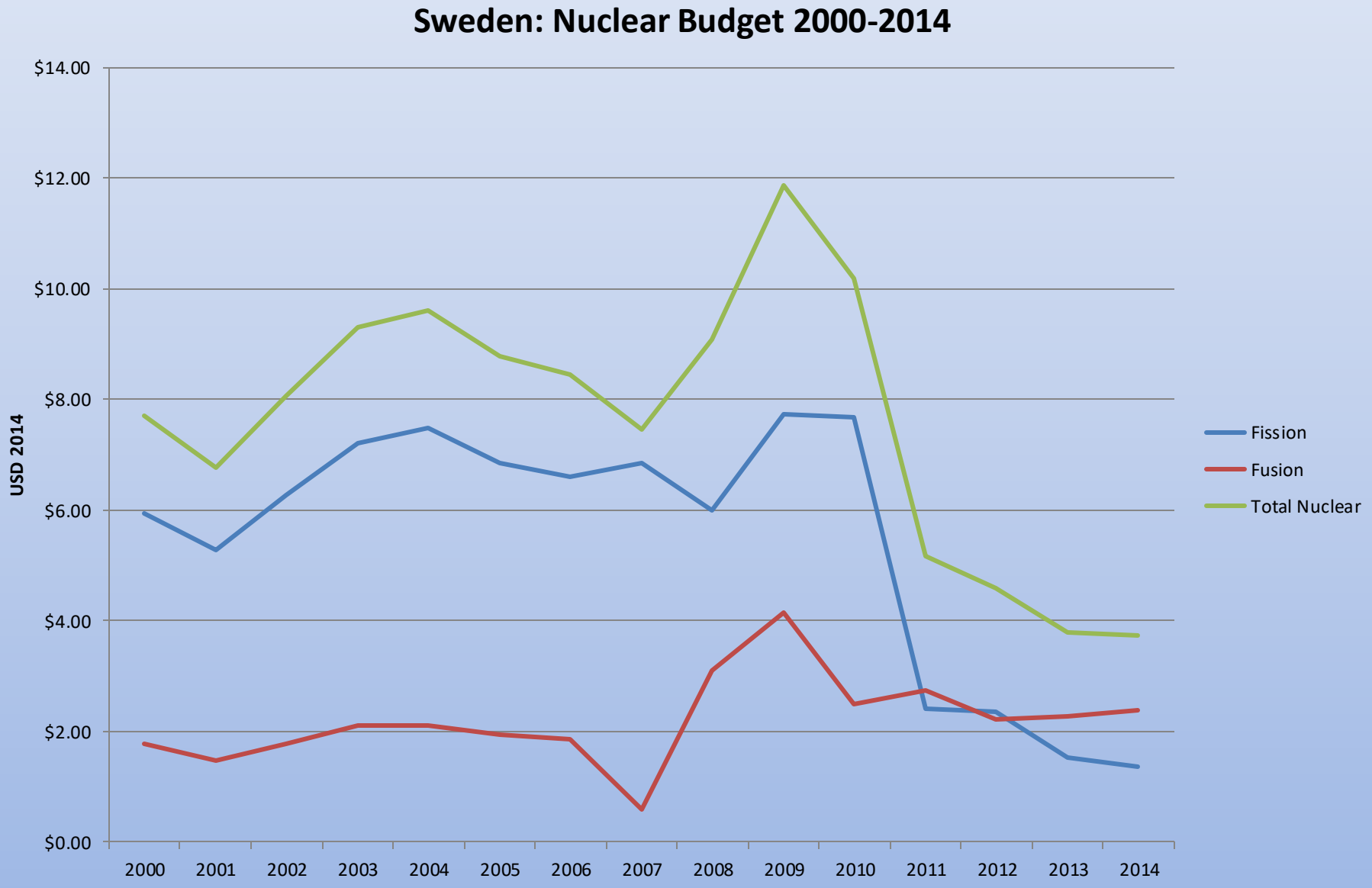
Netherlands: Nuclear Budget 2000-2014



Spain: Nuclear Budget 2000-2014







NI2050 SURVEY: Conclusions

- Great variety of survey returns
- Private budgets basically not available or relevant
- Limited comparison with IEA data
- Some questions also on IEA data
- Countries should reflect on how to improve their inputs

NI2050 Survey Report:

- Background and Questionnaire
- Graphs and country reports
- Short general analysis based on the IEA tends 1975-2015
- Graphs not to be modified anymore
- Country reports – comments/updates/additions via NDC contact person – strict deadline end November 2017
- Publication early 2018